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Letter to the Editor

Trait and state boredom: Associations with attention failure in children with Attention-Deficit/Hyperactivity Disorder

Boredom has been defined as an aversive state of wanting but being unable to engage in satisfying mental or physical activity. From this perspective, boredom is underpinned by under-utilized cognitive capacity (Eastwood et al., 2012). The link between boredom and attention in particular has been repeatedly demonstrated in healthy adults. For example, trait and state boredom were associated with symptoms of ADHD, and increased errors in tasks requiring sustained attention (Hunter and Eastwood, 2018). The state of boredom is associated with the brain's default mode network (DMN; Danckert and Merrifield, 2018). Coincidentally, ADHD-related periodic attention lapses are linked to reduced suppression of the DMN activity. Despite that boredom is considered as a form of attentional failure, research on the impact of boredom in individuals with ADHD is limited. A study which investigated risky decision making in adults with ADHD showed that adults with ADHD made more risky decisions than controls under a normal condition; however, receiving boredom induction did not significantly increase their risky decision making. Intriguingly, being bored led those without ADHD to engage in similar levels of risky decision making as people who have ADHD (Matthies et al., 2012). Thus, although boredom and ADHD symptomatology appear to converge in critical ways, most existing studies have been conducted with healthy adults, and the impact of boredom on children with ADHD remains understudied. As boredom may compromise individual's cognitive performance, the present study aims to investigate the impact of trait and state boredom on sustained attention in children with and without ADHD.

A total of 72 children with ADHD and 76 typically developing controls participated in the study and were included in statistical analyses. ADHD diagnosis was confirmed by a senior child psychiatrist (the corresponding author, V. C.-H. Chen) according to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-V). After informed consent was obtained, participants underwent an IQ assessment, the Conners Continuous Performance Test 3 (CPT), and rated their state boredom levels on the short form of multidimensional state boredom scale (MSBS; Cronbach's $\alpha = 0.78$) immediately after finishing the CPT. Parents or guardians completed the parent ratings of ADHD symptoms, the Child Behavior Checklist and a trait boredom questionnaire developed for this study (Cronbach's $\alpha = 0.74$). The experimental protocol was approved by the Chang Gung Medical Foundation Institutional Review Board (ref. 201601883B0). There was no significant group difference in age, gender, and estimated IQ (all $p > .05$). The parents of ADHD group rated their child as having more symptoms of ADHD and more emotional and behavioral problems compared with the control group (all $p < .05$).

In terms of the novel findings of this study, parent rating of their child's trait boredom was significantly higher in the ADHD group than in the control group ($t(146) = -6.60, p < .001$). There were moderate correlations between parent rating of their child's trait boredom and inattention symptoms for the ADHD and control groups (ADHD: $r = 0.40$, $p < .001$; control: $r = 0.43$, $p < .001$), and little to no correlation between trait boredom and impulsive symptoms for both groups (ADHD: $r = 0.02$, $p = .90$; control: $r = 0.24$, $p = .035$). Self-ratings of state boredom were significantly higher in the ADHD group than in the control group ($t(146) = -2.50$, $p = .014$). Moreover, the ADHD group displayed a significantly increased level of response time variability in CPT compared with the control group (SD of reaction time: $t(146) = -3.60, p < .001$; variability: $t(146) = 2.53$, $p = .013$). For the ADHD group, the self-rating of state boredom was positively correlated with the inattention indices of CPT (MSBS vs. d': $r = 0.25$, $p = .033$; MSBS vs. commissions: $r = 0.26$, $p = .029$; MSBS vs. variability: $r = 0.27$, $p = .022$). For the control group, state boredom was not correlated with CPT indices (all $p > .05$). Adding the trait boredom as covariate yielded a similar trend for both groups.

This study is the first to compare trait and state boredom and CPT performance between children with and without ADHD. Parent ratings of their child's trait boredom were significantly elevated in the ADHD group compared with the control group, and the parent rating of trait boredom displayed a moderate correlation with inattention symptoms and little to no correlation with impulsive symptoms of ADHD.

The association between self-ratings of state boredom and CPT indices, including response time variability in the ADHD group is particularly noteworthy. State boredom has been reported to be negatively correlated with sustained attention performance in tasks requiring vigilance. Moreover, researchers who have attempted to disentangle the causal relation between state boredom and attentional failures suggested that the relation between boredom and attentional failures is bidirectional (Hunter and Eastwood, 2018). Although the current study cannot address causality, the findings of elevated state boredom after continuous performance task in the children with ADHD shed light on the importance of studying how boredom can compromise cognitive performance in ADHD. Meanwhile, increased response time variability has been reliably observed in individuals with ADHD irrespective of the task or setting (Tamm et al., 2012). The underlying neural process of response time variability has not been widely examined. However, existing studies have suggested that individuals with ADHD are failing to suppress the DMN activity during tasks, leading to more variable responses or attentional lapses (Sonuga-Barke and Castellanos, 2007). The association between state boredom and response time variability in the ADHD group may implicate dysfunction of the DMN, but more work is needed to elucidate these relationships.

The construct of boredom provides window into the everyday attentional failures of children with ADHD. Both state (task-related) and trait (pervasive) boredom seem to characterize children with ADHD, and variability in boredom was implicated with variability of cognitive performance on a sustained attention task. Studying the role of boredom in ADHD would facilitate the development of coping strategies

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for individuals with attentional problems in clinical, educational and occupational settings.

CRediT authorship contribution statement

Chia-Fen Hsu: Data curation, Formal analysis, Validation, Writing - original draft. **John D. Eastwood:** Conceptualization, Methodology, Writing - review & editing. **Maggie E. Toplak:** Conceptualization, Writing - review & editing. **Jia-Chian Liang:** Data curation, Formal analysis. **Shoou-Lian Hwang-Gu:** Writing - review & editing. **Vincent Chin-Hung Chen:** Writing - review & editing.

Declaration of Competing Interest

The authors declare no conflicts of interest.

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