**Symposium Title:** Using Eye Tracking and Brain Data to Evaluate Speech and Language Processing in Neurodevelopmental Disorders: New Options for Difficult to Test Populations

**Chair:** Alexandra P. Key¹

**Discussant:** Ann Kaiser²

**Overview:** Speech and language processing abilities contribute significantly to adaptive functioning of persons with neurodevelopmental disorders and are frequent treatment targets. However, behavioral assessments of language processing can be complicated by the developmental level of the participants (e.g., preverbal) and severity of disability (e.g., minimally verbal). Thus, both phenotyping and treatment studies are increasingly turning to novel alternative measures of receptive communication that minimize demands on voluntary behavioral responses. The three presentations in this symposium will demonstrate applications of eye tracking and brain activity measures to objectively document speech and language processing in participants representing a range of ages and adaptive functioning. The first presentation describes the use of eye gaze data to assess comprehension in real time during naturalistic language processing (“looking while listening”) in children with autism spectrum disorder and demonstrates how these data supplement and extend the information from the traditional behavioral assessments. Presentation 2 highlights how a new stimulus type, child-directed speech, in combination with event-related potentials (ERPs), may provide a more sensitive measure of word-level processing compared to the commonly used adult-directed speech, leading to new insights into early language development in toddlers and young children with and without developmental disabilities. The last presentation reports findings from a study using ERPs during passive listening to speech to assess higher-order cognitive processes of auditory learning and memory in nonverbal children and adults with Angelman syndrome, for whom information about their receptive communication abilities has been previously obtained mainly from informant reports. The symposium concludes with a perspective from a behavioral scientist regarding the feasibility and potential applications of these new approaches in the context of future intervention studies.

**Paper 1 of 3**

**Paper Title:** Using Eye-Gaze Methods to Measure Language Comprehension in Children with Autism Spectrum Disorder

**Authors:** Courtney E. Venker³, Sara T. Kover³

**Introduction:** Accurately measuring language comprehension in children with neurodevelopmental disorders, including autism spectrum disorder (ASD), can be challenging. Unlike language production, which can be directly observed, comprehension is an internal process that typically must be inferred on the basis children’s behaviors. Two common methods for assessing language comprehension are examiner-directed assessments and parent report measures. Unfortunately, factors such as inattention, decreased motivation, limited social engagement, and anxiety can threaten the accuracy of these measures when used with children with neurodevelopmental disorders.

In response to the limitations of traditional measures, researchers have begun to explore the utility of eye-gaze methods as an alternative measure of language comprehension (Brady et al., 2014; Venker et al., 2016). One of the primary advantages of eye-gaze methods is that they have limited behavioral response demands (Venker & Kover, 2015). Instead of requiring children to point, follow directions, or answer questions, children simply sit and look at a screen while listening to spoken language. The proposed presentation will describe an example dataset (Venker, in press) to illustrate how one type of eye-gaze method—looking-while-listening (Fernald et al., 2008)—can measure language comprehension in children with ASD.

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Methods: Participants were 18 children with ASD (mean age = 76 months). Children participated in a looking-while-listening task in which they viewed two pictures on a screen and heard one of them named (e.g., Find the ball!). The direction of children’s gaze was determined automatically by a Tobii T60-XL eye tracker. The dependent variable was the proportion of time children looked at the named (i.e., target) picture, relative to the total amount of time they spent looking at either picture. The proportion of looks to the target picture was calculated from 200-1800ms after target noun onset.

Results: The mean proportion of time children looked at the target image was .77 (SD = .11, range = .55-.94). As predicted, the proportion of looking to target was significantly above chance (50%), t(17) = 9.56, p < .001, d = 2.27. Thus, children’s eye gaze provided evidence that they comprehended the target words. In addition to the specific results from this study, general considerations involved in processing, analyzing and interpreting eye-gaze data within the context of different experimental designs will be discussed. The presentation will also outline the types of dependent variables that can be derived (e.g., speed, accuracy), as well as different statistical approaches that can be used to analyze eye-gaze data.

Discussion: Eye-gaze methods are emerging as an alternative method for measuring language comprehension in children with ASD. Eye-gaze methods have limited behavioral response demands, measure comprehension in real time (as spoken language unfolds), and yield information about a child’s speed and accuracy of comprehension. In addition, eye-gaze methods may uncover emerging comprehension that is overlooked by traditional measures (e.g., Venker et al., 2016). Additional research will determine how eye-gaze methods can inform research and clinical practice focused on language comprehension in children with neurodevelopmental disorders—for example, by informing the determination of accurate prognoses, selection of intervention targets, and measurement of treatment outcomes.

References/Citations:

Paper Title: Is Child-Directed Speech a Better Index of Word Processing than Adult-Directed Speech in Typically Developing Toddlers and Children with Autism Spectrum Disorder?

Authors: Micheal Sandbank

Introduction: Child-directed speech (CDS) describes a set of speech patterns that adults tend to use when speaking to young children. It is characterized by long pitch contours, slower delivery, and shorter utterance length. Both theoretical and empirical evidence suggests it facilitates speech processing and vocabulary production in typically developing children (Ramirez-Esparza, Garcia-Sierra, & Kuhl, 2014). Typically developing infants naturally prefer child-directed speech to other types of auditory stimuli, but children with autism exhibit a reduced preference for child-directed speech as a group, and the extent of their inattention to CDS has been associated with increased autism symptomatology and deficits in speech processing (Kuhl, Coffey-Corina, Padden, & Dawson, 2005). Child-directed speech is commonly used by caregivers of children with ASD, as well as speech-language therapists in the course of clinical intervention. However, the extent to which this speech type facilitates word processing and acquisition in young children with ASD is unknown. The goal of the current set of studies was to examine word processing of child-directed speech in young typically developing children and those with ASD using event-related potential responses to words and nonwords delivered with different speech patterns.

Methods: A total of 40 participants (20 typically developing and 20 with ASD) were recruited for this study. Typically developing participants were children aged 12-36 months, with no report of developmental concerns, and expressive vocabulary scores designated as within the typical range of development (i.e., above the 25th percentile for age) on the MacArthur-Bates Communicative Development Inventories (MCDI). Eligible children with ASD were those aged 2-6 years with a diagnosis of autism (verified by an ADOS score obtained by a research-reliable administrator), and parent-reported receptive understanding of at least 10 words. Event-related potentials were recorded using 64 sensors placed on the scalp (using a stretchy geodesic sensor net) while participants listened to words (e.g., ball, book) and nonwords (e.g., teg, neem) delivered in child- and adult-directed speech. Word processing responses were examined at left temporal and parietal sensor clusters at the grand averaged level, and the mean amplitude to word across 200-500 ms at left temporal and parietal sensor clusters was used to index word processing within and across speech conditions. Associations between expressive vocabulary scores and word processing within and across speech types was compared.

Results: Both typically developing children and those with ASD exhibited stronger responses to words versus nonwords at left temporal electrode clusters. Left temporal responses to all words were significantly associated with concurrent scores of expressive vocabulary, as were left temporal responses to words delivered in child-directed speech.

Discussion: This is the first study to compare word processing of different speech types in typically developing toddlers and in children with autism. Results provide preliminary evidence that event-related responses to child-directed speech best index word processing in young language learning children, and that child-directed speech may be associated with improved word processing. Implications regarding practical recommendations for the use of CDS with children with ASD will be discussed.

References/Citations:

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Paper Title: Assessing Auditory Learning and Memory in Nonverbal Individuals with Angelman Syndrome: ERP Evidence

Authors: Alexandra P. Key, Dorita Jones, Sarika Peters, Caitlin Dold

Introduction: Angelman syndrome (AS) is a rare neurodevelopmental disorder caused by loss of function of the ubiquitin–protein ligase E3A (UBE3A) gene, which impairs synapse formation and experience-dependent synapse remodeling (Buiting et al., 2016). The combination of intellectual, communicative, and motor difficulties limit the use of standardized behavioral assessments in individuals with AS (Bird, 2014). Currently, caregiver reports are the main source of information about cognitive and adaptive functioning in this population. The subjective nature of these data limit their utility for evaluation of treatment effects. The goal of the present study was to examine feasibility of auditory event-related potentials (ERPs) as a direct and objective means to assess learning and social-emotional processing in individuals with AS.

Methods: Fifteen nonverbal individuals with the deletion subtype of AS, age 4-45 years, completed two brief passive listening paradigms while their auditory event-related potentials were recorded in response to spoken nonsense words (auditory incidental memory paradigm) and to known and unknown names (recognition of socially relevant stimuli). The two tasks targeted cognitive processes dependent on experience-dependent synapse remodeling and supported by a range of cortical and hippocampal areas, most affected by UBE3A loss (Jana, 2012). Caregivers completed the Communication and Socialization portions of the Vineland Adaptive Behavior Scales-3. Typically developing individuals of similar chronological age served as the comparison group.

Results: The ERP procedures were tolerated well by participants with AS (94% success rate for incidental memory, 85% for name recognition). Parietal amplitudes within 200-500ms revealed the expected incidental memory response for the repeated nonwords, which was associated with better adaptive communication skills. In the names task, mean parietal amplitudes within 450-750ms window yielded no significant evidence of known name recognition in participants with AS, although greater amplitude differences between own and unfamiliar names were associated with better interpersonal relationships and receptive communication abilities.

Discussion: These findings indicate that cortical auditory brain responses associated with learning and memory in nonverbal persons with AS are feasible and provide objective information complementary to the caregiver observations. Persons with AS are capable of retaining new information following repeated auditory exposure over a brief period of time, even in the absence of concurrent visual cues or explicit instructions. The lack of significant differentiation between familiar and novel names is consistent with high incidence of autism-related symptoms in this population. Without the requirement of behavioral responses, the use of auditory stimuli during brief test sessions made the procedures suitable for a wide range of ages and ability levels. Thus, our findings support the utility of passive brain-based measures for direct and objective evaluation of higher-order cognitive processes in nonverbal persons with neurodevelopmental disorders.

References/Citations: