Emotion Regulation and Heterogeneity in Attention-Deficit/Hyperactivity Disorder

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Objective: How best to capture heterogeneity in attention-deficit/hyperactivity disorder (ADHD) using biomarkers has been elusive. This study evaluated whether emotion reactivity and regulation provide a means to achieve this. **Method:** Participants were classified into three groups: children with ADHD plus low prosocial behavior (hypothesized to be high in callous/unemotional traits; n = 21); children with ADHD with age-appropriate prosocial behavior (n = 54); and typically developing children (n = 75). Children completed a task with four conditions: negative induction, negative suppression, positive induction, and positive suppression of affect. The task required children to view an emotion-laden film clip, while either facially mimicking (induction) or masking (suppression) the emotion of the main character. Parasympathetic and sympathetic nervous system activity were assessed via respiratory sinus arrhythmia (RSA) and cardiac pre-ejection period (PEP), respectively. Symptoms of anxiety, conduct, and oppositional defiant disorders were treated as covariates. **Results:** The ADHD-typical-prosocial group displayed atypically elevated parasympathetic reactivity (emotion dysregulation) during positive induction, along with increased sympathetic activity (elevated arousal) across conditions. In contrast, the ADHD-low-prosocial group displayed reduced parasympathetic reactivity and reduced sympathetic activity (low emotional arousal) across baseline and task conditions. Thus, both ADHD groups had altered patterns of autonomic functioning, but in two distinct forms. **Conclusion:** Although ADHD is heterogeneous clinically, results suggest that ADHD is also heterogeneous with regard to physiological indices of emotion and regulation. Future studies of emotion, regulation, and ADHD should take this into account. Further study of physiological responding in ADHD may yield clinically and etiologically distinct domains or groups. J. Am. Acad. Child Adolesc. Psychiatry; 2013; 52(2):163-171. **Key Words:** attention-deficit/hyperactivity disorder, autonomic nervous system, callous/unemotional traits, emotionality, emotion regulation

Attention-deficit/hyperactivity disorder (ADHD) is a clinically heterogeneous condition; however, its presumed biological heterogeneity remains in need of elucidation.[1–3] Emotion reactivity and dysregulation may provide a promising way to achieve this.[4–8] The present study evaluated the heterogeneity in ADHD using physiological indicators of emotion reactivity and regulation.

One suggestion for how to conceptually organize the interpretation of emotion and regulation data was put forward by Beauchaine.[9] This formulation suggests that respiratory sinus arrhythmia (RSA) can be understood as an index of parasympathetic-based regulation, and cardiac pre-ejection period (PEP) as an index of sympathetic arousal. The idea that RSA reactivity is an index of parasympathetic regulation, albeit heuristic, has been proposed by several theories[9–13] and has received empirical support.[14–17] The idea that PEP is an index of sympathetic arousal, although less extensively suggested in the literature, has support with regard to its sympathetic and β-adrenergic origins[18,19] and sensitivity to reward.[20] We have adopted this perspective because of its heuristic value in the current study.

These measures of autonomic reactivity in child psychopathology have been examined before. Indeed, an association of externalizing behavior with reduced sympathetic activity and altered parasympathetic response during emotion-based tasks and reward is rather well established.[22–27] However, it cannot be assumed that these same results will hold for ADHD. One study concluded


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that ADHD was also associated with reduced sympathetic activity during baseline.[21] In a separate study of preschoolers, autonomic responses to reward tasks were characterized by lengthened PEP, as well as parasympathetic withdrawal (dysregulation) in children with both ADHD and oppositional defiant disorder (ODD), suggesting that emotion dysregulation may be associated with both ADHD and ODD in young children.[26] Furthermore, altered parasympathetic nervous system reactivity has also been observed during both the induction and suppression of negative and positive affect in ADHD, with larger effects in the positive domain.[29] Thus, it is possible that physiological indices may help to clarify the heterogeneity in ADHD and reconfirm previous findings of elevated reactivity in response to emotional challenge.

In addition to the emerging role that emotion dysregulation has been hypothesized to play in ADHD, a particular ambiguity in ADHD concerns whether ADHD is characterized by over- or underarousal.[8,9,26–29] One group of children who reliably show underarousal is children with callous/unemotional traits (CU).[30–35] These children are deficit in prosocial emotions and behaviors, including low empathy, lack of a sense of guilt or remorse, shallow or blunted affect, and physiological underarousal.[30–35] In this study, we examine children with ADHD who differed on their prosocial behavioral phenotype (an empirically valid, and perhaps less stigmatizing proxy for CU traits) and validate this physiologically in an effort to clarify differences in arousal and emotion regulation.

In previous studies, CU traits have been studied primarily in the context of conduct disorder and antisocial behavior,[30–35] but, to a lesser degree, in children with ADHD. Experts have called for more careful consideration of CU in relation to ADHD.[36–38] Indeed, CU traits are associated with ADHD even after controlling for comorbid conduct disorder.[36–40] Thus, CU traits (and low prosocial behavior) are clinically important and perhaps theoretically informative for understanding heterogeneity of emotional arousal and regulation in ADHD.

It was hypothesized that variation in prosocial behavior will index biologically distinctions in ADHD on the basis of emotional arousal and regulation. To test this hypothesis, we assessed prosocial behavior and physiological indicators of emotional arousal and regulation in children with ADHD, excluding children with comorbid conduct disorder. We tested a double dissociation that may resolve prior contradictory conclusions about arousal and may also clarify the nature of emotion regulation variation in ADHD. Specifically, children with ADHD with age-typical prosocial behavior (here termed ''ADHD'') were predicted to have a pattern of parasympathetic reactivity that is characteristic of ADHD per se, which is to say, elevated parasympathetic activity from baseline across the affective and regulatory demands of an emotional task. If so, this would support prior findings of atypical regulation in response to emotional challenge among children with ADHD.[21,26,27] In contrast, we hypothesized that children with ADHD and low prosocial behaviors (here termed ''ADHD-low-prosocial'') would show a pattern more similar to that of past research on antisocial youths with CU traits—namely, reduced parasympathetic reactivity across task conditions along with reduced sympathetic activity (lower arousal).[30,31]

METHOD

Participants

Overview. Participants were 150 children 7 to 11 years of age (mean age = 7.60 years, SD = 0.56 years); 75 met *DSM-IV*[41] criteria for ADHD combined type, and 75 were typically developing comparison youth (Table 1). Of the ADHD group, we assigned 21 to the ADHD-low-prosocial group (criteria outlined below). None of the control group had atypical prosocial behavior scores. By design, none of the children in met *DSM-IV* criteria for conduct disorder.

Families were recruited from the community through advertisements and mailings. The local Institutional Review Board approved the study. All procedures conformed to the Ethical Principles of Psychologists and Code of Conduct.[42] Parents provided written informed consent, and children provided written assent.

Recruitment and Identification. Sample recruitment, assessment, and diagnostic assignment followed procedures identical to those described in more detail elsewhere.[27] In brief, volunteers passed through a multi-gate screening process to establish eligibility and group assignment. After completing a clinical structured diagnostic interview (Schedule for Affective Disorders and Schizophrenia for School-Age Children—Epidemiologic Version [KSAD-S-E]), parent and teacher standardized ratings, and an IQ screen, a clinical diagnostic team comprising a board-certified psychiatrist and licensed clinical psychologist independently reviewed all case information to arrive at diagnoses using *DSM-IV* criteria.