Title: Heart Rate-Defined Sustained Attention as a Psychophysiological Measure of Attention for Young Children with Down Syndrome

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Introduction: Heart rate-defined sustained attention (HRDSA) is indexed by the maintenance of a decelerated heart rate and has been used as a psychophysiological measure to study attention in infants and toddlers (Reynolds & Richards, 2008). Prior research has examined HRDSA in typically developing (e.g., Richards & Casey, 1991), at-risk (e.g., familial risk for autism spectrum disorder [ASD]; Tonnsen, Richards, & Roberts, 2018), and clinical populations (e.g., fragile X syndrome; Roberts et al., 2012). HRDSA has also been used as an outcome measure to track responses to treatment in clinical trials (Colombo et al., 2011). Yet, limited research has investigated HRDSA in young children with Down syndrome (DS), who exhibit a phenotype highly associated with attention problems (Brown et al., 2003) and elevated rates of attention-deficit/hyperactivity disorder (Schieve, Boulet, Boyle, Rasmussen, & Schendel, 2009). Given that approximately 50% of individuals with DS have congenital heart defects (Schieve et al., 2009), an important first step toward applying HRDSA in DS is determining whether HRDSA may serve as a sensitive psychophysiological measure of attention in this specific population. To address this need, the present study examined several dimensions of HRDSA in infants and toddlers with DS during semi-structured interactions and contrasted their biobehavioral responses with those of low-risk controls (LRC) without known developmental concerns.

Method: Twenty-five infants and toddlers between 11 and 27 months of age participated in the study, with data collection ongoing. Children with DS (n = 5) were older than LRC (n = 20; Wilcoxon z = 3.37, p < .001) and sex was similar across both groups (Fisher’s exact p = .623). Participants completed the Autism Observation Scale for Infants (AOSI; Bryson, Zwaigenbaum, McDermott, Rombough, & Brian, 2008), a set of behavioral presses designed to detect and monitor early signs of ASD. The present study focused on two attention-related behavioral presses: (1) toy press where children were expected to disengage attention from a toy and redirect attention to another toy when the latter was shaken; and (2) name press where children were expected to orient attention toward the examiner when their name was called. Heart activity was tracked throughout the AOSI, using the Actiwave Cardio heart rate monitor (CamNtech Inc., Boerne, TX). Interbeat intervals (IBIs) were derived from consecutive R-spikes identified using QRSTool (Allen, Chambers, & Towers, 2007). HRDSA was indexed by a minimum of five consecutive IBIs, each of which was longer than the baseline IBI, which was defined as the median IBI of five consecutive IBIs immediately prior to the onset of the AOSI (global baseline IBI) or toy/name press (local baseline IBI). We first used Wilcoxon rank-sum tests to examine whether three dimensions (i.e., proportion, duration, and depth) of global and local HRDSA were lower in DS. We then used Spearman correlations to determine associations between local HRDSA and response latency in individual trials of toy and name presses for both DS and LRC, where positive relationships were expected.

Results: Global HRDSA was similar between children with DS and LRC across all three dimensions (proportion: z = -1.39, p = .164; duration: z = -1.26, p = .209; depth: z = -0.99, p = .325), and moderate effect sizes (proportion: rpb = -.28; duration: rpb = -.25; depth: rpb = -.20) between the two groups were in the predicted direction. In terms of local HRDSA, children with DS exhibited greater depth (z = 2.10, p < .05, rpb = .17) than LRC, but similar levels of proportion (z = 1.06, p = .290, rpb = .08) and duration (z = 1.32, p = .186, rpb = .10). For LRC, response latency in individual toy and name presses tended to be positively associated with depth of local HRDSA (toy: r = .23, p = .081; name: r = .48, p = .069), but less so with proportion (toy: r = .14, p = .294; name: r = .26, p = .340) and duration (toy: r = .06, p = .658; name: r = .26, p = .341) of local HRDSA. For DS, positive relationships between all three dimensions of local HRDSA and response latency were observed in both toy (depth: r = .64, p < .05; proportion: r = .52, p = .054; duration: r = .55, p < .05) and name (depth, proportion, and duration: r = 1.00, p < .001) presses. Final analyses will extend these preliminary results by examining the interrelationships among HRDSA, type of behavioral press (i.e., toy vs. name), and trial-level behavior (i.e., success vs. failure in reorientation of attention), using an expanded sample of children with DS (n = 20).

Discussion: Global and local HRDSA measures during semi-structured interactions were successfully extracted for infants and toddlers with DS. Although global HRDSA was broadly comparable between DS and LRC, nuanced differences in local HRDSA (e.g., greater depth in DS) may reflect distinct attentional mechanisms and compensatory strategies in neurogenetic syndromes. Future research should incorporate other biobehavioral measures of attention, such as event-related potentials and eye tracking metrics, to provide converging evidence and refine the methodology of applying HRDSA to clinical research. Given its low-cost, non-invasive, and passive nature, HRDSA is a promising psychophysiological measure of attention for children with DS and other neurodevelopmental disorders.
References/Citations: