Behavioural and Neural Correlates of Orienting and Executive Control in High and Low Spider Fear Groups

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Statement of Sources

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

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Abstract

Research suggests that attentional bias to threat in specific fear can be demonstrated as facilitated orienting effects such as the rapid automatic detection and processing of threat-related information, and/or interference effects thought to be associated with impaired executive control processes such as the inhibition of task-irrelevant information. This study examined the influence of spider fear on the behavioural (RT and accuracy) and electrophysiological correlates (P1 and N1) of facilitated orienting and executive control. Twenty-six female participants (15 high-fear, 11 low-fear) completed a novel attentional networks test consisting of an alerting condition (present/absent), a pictorial (spider/cow) orienting cue (valid/invalid), and a central target flanked by distractors (congruent/incongruent). In relation to facilitated orienting, no between-group differences were observed, suggesting that greater levels of cognitive load increased interference effects, thus masking the facilitation effect for high-fear participants. Partial support for predictions of behavioural interference effects were observed. This finding was further supported by evidence of attenuated P1 and enhanced N1 amplitude for high-fear participants for incongruent targets preceded by spider images, however these effects were modulated by interactions between the attentional networks. This is a novel finding but is consistent with a complex and interactive attentional networks model.

Keywords: Attention Network Test, attentional networks, emotion regulation, P1, N1

Attentional Bias and Anxiety

Attentional bias toward threat, or the preferential allocation of attentional resources to threatening relative to neutral stimuli, is a consistent finding in high anxious populations (Cisler & Koster, 2010) with small to medium effect sizes found for groups with high trait-anxiety (d = 0.38), high state-anxiety (d = 0.65) and clinical anxiety (d = 0.45) in a recent meta-analysis (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007). Attentional bias is therefore argued to play a significant role in the aetiology and maintenance of anxiety disorders (Bar-Haim et al., 2007). Attentional bias is thought to consist of two early processes, the facilitated detection and processing of threat-related sensory information, and difficulty disengaging attention from threatening stimuli; and a later process of attentional avoidance of threat (Bar-Haim et al., 2007; Cisler & Koster, 2010). Consequently attentional bias toward threat can be demonstrated by facilitation effects, the enhanced detection and processing of targets when they are threat-related, and/or increased interference effects when distractor stimuli are threat-related (Gerdes, Alpers, & Pauli, 2008; Lipp, Derakshan, Waters, & Logies, 2004; Lipp & Waters, 2007).

Eysenck, Derakshan, Santos, and Calvo (2007) proposed that high trait anxiety impairs attentional control, due to facilitation effects which increase the influence of the stimulus-driven bottom-up attentional system, and simultaneous interference effects which act to decrease the influence of the goal-directed top-down attentional system. In addition, anxiety has been associated with impaired cognitive performance which is thought to result from the diversion of cognitive resources to anxiety reduction and goal achievement (Derakshan & Eysenck, 2009). However

generalisability of this model beyond trait-anxiety remains unclear. In particular, few studies have examined the applicability of this paradigm to specific fear.

Normal mechanisms underlying fear are thought to have evolved to enable the detection of danger and so facilitate an effective threat response (Bar-Haim et al., 2007). Therefore it is thought that evolutionary fear-relevant stimuli such as spiders are given attentional priority relative to neutral stimuli (Öhman, 2009). However a functionally adaptive relationship between emotion and attention is dependent on top-down regulation of emotional information such that threat-related stimuli are preferentially attended to when appropriate and inhibited when task-irrelevant (N. Cohen, Henik, & Mor, 2011). For example if you are sitting at a picnic table and notice a large spider approaching, giving preferential attention to this threatening stimulus would be appropriate. However if you are driving a car and see the same spider running over the dashboard, top-down attention regulation should prevent the diversion of attention from the cognitive task of driving. Inability to appropriately down-regulate the influence of emotional stimuli on behaviour has consistently been observed in highly anxious populations (Bar-Haim et al., 2007; Bishop, 2009).

Attentional bias is thought to be modulated by underlying neural mechanisms governing automatic and voluntary attention regulation, and attentional control (the ability to voluntarily control cognitive and emotional attentional processes, and to override pre-potent responses). For example the amygdala has been associated with the facilitation of automatic attention to threat, which in turn may produce interference in voluntary attentional processes, impairing attentional control and thus the ability to disengage attention from threat (Cisler & Koster, 2010). However, the interactive relationship between automatic and voluntary mechanisms remains unclear (Cisler & Koster, 2010; Petersen & Posner, 2012). The Attention Network

Test facilitates examination of the automatic and voluntary attentional mechanisms of the human attentional networks. Additionally, neural activity associated with attentional processes can be directly measured using event-related-potentials. To the best of the author's knowledge the present study was the first to utilise the Attention Network Test to examine behavioural and electrophysiological correlates of human attentional networks in a sample of high spider-fear individuals. Specifically, mechanisms associated with automatic visual processing and interference suppression were examined.

The Attentional Networks

Neuroimaging studies have significantly informed our understanding of the associations between anxiety and attentional processes. Posner and Petersen (1990) have proposed three anatomically and functionally distinct but interactive attentional networks of the human brain; the alerting network, the orienting network, and the executive control network. Both the alerting and orienting networks are predominantly associated with automatic, stimulus driven, bottom-up attention regulation. Alerting functions are related to optimal vigilance. The orienting network is associated with the selective allocation and shifting of attention, and the prioritisation of sensory information processing and includes a stimulus-driven ventral reorienting system and a goal-directed dorsal visuospatial system (Abundis-Gutierrez, Checa, Castellanos, & Rosario Rueda, 2014; Callejas, Lupianez, Funes, & Tudela, 2005; Petersen & Posner, 2012). In contrast, the executive control network involves goal-directed, top-down cognitive and emotional regulation and is associated with the conscious detection of stimuli, conflict monitoring and resolution, error detection, and response selection (Abundis-Gutierrez et al., 2014; Petersen & Posner, 2012). These conscious processes, also referred to as focal

attention, are constrained by the limited capacity of the executive system such that detection of one target can interfere with the detection of subsequent targets (Petersen & Posner, 2012). Anatomically, executive control is associated with extensive connections within a frontoparietal network including the medial frontal cortex and anterior cingulate cortex (Petersen & Posner, 2012).

Importantly, for high anxious individuals attentional bias to threat-related stimuli is thought to facilitate bottom-up attention regulation by amplifying threat signals from the amygdala, and to reduce top-down attention regulation by weakening recruitment of prefrontal control mechanisms (Bishop, 2007). This is consistent with previous research which supports a strong interactive relationship between the orienting and executive control networks (Callejas et al., 2005; Fan, McCandliss, Sommer, Raz, & Posner, 2002; Pacheco-Unguetti, Acosta, Marques, & Lupianez, 2011). For example attentional bias is thought to enhance orienting by facilitating automatic attention to threat, thus producing interference in executive control processes and impairing the ability to disengage and override pre-potent responses (Cisler & Koster, 2010; Petersen & Posner, 2012). Significantly the attentional networks model proposed by Petersen and Posner (2012) distinguishes between bottom-up stimulus-driven attentional processes and top-down goal-directed attentional processes. This is consistent with Beck and Clark (1997) who suggest that reducing the influence of automatic processing while increasing the influence of voluntary processing is central to the treatment of anxiety.

The Attention Network Test

The Attention Network Test (ANT; Fan et al., 2002) specifically enables experimental examination of the three attentional networks described by Petersen and Posner (2012). The ANT is comprised of alerting and orienting paradigms

together with a flanker task (Eriksen & Eriksen, 1974). The Eriksen flanker paradigm (Eriksen & Eriksen, 1974) is an established task used to assess attentional control (Fenske & Eastwood, 2003).

The ANT has been used to examine relationships between the attentional networks in normal and clinical populations (Posner & Rothbart, 2007). Reaction times are used to evaluate the efficiency of each network (Fan et al., 2009; Fan et al., 2002). Targets are preceded by visual spatial cues which enable examination of the orienting network. Cues can be valid (spatially predict the target location), or invalid (appear opposite the target location) and reaction times are typically faster for valid compared to invalid trials (the cueing effect). Furthermore, given that fear has been found to further facilitate attention towards threat (Lipp & Derakshan, 2005), reaction times are typically shorter for threatening relative to neutral cues, thus indexing hypervigilance towards threat. The flanker component of the ANT consists of five arrows. The participant is required to differentiate between the central target arrow which points to the left or right, and the four flanker arrows (two either side) which can be congruent (e.g. <<<<<) or incongruent (e.g. >><>>). This enables evaluation of interference effects on efficiency of the executive control network, which is demonstrated by slower reaction time (RT) on incongruent trials relative to congruent trials (Botvinick, Cohen, & Carter, 2004; Eysenck et al., 2007). Referred to as the congruency effect, this pattern of results indexes interference suppression within the executive control network (Eriksen & Eriksen, 1974; Fan et al., 2002).

However few studies have used the ANT to assess the influence of emotionally salient stimuli on the attentional networks (N. Cohen et al., 2011; Dennis & Chen, 2007) and to date research appears to focus on orienting, with few studies examining associations between emotion and executive control (N. Cohen et al.,

2011). Additionally there is support for a strong interactive relationship between the orienting and executive control networks such that the congruency effect is reduced on valid trials and increased on invalid trials (Callejas et al., 2005; Fan et al., 2009). This suggests that invalid cues increase cognitive load and interference due to increased competition for attentional resources shared by the orienting and executive control networks (Fan et al., 2009). For example the frontoparietal network is involved in orienting and executive control functions, while the anterior cingulate cortex is involved in both uncertainty (Behrens, Woolrich, Walton, & Rushworth, 2007) and conflict processing (Matsumoto & Tanaka, 2004). Thus detection of a congruent target following an invalid cue requires only the re-orienting function, while detecting an incongruent target following an invalid cue requires re-orienting and executive control functions (Fan et al., 2009).

Facilitated orienting towards threat has been demonstrated across a variety of paradigms including the dot-probe (Koster, Crombez, Verschuere, Van Damme, & Wiersema, 2006) and visual search tasks (Lipp et al., 2004). However studies using the ANT have typically failed to find support for facilitation effects. For example facilitated orienting was not demonstrated by unselected participants responding to negative relative to neutral stimuli (N. Cohen et al., 2011), for high anxious (state and trait anxiety) participants relative to controls when responding to neutral stimuli (Pacheco-Unguetti, Acosta, Callejas, & Lupiáñez, 2010; Pacheco-Unguetti et al., 2011), or for unselected participants responding to threat-related relative to neutral stimuli (Finucane & Power, 2010). In contrast, no significant behavioural (reaction time) between group differences were found in relation to orienting. As the likelihood of interference effects increases as cognitive load increases, these findings

suggest that the higher levels of cognitive load associated with the ANT increase the probability of interference effects, thus masking facilitation effects.

Few studies have examined the influence of specific fear on these networks, and to the author's knowledge no study has used the ANT to examine the interactions between the orienting and executive control networks in specific fear. The current study therefore aims to examine the influence of spider fear on orienting and executive control using the ANT. As this study constitutes part of a larger project the alerting network will not be specifically examined here.

Spider Fear and Facilitation

Hypervigilance. Research has consistently found that anxious individuals differentially demonstrate attentional bias towards threat as shown by facilitated attention to threat, attentional avoidance of threat, and disengagement difficulty (Cisler & Koster, 2010). The facilitation effect typically predicts automatic threat detection and preferential processing of threat-related information by the orienting network, and is therefore thought to index hypervigilance (Cisler & Koster, 2010). Support for attentional bias, and particularly hypervigilance, comes from numerous studies utilising a variety of experimental paradigms. For example, using a spatial cueing task, Koster et al. (2006) found that when responding to high threat cues, individuals with high relative to low trait-anxiety demonstrated facilitated attention (faster response to valid cues) and disengagement difficulty (slower response to invalid cues) when stimuli were presented for 100ms, but showed attentional avoidance (slower response to valid cues) when threat-related cues were presented for 200ms and 500ms. In relation to spider fear, Lipp and Derakshan (2005) found that high-spider-fear individuals responded faster to target probes replacing spider relative to neutral picture cues in a dot probe task.

Additionally amygdala activity has been implicated in the early visual processing of threat-related stimuli. Projections from the amygdala to the visual cortex include the primitive magnocellular pathway, which is thought to facilitate rapid and automatic processing of threatening information (Berggren & Derakshan, 2013). For example, amygdala activity was found to increase significantly in response to spider presentations, but not for neutral stimuli in an fMRI visual processing study (Alpers et al., 2009). Similarly, Bishop, Jenkins, and Lawrence (2007) found that state-anxiety was associated with amygdala hyper-responsivity enhancing threat detection and prioritising attentional processing of fearful face distractors relative to neutral face distractors. Therefore hypervigilance to threat is associated with automatic activation of the amygdala, facilitated orienting, and the preferential processing of threat-related stimuli (Bishop, 2007; Cisler & Koster, 2010). This is consistent with the assumption that threatening stimuli increase the influence of bottom-up attention regulation.

Spider Fear and Interference

Attentional Control. Consistent with the attentional networks model (Petersen & Posner, 2012), Eysenck et al. (2007) have proposed attentional control theory (ACT) to describe associations between anxiety, attentional control, and cognitive performance. Specifically ACT proposes that attentional control is a primary function of the central executive, a limited capacity component of working memory (Repovš & Baddeley, 2006) resembling the executive control network described by Petersen and Posner (2012). Attentional control is associated with the ability to monitor and resolve conflict, and to inhibit the allocation of attentional resources to task-irrelevant stimuli and responses (M. Cohen, 2014; Eysenck et al., 2007; Friedman & Miyake, 2004; Miyake et al., 2000; Nigg, 2000). Additionally,

ACT assumes that anxiety creates an imbalance between bottom-up and top-down attentional systems by simultaneously increasing the influence of the bottom-up attentional system while decreasing the influence of the top-down attentional system, thereby impairing attentional control. Specifically, anxiety is thought to impair attentional control in the presence of task-irrelevant stimuli as attentional processing resources are more likely to be diverted to competing distractor stimuli (Eysenck et al., 2007), as demonstrated by the congruency effect in the flanker task. Additionally, consistent with attentional bias the congruency effect is thought to be greater in the presence of threat-related stimuli as threatening information is preferentially processed by the alerting and orienting attentional networks, increasing the influence of bottom-up attention regulation and decreasing the influence of top-down attention regulation (Eysenck et al., 2007). This imbalance impairs cognitive performance (typically indexed by response time) and attentional processing efficiency. Processing efficiency can be conceptualised as the relationship between cognitive resources required to perform a task and performance effectiveness (typically indexed by performance accuracy). Specifically anxiety is thought to compromise processing efficiency of the central executive. A fundamental assumption of ACT is that high anxious individuals are able to compensate for reductions in executive processing efficiency by effortful control and the recruitment of additional cognitive resources with the result that performance effectiveness is not significantly affected. Consequently this reduces the availability of executive control resources for the processing of task-relevant information (Eysenck et al., 2007).

Support for ACT primarily comes from research examining trait-anxiety and clinical anxiety. For example, in the ANT clinically anxious populations relative to controls demonstrated an increased congruency effect and disengagement difficulties

to emotionally neutral stimuli as shown by significantly longer RT to invalid trials and incongruent targets (Pacheco-Unguetti et al., 2011). Furthermore, Berggren and Derakshan (2013) found that anxiety enhanced stimulus-driven attentional processing (i.e. reduced focal attention) thus increasing interference from distractor stimuli and impairing performance on a flanker task. Specifically unselected participants demonstrated slower RT to the incongruent target following exposure to fearful relative to other emotional faces. Furthermore, consistent with ACT, interference effects have been demonstrated using visual search tasks. For example, detection of a neutral target took longer in the presence of spider relative to neutral distractors for unselected participants (Lipp & Waters, 2007) and for spider phobics compared to non-phobics (Miltner, Krieschel, Hecht, Trippe, & Weiss, 2004).

However generalisability of attentional control theory remains unclear. For example, based on load theory of attention (Lavie, 1995; Lavie, Beck, & Konstantinou, 2014), Bishop (2007) argues that executive control is also modulated by perceptual load, or the attentional resources required to process target stimuli. In a response-conflict task, Bishop (2009) found that for neutral stimuli high trait-anxiety was associated with impaired rather than increased recruitment of executive control mechanisms when perceptual load was low. Conversely, when perceptual load was high neither trait nor state anxiety were associated with impaired performance or accuracy, but high trait-anxiety was associated with increased prefrontal cortex activation for the incongruent relative to the congruent condition, which is consistent with ACT (Bishop, 2009; Eysenck & Derakshan, 2011). Consequently, Bishop (2007) argues that under high perceptual load, competition for attentional resources prevents the processing of distractors, thus weakening the influence of bottom-up attentional processes. Conversely, for low perceptual load

tasks, anxiety is thought to weaken the active recruitment of attentional resources required to suppress interference from competing distractor stimuli thus impairing attentional control (Bishop, 2007).

Recent studies using the ANT provide additional evidence for differential effects of anxiety on attention (see Appendix A). For example threat-related compared to neutral stimuli were associated with improved attentional control for unselected participants (Finucane & Power, 2010); and Pacheco-Unguetti et al. (2010) found that high trait-anxiety was associated with impaired top-down attention regulation while high state-anxiety was related to increased influence of bottom-up attention regulation, suggesting a double dissociation. Similarly, Dennis and Chen (2009) found differential threat modulation of executive control mechanisms by anxiety, and suggested that for high trait-anxiety threat bias was associated with increased recruitment of cognitive resources and enhanced conflict monitoring such that cognitive performance was improved for high conflict conditions, but compromised in low conflict conditions.

In summary, anxiety is thought to create an imbalance between bottom-up and top-down attentional mechanisms thereby impairing attentional control. However current research suggests differential effects of type of anxiety and load on stimulus-driven and goal-directed attentional mechanisms. Crucially, to date few studies have examined the applicability of attentional control theory to specific fear.

Electrophysiological Correlates P1 and N1.

Neural activity associated with attentional bias and attention control can be directly measured using event-related-potentials (ERPs), which enable the time locked recording of neural responses to specific stimuli (Dennis & Chen, 2007; Woodman, 2010). Electrophysiological studies have demonstrated that modulations

of posterior P1 ERP component (maximal at lateral occipital sites, peaking 80-130 ms post-stimulus) is associated with early automatic orienting and the preferential processing of visual stimuli (Dennis & Chen, 2007; Fu, Caggiano, Greenwood, & Parasuraman, 2005; Kolassa, Musial, Kolassa, & Miltner, 2006; Mangun, 1995). Generated in the extra-striate visual areas, the P1 ERP component is thought to index enhanced early visual processing and attentional allocation (Mangun, 1995). Increased P1 amplitude is associated with the automatic suppression of unattended stimuli, enhanced focal attention and the recruitment of attentional control over emotional and conflicting information (Luo, Greenwood, & Parasuraman, 2001; Mangun, 1995). For example amplitude modulation of the P1 component ERP waveform has been demonstrated to be greater for validly cued trials relative to invalidly cued trials (Abundis-Gutierrez et al., 2014), and for threatening relative to neutral stimuli (Bublatzky & Schupp, 2012). Additionally, in the ANT, P1 amplitude was observed to be greater in anxious relative to non-anxious individuals for incongruent targets preceded by happy, neutral, and fearful faces (Dennis & Chen, 2007).

Additionally modulations of P1 amplitude are thought to index hypervigilance with greater P1 amplitude reflecting facilitated attention towards threat (Kolassa et al., 2006; Michalowski et al., 2009). For example Michalowski et al. (2009) found that spider phobics relative to controls responded with greater P1 amplitudes to both spider-relevant and irrelevant pictures in an ERP study, demonstrating general hypervigilance, and Venettacci (2014) found that high-spider-fear relative to low-spider-fear participants exhibited faster reaction time and greater P1 amplitude to spider relative to flower targets in a modified flanker task, suggesting specific hypervigilance towards spiders. This initial ‘negativity bias’ may involve an early

amygdala response reflecting specific automatic attentional responses to phylogenetically fear-relevant animals, and is consistent with studies that suggest the amygdala receives visual threat-related information via the primitive magnocellular pathway involving a thalamo-amygdala connection which rapidly conveys visual information from the eye to the visual cortex (Berggren & Derakshan, 2013; Carlson, 2010; Öhman, 2009).

Similarly, modulation of the posterior N1 ERP component (maximal at lateral occipital sites, peaking 100-200ms post-stimulus) is associated with early automatic orienting and the preferential processing of visual information within the extra-striate visual cortex (Fu et al., 2005; Mangun, 1995). For example, N1 amplitude modulation is associated with spatial attention and visual discrimination and is thought to reflect early facilitated perceptual processing and discriminative processing of stimuli within the attended location (Griffin, Miniussi, & Nobre, 2002; Mangun, 1995; Niu, Wei, & Luo, 2008). Thus enhanced N1 amplitude is thought to reflect improved focal attention particularly when discrimination of target stimuli is required. For example enhanced N1 amplitude has been demonstrated in discriminative relative to simple detection tasks in the spatial cueing task (Mangun, 1995; Mangun & Hillyard, 1991), and the visual search task (Weymar, Gerdes, Löw, Alpers, & Hamm, 2013). Consistent with this finding, enhanced N1 amplitude has also been demonstrated in the flanker task for incongruent relative to congruent trials (Johnstone, Barry, Markovska, Dimoska, & Clarke, 2009; Nicholls, Bruno, & Matthews, 2015).

Additionally, research suggests that N1 amplitude is also modulated by emotion. For example, enhanced N1 amplitude has been found for incongruent relative to congruent trials when stimuli were negative, but for congruent trials when

stimuli were positive (Li et al., 2014), and for high relative to low trait-anxiety individuals in response to threatening relative to neutral pictures (Penf, Yang, & Luo, 2013). In relation to spider fear, Weymar et al. (2013) found that spider fearful participants relative to controls demonstrated enhanced N1 amplitude to spider relative to neutral distractors in a visual search task, however no significant between group differences in RT were observed. Therefore N1 modulation is thought to index perceptual processing of discriminative target stimuli, such that N1 amplitude is expected to be enhanced for incongruent relative to congruent targets. To the author's knowledge, no study has used the ANT to examine P1 or N1 modulation in specific fear.

Rationale and Aim

The purpose of this study was to examine the effect of specific fear on the efficiency of the orienting and executive control networks. Research appears to support a disruptive effect of anxiety on attentional mechanisms leading to an imbalance between the stimulus-driven bottom-up attention system and the goal-directed top-down attention system. However, although attentional bias towards threat is strongly supported it is unclear if interference effects result from impaired disengagement, facilitated detection, or threat avoidance and further research is required to establish if these inconsistencies reflect differential effects of anxiety or methodological variability. Additionally, studies examining the effect of specific fear on attention have to date focussed on attentional capture and preferential processing with few specifically examining the influence of specific fear on attentional control and interference suppression. Consequently, despite evidence for a strong interactive relationship between orienting and executive control this relationship is not well understood in relation to specific fear. Therefore, using a

modified ANT, the current study aimed to examine the specific effects of spider fear on the behavioural (RT and accuracy) and electrophysiological (P1 amplitude) correlates of the orienting and executive control networks.

Hypotheses

Consistent with predictions of the ANT, all participants were expected to demonstrate significantly faster RT to alert, valid, and congruent trials relative to no-alert, invalid, and incongruent trials respectively. Given previous research using simple dot-probe tasks, and if spider fear is associated with an attentional bias towards threat (hypervigilance), it was expected that when the orienting cue was valid and fear-relevant (spider) high relative to low-spider-fear participants would demonstrate faster RT, and enhanced P1 and N1 amplitude.

Conversely, if the likelihood of interference effects was increased due to higher cognitive load associated with the ANT, then consistent with the prediction that fear impairs the ability to suppress distracting stimuli, it was expected that high relative to low-spider-fear participants would instead demonstrate reduced processing efficiency of the executive control network on incongruent relative to congruent targets when preceded by spider cues, as indexed by slower RT, reduced P1 amplitude, and enhanced N1 amplitude. Further, consistent with previous studies (Bishop, 2009; Eysenck & Derakshan, 2011; Eysenck et al., 2007; Venettacci, 2014) it was expected that high-fear relative to low-fear participants will not demonstrate reduced performance effectiveness (reduced accuracy).

Method

Participants

The University of Tasmania Human Research Ethics Committee (see Appendix B) approved this study. First year psychology students were invited to

participate in the study in return for course credit. Individuals known to the experimenters were also invited to participate. Ninety-one females were screened online for ERP exclusion criteria which included; a history of previous severe head trauma, neurological or psychiatric disorders, convulsions, other serious physical conditions, current sleep disorder, current regular use of prescription medication, current or history of substantial illicit drug use, pregnancy; potential alcohol dependence as indexed by a score > 16 on the Alcohol use Disorders Identification Test (AUDIT; Saunders, Aasland, Babor, De la Fuente, & Grant, 1993) (see Appendices C, D, and E); and high psychological distress as indexed by a score >30 on the Kessler Psychological Distress Scale (K10; Kessler et al. 2002). Online screening also included the Spider Phobia Questionnaire (SPQ; Watts & Sharrock, 1984) which was used to select high and low spider fear participants based on a median split (> < 50). Following online screening, fifteen low fear and sixteen high fear participants were invited to participate in the study. Participants were instructed to abstain from nicotine and caffeine for 8 hours and from alcohol for 24 hours prior to the experimental session.

Following the experimental session, two low fear participants were excluded for not completing the task and for incorrect button use, one high fear participant was excluded due to extreme outlying RTs (determined from box plots), and two low fear participants were excluded due to low accuracy scores (correct responses <70%). The final participant sample consisted of 11 low-spider-fear and 15 high-spider-fear females (18–34 years of age). In relation to illicit drug use, each group included two participants who reported drug use within the last six months (less than monthly use. All participants had normal/corrected-to-normal vision, and except for one low-fear participant, were right handed.

Materials

Attention Network Test (ANT). The ANT has been widely used to simultaneously measure cognitive processes within the three attentional networks (alerting, orienting, and executive control) (Fan et al., 2002; Liu, Xiao, & Shi, 2013). The ANT used in the present study was presented using NeuroScan STIM 3.1 software. The task consisted of 480 fully randomised, equiprobable trials (60 trials for each of the 8 conditions) divided into four equal blocks. Each trial sequence began with the presentation of a central fixation cross which was visible throughout the task. Following a variable duration (randomised equally between 200, 400, 600, 800, or 1000ms) during which only the fixation cross was present, an audio alerting condition (Alerting: alert, no-alert) was presented for 50ms, followed by a 400ms inter-stimulus interval (ISI). This was followed by a visual orienting cue (Cue: valid, invalid) for 100ms. Following a 50ms ISI (i.e., a target SOA of 150ms), the flanker target stimulus was presented. A short SOA was chosen to maximise the likelihood of facilitation effects (Weierich, Treat, & Hollingworth, 2008). The flanker target stimulus (Congruency: congruent, incongruent) was presented for 1700ms or until the participant responded. The inter-trial interval was 2000ms minus the RT for the previous trial.

Stimuli for the orienting cue consisted of 16 spider (fear-relevant) and 16 cow (fear-irrelevant) colour photos downloaded from an internet database (www.flickr.com) under a creative commons license. Photos were resized to 4.5cm high x 6.5cm wide and were presented 0.2cm to the left or right of the fixation point. The flanker target stimulus measured 2cm in width, consisted of a central arrow flanked by four congruent or incongruent distractor arrows, was centred in relation to the photo, and appeared 2.3cm to the left or right of the fixation point in either the

same (valid) or opposite (invalid) location as the orienting cue. Stimuli were presented at a viewing distance of 55cm, white font on a black screen.

Questionnaire measures. The SPQ consisted of 33 yes/no spider-related questions (e.g., '*Are you always on the lookout for spiders?*') and measures cognitive-behavioural dimensions of coping/avoidance, vigilance, and preoccupation responses to spiders. The Fear of Spiders Questionnaire (FSQ) measures spider phobic symptoms and compliments the SPQ (Muris & Merckelbach, 1996). The FSQ consists of 18, 7-point Likert scale questions (e.g., '*I now think a lot about spiders.*') ranging from definitely not (1) to absolutely (7) (Szymanski & O'Donohue, 1995). The SPQ and FSQ have both demonstrated good test-retest reliability (r = 0.94 and 0.91 respectively) and internal consistency (Chronbach's alpha of 0.91 and 0.91 for the SPQ, and 0.95 and 0.97 for the FSQ). Both the SPQ and FSQ correlate meaningfully with alternative spider fear self-report measures, and are responsive to exposure therapy, thus providing evidence for validity (Muris & Merckelbach, 1996).

Trait anxiety was measured using the trait anxiety sub-scale of the State-Trait Anxiety Inventory Form Y-2 (STAI; Spielberger, 1983). The scale consists of 20, 4-point Likert questions (e.g., *'I feel inadequate.'*) ranging from 'almost never' to 'almost always'. Higher scores on this self-report questionnaire are associated with higher trait anxiety. The K10 (Kessler et al., 2002) was used to assess current levels of psychological distress. Due to the confounding effects of psychological distress, participants scoring more than 30 were excluded from the study. The Wechsler Test of Adult Reading (WTAR; Mathias, Bowden, & Barrett-Woodbridge, 2007) is a widely used measure of verbal intelligence and was used to examine differences in general intelligence between low and high fear groups. The AUDIT (Saunders et al., 1993) is a commonly used measure of alcohol use. Due to the confounding effects of

excessive alcohol use on brain activity participants scoring higher than 16 were excluded from the study.

Additionally, a Video Gaming Experience question ('*How often would you normally play video games?*') was constructed by the author with response choices ranging from '*Never play video games*' to '*Often play video games (more than 5 hours a week)*'(see Appendix H). Finally, menstrual cycle was examined using a Menstrual Cycle Questionnaire (see Appendix I).

Electroencephalographic (EEG) recording. A NeuroSCAN system (Scan 4.4), a 32 channel Synamps, and a Quik-Cap with Ag/AgCl sintered electrodes positioned in accordance with the 10-20 system were used to record EEG activity. EEG data was continuously recorded from 32 sites, sampled at a rate of 1000Hz. Standard skin preparation procedures were employed for Quik-Cap fitting. Electrodes were referenced to linked mastoids. Electrodes were attached to outer canthi of both eyes, and to above and below the left eye to measure horizontal and vertical electro-oculographic activity respectively. Electrode impedance was limited to 5kΩ or below.

Behavioural and continuous EEG files were merged during editing then filtered using Zero-phase-shift filter (30Hz, 24dB/Oct). Ocular artefact reduction was then performed to mitigate eye blink effects on other electrodes. Subsequently epoching was performed from 200ms before stimulus onset to 900ms post onset. Baseline correction and artefact rejection were then conducted with trials including artefacts above 70µV and below -70µV being rejected. The occipital P1 and N1 components were defined from grand averaged waveforms as the maximum amplitude 60-100ms and 100-150ms respectively, after stimulus onset.

Procedure

After completing online screening tasks, eligible participants were invited to attend the two hour experimental session. All participants were given a participant information sheet and gave Informed consent (see Appendix F) prior to commencement. To ensure continued eligibility participants were screened for nicotine, caffeine, alcohol, drug, and prescription medication use since completion of the screening questionnaire (see Appendix G). After completing the Karolinska Sleepiness Scale (Åkerstedt & Gillberg, 1990), the Video Gaming Experience Questionnaire (Appendix H), the Menstrual Cycle Form (Appendix I), the STAI, and the WTAR participants were prepared for the EEG recording. Seated approximately 55cm from the computer screen participants first completed a dot-probe task (approximately 10 minutes) and two ANT tasks in counterbalanced order (approximately 25 minutes each). All tasks constitute components of a larger study.

For the ANT task used in the present research, participants were required to respond as accurately and quickly as possible to the direction of the central target arrow by making left (left arrow) or right (right arrow) button press responses using a response pad. Participants first completed a 10-trial practice block, and to minimise fatigue participants were given three short breaks between blocks. On completion of the session participants completed a picture rating task (arousal and valence) for all images used and were debriefed.

Design and Data Analysis

Individual reaction times more than three standard deviations above each participants mean were identified as outliers and excluded. Behavioural dependent variables were calculated as mean RT for correct trials and accuracy (% of correct trials) for each trial type. Consistent with similar studies, analysis of behavioural and ERP data was conducted using mixed measures ANOVA (Abundis-Gutierrez et al.,

2014; Callejas et al., 2005; Dennis & Chen, 2007; Fan et al., 2002; Pacheco-Unguetti et al., 2010; Pacheco-Unguetti et al., 2011; Tortella-Feliu et al., 2014).

In order to examine the effect of spider fear on the orienting and executive control networks, mean RT was analysed using a 2 (Group: low fear, high fear) x 2 (Alerting; alert, no-alert) x 2 (Cue: valid, invalid) x 2 (Image: spider, cow) x 2 (Congruency: congruent, incongruent) mixed design ANOVA. To examine the effect of spider fear an early attentional processes, P1 and N1 amplitudes were examined using 2 (Group: low fear, high fear) x 2 (Alerting; alert, no-alert) x 2 (Validity: valid, invalid) x 2 (Image: spider, cow) x 2 (hemisphere: left, right) mixed design ANOVAs. Analysis of P1 and N1 amplitude were confined to the midline occipital electrode site Oz.

Pair-wise comparisons and simple effects analysis were used to follow up significant (p<.05) and theoretically relevant main effects and interactions. Greenhouse-Geisser corrections were used to counter violations of sphericity and Bonferroni corrections were used to keep the family-wise error rate at .05. Effect sizes were measured using partial eta square for omnibus ANOVAs, and Cohen's *d* was used for pair-wise comparisons and interpreted as 0.2=small, 0.5=medium, and 0.8=large (J. Cohen, 1992).

Results

Demographics

Participant descriptives are shown in Table 1. There were no significant between group differences for age, scores on measures of trait anxiety (STAI), verbal literacy (WTAR), or alertness on the day of testing (Karolinska Sleepiness Scale; Akerstedt & Gillberg, 1990). As expected, high fear relative to low fear participants displayed significantly higher scores on both measures of spider fear (SPQ and FSQ).

However, contrary to expectation low fear participants scored significantly higher for psychological distress (K10) relative to high fear participants. To examine between group differences using one-way ANOVA the Video Gaming Questionnaire (see Table 1), was converted to a 3-point scale ranging from 'never' play video games to 'regularly' (> 2 hours per week) play video games, no significant differences were found.

Table 1.

Mean Scores for Age, Spider Fear Measures, Anxiety, Alcohol Use, Verbal Literacy, Sleep, Alertness, and Gaming Experience for High and Low Spider Fear Groups

	Low Fear	High Fear			
	M(SD)	*M(SD)*	*F*(1,24)	*p*	Cohen's *d*
Age	21.5 (4.44)	22.1 (4.25)	0.18	.725	0.14
SPQ Total$_{/33}$	5.1 (1.87)	17.3 (4.14)	83.24	<.001	3.62
FSQ Total$_{/126}$	33.6 (16.46)	93.5 (22.11)	57.36	<.001	3.01
K10 Total$_{/50}$	17.2 (4.71)	13.1 (2.07)	8.81	.007	1.18
STAI Total$_{/80}$	34.9 (5.52)	32.7 (7.63)	0.64	.43	0.32
AUDIT Total$_{/40}$	5.5 (2.88)	4.9 (3.69)	0.52	.701	0.15
WTAR Total$_{/50}$	38.6 (3.21)	36.1 (7.28)	1.05	.316	0.41
Alertness	3.9 (1.58)	3.7 (1.33)	0.13	.718	0.15
Gaming Experience	1.6 (0.67)	1.7 (.72)	0.01	.914	0.04

Picture Ratings

In relation to image arousal, there was a significant main effect of Image, $F(1,24)=8.87$, $p<.001$, $d=0.84$, whereby spider images ($M=3.7$, $SD=1.9$) were rated as being significantly more arousing than cow images ($M=2.3$, $SD=1.4$), however the

Image x Group interaction was non-significant, $F(1,24)=2.15$, $p=.157$, $\eta_p^2=.09$. The main effect of Group was non-significant, $F(1,24)=1.04$, $p<.001$, $d=0.44$. In relation to image valence, there was a significant main effect of Image, $F(1,24)=45.59$, $p<.001$, $d=2.38$, whereby spider images ($M=3.3$, $SD=1.1$) were rated as being significantly less pleasant than cow images ($M=5.7$, $SD=0.2$). The main effect of Group trended toward significance, $F(1,24)=4.01$, $p=.058$, $d=0.86$. The Image x Group interaction (see Figure 1) was significant, $F(1,24)=5.49$, $p=.029$, $\eta_p^2=.21$, whereby high fear participants rated spider images as being significantly less pleasant in comparison to cow images $F(1,14)=47.75$, $p<.000$, $d=3.02$, and in comparison to low fear participants, $F(1,10)=9.66$, $p=.014$, $d=1.9$.

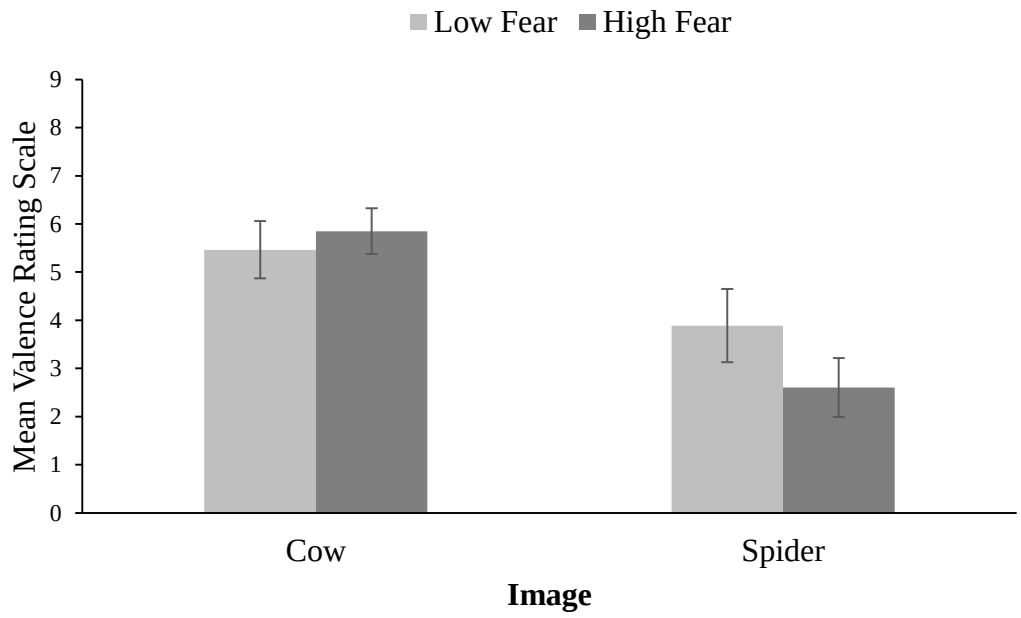

Figure 1. Valence ratings among low and high fear participants for the cow and spider images (error bars represent 95%CIs).

Reaction Time

The main effect of Image was non-significant, $F(1,24)=2.05$, $p=.165$, $d=.04$. There was a significant main effect of Alerting, $F(1,24)=13.85$, $p<.001$, $d=0.18$,

whereby RT was significantly faster to alerting (*M*=675.2, *SD*=86.0) relative to no-alerting trials (*M*=686.4, *SD*=88.7). The Alerting x Group interaction was non-significant, $F(1,24)=2.46$, $p=.13$, $\eta_p^2=.093$. There was a significant main effect of Cue, $F(1,24)=314.5$, $p<.001$, $d=0.88$, whereby RT was significantly faster to valid (*M*=642.4, *SD*=90.2) relative to invalid trials (*M*=719.2, *SD*=85.1). The Cue x Group interaction was non-significant, $F(1,24)=0.63$, $p=.434$, $\eta_p^2=.03$. There was a significant main effect of Congruency, $F(1,24)=311.6$, $p<.001$, $d=2.84$, whereby RT was significantly faster to congruent (*M*=545.3, *SD*=56.0) relative to incongruent trials (*M*=816.3; *SD*=122.7). The Congruency x Group interaction was non-significant, $F(1,24)=0.08$, $p=.774$, $\eta_p^2=.004$. The Cue x Congruency interaction was significant, $F(1,24)=14.81$, $p=.001$, $\eta_p^2=.38$. Examination of simple main effects ($\alpha=.025$ Bonferroni corrected) revealed that the main effect of Congruency was greater for invalid, $F(1,24)=429.48$, $p<.001$, $d=3.1$ relative to valid trials $F(1,24)=212.72$, $p<.001$, $d=2.55$.

The Cue x Congruency x Group interaction, $F(1,24)=3.18$, $p=.087$, $\eta_p^2=.12$, the Alerting x Cue x Congruency x Group interaction, $F(1,24)=4.04$, $p=.056$, $\eta_p^2=.14$, and the Alerting x Cue x Congruency x Image x Group interaction $F(1,24)=3.55$, $p=.072$, $\eta_p^2=.13$, all trended towards significance. Examination of simple interaction effects revealed a significant Cue x Congruency x Group interaction when targets were preceded by an auditory alerting cue (alerting trials) and a spatial spider cue (see Figure 2), $F(1,24)=10.6$, $p=.003$, $\eta_p^2=.31$. Under these conditions, when the target stimulus was incongruent, the Cue x Group interaction trended toward significance, $F(1,24)=7.63$, $p=.011$, $\eta_p^2=.24$. Examination of simple main effects ($\alpha<.012$ Bonferroni corrected) revealed that the main effect of Cue was greater for low fear $F(1,10)=76.51$, $p<.001$, $d=1.6$, relative to high fear participants,

$F(1,14)=38.23$, $p<.001$, $d=0.5$. While there was no statistically significant difference between the groups for valid, $F(1,24)=0.766$, $p=.390$, $d=0.35$, or invalid trials, $F(1,24)=0.011$, $p=.918$, $d=0.04$, effect sizes were small and negligible respectively.

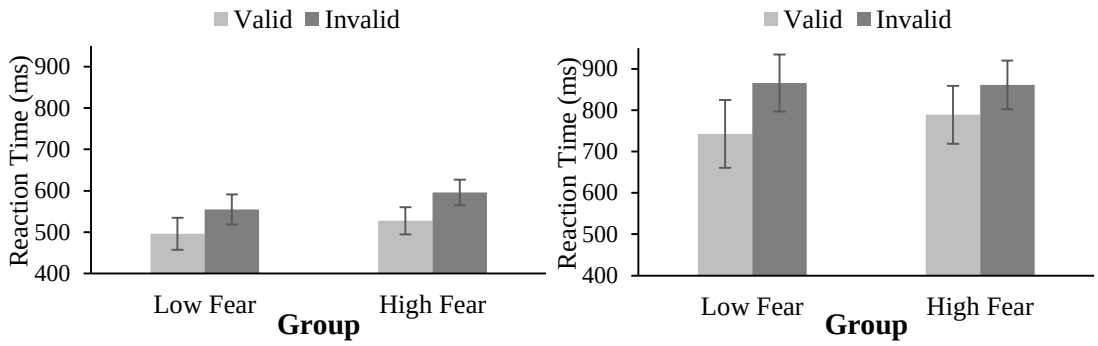

Figure 2. Mean reaction time to congruent (left) and incongruent (right) targets preceded by valid and invalid spider images on alerting trials, for low and high fear participants (error bars represent 95%CIs).

No other main effects or interactions were significant ($p>.05$). See Table 1 in Appendix J for non-significant F-tests.

Accuracy

Accuracy analysis (percentage of correct trials) demonstrated a significant main effect of Congruency, $F(1,24)=33.31$, $p<.001$, $d=.95$, such that participants demonstrated a higher accuracy rate for congruent ($M=96.3$, $SD=4.0$) relative to incongruent trials ($M=91.2$, $SD=6.5$). However, the Congruency x Group interaction was non-significant, $F(1,24)=1.3$, $p=.266$, $\eta_p^2=.05$. There was a significant main effect of Image, $F(1,24)=5.86$, $p=.023$, $d=.19$, such that participants demonstrated a greater percentage of correct responses for targets preceded by cow ($M=94.2$,

SD=4.6) relative to spider cues (*M*=93.3, *SD*=5.3). However, the Image x Group interaction was non-significant, $F(1,24)=1.43$, $p=.243$, $\eta_p^2=.06$.

The Cue x Group interaction was significant, $F(1,24)=5.74$, $p=.025$, $\eta_p^2=.19$. However, this was modified by a significant Cue x Congruency x Group interaction that trended toward significance (see Figure 3), $F(1,24)=4.44$, $p=.046$, $\eta_p^2=.16$, indicating that for invalid incongruent trials low-spider-fear participants had a greater percentage of correct responses, (*M*=92.8, *SD*=11.0) relative to high-spider-fear participants (*M*=89.4, *SD*=9.5). No other main effects or interactions of theoretical importance were significant.

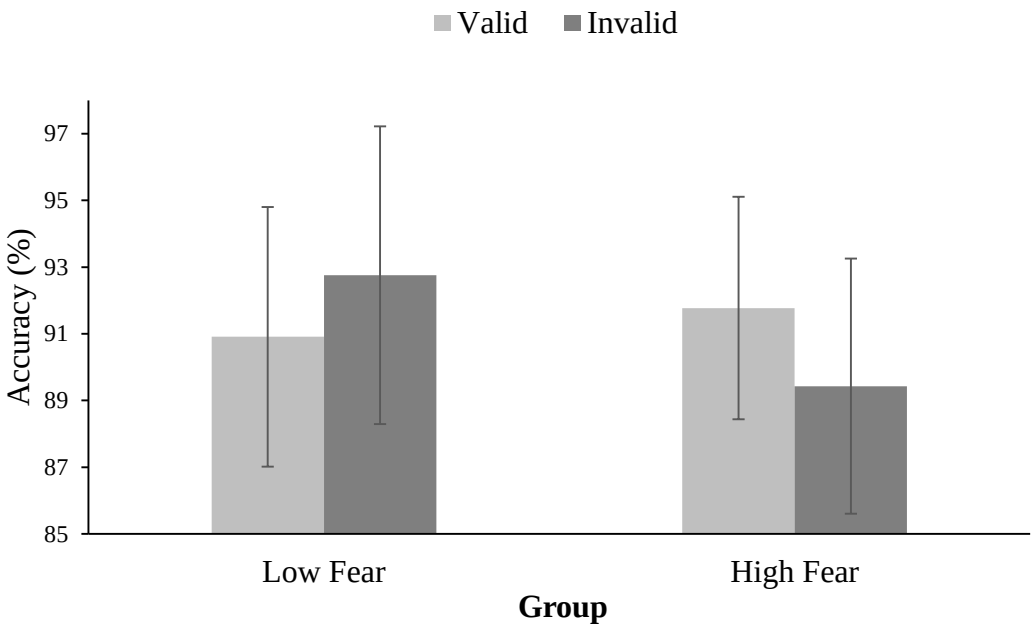

Figure 3. Percentage of correct responses to incongruent targets for low and high fear participants for valid and invalid trials (error bars represent 95%CIs).

Peak P1 and N1 Waveforms

Figures 4 and 5 show the grand averaged waveforms for low and high fear participants at the midline occipital site (Oz), peaking at approximately 100ms (P1) and 120ms (N1). Figure 4 shows that overall for high fear participants' peak P1

amplitude was reduced for spider relative to cow trials, and for incongruent relative to congruent trials, while peak N1 amplitude was enhanced for incongruent spider trials. Figure 5 shows that for low fear participants' peak P1 amplitude did not differ across trials, and peak N1 amplitude was enhanced for cow trials overall.

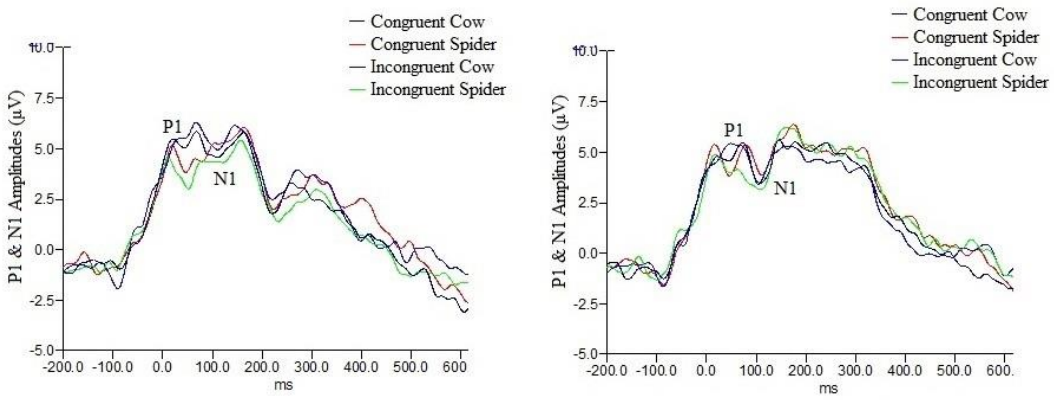

Figure 4. Grand averaged waveforms for high fear participants at midline occipital site Oz for valid (left) and invalid (right) trials.

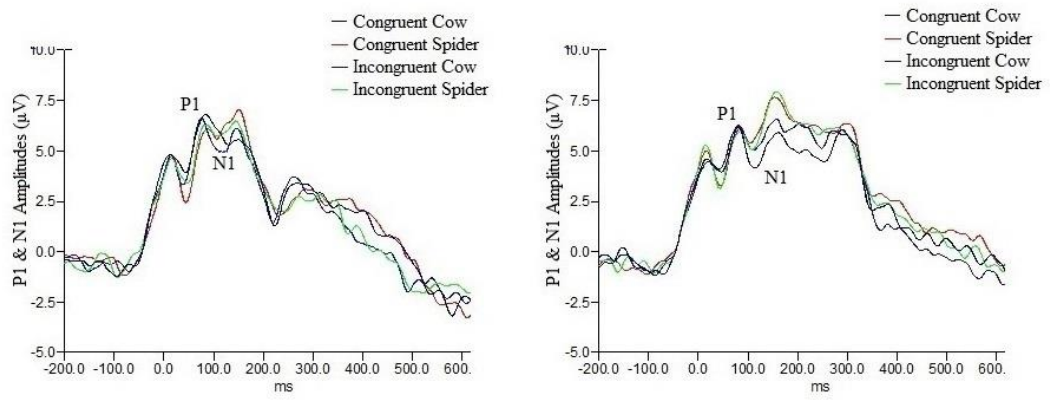

Figure 5. Grand averaged waveforms for low fear participants at midline occipital site Oz for valid (left) and invalid (right) trials.

Peak P1 Amplitude

The main effects of Group, $F(1,24)=0.15$, $p=.701$, $d=0.11$, Cue, $F(1,24)=0.18$, $p=.675$, $d=0.02$, and Congruency, $F(1,24)=0.4$, $p=.532$, $d=0.03$, were all non-significant. The main effect of Image was significant, $F(1,24)=5.33$, $p=.03$, $d=0.19$, indicating greater P1 amplitude for cow ($M=7.5$, $SD=3.4$) relative to spider images ($M=6.8$, $SD=3.3$).

The Alerting x Cue interaction approached significance, $F(1,24)=4.23$, $p=.051$, $\eta_p^2=.15$. There was a significant Image x Alerting x Cue x Congruency x Group interaction, $F(1,24)=4.93$, $p=.036$, $\eta_p^2=.17$. The Image x Congruency x Group interaction was significant, $F(1,24)=5.58$, $p=.027$, $\eta_p^2=.19$, such that the Image x Congruency interaction was significant for high fear, $F(1,14)=6.21$, $p=.026$, $\eta_p^2=.31$ (see Figure 6) but not low fear participants, $F(1,10)=0.78$, $p=.399$, $\eta_p^2=.07$ (see Figure 7), whereby high fear participants demonstrated lower P1 amplitude when cued by spiders relative to cows when the target was incongruent.

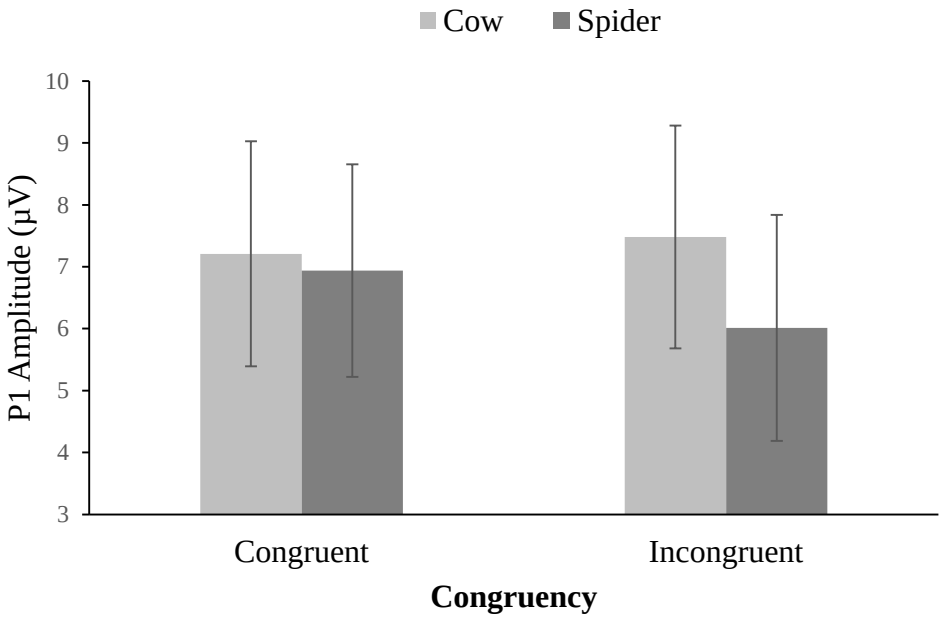

Figure 6. P1 amplitude for high fear participants to congruent and incongruent targets cued by cow and spider images (error bars represent 95%CIs).

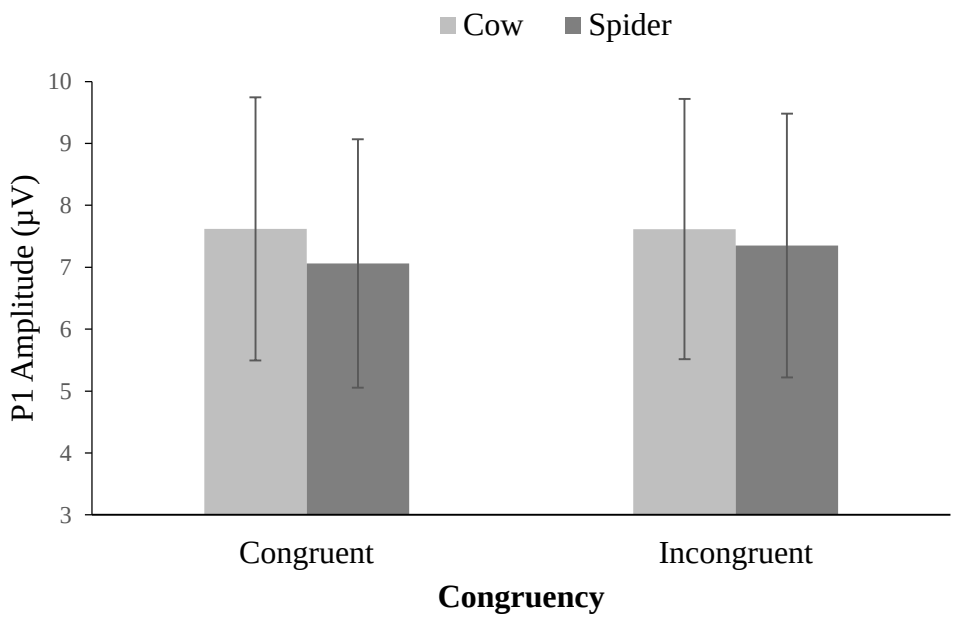

Figure 7. P1 amplitude for low fear participants to congruent and incongruent targets cued by cow and spider images (error bars represent 95%CIs).

Under these conditions, when the target stimulus was incongruent and preceded by a spider image, the Alerting x Cue interaction was significant for high fear, $F(1,14)=6.55$, $p=.023$, $\eta_p^2=.319$, but not low fear participants, $F(1,10)=0.52$, $p=.487$, $\eta_p^2=.05$. Examination of simple main effects ($\alpha<.008$ Bonferroni corrected) revealed that for valid trials the main effect of Alerting trended toward significance for high fear, $F(1,14)=6.57$, $p=.023$, $d=0.41$, but not low fear participants, $F(1,10)=0.65$, $p=.439$, $d=0.14$, whereby high fear participants demonstrated enhanced P1 amplitude when the alerting cue was present, ($M=6.9$, $SD=3.9$) relative to when the alerting cue was absent, ($M=5.1$, $SD=4.7$) (see Figure 8).

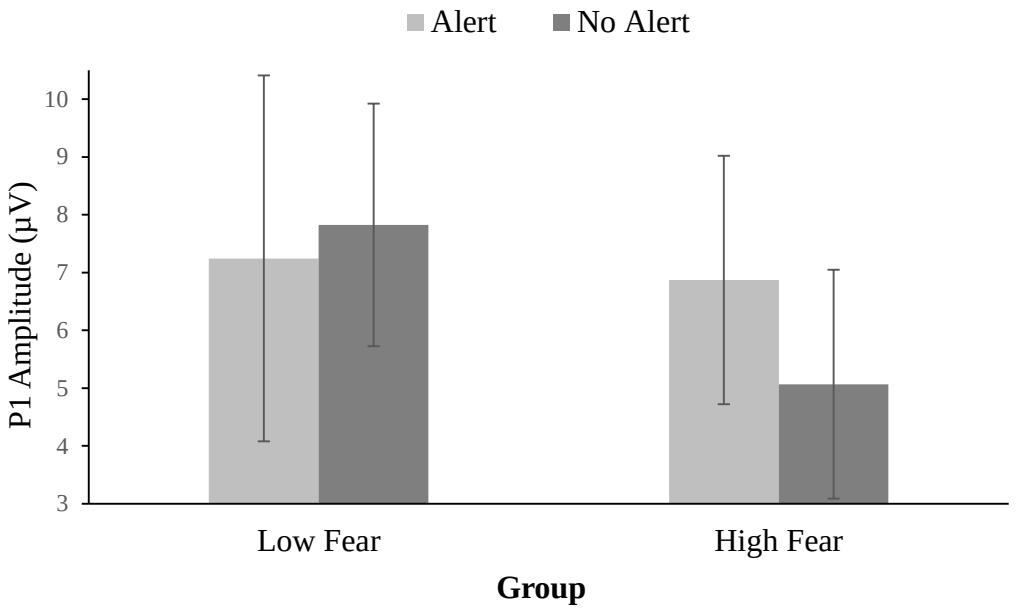

Figure 8. P1 amplitude for high and low fear participants to incongruent targets preceded by valid spider cues for alerting and no-alerting trials (error bars represent 95%CIs).

Peak N1 Amplitude

The main effects of Image, $F(1,24)=0.87$, $p=.361$, $d=0.35$, Congruency, $F(1,24)=0.27$, $p=.61$, $d=0.01$, and Group, $F(1,24)=0.29$, $p=.594$, $d=0.21$, were all non-significant. The main effect of Alerting trended toward significance, $F(1,24)=3.85$, $p=.061$, $d=0.16$, indicating that N1 amplitude was enhanced for alerting ($M=2.8$, $SD=3.3$) relative to no-alerting trials ($M=3.3$, $SD=3.$). The Alerting x Group interaction trended toward significance, $F(1,24)=4.2$, $p=.052$, $\eta_p^2=.15$. An analysis of simple main effects ($\alpha=.012$ Bonferroni corrected) indicated a main effect of Alerting for low fear $F(1,10)=7.41$, $p=.022$, $d=0.16$, but not high fear participants $F(1,14)=0.004$, $p=.95$, $d=0.01$, such that for low fear participants N1 amplitude was enhanced for alerting ($M=2.9$, $SD=3.2$) relative to no-alerting trials ($M=4$, $SD=3.4$). The main effect of Cue was non-significant, $F(1,24)=0.21$, $p=.207$, $d=0.11$. The Cue

x Group interaction trended toward significance, $F(1,24)=4.19$, $p=.052$, $\eta_p^2=.15$. Examination of the simple main effects of Cue (α=.025 Bonferroni corrected) for each group (see Figure 9) showed a non-significant effect of Cue for low fear participants, $F(1,10)=0.152$, $p=.705$, $d=0.08$. However, for high fear participants the simple main effect of Cue was significant, $F(1,14)=11.68$, $p=.004$, $d=0.25$, whereby N1 amplitude was significantly greater for invalid ($M=2.3$, $SD=4.1$) relative to valid trials ($M=3.2$, $SD=3.4$).

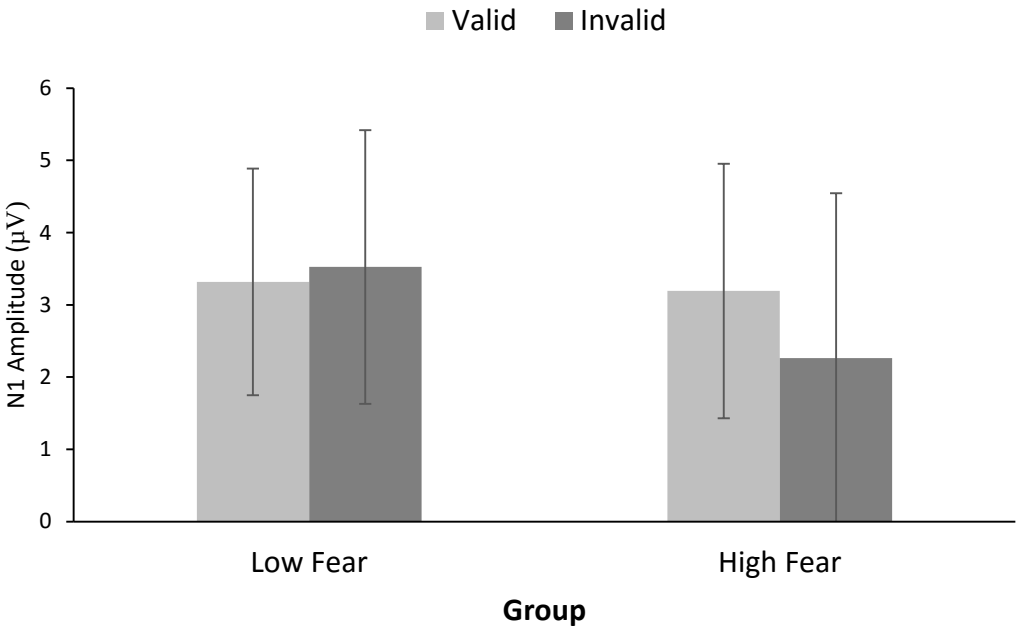

Figure 9. N1 amplitude for high and low fear participants to valid and invalid trials (error bars represent 95%CIs).

The Image x Congruency interaction was significant, $F(1,24)=9.6$, $p=.005$, $\eta_p^2=.29$. However, this was modified by an Image x Congruency x Group interaction which trended toward significance, $F(1,24)=4.2$, $p=.051$, $\eta_p^2=.15$, and a significant Image x Cue x Congruency x Group interaction, $F(1,24)=7.29$, $p=.013$, $\eta_p^2=.23$.

Examination of the simple interaction effects for cue (α=.025 Bonferroni corrected) showed that this 4 way interaction was driven by a significant Image x Congruency x Group interaction for valid $F(1,24)=11.94$, $p=.002$, $\eta_p^2=.33$, but not invalid trials $F(1,24)=0.13$, $p=.724$, $\eta_p^2=.01$. For valid trials there was a significant Image x Congruency interaction for high fear, $F(1,14)=12.27$, $p=.004$, $\eta_p^2=.47$ (see Figure 10) but not low fear participants, $F(1,10)=2.25$, $p=.165$, $\eta_p^2=.18$ (see Figure 11). An analysis of simple main effects (α=.012 Bonferroni corrected) for high fear participants indicated that the main effect of Congruency trended toward significance for spider trials $F(1,14)=5.99$, $p=.028$, $d=0.27$, and was significant for cow trials, $F(1,14)=9.94$, $p=.007$, $d=0.22$, N1 amplitude was enhanced for incongruent ($M=2.6$, $SD=4.4$) relative to congruent spider trials ($M=3.7$, $SD=3.7$). However this effect was reversed for cow trials such that high fear participants demonstrated reduced N1 amplitude for incongruent ($M=3.8$, $SD=3.2$) relative to congruent trials ($M=2.7$, $SD=3.2$).

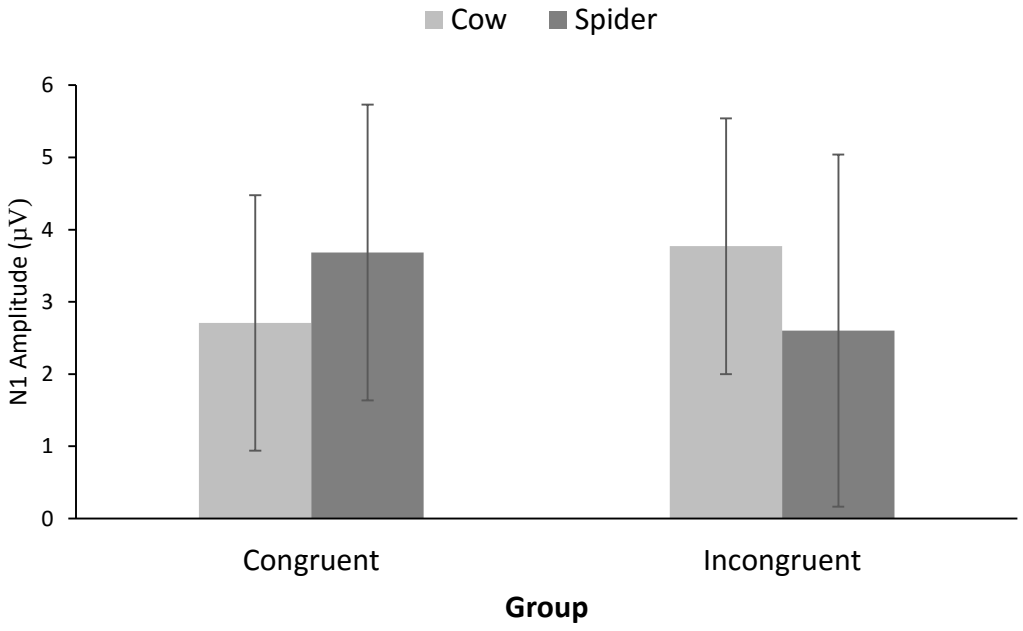

Figure 10. N1 amplitude for high fear participants to valid congruent and incongruent, cow and spider trials (error bars represent 95%CIs).

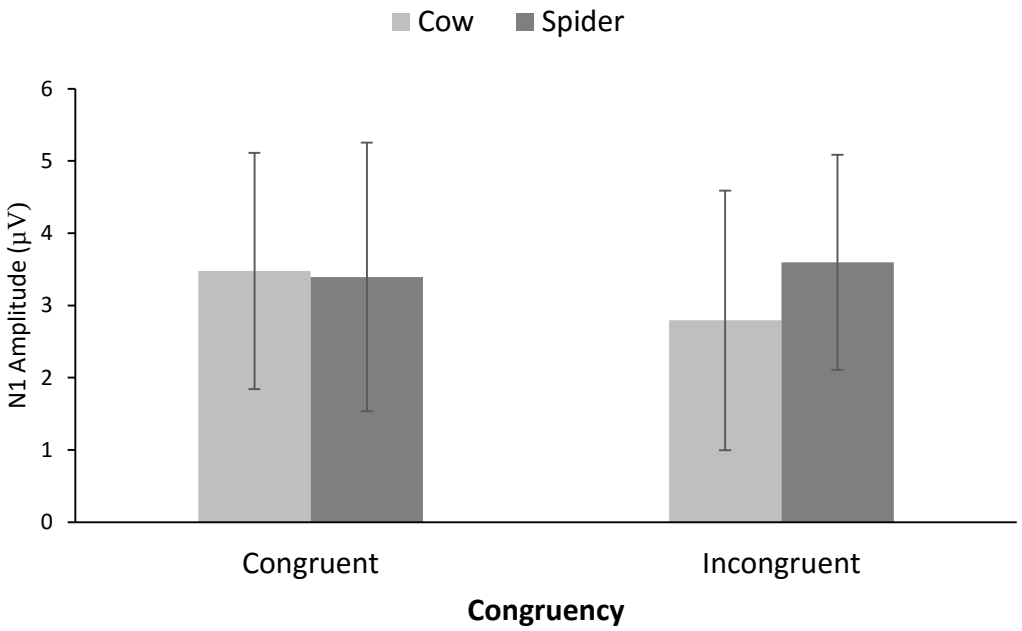

Figure 11. N1 amplitude for low fear participants to valid congruent and incongruent, cow and spider trials (error bars represent 95%CIs).

No other main effects or interactions were significant (p>.05). See Table 1 in Appendix J for non-significant F-tests.

Discussion

The results of the present study provide partial support for the experimental hypotheses. Overall the expected alerting, cueing, and congruency effects were demonstrated in both low and high fear groups, such that RT was significantly faster for alerting, valid, and congruent trials relative to no-alerting, invalid, and incongruent trials respectively. In relation to facilitation effects however, facilitated orienting was not found to be modulated by spider fear. High fear participants were expected to demonstrate an increased cue effect reflecting facilitated orienting for targets preceded by valid spider cues. In contrast, partial support for the interference hypothesis was found, such that high fear participants were expected to demonstrate

a relative increase in the congruency effect for targets preceded by a spider image, as shown by slower RT to incongruent spider trials relative to low fear participants. As expected, high-spider-fear participants demonstrated slower RT to incongruent targets preceded by spider cues, however this finding was only observed when the cue was valid. In addition, and contrary to expectations, high relative to low-spider-fear participants showed a reduction in accuracy on invalid incongruent trials. In contrast to expectations results suggest a facilitation effect on incongruent flanker trials for low rather than high-spider-fear participants, such that low-spider-fear participants demonstrated faster RT for incongruent targets preceded by valid spider cues. This finding was further supported by the fact that low fear participants tended to respond faster overall.

The behavioural findings of the current study were partially supported by modulation of posterior P1 and N1 amplitudes. Contrary to predictions of general hypervigilance, no between group differences were observed for P1 amplitude modulation. Within groups, P1 amplitude did not vary significantly across trials for low fear participants, however consistent with interference predictions, P1 amplitude was attenuated for incongruent spider trials for high fear participants, and this effect was pronounced for valid trials not preceded by an alerting cue. Further, consistent with interference predictions, overall N1 amplitude was enhanced for high relative to low-spider-fear participants for incongruent spider trials. In contrast N1 amplitude was attenuated for low relative to high-spider fear participants, except for incongruent cow trials. Within groups, high fear participants demonstrated enhanced N1 for invalid relative to valid trials overall. However for valid trials, N1 amplitude was modulated by image such that N1 amplitude was enhanced for congruent relative to incongruent targets preceded by cow images, but for incongruent relative

to congruent targets preceded by spider images. In contrast, for valid trials low fear participants demonstrated enhanced N1 amplitude for cow relative to spider cues regardless of congruency.

Facilitation Effects

The finding of slower reaction times for high-spider-fear participants for trials preceded by valid spider cues was not expected. For example, research has typically found facilitation effects to be greater for high relative to low-spider-fear participants as demonstrated by faster RT in the object identification (Stroop) task (Kolassa et al., 2006; Kolassa, Musial, Mohr, Trippe, & Miltner, 2005), the visual probe task (Mogg & Bradley, 2006), and the visual search task (Ouimet, Radomsky, & Barber, 2012). Further, threat-related facilitation of the P1 amplitude has typically been demonstrated by spider phobic populations relative to controls when responding to both spider and neutral images across a variety of paradigms including passive viewing tasks (Michalowski et al., 2009; Michalowski, Pané-Farré, Löw, & Hamm, 2015), and the emotional Stroop task (Kolassa et al., 2007; Kolassa et al., 2006), thus indexing general hypervigilance in high fear populations. These findings are consistent with attentional bias which predicts the automatic and preferential processing of threat-related information within the orienting network (Cisler & Koster, 2010). Therefore it was expected that high relative to low-spider-fear participants would demonstrate facilitated orienting for targets preceded by valid spider cues, thus indexing hypervigilance to threat.

In relation to the ANT, however facilitation effects have not been supported for unselected participants responding to negative relative to neutral stimuli (N. Cohen et al., 2011), threatening relative to neutral stimuli (Finucane & Power, 2010), or for high relative to low state anxiety participants responding to fearful relative to

neutral faces (Dennis, Chen, & McCandliss, 2008). In contrast studies using the ANT have found no effect of emotion (N. Cohen et al., 2011) or fear (Finucane & Power, 2010) on the cueing effect, such that reaction times did not differ significantly for targets preceded by valid threat-related cues relative to non-threat-related cues. Facilitation effects are typically demonstrated in studies using low cognitive load tasks such as the visual probe (Mogg & Bradley, 2006) and emotional Stroop (Kolassa et al., 2006). This is concordant with research demonstrating that facilitation effects are not observed under condition of greater cognitive load. For example, when the number of response options was increased from two to three in a colour identification task (emotional Stroop), interference effects were observed (Matthews, Feriz, & Kirkby, manuscript in preparation for submission). This suggests that the increase in response options represented an increase in cognitive load that was sufficient to produce interference rather than facilitation effects

Consequently, a possible explanation for findings in the present study is that higher cognitive load conditions associated with the ANT have increased the likelihood of interference effects for high fear individuals. Increased cognitive load associated with the ANT has been demonstrated by the fact that alerting typically enhances both the cueing and congruency effects (such that for alerting relative to non-alerting trials the difference between valid and invalid trials, and congruent and incongruent trials is greater), while valid cues typically enhance the congruency effect (Abundis-Gutierrez et al., 2014; Callejas et al., 2005; Fan et al., 2009; Fan et al., 2002; Fuentes & Campoy, 2008; Tortella-Feliu et al., 2014). This is consistent with previous research that suggests invalid cues increase competition for the limited attentional resources shared by the orienting and executive control networks, thus increasing cognitive load and the likelihood of interference (Behrens et al., 2007; Fan

et al., 2009; Matsumoto & Tanaka, 2004). This is concordant with the attentional networks model which describes an interactive association between bottom-up and top-down attentional systems (Petersen & Posner, 2012). In relation to the present study, findings suggest a complex interactive relationship between the attentional networks that is consistent with predictions of greater levels of cognitive load in the ANT (described in more detail below). For example examination of reaction time data indicates that overall invalid cues increased the congruency effect.

As previously mentioned attentional bias can be observed as facilitation and/or interference effects. Additionally visual object processing models suggest that facilitation and interference effects develop simultaneously, however interference effects are typically thought to be masked by the larger effect of facilitated orienting (Posner & Cohen, 1984). This suggests that in the present study increased levels of cognitive load associated with the ANT were sufficient to increase the saliency of interference effects, thus attenuating facilitation effects for high relative to low fear-spider-fear participants. Therefore the present findings indicate that high fear participants did not demonstrate facilitated orienting to valid spider trials as cognitive load increased, interference effects became more salient such that for high fear participants the ability to down-regulate emotional effects on behaviour was impaired. In contrast low fear participants demonstrated a benefit effect for valid spider trials relative to high fear participants.

Attentional Control and Interference

Attentional control theory (Eysenck et al., 2007) predicts that increasing levels of conflict increase the likelihood of interference effects, thus it was expected that overall increasing levels of conflict would be demonstrated by slower RT for incongruent relative to congruent trials. Additionally, ACT (Eysenck et al., 2007)

and neurocognitive models of attentional bias (Bishop, 2007) predict that anxiety increases the influence of the stimulus-driven attentional networks, reducing the availability of cognitive resources to the executive control network. Further, as threat-related relative to neutral stimuli are preferentially processed by the stimulus-driven attentional system (Eysenck et al., 2007) it was expected that fear would impair the ability to suppress distracting stimuli. Therefore it was predicted that for incongruent targets preceded by a spider cue, high relative to low-spider-fear participants would experience impaired focal attention and reduced ability to inhibit distractor stimuli, as demonstrated by slower RT, reduced P1 amplitude, and enhanced N1 amplitude, thus indexing reduced processing efficiency of the executive control network.

The current findings show partial support for behavioural (RT and accuracy) interference effects. High fear relative to low fear participants demonstrated slower RT to incongruent targets preceded by spider cues, but only when the cue was valid. However, support for interference effects was strengthened by the accuracy results. High fear participants relative to controls demonstrated reduced accuracy on incongruent trials preceded by invalid cues, suggesting greater interference effects for this condition.

Consistent with expectations, relative to controls, high fear participants demonstrated reduced P1 amplitude to incongruent spider trials. Additionally, and consistent with an interactive attentional networks model, this effect was pronounced when the target was preceded by a valid cue and the auditory alerting tone was absent. Enhanced P1 amplitude is associated with the automatic inhibition of task-irrelevant information and greater attentional control over conflicting, emotional, and threat-related stimuli (Bublatzky & Schupp, 2012; Dennis & Chen, 2007; Luo et al.,

2001; Mangun, 1995). Therefore it was expected that interference effects in high fear participants would be demonstrated by attenuated P1 amplitude to incongruent targets preceded by a spider cue, reflecting reduced focal attention, weakened ability to suppress interference from distractor stimuli, and impaired executive control.

The present study is the first to examine specific-fear modulation of P1 amplitude using the ANT. While research has typically found enhanced P1 amplitude in response to threat-related stimuli (Bublatzky & Schupp, 2012; Dennis & Chen, 2007), support for specific-fear modulation of P1 amplitude has not been consistent. For example in a visual search task, spider fearful individuals demonstrated enhanced N1 but not P1 amplitude to spider and neutral stimuli (indicating general hypervigilance), suggesting that detection of fear-relevant stimuli is associated with re-entrant processing from other brain regions such as the amygdala, extra-striate cortex, and frontoparietal networks (Weymar et al., 2013). This is concordant with the current findings, which indicate that detection and processing of specific-fear stimuli involves complex and interactive associations within the attentional networks.

Consistent with expectations high relative to low-spider-fear participants demonstrated enhanced N1 amplitude overall and this effect was pronounced for incongruent targets preceded by valid spider cues. This finding is concordant with studies that have demonstrated enhanced N1 amplitude for participants responding to incongruent relative to congruent targets in the flanker task when stimuli were neutral (Johnstone et al., 2009; Nicholls et al., 2015), and when stimuli were negative (Li et al., 2014). Additionally enhanced N1 amplitude was demonstrated by spider fearful participants relative to controls in the visual search task (Weymar et al., 2013).

Enhanced N1 amplitude for high relative to low fear participants in response to incongruent spider trials is consistent with ACT predictions that high anxious individuals compensate for impaired executive processing efficiency by effortful control and the recruitment of additional cognitive resources. Further, this finding is concordant with research showing effortful control related modulation of N1 amplitude originating in the anterior cingulate cortex in a choice reaction task (Esposito, Mulert, & Goebel, 2009).

In addition, N1 amplitude has been shown to increase for tasks when visual perception of stimuli requires a large sampling spread of the visual field relative to stimuli requiring a small spread (Benwell, Harvey, & Thut, 2014; Snyder, Shpaner, Molholm, & Foxe, 2012). This is consistent with research that suggests N1 modulation indexes the need for the reorientating of attention with enhanced N1 amplitude being demonstrated for invalid (Wright, Geffen, & Geffen, 1995), and neutral trials relative to valid trials (Galvao-Carmona et al., 2014). In the current study, high but not low fear participants demonstrated enhanced N1 amplitude to invalid relative to valid trials. This suggests that the cognitive resources required for re-orienting to the target location was greater for high fear participants relative to controls. Therefore, these findings are consistent with ACT which predicts that high anxious individuals are able to compensate for impairments in processing efficiency of the executive attentional system by effortful control and the recruitment of additional cognitive resources.

Overall, findings of the current study suggest that high fear relative to low fear participants experienced reduced ability to automatically suppress task-irrelevant stimuli, and impaired recruitment of attentional control resources over conflicting information, as demonstrated by attenuated P1 amplitude to incongruent targets

preceded by spider cues, and particularly for valid no-alerting trials. Additionally, high relative to low-spider-fear participants demonstrated slower reaction time overall, but also enhanced N1 amplitude for invalid relative to valid trials and for incongruent targets preceded by valid spider trials indicating that increased recruitment of cognitive resources was associated with impaired attentional control and reduced processing efficiency of the executive control network. This is further supported by accuracy data which indicates increased interference effects for high fear participants for invalid trials. In contrast, relative to high fear participants, P1 amplitude was not modulated by fear or cognitive load for low fear participants who also demonstrated faster RT overall, suggesting improved focal attention and greater ability to down-regulate the effects of emotional stimuli on behaviour.

However, the present behavioural and electrophysiological data should be interpreted with caution. While the results appear to represent differential effects of cognitive load for high relative to low fear participants, no significant between group differences were observed, however this was to be expected considering the small sample size and extensive individual variability in ERP components. An additional methodological issue that may have attenuated fear modulation of attentional processes was the fact the participants were selected according to a median split on the SPQ. Thus the current sample definition did not satisfy clinical criteria associated with a diagnosis of spider phobia. Further recruitment of additional participants into the study will enable selection of participants based on stricter definitions of spider fear. Further a larger sample size would increase overall power and strengthen findings which are currently only trending toward significance.

Summary and Conclusion

The current study was the first to use the ANT to examine the effect of specific fear on behavioural and neural correlates of attention. Consistent with ACT (Eysenck et al., 2007) high fear participants demonstrated that as cognitive load increased interference effects became more salient such that for high fear participants the ability to down-regulate emotional effects on behaviour was impaired. This finding was further qualified by attenuated P1 amplitude for high fear participants for incongruent targets preceded by pictorial spider cues. Further, differential modulation of N1 amplitude for high relative to low-spider-fear participants suggests that for high fear participants greater recruitment of cognitive resources was required for facilitated visual processing and discriminative processing of incongruent targets preceded by spider cues.

Notably, the current findings are consistent with a strong and interactive relationship between the attentional networks (Petersen & Posner, 2012), such that for specific-fear increases the competition for limited attentional resources shared by the orienting and executive control networks, reducing cognitive performance and impairing processing efficiency of the executive attentional system (Eysenck et al., 2007; Fan et al., 2009). While these findings should be considered preliminary, further investigation is justified. Few studies have examined the influence of specific fear on the individual and interactive components of the attentional networks. Additionally, alerting effects have been found to influence the orienting and executive control networks, however these effects were not specifically examined here. Therefore future research could aim to include examination of interactive effects of alerting.

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Appendices

Appendix A

Attentional Networks Test Literature Review

Table 1

Differential Findings for the Effect of Anxiety on Attention using the Attentional Network Test

	Participant	Anxiety	Stimulus (duration in ms), Presentaion (P)	Target SOA	Attentional Bias		Interference		Group Effects	Network interactions
					Behavioural	ERP	Behavioural	ERP		
Fan, McCandliss, Sommer, Raz & Posner (2002)	23 F, 17 M	None	N/A	500ms	ME of Alert and Cue	N/A	ME of Cong	N/A	N/A	Alert x Cong, (Alert enhanced Cong effects) & Cue x Cong (valid cues reduced Cong effect)
Callejas, Lupianez, Funes, & Tudela (2005)	19 F, 5 M	None	N/A	500ms	ME of Alert and Cue; Positive correlation between trait anxiety and cue effects	N/A	ME of Cong	N/A	N/A	Alert x Cong, (Alert enhanced Cong effect for RT and acc) & Cue x Cong (invalid cues increased Cong effect)
Fuentes & Campoy (2008)	24 adults	None	N/A	100 - 1200ms	ME of Alert and Cue	N/A	ME of Cong	N/A	N/A	Alert x Cueing (Alert enhanced cueing effect for SOA 100-500ms); Cue x Cong (valid cue reduced Cong effect)
Pacheco-Unguetti et al 2010	43 F, 5 M	Trait anxiety: low and high trait anxiety (STAI)	N/A	100ms	ME of Alert and Cue	N/A	ME of Cong	N/A	MEs & interactions n.s.; Cong effect greater for HA group (with state anxiety as covariate)	Alert x Cue and Cong (Alert enhanced cue and Cong effects); Cue x Cong (valid cues reduced Cong effect)
	57 F, 9 M	Mood Induction, 2 groups: (median trait anxiety, STAI)	10 positive, 10 negative photos; (P) mood induction prior to	100ms	ME of Alert and Cue	N/A	ME of Cong	N/A	With trait anxiety as covariate; Between group differences, AMI group showed enhanced Alert and cue effects (&	Alert x Cue and Cong, (Alert enhanced cue and Cong effects) & Cue x Cong (valid cues reduced Cong effect)

			experimental task						reduced Cong effect but n.s.)	
Pacheco-Unguetti et al 2011	9 F, 15 M	13 (anxiety disorder & attending CBT), 13 controls	N/A	100ms	ME of Alert and Cue	N/A	ME of Cong; Positive correlation between Cong effects and trait and state anxiety	N/A	MEs of Cue and Cong; Enhanced Cong effect for HA group, modulated by Alert;	Alert x Cue and Cong (Alert enhanced cue and Cong effects), & Cue x Cong (valid cues reduced Cong effect)
Cohen, Avishai, & Mor (2011)	16 F, 1 M	None	16 neutral, 16 negative (IAPS images); 100ms, (P) orienting cue	150ms	ME of Alert and Cue	N/A	ME of Cong: Stimulus Valence x Cong interaction was significant (negative cues impaired executive control for non-conflict trials & reduced Cong effect, i.e. increased RT to cong trials)	N/A	N/A	N/A
Finecune & Power (2010)	100 F	Low & High Fear: using fear sub-scale of the Basic Emotions Questionnaire	8 fear-eliciting, 8 neutral (IAPS images); 1000ms (P) prior to fixation	500ms	MEs not reported;	N/A	ME not reported: Stimulus Valence x Cong interaction was significant (negative cues enhanced executive control for conflict trials and reduced Cong effect, i.e. decreased RT to incong trials)	N/A	Group interactions n.s.; State and trait anxiety negatively correlated with executive attention costs in the fear condition, r=-.26 & -.19 respectively	Alert/Orienting x Cue Valence n.s.
Crump, Kishore, & Zaidel (2013)	61 F, 54 M	Trait anxiety: median split into low and high trait anxiety	Schematic happy, neutral, or angry face; 180ms, (P) orienting cue	330ms	ME of cue	N/A	ME of Cong	N/A		Cue x Cong

Dennis, Chen, & McCandliss (2008)	46 F, 17 M	State anxiety: low & high state anxiety based on median split (STAI)	3 cues: 2 b&w faces (fearful, neutral), 1 grey square; 50ms, (P) prior to fixation	500ms	ME of Cue; ME of Face Type for Alert (Alert effect reduced for fearful faces); Anxiety positively correlated with Alert;	N/A	ME of Cong	N/A	MEs between group differences n.s.; Face Type x Group interaction for executive attention (executive attention reduced following fearful faces for LSA)	Cue x Cong (valid cues reduced Cong effect)
Neuhaus, Urbanek, Opgen-Rhein, Hahn, Tam Ta, Koehler, Gross, Dettling (2010)	22 F, 22 M	None	N/A	500ms	ME of Alert and Cue	Greater N1 (parietal, occipital) amplitude to Alert and cued trials	ME of Cong	For incong trials P3 amplitude was greater for frontal but reduced for parietal sites.	N/A	N/A
Abundis-Gutierrez, Checa, Castellanos, & Rueda (2014)	^15 adults, 46 children	None	N/A	150ms	MEs of Alert, Cue, & Cong	Significant effect of Alert (Fcz) on P1, N1, & P2 amplitudes; Significant effect of Cue on P3 (CPz, Pz) amplitude; P1 & N1 (Oz, O1, O2) amplitudes (t-test differences between conditions).	ME of Cong	Significant effect of Cong on SP (Pz) amplitude (greater amplitude for incong trials); Significant effect of Cong on N2 (Fcz) amplitude (t-test differences between conditions)		Alert x Cong (Alert reduced RT in cong trial, enhancing Cong effect), Cue x Cong (invalid cues enhanced Cong effect, longer RT to incong trials) Alert x Cong effect on SP (Alert increased Cong effect on SP);
Galvao-Carmona, Gonzalez-Rosa, Hidalgo-Munoz, Paramo, Benitez,	10 F, 15 M	None	N/A	1150ms	ME of Cue	P1 (P05, P06), amplitude greater for valid cues, N1 (P05, P06) amplitude greater for central cues	ME of Cong	ME of Cong, P3 (Pz) amplitude greater for cong trials	N/A	Cue x Cong interaction

Izquierdo, & Vazquez-Marrufo (2014)						(greater for valid relative to no cue)				
Dennis & Chen (2007)	26 F, 10 M	Threat sensitivity: low & high threat sensitivity (BIS) based on median split	3 faces (b&w photos); fearful, sad, & happy; 50ms, (P) prior to fixation	500ms	N/A	P100, N140, P200 n.s. for emotion, or group	ME of emotion (executive control enhanced for sad faces)	LTS group: enhanced N200 associaeted with reduced exec attent prerformance: HTS group enhanced N200 associated with improved executive attention	Threat sensitivity positively correlated with P100, P200, N200:	N/A
Dennis & Chen (2009)	26 F, 10 M	Trait anxiety: low & high trait anxiety based on median split	4 faces (b&w photos); fearful, sad, happy, & neutral; 50ms, (P) prior to fixation	500ms	N/A	N/A	ME of Cong	N2 amplitude greater to incong trials; Following threat HA group showed reduced Cong modulation of N2 & greater N2 amplitude to cong trials; Reduced N2 associated with improved attention performance	ME of Cong n.s.	N/A

Note: SOA = stimulus onset asynchrony; F = female; M = male; b&w = black and white; STAI = State Trait Anxiety Inventory; BIS = behavioural inhibition system; CBT = cognitive behaviour therapy; ME = main effect; Cong = Congruency; Alert = Alering; ME of Cue = orienting cue; HA = high anxiety; LA = low anxiety; LTS = low threat sensitive; HTS = high threat sensitive; AMI = anxious-mood-induction; SP = slow positive potential; ME of alerting, cue, and congruency indicates faster reaction times to alerting relative to non-alerting, valid relative to invalid/no cue, and cong relative to incong trials: ^ only results for adult participants reported.

Appendix B

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 C

Demographics Screening questionnaire

Screening Questionnaire

Section 1 - Demographics

1. **Age** _____

2. **Sex** _____

3. **Females only:**

Are you currently on the contraceptive pill? **Yes / No**
Are you currently pregnant or breastfeeding? **Yes / No**
Is there any possibility that you could be pregnant? **Yes / No**

4. **Is English your first language? Yes/no?**

   (if no please specify_____)

5. **Are you left or right handed? Right [1] Left [2]**

6. **What grade of school did you complete?**

   Year_____

7. **Have you completed any courses after school?**

   No……0

   Yes, trade/technical…...1

   Yes, university……..…2

   Specify qualifications_____

8. **Are you currently studying?**

   No……0

   Yes, trade/technical…….1

   Yes, university…….. 2

   Specify _____

Appendix D

Health and medical history screening questionnaire

Section 3 – Health and Medical History

1. Have you ever suffered from any of the following:

Epilepsy	**Yes**	**No**
Severe head injury	**Yes**	**No**
Diabetes	**Yes**	**No**
Fits or convulsions (that were not related to a fever)	**Yes**	**No**
Loss of consciousness (greater than 2 minutes)	**Yes**	**No**
Concussion in last 6 weeks	**Yes**	**No**
Regular Giddiness	**Yes**	**No**
Heart condition or any other serious physical condition	**Yes**	**No**
Sleep disorder (or any major sleeping difficulties)	**Yes**	**No**
Visual problems (that are not fixed with glasses/contact lenses)	**Yes**	**No**
Hearing problems	**Yes**	**No**

If you answered yes to any of the questions above, please provide some extra information on the condition (and the length of time and severity.

2. Are you currently taking any prescribed medications? Yes / No
If yes, please specify:
.....
.....
.....

3. Do you have sensitive skin? Yes / No
(Skin preparation for EEG recording includes using alcohol wipes and exfoliant in order to get the best reading possible from electrodes, people with sensitive skin may find this irritating)

Section 4 – Mental health

1. Have you ever been diagnosed with a mental health condition? Yes / No
If yes, please provide some extra information (including the condition and time frame):
.....
.....
.....

2. Have you ever been prescribed medications for mental health problems? Yes / No
If yes, please state which medications and how long ago
.....
.....
.....
.....

8. Did you feel that everything was an effort?
All of the time.....1
Most of the time.....2
Some of the time.....3
A little of the time.....4
None of the time 5

9. Did you feel so sad that nothing could cheer you up?
All of the time.....1
Most of the time.....2
Some of the time.....3
A little of the time.....4
None of the time 5

10. Did you feel worthless?
All of the time.....1
Most of the time.....2
Some of the time.....3
A little of the time.....4
None of the time 5

Appendix E

Substance use questionnaire and AUDIT

Section 5 – Substance use

The following questions are about your use of tobacco, alcohol and other substances

1. In the last 6 months, how often have you used tobacco/nicotine?

Never 0

Less than monthly 1

Monthly 2

Weekly 3

Daily or almost daily 4

2. In the last 6 months, how often have you used illicit drugs (e.g., cannabis, ecstasy, speed)?

Never 0

Less than monthly 1

Monthly 2

Weekly 3

Daily or almost daily 4

3. On how many occasions have you ever used illicit drugs?

None 0

1-5 1

5-10 2

10-15 3

More than 10 occasions 4

AUDIT

Q1. How often do you have a drink containing alcohol?

Never.....0

(Go to Q9)

Monthly or less 1

2–4 times per month.....2

2–3 times per week.....3

4 or more times a week.....4

Q2. How many drinks containing alcohol do you have on a typical day when you are drinking?

1 or 2.....0

3 or 4.....1

5 or 6.....2

7 to 9.....3

10 or more 4

Q3. How often do you have six or more drinks on one occasion?

Never.....0

Less than monthly.....1

Monthly.....2
Weekly 3
Daily or almost daily 4

Q4. How often during the last year have you found that you were unable to stop drinking once you had started?

Never.....0
Less than monthly.....1
Monthly.....2
Weekly 3
Daily or almost daily 4

Q5. How often during the last year have you failed to do what was normally expected from you because of drinking?

Never.....0
Less than monthly.....1
Monthly.....2
Weekly 3
Daily or almost daily 4

Q6. How often during the last year have you needed a first drink in the morning to get yourself going, after a heavy drinking session?

Never.....0
Less than monthly.....1
Monthly.....2
Weekly 3
Daily or almost daily 4

Q7. How often during the last year have you had a feeling of guilt or remorse after drinking?

Never.....0
Less than monthly.....1
Monthly.....2
Weekly 3
Daily or almost daily 4

Q8. How often during the last year have you been unable to remember what happened the night before because you had been drinking?

Never.....0
Less than monthly.....1
Monthly.....2
Weekly 3
Daily or almost daily 4

Q9. Have you or someone else been injured as a result of your drinking?

No.....0
Yes, but not in the last year 2
Yes, during the last year 4

Q10. Has a relative or friend or doctor or other health worker been concerned about your drinking or suggested you cut down?

No.....0

Yes, but not in the last year 2
Yes, during the last year 4

Appendix F

Participant Information Sheets and Consent Form

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.

Chief Investigator: Dr Allison Matthews
Student Investigators: Isabel Hoystead, Amber Johnstone, and Shelley Flynn

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

Chief Investigator: Dr Allison Matthews

Student Investigators: Isabel Hoystead, Amber Johnstone, and Shelley Flynn

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

Coping with Anxiety

The Nature of Anxiety

Anxiety is a normal and healthy reaction that allows you to deal with threat or danger. When you are confronted by a threatening situation your body automatically releases hormones which send signals to the body to prepare to 'fight' or 'flight'. We become more alert, our heartbeat speeds up, the muscles get tense ready for action, sweating increases to cool the body, and breathing rate speeds up so that we can get oxygen into our bodies more quickly. These changes allow us to run very quickly or fight our enemies. Sometimes when our breathing rate increases, we tend to over breathe or hyperventilate. This hyperventilation may cause a number of symptoms including dizziness, breathlessness or chest pains. It is important to realise that these feelings are part of a physical response to threat and are not a sign that you have some physical disease. These symptoms do not mean that you will die, go crazy, or lose control.

Management of Anxiety

Although anxiety is a normal, and at times, a useful response, excessive anxiety may interfere with your everyday life. Anxiety can be managed by reversing or interrupting the flight-or-flight response through the use of breathing or relaxation techniques. To reduce symptoms of hyperventilation it is necessary to increase and steady the levels of carbon dioxide in the blood. One method to do this is breathing into a paper bag. Another method to reduce over breathing and to **prevent anxiety from escalating** is the slow breathing exercise (see below). This exercise can be practiced daily **and** used at any time that you notice sensations of anxiety.

Breathing Exercise

1. Hold your breath and count to 5 (do not take a deep breath).
2. When you get to 5, breathe out and say the word 'relax' in a calm soothing manner.
3. Breathe in and out slowly through your nose in a 6 second cycle (breathe in for 3 seconds & out for 3 seconds). This will produce a breathing rate of 10 breaths per minute. Say 'relax' to yourself when you breathe out.
4. At the end of each minute hold your breath for 5 seconds and then continue breathing using the 6 second cycle
5. Continue breathing this way until all of the symptoms of over breathing have gone.

Exposure Treatment for Anxiety

If your anxiety is associated with specific objects or situations (such as spiders) it is also possible to reduce anxiety through exposure to the feared object or situation. **It is important to remain in the feared situation until there is a decrease in anxiety. Although your anxiety may rise when confronting the situation, it will also fall within a few minutes.** By remaining in the situation you will learn that there is nothing to fear.

What do I do if I am experiencing high levels of anxiety during the treatment?

If you are feeling anxious during the treatment, try to remain calm and do the above breathing exercise. Remember your anxiety will fall in a few minutes. If your anxiety becomes overwhelming, you are free to stop the treatment. If you are undertaking a session in the research clinic you will be assisted by the researchers to regain your composure. You do not have to continue with the treatment if you do not wish to.

If your anxiety becomes overwhelming when you are completing the treatment at home, again, try to remain calm and do the above breathing exercise. Remember your anxiety will fall in a few minutes. If you choose to stop following a circle on the screen with the computer mouse, the stimulus on the screen will disappear. This will allow you time to regain your composure. When you are ready to start again, you can start following the circle and the image will reappear. Again you are free to stop the treatment at any stage. You may like to enlist the help of a friend or relative, by showing them this information, they may be able to assist you should the need arise. If you are hyperventilating and the breathing exercise does not help, you may like to have a paper bag handy that you can breathe into. This will help to stop you from over breathing.

What if I need further help or treatment?

Please note that this information is NOT a substitute for diagnosis and treatment by an appropriate health professional. Please let us know if you require further assistance and we can refer you to an appropriate health professional. Your GP will also be able to refer you for further assessment and treatment if required.

The School of Medicine (Psychology), University of Tasmania, is not a health or crisis service and does not have the capacity to provide clinical advice or assistance if you require these services. **If you need urgent medical or psychological assistance, please contact your local doctor/GP or other health professional, or the emergency department of your local hospital.**

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Coping with Anxiety (for researchers)

Dealing with anxiety during treatment

1. Be familiar with the above information on the nature of anxiety and its management. Go through this information with participants and answer any questions that they may have.
2. Allow participants to work through their anxiety unless they become particularly distressed and indicate that they wish to stop the treatment, in which case exit the program for them and reassure them that this is ok.
3. Ask them to concentrate on breathing slowly and regularly and perhaps work through the above breathing exercise.
4. If the participant is hyperventilating and the breathing exercise has not worked, assist participant to breathe into a paper bag.
5. It is probably best that the participant does not leave until their anxiety has subsided. They may like a decaffeinated drink.
6. In the case that the above measures have not been helpful contact the consulting psychiatrist, Prof. Kenneth Kirkby on 0419120041

Referral

If participants request referral for specialised treatment, discuss with Prof. Ken Kirkby, who will arrange appropriate referral.

Appendix G

Participant on the day 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 H

Participant video gaming experience questionnaire

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 I

Participant menstrual cycle form

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
19	20	21	22	23	24	25
26	27	28	29	30	31	

Appendix J

Non-significant, hypothesis relevant effects

Table 1

Non-significant F-tests

Effect	$F(1,24)$	p	η_p^2
Behavioural (RT)			
Image x Group	0.62	.440	.03
Cue x Congruency x Group	0.69	.415	.03
Cue x Image	0.03	.867	.001
Cue x Image x Group	0.07	.792	.003
Congruency x Image	0.003	.957	.000
Congruency x Image x Group	0.03	.856	.001
P1 Amplitude			
Image x Group	0.68	.417	.03
Cue x Group	0.01	.914	.00
Congruency x Group	2.56	.123	.1
Image x Cue	1.96	.174	.08
N1 Amplitude			
Image x Group	0.92	.347	.04
Congruency x Group	0.04	.85	.002