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Structural and Functional Correlates of Reaction Time Variability in a Large Sample of Healthy Adolescents and Adolescents with ADHD Symptoms

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Abstract : Reaction time (RT) variability on cognitive tasks provides the index of the efficiency of executive control processes (e.g. attention and inhibitory control) and is considered to be a hallmark of clinical disorders, such as attention-deficit disorder (ADHD). Increased RT variability is associated with structural and functional brain differences in children and adults with various clinical disorders, as well as poorer task performance accuracy. Furthermore, the strength of functional connectivity across various brain networks, such as the negative relationship between the task-negative default mode network and task-positive attentional networks, has been found to reflect differences in RT variability. Although RT variability may provide an index of attentional efficiency, as well as being a useful indicator of neurological impairment, the brain substrates associated with RT variability remain relatively poorly defined, particularly in a healthy sample. Method: Firstly, we used the intra-individual coefficient of variation (ICV) as an index of RT variability from "Go" responses on the Stop Signal Task. We then examined the functional and structural neural correlates of ICV in a large sample of 14-year old healthy adolescents (n=1719). Of these, a subset had elevated symptoms of ADHD (n=80) and was compared to a matched non-symptomatic control group (n=80). The relationship between brain activity during successful and unsuccessful inhibitions and gray matter volume were compared with the ICV. A mediation analysis was conducted to examine if specific brain regions mediated the relationship between ADHD symptoms and ICV. Lastly, we looked at functional connectivity across various brain networks and quantified both positive and negative correlations during "Go" responses on the Stop Signal Task. Results: The brain data revealed that higher ICV was associated with increased structural and functional brain activation in the precentral gyrus in the whole sample and in adolescents with ADHD symptoms. Lower ICV was associated with lower activation in the anterior cingulate cortex (ACC) and medial frontal gyrus in the whole sample and in the control group. Furthermore, our results indicated that activation in the precentral gyrus (Broadman Area 4) mediated the relationship between ADHD symptoms and behavioural ICV. Conclusion: This is the first study first to investigate the functional and structural correlates of ICV collectively in a large adolescent sample. Our findings demonstrate a concurrent increase in brain structure and function within task-active prefrontal networks as a function of increased RT variability. Furthermore, structural and functional brain activation patterns in the ACC, and medial frontal gyrus plays a role-optimizing top-down control in order to maintain task performance. Our results also evidenced clear differences in brain morphometry between adolescents with symptoms of ADHD but without clinical diagnosis and typically developing controls. Our findings shed light on specific functional and structural brain regions that are implicated in ICV and yield insights into effective cognitive control in healthy individuals and in clinical groups.

Keywords : ADHD, fMRI, reaction-time variability, default mode, functional connectivity
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