Psychoneuroendocrinology (2014) 44, 88—99

Available online at www.sciencedirect.com

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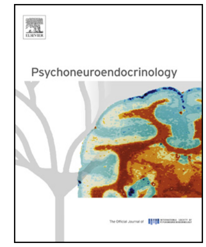

The impact of attentional training on the salivary cortisol and alpha amylase response to psychosocial stress: Importance of attentional control

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Received 3 August 2013; received in revised form 4 January 2014; accepted 27 January 2014

KEYWORDS
Attentional training;
Attention modification;
Attentional control;
Executive attention;
Salivary cortisol;
Salivary alpha amylase;
Stress

Summary
Introduction: This study examined the effects of three consecutive days of attentional training on the salivary alpha amylase (sAA), cortisol, and mood response to the Trier Social Stress Test (TSST). The training was designed to elicit faster disengagement of attention away from threatening facial expressions and faster shifts of attention toward positive ones.
Method: Fifty-six healthy participants between the ages of 18 and 30 participated in a double-blind, within-subject experiment. Participants were randomly assigned to one of three attentional training conditions — *supraliminal* training: pictures shown with full conscious awareness, *masked* training: stimuli presented with limited conscious awareness, or *control* training: both supraliminal and masked pictures shown but no shifting of attention required. Following training, participants underwent the TSST. Self-reported mood and saliva samples were collected for the determination of emotional reactivity, cortisol, and sAA in response to stress post-training.
Results: Unexpectedly, participants in both attentional training groups exhibited a higher salivary cortisol response to the TSST relative to participants who underwent the control training, $F(4, 86) = 4.07$, $p = .005$, $\eta_p^2 = .16$. Supraliminal training was also associated with enhanced sAA reactivity, $F(2, 44) = 13.90$, $p = .000$, $\eta_p^2 = .38$, and a more hostile mood response ($p = .021$), to the TSST. Interestingly, the effect of attention training on the cortisol response to stress was more robust in those with high attentional control than those with low attentional control ($\beta = -0.134$; $t = -2.24$, $p = .03$).
Conclusion: This is among the first experimental manipulations to demonstrate that attentional training can elicit a paradoxical increase in three different markers of stress reactivity. These findings suggest that attentional training, in certain individuals, can have iatrogenic effects.

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0306-4530/$ — see front matter © 2014 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.psyneuen.2014.01.024

1. Introduction

It is well known that anxiety disorders and other mental illnesses such as depression are associated with abnormalities in the selective processing of emotional stimuli (MacLeod et al., 1986; Williams et al., 1996; Mathews and Macleod, 2005; Peckham et al., 2010). It is not known, however, whether alterations in emotional information processing represent a correlate or symptom of the disordered state, or contribute to the development or maintenance of these disorders. Recently, randomized-control studies attempting to experimentally modify the focus of attention, known as *attentional training*, have been conducted in an effort to clarify the issue of causality. If the relationship between attentional abnormalities and anxiety is etiological, then changes in attention should elicit a decrease in anxiety and symptom relief. Indeed, attentional training has been effective in reducing symptoms of anxiety (Bar-Haim, 2010; Li et al., 2008; Hakamata et al., 2010), as well as emotional reactivity to stress (MacLeod et al., 2002; Amir et al., 2008). Less is known, about the link between attentional biases, attentional training, and physiological markers of stress, as well as the role of attentional control in these associations.

Several studies have shown that baseline, early stage attentional biases predict cortisol responses to stress (Ellenbogen et al., 2006; Fox et al., 2010; Roelofs et al., 2007; Pilgrim et al., 2010). Fox et al. (2010) showed that baseline attentional biases predict cortisol reactivity eight months later while controlling for neuroticism, trait anxiety, and depression. Similarly, faster shifts of attention toward masked angry faces during stress, a marker of automatic processing, was associated with higher cortisol in response to the Trier Social Stress Test (TSST; Ellenbogen et al., 2010). These findings suggest that attention training, particularly at early stages, may influence physiological indices of stress in important ways. Although techniques such as cognitive behavioral stress management (Gaab et al., 2003, 2006) and meditation (Lutz et al., 2008; Sood and Jones, 2013) may also attenuate cortisol levels (Brand et al., 2012; Fan et al., 2014; Gaab et al., 2003, 2006; Regehr et al., 2013) and heart rate (Nyklíček et al., 2013), attentional training, which specifically aims to change attentional biases, may shed light on the causality of the relationship between attention and stress.

Few studies have examined the impact of attentional training on physiological markers of stress (Dandeneau et al., 2007; Baert et al., 2012; Heeren et al., 2012; Higgins and Hughes, 2012). Training toward happy faces increased self-esteem and lowered basal cortisol in young adults working in a stressful environment (Dandeneau et al., 2007), while six days of training facilitated disengagement away from threat and improved heart rate variability (a marker of autonomic system functioning) during the recovery phase of a simulated job interview (Baert et al., 2012).

Despite these results the exact mechanism by which attentional training occurs, remains largely unknown (Heeren et al., 2013). Attentional biases may be the result of a valence-specific system which modifies initial threat detection (Heeren et al., 2013) and/or sharpens attentional control (Heeren et al., 2013; Klumpp and Amir, 2010; Paulewicz et al., 2012) which, rather than reducing early threat processing would modify responses to incoming threat. According to this view, attentional control regulates bottom-up emotional responses. This is supported by evidence that attentional control moderates the link between trait anxiety and fear during exposures to biological challenge (i.e., a single inhalation of 35% CO_2 enriched gas; Richey et al., 2012). Derryberry and Reed (2002) also showed that strong attentional control predicts faster disengagement from threat and/or engagement toward non-threatening information, irrespective of trait anxiety. Similarly, the strength of the relationship between trait anxiety and amygdala activation in response to stress was moderated by attentional control (Bishop, 2009). These findings suggest that attentional control may play a role in the top-down regulation of stress.

Taken together, there is some evidence that attentional training influences stress reactivity, but more research is necessary. Given the link between rapid threat processing and cortisol reactivity observed across several studies (Ellenbogen et al., 2006, 2010; Fox et al., 2010), it is possible that training early attentional processes may influence stress reactivity in unique ways. The present study compared training of early versus later stages of attention on the stress response as indexed by the subjective emotional response and two major biological stress systems — the sympathetic nervous system (SNS) and the hypothalamic—pituitary—adrenal (HPA) axis. The SNS is triggered immediately following stress, representing an early stage of the stress response, while the HPA axis, which responds 20—30 min later (Chrousos, 2009), reflects a later stage of reactivity or adaptation to an ongoing challenge. Both salivary alpha amylase (sAA), a digestive enzyme and marker of SNS activity (Nater and Rohleder, 2009), and salivary cortisol, the major human glucocorticoid stress hormone secreted by the HPA axis, will be collected in the present study. It is important to determine if attentional training has specific effects on the HPA axis, consistent with some past correlational research (Ellenbogen et al., 2006), or whether it influences stress reactivity across all systems (mood state, cortisol, and sAA). In the present study, healthy participants were randomly assigned to one of three attention training manipulations: a masked condition using briefly presented stimuli (17 ms) followed by a mask (733 ms; limited conscious awareness), a supraliminal condition using pictures displayed for 750 ms (full conscious awareness), and a control condition where participants were exposed to both picture types but not required to shift attention.

Attentional training took place over three days and was aimed at facilitating attentional disengagement away from threat (angry faces) and promoting shifts of attention toward positive stimuli (happy faces). The hypotheses were: (1) attention training will elicit faster disengagement from threat, (2) attention training will attenuate mood, cortisol, and sAA reactivity post-training, (3) attention training with masked stimuli will have a more robust effect on the cortisol response to stress than supraliminal training, and (4) baseline attention control will moderate the association between attentional training and parameters of stress reactivity.

2. Methods

2.1. Participants

Fifty-six healthy (30 female; 26 male) participants between the ages of 18 and 30 years were recruited via advertisements