Increased Reaction Time Variability in ADHD: A Novel Approach to Detect Inattention

Parisa Nilchian 1 & Aaron T. Mattfeld 2

1, 2 Department of Psychology, 1 Florida International University, Miami, FL, USA

Motivating questions

- What are the neurobiological mechanisms behind increased Reaction Time Variability (RTV) in ADHD?
- Is RTV a suitable metric for detecting inattention?

Attention-Deficit/Hyperactivity Disorder (ADHD) is the most common mental condition among U.S. children (Fig 1).1

Usual symptoms of ADHD are impulsivity, hyperactivity, and inattention.

The current system to diagnose ADHD lacks efficiency and is based on potentially biased parental and teacher observations of children’s behavior.

In experimental tasks, the reaction times (RT) of individuals with ADHD fluctuate more compared to healthy subjects (Fig 2A,B).2 RTV, measured as the standard deviation of RT, is a metric to quantify these fluctuations.3 We believe that high RTV can be used to detect inattention.

Reaction Time and Reaction Time Variability

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- Increased RTV is primarily the result of abnormally slow responses, which result in a right-skewed RT distribution (Fig 2C).2
- High RTV is not unique to ADHD. Numerous studies have linked elevated RTV with Alzheimer’s Disease, bipolar disorder, autism spectrum disorder (ASD), and traumatic brain injury.2
- RTV has a genetic component and is heritable.4 Studies have shown that the siblings of children with ADHD likewise express high RTV, even though they may not have the disorder.5,6

RTV can be used to detect inattention and develop a novel approach to diagnose ADHD.

The Default Mode Network

The Default Mode Network (DMN) is a functional brain system that is responsible for internal mentation and self-referential tasks (Fig 3).7 The DMN is deactivated during active states and is most active when not engaged in focus-requiring tasks.8

Activation of the DMN may cause inattention and lead to increased RTV. We expect a positive correlation between increased RTV and DMN activation. DMN activation will be increased during periods of high RTV compared to episodes of stable RTV.

Methods

- 17 subjects (8-12 years old), performed 4 runs each.
- Sustained attention to response task (SART): Subjects press a button for every number (1-9) displayed on a screen except for the number 3. RTs are recorded, RTV is calculated.
- Blood oxygen-level dependent (BOLD) magnetic resonance imaging (MRI) is used to identify the DMN and record neural activation.

Results

- Even though previous studies have ascertained an association between increased RTV and DMN activation, our data do not support this relationship.
- Capturing the subjects’ DMN with enhanced masks will be the key for extracting DMN activation data exclusively. Findings from the DAN suggest that our data might be “noisy”.
- Our masks include a significant number of brain regions that are not part of the networks of interest. Activation during periods of high RTV is reduced by suppression of other brain regions so that the overall activation is balanced out.

Discussion

- Develop code to enhance the DMN and DAN mask.
- Compare DMN activation in ADHD subjects to activation in control subjects during episodes of increased vs. stable RTV (Between-group analysis).

References