Title: Infants' Behavioral Responses to Name are Accompanied by Greater Heart Rate Deceleration: A Biobehavioral Approach

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Introduction: Diminished or inconsistent behavioral responses to name in early childhood index risk for autism spectrum disorder (ASD) and other neurodevelopmental conditions (Zhang et al., 2018; Zwaigenbaum et al., 2015). However, a lack of behavioral response to name during infancy, by itself, has limited sensitivity and positive predictive value for identifying ASD (Miller et al., 2017; Nadig et al., 2007), potentially reflecting behavioral heterogeneity in ASD and varied patterns of emerging behaviors in the rapid developmental period of infancy. It is plausible that psychophysiological responses to name may serve as more sensitive risk markers. To date, such psychophysiological research has focused on neural measures and paid limited attention to cardiac measures, which are less costly, less intrusive, and more amenable to field-based early detection efforts. Although heart rate (HR) deceleration is a robust indicator of attentional orienting and sustained attention (Reynolds & Richards, 2008), no studies have investigated HR deceleration when infants behaviorally respond to or fail to orient to their names. As a first step toward informing whether HR deceleration is a viable, sensitive psychophysiological measure for responses to name, we examined the congruency between behavioral and cardiac responses to name in infancy and predicted that HR deceleration would be greater when infants responded behaviorally to their names than when they failed to do so. Additionally, given that HR deceleration has been operationalized in several ways in the literature, we explored which HR deceleration metrics most closely aligned with behavioral responses to name.

Method: Participants were drawn from an ongoing longitudinal study of early development and included 34 infants (52.9% male) between 10.5 and 14.0 months of age (M = 12.3, SD = 0.9). These infants were born at term, had no known developmental concerns, and had no first-degree familial history of ASD or intellectual disabilities. For the present study, we focused on the *Orients to Name* press in the Autism Observation Scale for Infants (AOSI, Bryson et al., 2008). Per AOSI administration protocol, each infant participated in up to six trials where his/her name was called and considered to have responded behaviorally for a given trial if he/she oriented to look at the individual calling him/her within two seconds. We collected infant electrocardiography (ECG) signals throughout the AOSI using a HR monitor. After extracting five seconds of ECG data before and after the name call for each trial, we marked and used R-waves of ECG signals to obtain interbeat interval (IBI) data. Next, for each trial, we calculated baseline IBI (defined as median IBI during the pre-name call period) and subtracted baseline IBI from individual IBIs in the post-name call period, such that increased IBIs indexed HR deceleration. We operationalized the degree of HR deceleration in the post-name call period using three metrics: (1) maximum HR deceleration; (2) median HR deceleration; and (3) proportion of time in HR deceleration. To test whether HR deceleration was greater when infants responded behaviorally to their names (i.e., Response trials) than when they did not (i.e., Non-Response trials), we used Wilcoxon rank-sum tests and quantified effect sizes using point biserial correlations.

Results: Infants exhibited varied behavioral and cardiac responses. Behaviorally, 7 (20.6%) infants responded on 100% of their trials, 7 (20.6%) infants failed to orient to their names on 100% of their trials, and the remaining 20 (58.8%) infants responded only on some of their trials. As expected, median HR deceleration (Z = 2.11, p = .035, r_{pb} = .20) and proportion of time in HR deceleration (Z = 2.07, p = .038, r_{pb} = .19) were greater for Response than Non-Response trials. Relative to Non-Response trials, infants exhibited a larger median HR deceleration of 10.2 ms and spent an additional 15.0% of the post-name call period in HR deceleration during Response trials. Contrary to predictions, maximum HR deceleration did not differ between Response and Non-Response trials (Z = 1.19, p = .234, r_{pb} = .11).

Discussion: The present study examined the congruency between infants' behavioral and cardiac responses to their names across three HR deceleration metrics. Our findings indicate that the degree of congruency depended on how HR deceleration was operationalized. Specifically, we found evidence for greater median HR deceleration and proportion of time in HR deceleration when infants responded behaviorally to their names than when they failed to do so, but not for the metric of maximum HR deceleration. These differential results raise the possibility that "aggregate" measures of HR deceleration (i.e.,

median HR deceleration and proportion of time in HR deceleration) may be less influenced by naturally-occurring variation in IBIs and outliers; therefore, these two HR decelerations metrics may potentially serve as useful, objective indices for infants' physiological responses to their names. Future research should clarify the contexts in which different HR deceleration metrics may be more suited for indexing distinct attentional processes as well as extend this work to pediatric populations at risk for ASD. Given that cardiac measures offer an optimal balance between the sensitivity of neural measures and practicality of behavioral measures, HR deceleration holds promise as a portable and cost-effective measure of infants' responses to their names.

References:

Bryson, S. E., Zwaigenbaum, L., McDermott, C., Rombough, V., & Brian, J. (2008). The Autism Observation Scale for Infants: Scale development and reliability data. *Journal of Autism and Developmental Disorders*, *38*(4), 731–738. https://doi.org/10.1007/s10803-007-0440-y

Miller, M., Iosif, A.-M., Hill, M., Young, G. S., Schwichtenberg, A.J., & Ozonoff, S. (2017). Response to name in infants developing autism spectrum disorder: A prospective study. *Journal of Pediatrics*, *183*, 141–146. https://doi.org/10.1016/j.jpeds.2016.12.071

Nadig, A. S., Ozonoff, S., Young, G. S., Rozga, A., Sigman, M., & Rogers, S. J. (2007). A prospective study of response to name in infants at risk for autism. *Archives of Pediatric and Adolescent Medicine*, *161*(4), 378–383. https://doi.org/10.1001/archpedi.161.4.378

Reynolds, G. D., & Richards, J. E. (2008). Infant heart rate: A developmental psychophysiological perspective. In L. A. Schmidt & S. J. Segalowitz (Eds.), *Developmental psychophysiology: Theory, systems, and methods* (pp. 173–212). Cambridge University Press. https://doi.org/10.1017/CBO9780511499791.009

Zhang, D., Roche, L., Bartl-Pokorny, K. D., Krieber, M., McLay, L. Bölte, S., Poustka, L., Sigafoos, J., Gugatschka, M., Einspieler, C., & Marschik, P. B. (2018). Response to name and its value for the early detection of developmental disorders: Insights from autism spectrum disorder, Rett syndrome, and fragile X syndrome. A perspectives paper. *Research in Developmental Disabilities*, *82*, 95–108. https://doi.org/10.1016/j.ridd.2018.04.004

Zwaigenbaum, L., Bauman, M. L., Stone, W. L., Yirmiya, N., Estes, A., Hansen, R. L., McPartland, J. C., Natowicz, M. R., Choueiri, R., Fein, D., Kasari, C., Pierce, K., Buie, T., Carter, A., Davis, P. A., Granpeesheh, D., Mailloux, Z., Newschaffer, C., Robins, D., … Wetherby, A. (2015). Early identification of autism spectrum disorder: Recommendations for practice and research. *Pediatrics*, *136*(Supplement 1), S10–S40. https://doi.org/10.1542/peds.2014-3667C

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