Title: Language Abilities in Young Children with Down Syndrome are Associated with Multiple Stages of Speech Processing in the Brain

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Introduction: Children with Down syndrome often experience difficulties with language acquisition (Yoder & Warren, 2004), attributable at least in part to inefficient processing of spoken inputs. Auditory event-related potentials (ERP) offer a noninvasive means to document multiple stages of information processing with millisecond-level precision and without requiring an overt behavioral response, minimizing confounding effects of intellectual disability. This study examined whether neural differences in syllable- and word-level speech processing could account for variance in individual differences in expressive and receptive language abilities of preschoolers with Down syndrome.

Method: Sixteen children with Down syndrome, ages 2 to 4 years (M=3.69, SD=0.66) participated in the study. Auditory ERPs were recorded during two passive listening paradigms using natural speech stimuli: (1) consonant differentiation (voice onset time and place of articulation contrasts), previously established as sensitive to individual differences in typical language abilities and predictive of later developmental outcomes (Molfese et al., 2005), and (2) auditory incidental memory paradigm, a novel task assessing the extent of spontaneous engagement with and processing of the word-level novel spoken inputs. Conversational samples were collected from each participant in two settings: with a familiar (parent) and novel (examiner) partner. The two interactions were audio-recorded and transcribed to quantify the number of utterances and individual spoken words. Standard scores from norm-referenced tests (Mullen Scales of Early Learning, Preschool Language Scales) further characterized receptive and expressive language ability of the study participants. Different examiners administered and scored ERPs and standardized language tests.

Results: Evidence of consonant differentiation was observed for the P1-N1-P2 responses only to the voice onset time contrast (/ba-pa/). Greater N1 and P2 amplitude differences between the consonants were associated with a larger number of utterances, words and variety of different words spoken (r=.583-.752) during the parent-child interaction. A similar trend was observed for verbal output during the language sample with an unfamiliar examiner (r=.489-.523). In the incidental memory task, children with Down syndrome demonstrated the expected “old/new” memory response (more positive parietal amplitudes between 500-900ms in response to repeated nonwords than the stimuli heard once). Correlation analysis indicated that better auditory incidental memory was associated with higher receptive language standard scores (r=.749).

Discussion: Our study provides new support for the hypothesis that language difficulties in Down syndrome may be due in part to atypical processing of spoken inputs. Extending prior work, we demonstrated that not only the early perceptual stages (indexed by the obligatory P1-N1-P2 responses) but also the later higher-order cognitive processing (the “old/new” response) of auditory stimuli may be relevant for expressive and receptive language abilities in children with Down syndrome. Identification of these specific neural processes, which can be measured noninvasively and without behavioral responses, offers a new way to characterize individual differences in language functioning of children with Down syndrome. Future studies will examine whether these neural responses may serve as the predictors of language treatment outcomes.

References/Citations: