



# Thinking anxious, feeling anxious, or both? Cognitive bias moderates the relationship between anxiety disorder status and sympathetic arousal in youth<sup>☆</sup>



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## ABSTRACT

Cognitive bias and physiological arousal are two putative markers that may underlie youth anxiety. However, data on relationships *between* cognitive bias and arousal are limited, and typically do not include behavioral measurement of these constructs in order to tap real-time processes. We aimed to examine the relationship between performance-based cognitive bias and sympathetic arousal during stress in clinically anxious and typically-developing youth. The sample included children and adolescents ages 9 to 17 (Mean age = 13.18, SD = 2.60) who either met diagnostic criteria for primary generalized anxiety, social phobia, or separation anxiety (N = 24) or healthy controls who had no history of psychopathology (N = 22). Youth completed performance-based measures of attention and interpretation bias. Electrodermal activity was assessed while youth participated in the Trier Social Stress Test for Children (TSST-C; Buske-Kirschbaum, Jobst, & Wustmans, 1997). A mixed models analysis indicated significant linear and non-linear changes in skin conductance, with similar slopes for both groups. Interpretation bias, but not attention bias, moderated the relationship between group status and sympathetic arousal during the TSST-C. Arousal trajectories did not differ for anxious and healthy control youth who exhibited high levels of threat interpretation bias. However, for youth who exhibited moderate and low levels of interpretation bias, the anxious group demonstrated greater arousal slopes than healthy control youth. Results provide initial evidence that the relationship between anxiety status and physiological arousal during stress may be moderated by level of interpretation bias for threat. These findings may implicate interpretation bias as a marker of sympathetic reactivity in youth. Implications for future research and limitations are discussed.

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## 1. Introduction

Anxiety disorders are distressing, disabling, and the most common mental health problem in children and adolescents (up to 25%; Beesdo, Knappe, & Pine, 2009). Core features of anxiety include hyper-reactivity to environmental stimuli across cognitive, physiological, and behavioral domains. Indeed, information processing (e.g., Daleiden, 1997; Field & Lester, 2010) and tripartite (e.g.,

Chorpita, Plummer, & Moffitt, 2000) theories of youth anxiety suggest that children and adolescents selectively attend to threat and interpret threat from ambiguity, and also experience physiological arousal across autonomic processes in response to stress. It follows that our current gold-standard psychosocial intervention for youth anxiety, cognitive behavioral therapy, targets threat-based and/or negative thinking with cognitive restructuring and physiological arousal/somatic symptoms with relaxation training (Kendall & Hedtke, 2006). However, relationships *between* these potential markers of disorder are understudied. A better understanding of potential relationships between these implicated processes would provide more direct cognitive and biological prevention and treatment targets.

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### 1.1. Cognitive biases and youth anxiety

Anxious youth have also been shown to demonstrate an attention bias, or selectively attend to threat (e.g., Bar-Haim, Lamy, & Pergamin, 2007) and an interpretation bias, or interpret threat from ambiguous information (e.g., Cannon & Weems, 2010; Rozenman, Amir, & Weersing, 2014), using performance-based tasks. The attention bias literature in youth is mixed, suggesting that selective attention to threat may be quite heterogeneous and not necessarily a ubiquitous phenomenon in youth (e.g., Bar-Haim, Kerem, Lamy, & Zakay, 2010; Eldar, Apter, Lotan, & Edgar, 2012; Waters, Bradley, & Mogg, 2014). In contrast, a growing body of research supports the notion that anxious youth consistently demonstrate an interpretation bias, or resolve ambiguity with threatening appraisals (Creswell, Schniering, & Rapee, 2005; Muris, Huijding, Mayer, & Remmerswaal, 2009; Rozenman et al., 2014; Vassilopoulos, Banerjee, & Prantzalou, 2009).

Of note, in the last two decades, cognitive bias modification (CBM) interventions have been used to directly intervene upon attention and interpretation biases with the goal of reducing anxiety symptoms (for reviews, see Beard, Sawyer, & Hofmann, 2012; Hakamata, Lissek, Bar-Haim, & Britton, 2010; Hallion & Ruscio, 2011; Menne-Lothmann, Viechtbauer, & Höhn, 2014). In addition to reducing anxiety symptoms in clinically anxious adolescents (Reuland & Teachman, 2014), CBM for interpretation bias in particular has been shown to reduce self-reported anxiety during psychological challenge (Lau, Belli, & Chopra, 2013) and life stress (Telman, Holmes, & Lau, 2013) in non-diagnosed youth samples.

### 1.2. Autonomic arousal and anxiety

Physiological arousal, or the nervous system's response to real or perceive threat, is also an associated feature of anxiety. Psychophysiology can be assessed with several measures, although these differ in the information provided about autonomic nervous system activity. Heart rate and respiratory sinus arrhythmia reflect an interplay between sympathetic and parasympathetic nervous system activity (e.g., Appelhans & Luecken, 2006), which may reflect both initial arousal and the attempt to downregulate or return to homeostasis and occurs several to many seconds after stimulus onset. Conversely, electrodermal activity (EDA) provides a relatively quick and undiluted representation of sympathetic activity (e.g., Cacioppo, Tassinary, & Berntson, 2007), which may be more reflective of an immediate physiological response to threat. EDA has been demonstrated as a validated physiological marker of anxiety in threatening situations (Beauchaine, 2001; Erath, Tu, & El-Sheikh, 2012; Fowles, Kochanska, & Murray, 2000) and, because it directly reflects sympathetic fear response, has been used as a proxy for fear acquisition in Pavlovian conditioning tasks (e.g., Craske, Waters, Bergman, & Naliboff, 2008). Interestingly, behavioral measures and self-reports of arousal do not always converge in youth samples (De Los Reyes et al., 2012; Kristensen, Oerbeck, & Torgersen, 2014; Miers, Blote, Sumter, & Kallen, 2011) suggesting that psychophysiological measures may provide distinct information about fearful autonomic responding that might not be acquired by self-report alone.

Several studies have found that youth with elevated anxiety symptoms and anxiety disorders exhibit autonomic nervous system hyper-arousal, including elevated resting heart rate, increased sympathetic and parasympathetic activity during stress, and impaired autonomic recovery following stress (Blom, Olsson, & Serlachius, 2010; Boyce, 2001; Krämer, Seefeldt, & Heinrichs, 2012; Monk, Kovelenco, & Ellman, 2001; Schmitz & Krämer, 2011; Sharma, Balhara, Sagar, Deepak, & Mehta, 2011). Other investigations have found that, depending on the task and measure of arousal, anxious and typically-developing youth demonstrate com-

parable levels of arousal (Alkozei, Creswell, Cooper, & Allen, 2015; Anderson & Hope, 2009; Gonzalez, Moore, & Garcia, 2011). These seemingly discrepant findings may be accounted for by cognitive bias, as theoretical models suggest an interplay between cognitive and physiological features of anxiety. We now turn to a brief description of the literature on relationships between cognitive bias and physiological arousal.

### 1.3. Cognitive bias and autonomic arousal: interactive processes?

Anxiety theories propose aberrant hyper-arousal in cognitive and physiological processes (Barlow, 2000) and, as described above, the literature supports links between each of these processes and anxiety symptoms and avoidance behavior. However, links *between* these processes have not been well-studied. This is surprising, given that our theoretical models (and the resultant rationale for targeting thoughts and feelings in CBT) clearly specify that the interactions between deficits in cognition and psychophysiology play a causal role in the development and maintenance of anxiety over time. Yet empirical studies typically only test relationships between anxiety symptoms and either cognitive bias or physiological arousal, but not both. While it is important to test relationships between proposed underlying mechanism and resultant psychopathology, it is equally important to understand relationships between these mechanisms in order to understand how they influence the mental health construct under study (Garvey, Avenevoli, & Anderson, 2016). Of particular relevance to anxiety, cognitive and physiological responses do not always correlate or move in synchronicity (e.g., Hodgson & Rachman, 1974; Lang, 1968; Zinbarg, 1998), suggesting that cognitive bias may exacerbate or interact with autonomic reactivity to produce anxiety (Alfano, Beidel, & Turner, 2006). Thus, the influence of cognition on psychophysiology should be examined in youth.

Only a handful of studies have examined both physiological arousal and cognitive bias in children and adolescents, finding each to predict anxious symptoms and avoidance (Dalrymple-Alford & Salmon, 2015; Field & Lawson, 2003; Weems, Zakem, & Costa, 2005). Moreover, when researchers provide verbal threat information (with the intent of inducing a threat bias) to community children, these youth exhibit elevated physiological arousal during behavioral approach toward the stimuli about which they were provided threat information (Askew, Hagel, & Morgan, 2015; Field & Price-Evans, 2009; Field & Schorah, 2007; Reynolds, Field, & Askew, 2014). These data provide preliminary evidence that cognitive bias may influence physiological arousal, which in turn may lead to anxious avoidance or symptoms. The above-described studies that have looked at relationships between cognitive bias and autonomic arousal are almost exclusively limited to typically-developing samples of youth, despite the fact that both constructs are considered core features of anxiety disorder. It is yet unclear whether cognition and psychophysiology may influence one another similarly in anxious versus typically-developing youth; such work is important for both our conceptualization of pediatric anxiety and maximizing intervention and prevention efforts to target underlying mechanisms.

As the field moves towards examination of these cognitive and physiological markers of anxiety in order to directly target these processes with translational, novel, and personalized intervention (March, 2011), it is critical to understand the respective and interactive contributions of autonomic arousal and cognitive bias to anxiety. We conducted this study in order to begin answering the question: does cognitive bias moderate the relationship between anxiety disorder status and sympathetic arousal in youth? Given prior theories suggesting that level of cognitive bias may influence degree of arousal (Alfano et al., 2006), and the findings in typically-developing youth that increasing cognitive bias leads to autonomic

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