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Perception of the prosody and content of sentences in an unfamiliar language in children with autism spectrum disorders

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ABSTRACT

Prior research suggests that children with autism spectrum disorders (ASD) show atypical patterns of attention to the prosody (intonation and emotional tone of voice) and content (words) of spoken sentences. Using a discrimination-choice procedure embedded in a custom-made videogame, we examined attention to these features of sentences in 15 children with ASD (ages 5 years, 5 months–18 years) and 15 age-matched typical controls (TYP). Using an unfamiliar language (German) to remove semantics, we assessed the role of meaning in promoting attention to content over prosody. As in a previous study with English sentences, TYP children attended to content to a greater extent than children with ASD while maintaining equivalent levels of discrimination based on prosody. However, in contrast to previous results, TYP children did not show a preference for enthusiastic over grouchy tone of voice, which suggests that the unfamiliar language rendered affective valence less salient. The results confirm intact perception of prosody in children with ASD, and a more selective pattern of attention to content in TYP children.

Language deficits are common in children with autism spectrum disorders (ASD) as indicated in previous and current versions of the *Diagnostic and Statistical Manual of Mental Disorders* (e.g., DSM-5; American Psychiatric Association, 2013). Whereas considerable research has documented children's deficits in language production and comprehension, relatively few studies have examined their speech perception, especially with regard to the processing of different features of speech such as content and prosody (cf. O'Connor, 2012). Spoken sentences are inherently complex and multi-faceted, and attention may be drawn to the lexical content of the sentence (i.e., word meaning), or alternatively to physical features such as loudness, speech rate, intonation, and tone of voice. From a behavior-analytic perspective, speech consists of compound stimuli whose elements may command different degrees of stimulus control. Two prominent features of spoken language are content and prosody, with content defining what is said and prosody defining how it is said. For example, the intonation of an utterance can be used to distinguish speech acts, with rising intonation for questions and falling intonation for statements (e.g., Ploog, Banerjee, & Brooks, 2009). Or, tone of voice can distinguish the attitudes, emotions, and physical state

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of the speaker, for example, whether the speaker likes or dislikes what s/he is talking about and whether the speaker is happy, angry, nervous, or tired (e.g., Brooks & Ploog, 2013). In children with communicative impairments, disordered prosody has been linked to difficulties in pragmatic or conversational aspects of language (e.g., Sahlén & Nettlebladt, 1993; Samuelsson, Nettlebladt, & Lofqvist, 2005). It has also been suggested that disordered prosody may be linked in general to impairments in learning social behaviors (e.g., Paul et al., 2005; Ploog, 2010).

Two recent articles reviewed the literature on auditory processing and speech perception in ASD (Haesen, Boets, & Wageman, 2011; O'Connor, 2012). These review articles addressed auditory processing of receptive and expressive speech, tones, and noise, in terms of behavioral, electrophysiological, functional magnetic resonance imaging, and neuroanatomical assessments. For the present purpose, we limited the literature review to receptive prosody yielding inconsistent, often contradictory results, which appeared to depend on the particular paradigm employed. For example, if the task required children to match affective prosody to a visual stimulus, poor performance leaves open the possibility that the children heard the difference in prosody accurately but were unable to negotiate the selection of the visual stimulus. To summarize, some studies indicate that individuals with ASD show superiority in processing prosody relative to typical (TYP) controls (e.g., Järvinen-Pasley, Wallace, Ramus, Happé, & Heaton, 2008), others indicate deficiency (e.g., Arciuli & Paul, 2012; Grossman & Tager-Flusberg, 2012b; Korpilahti et al., 2007; Oerlemans et al., 2013; Peppé, McCann, Gibbon, O'Hare, & Rutherford, 2007), others indicate little to no differences between ASD and TYP groups (e.g., Brennand, Schepman, & Rodway, 2011; Chevallier, Wilson, Happé, & Noveck, 2010; Grossman, Bemis, Skwerer, & Tager-Flusberg, 2010), and finally some studies yield conflicting results across different experiments within the same study, possibly depending on what stimuli or methods were employed (Doi et al., 2013; Grossman & Tager-Flusberg, 2012a; Li, Law, Lam, & To, 2013). It should also be noted that for most prosody studies high-functioning participants with ASD were recruited (including participants with Asperger's Syndrome), possibly because the more severe language deficits that are typical of low-functioning individuals with ASD may render many of the assessment approaches unfeasible (e.g., a child may not be able to follow complex task instructions or cannot communicate the difference between an angry or happy voice even though the child might very well hear the difference).

The current study, like both of our previous studies (Brooks & Ploog, 2013; Ploog et al., 2009), represents an attempt to clarify some of these inconsistencies. All three studies included low- to moderate-functioning individuals with ASD—a population that is generally under-represented in language research and receiving services. All studies used a videogame paradigm anchored in a long tradition of behavior-analytic research on attention (e.g., Lovaas, Schreibman, Koegel, & Rehm, 1971, with visual, auditory, and tactile stimuli in a landmark study identifying abnormal attention patterns in children with ASD, which they labeled "stimulus overselectivity"; Reynolds, 1961, with a pioneering study with pigeons, which served as the basis for Lovaas et al., 1971; see also Ploog, 2011, with squirrel monkeys; Schreibman, Kohlenberg, & Britten, 1986, with children with ASD using speech-like stimuli). In such a behavior-analytic paradigm, typically two or more compound stimuli comprising multiple elements are presented during training: Responding to one, the so-called S+, is correlated with reinforcement whereas responding to an alternative, the so-called S−, is followed by extinction (i.e. no reinforcement). During testing, stimulus elements are presented in isolation or in old and new combinations, and the degree of responding to the individual stimulus elements is interpreted as reflecting the degree of stimulus control, that is, attention to individual stimulus elements.

In a pioneering experiment, Schreibman et al. (1986) employed such a behavior-analytic paradigm to study speech perception in children with ASD. These researchers presented sequentially prerecorded nonsense, two-syllabic words (e.g., "MIN-MIN" vs. "NUR-nur" with lower case letters indicating a lower pitch) that therefore differed in content and intonation (a form of prosody). The children's response pattern in test trials (e.g., "MIN-min" vs. "NUR-NUR") was analyzed according to whether TYP and ASD children responded to content or intonation. Schreibman and her colleagues found "stimulus overselectivity" with respect to either intonation or content in children with ASD but not in TYP children.

Similarly, Ploog et al. (2009) and Brooks and Ploog (2013) found evidence of atypical attention in receptive speech. However, the response patterns did not specifically indicate stimulus overselectivity—if at all, the TYP children appeared *more* selective with regard to content than the children with ASD (see also Ploog & Kim, 2007, with tactile stimuli). Ploog et al. (2009) trained the participants to discriminate between two spoken sentences that differed in content and prosody (e.g., "Max ate a grape!" [statement] vs. "Tom threw a ball?" [question]). During testing, the prosody and content elements were switched (e.g., "Max ate a grape?" [question]) such that it could be shown which aspect of the speech stimuli (i.e., content or prosody) the children tracked on test trials (e.g., "Max ate a grape?" vs. "Tom threw a ball!"). If, for example, the children responded consistently to "Max ate a grape" regardless of prosody, it provided evidence for attention to content. The results indicated that the children with ASD attended to both, content and prosody, whereas the TYP children showed a preference for content over prosody. Also, importantly, both groups were able to discriminate accurately based on content and prosody, thus indicating *no* perceptual deficit per se. Brooks and Ploog (2013) replicated the findings with respect to the prosody of statements and questions but extended the findings by introducing affective prosody (i.e., grouchy vs. enthusiastic sentence stimuli). Again, the children showed no perceptual deficit per se but the TYP and ASD groups still differed: Whereas the TYP children showed a preference for the enthusiastic prosody over its grouchy counterpart, the children with ASD did not. Because of evidence indicating atypical but not necessarily overselective attention patterns, Brooks and Ploog proposed a compatible but broader hypothesis than the stimulus-overselectivity hypothesis—the prioritization deficit hypothesis (e.g., Brooks & Ploog, 2013; Ploog, 2012) based on an early concept of "relevance" and stimulus control proposed by Etzel, LeBlanc, Schilmoeller, and Stella (1981).

In sum, the findings of Brooks and Ploog (2013) and Ploog et al. (2009) failed to find evidence of deficiencies in the *perception* of speech prosody in low- to moderate-functioning children with ASD—including non-verbal children.