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Attentional control predicts change in bias in response to attentional bias modification

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ABSTRACT

Procedures that effectively modify attentional bias to negative information have been examined for their potential to be a source of therapeutic change in emotional vulnerability. However, the degree to which these procedures modify attentional bias is subject to individual differences. This generates the need to understand the mechanisms that influence attentional bias change across individuals. The present study investigated the association between individual differences in attentional control and individual differences in the magnitude of bias change evoked by an attentional bias modification procedure. The findings demonstrate that individual differences in two facets of attentional control, control of attentional inhibition and control of attentional selectivity, were positively associated with individual differences in the magnitude of attentional bias change. The present findings inform upon the cognitive mechanisms underpinning change in attentional bias, and identify a target cognitive process for research seeking to enhance the therapeutic effectiveness of attentional bias modification procedures.

1. Introduction

Cognitive models of anxiety vulnerability implicate a bias in attentional processing that favours the processing of negative information as a key factor in the aetiology and maintenance of heightened anxiety vulnerability (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; Mathews & Mackintosh, 1998; Mogg & Bradley, 1998). This attentional bias is assessed via procedures that attempt to measure the distribution of attentional deployment to stimuli that vary in emotional tone. The most common means of assessment is the attentional-probe task (MacLeod, Mathews, & Tata, 1986). In this task, individuals are briefly presented with pairs of emotionally discrepant stimuli, often words. One stimulus depicts emotionally negative material (e.g. "kill") while the other depicts neutral material (e.g. "chair"). After presentation of the stimulus pair, participants must discriminate the identity of a probe that appears in a location previously occupied by one of the stimuli. Attentional bias to negative information is revealed by relative speeding to discriminate probes presented in the location of emotionally negative information, as compared to emotionally neutral information. Using this task, MacLeod et al. (1986) affirmed earlier research demonstrating anxious individuals displayed heightened attentional bias to negative information as compared to non-anxious individuals. The association between heightened anxiety vulnerability and heightened attentional bias to negative information has since been firmly established (Bar-Haim et al., 2007).

Discovery of the association between anxiety vulnerability and attentional bias to negative information has led researchers to investigate the causal nature of this relationship. By manipulating attentional bias to negative information directly, researchers have demonstrated that this bias can causally contribute to anxiety vulnerability. For example, MacLeod, Rutherford, Campbell, Ebsworthy, and Holker (2002) employed a modified attentional-probe procedure designed to increase, or decrease, participants' attentional bias to negative information through the implementation of a contingency. Specifically, in order to encourage the adoption of an attentional bias towards negative information, probes always appeared in the location previously occupied by emotionally negative stimuli. Conversely, in order to encourage the

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adoption of an attentional bias away from negative information, probes always appeared in the location opposite the emotionally negative stimuli (i.e. in the location of the emotionally neutral stimuli). MacLeod et al. (2002) observed that the implementation of these contingencies effectively manipulated attentional bias to negative information in the intended direction, and changes in attentional bias to negative information were associated with corresponding changes in anxiety vulnerability.

It has since been demonstrated that procedures designed to attenuate attentional bias to negative information hold potential value as a treatment for anxiety symptomatology (Linetzky, Pergamin-Hight, Pine, & Bar-Haim, 2015). For instance, Schmidt, Richey, and Buckner (2009) investigated the impact of an attentional bias modification procedure on patients diagnosed with generalised social anxiety disorder. As predicted, patients who completed a training procedure involving a contingency designed to facilitate an attentional bias away from negative information exhibited significantly greater reductions in social anxiety compared to patients who received a control procedure. In another example, Amir, Beard, Burns and Bomyea (2009) demonstrated that completion of a multi-session programme attentional bias modification procedures, but not completion of a placebo control programme, was able to effectively reduce symptoms of generalised anxiety amongst individuals meeting diagnostic criteria for generalised anxiety disorder.

Crucially however, while early studies examining the potential value of attentional bias modification procedures demonstrated evidence supporting their therapeutic potential (Hakamata et al., 2010), in more recent years a number of meta-analytic studies have failed to demonstrate commensurate effects (Cristea, Kok, & Cuijpers, 2015; Heeren, Mogoaşe, Philippot, & McNally, 2015; Mogoaşe, David, & Koster, 2014). These mixed findings have led theorists to correctly note that attentional bias modification procedures do not yet demonstrate sufficient efficacy to serve as a formal treatment for emotional dysfunction, and that greater research is needed prior to their adoption in this way.

With the aim of further understanding the circumstances under which attentional bias modification procedures successfully lead to therapeutic benefits, researchers have highlighted the distinction between the process of attentional bias change and the ability of attentional bias modification procedures to successfully evoke this process. For example, in a recent review of the literature Macleod and Clarke (2015) demonstrated that when the completion of an attentional bias modification procedure successfully evoked change in attentional bias (i.e., the process), then a consistent and reliable change in social anxiety symptoms was also observed. In contrast, when the procedures had failed to evoke this process, then change in symptoms was absent. Additionally, researchers have identified that the degree of symptom reduction that arises from the completion of an attentional bias modification procedure is associated with the degree of bias change that resulted from the modification procedure (Kuckertz & Amir, 2015; Price et al., 2016).

This has led some theorists to propose that recent failures of some meta-analyses to demonstrate a therapeutic effect of attentional bias modification, are likely due to the unreliability of attentional bias procedures in evoking the process of attentional bias change (Clarke, Notebaert, & Macleod, 2014; Macleod & Clarke, 2015; MacLeod & Grafton, 2016). Hence, in order for attentional bias modification procedures to be maximally effective in their capacity to serve as therapeutic tools, it is critically important that research identifies the mechanisms that influence the degree to which the process of attentional bias change is evoked by attentional bias modification procedures.

Some researchers have sought to shed light on these mechanisms by examining genetic markers that may be associated with individual differences in magnitude of change in attentional bias in response to a bias modification procedure. Specifically, Fox, Zougkou, Ridgewell, and Garner (2011) compared change in attentional bias in response to a modification procedure designed to induce a bias toward negative information, or induce a bias away from negative information, across individuals with alternate forms of the serotonin transporter gene (5-HTTLPR). Comparison of these groups revealed that individuals with a low-expression form of the gene demonstrated greater change in attentional bias, relative to those with the high-expression form of the gene. Importantly, this effect was consistent regardless of the direction in which the modification procedure altered attentional bias, leading the authors to propose that this genetic mechanism may underpin variation in generalised malleability of attentional responding to environmental contingencies, rather than the capacity to adopt bias in a single direction.

While such studies are informative for understanding biological factors that influence individual differences in the magnitude of attentional bias change evoked by bias modification procedures, research has yet to investigate cognitive mechanisms that may also influence such variability. This has important clinical implications, as identifying such mechanisms could reveal targets for cognitive interventions seeking to improve the effectiveness of attentional bias modification procedures. Hence, the investigation of cognitive mechanisms represents an important avenue for research.

One candidate cognitive mechanism is attentional control, reflecting the capacity to execute goal-directed attentional deployment. A large scope of research has suggested that heightened anxiety vulnerability is associated with a reduced capacity to exert attentional control effectively (Berggren & Derakshan, 2013). Theoretical accounts of the relationship between attentional control and anxiety vulnerability have espoused the theoretical importance of investigating the association between attentional control and other cognitive processes associated with anxiety vulnerability (Eysenck, Derakshan, Santos, & Calvo, 2007). Hence, the importance of investigating attentional control is not only derived from practical concerns but also holds strong theoretical relevance by expanding understanding of the associations between cognitive processes that underpin anxiety vulnerability.

Chen, Clarke, Watson, MacLeod, and Guastella (2014) observed that individuals who completed an attentional bias modification procedure subsequently demonstrated heightened performance on inhibitory attentional control measures, as compared to individuals who received no attentional modification procedure. Additionally, some researchers have suggested that heightened attentional control may enhance the process of bias change evoked in response to attentional bias modification procedures. Clarke, Browning, Hammond, Notebaert and Macleod (2014) and Clarke, Notebaert, et al. (2014) induced stimulation of the dorsolateral prefrontal cortex (DLPFC) via transcranial direct current stimulation (tDCS) while participants completed an attentional bias modification procedure. The DLPFC is a cortical region believed to be involved in the regulation of attentional control (Miller & Cohen, 2001; Ochsner, Silvers, & Buhle, 2012). The investigators observed that participants receiving active stimulation, as compared to a sham stimulation procedure, showed enhanced acquisition of attentional bias in the targeted training direction. Crucially however, while these findings support the hypothesis that increased attentional control may contribute to bias change, this study did not examine the impact of tDCS stimulation on attentional control, and then therefore not rule out that the effects were driven my nan impact of tDCS on some other cognitive construct. Therefore, a complimentary approach to examining this hypothesis involves the assessment of attentional control and its contribution to bias change.

Importantly, if individual differences in attentional control