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First theme choice: Clinical/Behavioral/Intervention

Hierarchical Acoustic Structure During Parent-Child Interactions of Toddlers with Typical Development and Autism Spectrum Disorder

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Introduction: Timing is essential for successful social interactions that support communication development in children with and without ASD. Infant Directed Speech (IDS) exhibits greater temporal clustering of acoustic events across timescales (e.g., syllables nested within phrases nested within utterances) than Adult Directed Speech, which likely supports children's attention to the speech signal (Falk & Kello, 2017). Greater temporal clustering also occurs in conversations with reduced reciprocity (Abney et al., 2014). We examined the acoustic Hierarchical Temporal Structure (HTS) of parent-child interactions longitudinally to determine its change as a function of linguistic and social development in TD toddlers. Additionally, we compared the HTS of interactions of parent-child dyads of toddlers with and without ASD to explore effects of delayed language and social development in acoustic temporal structure.

Methods: 51 parent-child dyads of TD infants were audio-recorded at 9, 12, and 18-months of age, as well as 19 parent-toddler dyads of children with ASD (27.9 ± 4.5 months) 53 parent-child dyads (19 ASD; 34 TD (22 chronological age-matched, 12 language age-matched)) were audio-recorded during a 10-minute parent-child free-play activity. Peak amplitude events in audio-recordings were used to compute Allan Factor (AF) variances (i.e., which reflects event clustering at multiple time scales (from a 0.0146-second scale to a 30-second scale). Quadratic slopes were fit across each dyad's Allan Factor (AF) functions to quantify acoustic clustering patterns across timescales. We tested the longitudinal change in AF slopes using mixed-effects models used mixed-effects models to compare the AF slopes at different longitudinal time points, and compared slopes of age-matched, language-matched TD and ASD dyads and using Welch two-sample t-tests to compare the AF slopes of age-matched, language-matched TD dyads, and ASD dyads were compared using Welch two-sample t-tests.

Results: Age was a significant predictor of HTS in the interaction between TD toddlers and their parents, with slopes decreasing as the children aged ($B=-0.007$, $p<.001$). The ASD child-parent dyads had significantly higher slope ($M=0.75$, $SD=0.077$) compared to a subgroup of TD dyads ($M=0.67$, $SD=0.078$) matched for non-verbal age; however, the ASD dyads' slopes were comparable to those of younger TD dyads matched for language age ($M=0.74$, $SD=0.077$). Taken together these results point to language development, specifically, as a driver of the change in the temporal organization of the acoustics of parent-child interactions.

Discussion: Results add to evidence that temporal clustering is impacted by social communicative factors, with greater HTS in parent-child dyads of younger TD children, and of ASD versus TD age-matched toddlers. The similar degree of acoustic clustering between the ASD and language-matched sample indicates that decreased acoustic HTS may be related to adaptations in interpersonal vocal dynamics based on the vocal skill of the communication partner.

References, if any: Abney, D. H., Paxton, A., Dale, R., & Kello, C. T. (2014). Complexity matching in dyadic conversation. *Journal of Experimental Psychology: General*, 143(6), 2304. Falk, S., & Kello, C. T. (2017). Hierarchical organization in the temporal structure of infant-direct speech and song. *Cognition*, 163, 80-86.

Keywords:

Communication development, Autism spectrum disorders, Hierarchical temporal structure