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Attentional Control Moderates Fearful Responding to a 35% CO_2 Challenge

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Attentional control (AC) is an individual difference variable indexing the ability to voluntarily focus attention and shift attention when desired. AC is thought to impact the experience of fear by facilitating the disengagement of attention from threat and promoting the deployment of attentional resources toward regulatory or coping strategies. Whereas previous research has focused on visual threat cues, in the current study we examined whether this model also applies to interoceptive threat by evaluating the extent to which individual differences in AC moderated the relationship between trait anxiety and self-reported fear in response to a single vital capacity inhalation of a 35% CO_2, 65% balanced O_2 gas mixture. The sample comprised a large nonclinical group of young adults (N=128). Results indicated that AC moderated the relationship between trait anxiety and fearful responding to the challenge. Findings suggest that AC plays a significant and clinically important role in modulating self-reported fear.

Keywords: attentional control; anxiety; biological challenge

In recent years, significant advances have been made in the identification of risk factors for anxiety pathology. One comparatively understudied protective factor is attentional control (AC), an individual difference variable indexing the ability to focus attention and shift attention when desired (Derryberry & Reed, 2002; Fox, 1993; Fox, Russo, & Dutton, 2002; Moriya & Tanno, 2011). Because atypical patterns of involuntary and voluntary attention are implicated in the development and maintenance of anxiety disorders (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; Frewen, Dozois, Joanisse, & Neufeld, 2008), a more complete understanding of their mutual and relative connections with aversive arousal is warranted. In the current study, we therefore test a putative model of AC, in which individual differences in cognitive control of attention are hypothesized to moderate the relationship between traitwise anxiety and the experience of fear during a brief but acute biological challenge (a single vital capacity inhalation of 35% CO_2 enriched gas).

In the context of a threat stimulus, humans must make choices about the substantive nature of the stimulus in order to select an optimal response from among multiple alternative action outcomes. This implies both evaluation of a stimulus via cognitive appraisal as well as planning a regulatory strategy (or motor response) tailored to its substantive nature. Both of these processes are predicated upon successful allocation of attentional resources (a) away from the threatening stimulus itself, and (b) toward the cognitive activity of response selection. In the alternative, unsuccessful reallocation of attention should result in prolonged perseveration upon the threat stimulus and a concurrent prolongation of the

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fear response (Garner, Attwood, Baldwin, James, & Munafo, 2011; Kamphuis & Telch, 2000). However, anxiety research in humans has also clearly indicated that the very attentional resources required to accomplish this task are consumed as a direct function of the intensity of the threat (Ladouceur et al., 2009; Vermeulen, Godefroid, & Mermillod, 2009). That is, the more potent the threat value of the stimulus (and the concurrent fear response), the more difficult it is to disengage attention (Fox, Russo, & Georgiou, 2005). Therefore, the resultant experience of fear in the context of a threat stimulus (when holding its intensity constant) may be described in a moderational framework, in which intra-individual variation in the ability to disengage from the threat and allocate attentional resources to the selection of a response strategy directly impacts the relationship between preexisting risk factors to experience fear in the context of that threat, and the actual experience of fear itself. In considering individual difference variables in humans, this ability to voluntarily allocate attentional resources is thought to be normally distributed in the population (Meesters, Muris, & van Rooijen, 2007) and embodied in the construct of AC.

As noted above, AC indexes the ability to willfully focus and shift attention to and from environmental stimuli (Eisenberg & Fabes, 1992; Kochanska, Murray, & Harlan, 2000; Kopp, 1989; Rothbart & Rueda, 2005). AC is generally considered a subcomponent of the higher-order construct of effortful control, the self-regulatory aspect of temperament, defined as the ability to voluntarily suppress a dominant response in order to perform a subdominant response (Derryberry & Rothbart, 1997; Rothbart & Rueda, 2005). Psychometric evidence indicates that AC can also be decomposed into distinct subprocesses including attentional disengagement (i.e., willful termination of ongoing attentional focus) and voluntary visuospatial reorienting, both of which are separable from faster and more automatic aspects of attention such as alerting and initial orienting (Derryberry & Reed, 2002). To understand a possible role for AC in the development of anxiety psychopathology, it is instructive to delineate the mechanism by which AC is thought to support normal emotional experience. First, it is essential to recognize that AC is not necessarily an emotion regulation process, so much as a mechanism of *perceptual selection* (Banich et al., 2009; Herrington et al., 2005; Ochsner et al., 2009). This distinction is subtle but important. Whereas emotion regulation processes broadly pertain to the reduction, intensification, or maintenance of an internal sensation (Gross, 1998, 2002; Ochsner et al., 2004), AC, on the other hand, reflects the ability to voluntarily orient attention in space (i.e., engage, disengage, or switch attentional focus; Asplund, Todd, Snyder, & Marois, 2010). Successful disengagement from a threatening stimulus, for example, provides the conditions necessary for deployment of secondary responses by freeing attentional resources (previously occupied by the threat) for use in other, more cognitively demanding tasks. These secondary tasks may include direct coping strategies such as cognitive reappraisal or other emotion-regulation strategies (Ochsner et al., 2009; Ray et al., 2005). Consistent with this conceptualization, Derryberry and Reed (2002) note that individuals high in AC are able to use attention to constrain their emotions by either (a) terminating focus on a given threat stimulus, regardless of the sensory modality; or (b) reorienting toward "safe" or nonthreatening stimuli, possibly including direct coping strategies through attentional shifting (Derryberry & Reed, 1994, 2002), or a combination of these processes.

In considering how individual variation in AC may impact the experience of fear, prior work in the area of cognitive neuroscience has suggested that cognitive load may moderate the relationship between traitlike risk factors for anxiety and neural processing of threat stimuli. For example, in a functional magnetic resonance imaging (fMRI) study, Bishop, Jenkins and Lawrence (2007) demonstrated that cognitive load (induced by variation in perceptual task demands) moderates the relationship between trait anxiety and neural processing of fear faces in the amygdala. This indicates that the relationship between trait anxiety and the neural precursors of fear is moderated by the proportion of attentional resources consumed by task demands. This is conceptually similar to the operational definition of AC, in that AC indexes one's ability to minimize demands placed on executive resources by prepotent responses. If this model is correct, then extrapolation of this finding from the neural into the behavioral realm yields the prediction that individual variation at the level of AC (i.e., the differential ability to shift attention away from a target that confers high cognitive load) should moderate the relationship between trait anxiety and the experience of fear in the context of an acute threat. This is thought to be due to a comparatively greater capacity to recruit secondary responses such as cognitive reappraisal for individuals high in AC. Hence, AC may differentially enable the deployment of secondary responses, possibly including coping strategies.

The bulk of previous research examining the relationship between AC and anxiety has relied on tasks of visuospatial attention and working