Habituation of self-reported anxiety and cortical hyper-vigilance during image-based exposure to spiders

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ABSTRACT

Background and objectives: The aim of the study was to examine habituation of subjective anxiety and electrophysiological correlates of cortical hyper-vigilance during exposure to spider images among high (n = 12) and low (n = 11) spider fear groups.

Methods: Participants viewed a six-stage hierarchy of spider images. The images used at stage 1 and stage 6 were the same. Subjective anxiety was rated at four intervals during each three-minute exposure stage (0, 60, 120, and 180 s) and event-related potentials (ERPs) were averaged across these epochs (0–60, 60–120, 120–180).

Results: High spider fearfuls demonstrated greater habituation of self-reported anxiety within and between exposure stages compared to low fearfuls. Consistent with attentional hyper-vigilance, the high-fear group also demonstrated greater P1 amplitude in response to spider images. In both groups, habituation of P1 amplitude was found at later relative to earlier stages, but increased at stage six when the stage 1 image was re-presented, despite low subjective anxiety.

Limitations: While the passive viewing paradigm mirrored image-based exposure, it was not possible to determine whether participants engaged in avoidance strategies. In addition, further research is needed to assess the relevance of habituation and reinstatement of P1 amplitude to therapeutic outcome.

Conclusions: Habituation of subjective anxiety during image-based exposure is not necessarily accompanied by a reduction in measures of cortical hyper-vigilance. The reinstatement of the P1 response may indicate either re-activation of previous associations, less avoidance, or a more generalised dishabituation mechanism.

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1. Introduction

Graded exposure treatment involves progression through a hierarchy of exposure stages (from least to most anxiety-provoking) until a reduction in anxiety is observed, a process known as habituation (Choy, Fyer, & Lipsitz, 2002; Öst, 1989). While in vivo exposure is the gold standard for phobia treatment (Choy et al., 2002), exposure-based treatments may also be imaginal, virtual, or vicarious in nature. For example, exposure to images is effective in the treatment of specific phobia and can be delivered in the online environment (Bornas, Tortella-Feliu, Labrè, & Fullana, 2001; Matthews, Naran, & Kirkby, 2015; Matthews, Scanlan, & Kirkby, 2012; Müller, Kull, Wilhelm, & Michael, 2011). Given that many do not seek treatment for specific phobia (Andrews, Henderson, & Hall, 2001; Lépine, 2002), online exposure treatments have potential to overcome barriers such as the time, cost and accessibility of traditional face-to-face treatments (Bebbington et al., 2000; Stinson et al., 2007). Exposure to images also allows exploration of the mechanisms underlying exposure treatment, including the electrophysiological processes involved in the activation and habituation of fear. While the P1 component of the ERP waveform has been suggested as a cortical mechanism related to attentional hyper-vigilance in specific fear and other anxiety disorders (O’Toole & Dennis, 2012), to our knowledge there is little research examining the habituation of the P1 component during exposure to fear-related images.

According to Emotional Processing Theory (EPT), activation of the fear response (self-report or physiological) followed by a
reduction in anxiety (both within and between exposure trials) is necessary for corrective learning to occur, such that existing stimulus-response associations are replaced or inhibited by new associations that are incompatible with the fear response (Foa & Kozak, 1986; Foa, Huppert, & Cahill, 2006). While there is mixed evidence with regard to the relationship between habituation and therapeutic outcome (Craske et al., 2008), generalisation of habituation across multiple different images (an analogue to between stage habituation) has been associated with less behavioural avoidance of spiders in image-based exposure (Matthews et al., 2015). According to inhibitory learning perspectives, simultaneous activation of new associations and the suppression of old associations is necessary for long-term treatment benefits, and factors such as context, time, and optimal attentional focus are important moderators of treatment outcome (Bouton, 1993; Craske et al., 2008; Myers & Davis, 2007). Consistent with this view, return of fear can be contextually driven, and is greater when assessed in a different context to exposure (Mystkowski, Craske, Echiverri, & Labus, 2006). Thus, demonstrating extinction learning to multiple different contexts (or images) is likely to be important.

While inhibitory learning perspectives focus on extinction processes (reductions in the strength of learned responses) and EPT focuses on corrective learning through habituation (reduction in strength of unlearned responses), both perspectives highlight the importance of attentional focus in exposure therapy. Attentional focus is considered important for noticing and processing non-threatening information about the stimulus in order to either eliminate maladaptive stimulus-response associations (as suggested in EPT), or to develop new non-fearful learned associations (as suggested in inhibitory learning perspectives) (Podina, Koster, Philippot, Dethier, & David, 2013). However, automatic attentional bias toward threat-related stimuli is also cited as a potential factor in the onset and maintenance of anxiety disorders such as specific phobia (Bar-Haim, Lamy, Perugini, Bakermans-Kranenburg, & van IJzendoorn, 2007; Cisler & Koster, 2010; Mogg & Bradley, 2006; Van Bockstaele et al., 2014). There are three specific components of attentional bias: enhanced attention capture, difficulty disengaging attention, and attentional avoidance of threat-related stimuli (Cisler & Koster, 2010). Each component may be activated according to a different time-course and to a differing extent depending on the experimental task and the anxiety disorder in question (Cisler, Bacon, & Williams, 2009; Weierich, Treat, & Hollingworth, 2008). In specific fear, there is evidence for enhanced attentional capture of fear-relevant stimuli across a number of experimental paradigms (Bar-Haim et al., 2007; Cisler & Koster, 2010; Cisler et al., 2009; Mogg & Bradley, 2006), a phenomenon known as attentional hyper-vigilance (Pflugshaupt et al., 2005). Automatic capture of attention may also be followed by difficulty disengaging attention from fear-relevant stimuli (Gerdes, Pauli, & Alpers, 2009), or a vigilant-avoidant pattern in which automatic capture is followed by abrupt attentional dis-engage ment which may act to facilitate escape or avoidance (Mogg & Bradley, 2006; Pflugshaupt et al., 2005; Ohman & Mineka, 2001).

Attentional hyper-vigilance towards fear-relevant stimuli is thought to be mediated by a direct thalamic-amygdala pathway which acts to enhance attentional capture via projections to the visual cortex (Garrido, Barnes, Sahani, & Dolan, 2012). In specific phobia, amygdala activation is enhanced during subliminal exposure to images of spiders (Ipser, Singh, & Stein, 2013) and when attention is directed towards phobic relative to neutral stimuli within the same array (Alpers & Gerdes, 2009). The amygdala also plays an important role in the acquisition, storage and expression of fear-related memories, including the automatic activation of conditioned fear responses (LeDoux, 2000; Ohman & Mineka, 2001), and modulation of the emotional content of explicit memories (LeDoux, 2000).

It has been theorised that the balance of automatic (bottom-up) and goal-directed (top-down) attentional mechanisms is disrupted in anxiety disorders. According to Attentional control theory, anxiety is associated with increased influence of the automatic attentional system involving the temporo-parietal and ventral-frontal cortices, and reduced influence of a goal-directed attentional system centred in the prefrontal cortex (Eysenck, Derakshan, Santos, & Calvo, 2007). Similarly, Bishop (2007) suggests that threat-related attentional biases occur due to an amplified threat signal from the amygdala, and a reduced control signal from the prefrontal cortex. Both of these structures have re-entrant connections to the visual cortex and may modulate visual processing via these connections (Bishop, 2007). The extinction of learned fear is also mediated by the prefrontal cortex (PFC) through its interaction with structures such as the amygdala and hippocampus (McNally, 2007; Sotres-Bayon, Cain, & LeDoux, 2006). Thus, the medial PFC may act to inhibit the activity of the amygdala in order to regulate the expression of fear.

While brain-imaging research provides insight into the brain areas associated with phobic symptoms, event-related potentials (ERPs) allow examination of the time course of cognitive processes with millisecond resolution. The P1 ERP component is a positive inflection occurring approximately 100–200ms post-stimulus which reflects processing within early extra-striate visual pathways (Clark & Hillyard, 1996; Mangun, 1995). P1 amplitude is modulated by attention (Clark & Hillyard, 1996; Mangun, 1995) and by stimulus valence, particularly for negative stimuli (Olofsson, Nordin, Sequeira, & Polich, 2008). Unlike later ERP components such as the LPP and P300, in which enhancement may reflect emotional significance and broader attentional allocation (Leutgeb, Schafer, & Schienle, 2009), the P1 component is argued to reflect automatic capture of attention (cortical hyper-vigilance) and may be influenced by activation of the amygdala (Olofsson et al., 2008).

Several studies have demonstrated that people with anxiety disorders such as specific phobia show enhanced P1 amplitude relative to controls (Kolassa, Musial, Kolassa, & Miltener, 2006; Michalowski et al., 2009). For example Kolassa et al. (2006) reported enhanced P1 amplitude to spider stimuli among both spider and social phobics compared to a non-phobic group, suggesting generalised as opposed to fear-specific hyper-vigilance. Similarly, Michalowski et al. (2009) found that spider and non-spider phobics demonstrated higher P1 amplitude to all images (pleasant, unpleasant, neutral) relative to non-phobics during a passive viewing task, again suggesting non-specific attentional hyper-vigilance.

While previous research has demonstrated habituation of self-report and physiological measures of anxiety during computer-delivered exposure to images (Bornas et al., 2001; Matthews et al., 2012, 2015; Müller et al., 2011), it is not clear whether exposure to images results in habituation of cortical hyper-vigilance as indexed by the P1 component. Leutgeb et al. (2009) examined later P300 and LPP amplitudes in response to cognitive behavioural therapy (CBT) including exposure among spider phobics. Following treatment, the treatment group showed reduced symptom severity and rated pictures of spiders as less negative than before the treatment. However, contrary to predictions, there were no reductions in P300 or early LPP amplitude in response to spider images at post-treatment. Thus, it was argued that CBT did not impact attentional hyper-vigilance. In contrast, an increase in late LPP amplitude suggested more elaborate processing of emotional stimuli following treatment. However, this study did not specifically examine early attentional allocation as indexed by the P1 component.

Although no previous study has examined the effects of exposure to fear-relevant images on ERP indices of early selective processing, the current study provides evidence that these indices remain stable following treatment.
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