

PROSODIC CHARACTERISTICS IN YOUNG CHILDREN
WITH AUTISM SPECTRUM DISORDER

By

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ABSTRACT

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This study investigated perceptual and acoustical differences in prosody between the speech of young children with autism spectrum disorders (ASD) and typically developing (TD) controls. Seven individuals with a severe ASD diagnosis with ages ranging from 38 to 93 months of age and seven TD controls matched on language-age equivalency with ages ranging from 20 to 30 months of age participated in the study. Spontaneous speech samples were extracted from video recordings of parent-child interactions in which no therapy was provided. In one study, acoustic analyses were conducted to measure speech rate, articulation rate, and aspects of global fundamental frequency (F0). The results of this study revealed a significant difference in mean, maximum, and minimum F0 for the ASD group compared to the TD control group. Moreover, in a second study 18 undergraduate students from the College of Communication Arts and Sciences at Michigan State University blind to the diagnosis of speakers gave perceptual ratings for the 14 ASD and TD speakers on intelligibility, estimated age, pitch, speech rate, degree of animation, and certainty of diagnosis. The results of the study revealed no significant differences in any measure except for estimated age. Taken together, the studies suggest that there are few prosodic differences that distinguish young ASD and TD children matched on expressive language skill, so that prosody may not be a suitable early diagnostic marker of ASD.

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Introduction

Autism, also known as autism spectrum disorder (ASD), is a developmental disability that affects individuals' ability to communicate, their social skills, and the ability to effectively function in and interact with the world around them (ASHA, 2006). Due to its extensive range of symptoms and severity, which can vary widely from person to person, autism is considered to be a 'spectrum disorder'. Depending upon individuals' placement on the autism spectrum, they may exhibit extremely severe symptoms of the sort that can dramatically reduce quality of life (ASHA, 2006).

Background

Diagnosis. According to the Diagnostic and Statistical Manual of Mental Disorders 5th edition (American Psychiatric Association, 2013), several criteria must be demonstrated in order to support diagnosis of an ASD. The first of these involves a determination that the individual presents with “persistent deficits in social communication and social interaction across multiple contexts”. Such deficits may manifest in difficulties with social-emotional reciprocity, a lack of nonverbal communicative behaviors used for social interaction, or deficits in the development, maintenance, and understanding of relationships.

The second diagnostic category enumerated in DSM-V pertains to “restricted, repetitive patterns of behavior, interests, or activities,” in which the individual must demonstrate at least two among several typical characteristics. These characteristics include “stereotyped or repetitive motor movements, use of objects, or speech”; “insistence on sameness, inflexible adherence to routines, or ritualized patterns of verbal or nonverbal behavior”; “highly restricted,

fixated interests that are abnormal in intensity or focus”; and “hyper- or hyporeactivity to sensory input or unusual interest in sensory aspects of the environment”.

DSM-V next requires that symptoms of an ASD must be observed early within the developmental period, and that the symptoms observed must result in significant impairment in social, occupational, and/or other important areas of function. Finally, DSM-V notes that the diagnostician should confirm that the symptoms in question would not be better explained by an intellectual disability.

These issues, as well as the myriad of communicative deficits which often present in those with autism spectrum disorders, are of particular interest to researchers. According to the American Speech Language Hearing Association, symptoms of ASD affecting communication may include, but are not limited to, minimally expressive language or non-verbal behavior; deficits in the expression of needs and wants; and difficulty in answering questions. Affected individuals may also present with echolalia, a symptom in which the individual repeats things heard previously. The individual may repeat the word or phrase immediately after hearing it spoken, or later on in an unrelated or inappropriate context. Individuals with ASD may additionally exhibit atypical-sounding speech characteristics characterized by differences in prosody and pitch (Bellon-harn et al., 2007). Children with ASD often present with deficits in eye contact with other people, may exhibit poor play skills in play involving imagination or engagement in activities with other children, and may fixate on certain topics or objects of interest (Bellon-harn et al., 2007). Other characteristics common to children with ASD are self-stimulating behaviors such as rocking or other repetitive movements, difficulty adjusting to change in daily routines, sensory integration deficits, and atypical object attachment (ASHA, 2006).

Early intervention. In recent decades a growing body of research has emphasized the importance of early intervention for young children with ASD. Harris and Handleman (2000) observed that outcomes for young children affected by autism were much improved when intervention was provided before the age of three, as compared to children for whom intervention did not begin until after the age of five. However, as noted by Filipek et al. (1999), the average age of diagnosis for children with ASD in the United States is between ages 3 and 4 years. Research conducted by Prizant and Wetherby (1993) suggests that the lack of early diagnosis is a significant stressor for families. Specifically, this research found that for families with young children suspected of having ASD, the deficits in communication and the difficulties involved in identifying and understanding the diagnosis of ASD can put families under a great deal of stress. The primary causes of this stress stem from the common disagreement between professionals as to whether or not the delays exhibited by young children are a cause for concern, or simply the result of natural variability in the behavior of young children. Subsequent research has offered promise for earlier and more precise diagnoses, however. Studies completed by Lord (1995) and Stone et al. (1999) have demonstrated that reliable diagnoses of ASD can be made by 24 months of age. In these studies, more than 80% of children who had been diagnosed with ASD at age 24 months were again assessed and given the same ASD diagnosis at 36 months of age. Research by Lord (1995) indicated that while the first two diagnostic features of ASD as listed in the then-current DSM-IV (deficits in communication and social interaction) were exhibited by 24 months, the third diagnostic feature of repetitive behaviors does not emerge until the child is closer to 36 months of age. Despite the absence of certain diagnostic features in very young children, these findings provide encouragement that accurate diagnoses of ASD can still

be made at ages as early as 24 months – a possibility which could portend significant relief from the familial stress that results from diagnostic uncertainty.

Numerous researchers have found support for the hypothesis that participation in early intervention for language development is associated with long-term positive outcomes in children with ASD (e.g., Dawson & Osterling, 1997; Koegel & Koegel, 1988; Lovaas, 1987; Rogers, 2005; Rogers & Vismara, 2008). Among other findings, the evidence demonstrates that children with ASD, and who have acquired spoken language in part through early intervention on language development, tend to be more successful later in childhood and adulthood (Gillberg & Steffenburg, 1987; Howlin et al., 2004; Venter, Lord, & Schopler, 1992). Lord and Paul (1997) also reported that if intervention can be implemented very early on to assist with the acquisition of fluent speech before the age of 5, the resulting expressive skills can be utilized as a predictive measure for language skills, adaptive skills, IQ, and educational performance later in adolescence.

Prosodic features in speech. The term “prosody” refers to suprasegmental characteristics in speech; these are typically described as including the rhythm, duration, and intonation patterns of speech (Grossman et al., 2010). The overall purpose of prosody is to modulate and enhance the meaning of the spoken signal (Shriberg et al., 2001). Prosody is an important component of grammatical, pragmatic and affective communicative functions (McCann et al., 2007). The contributions of prosody to each of these communicative areas are considered below.

According to Warren (1996), grammatical prosody consists of suprasegmental cues within speech, which denote information relating to the syntactical structure of the message. This is to say that emphasis on the *way* words are spoken can alter the meaning of the word in

certain cases. For example, the word “present” can be spoken and perceived as either a noun or a verb depending upon which syllable is stressed. Utterances may also be spoken and perceived differently simply as a result of adjustment in the pitch contours of the phrase. These contours can allude to whether the message is intended to be a question (through rising pitch), or a statement (through falling pitch) (Gerkin, 1996; Gerkin & McGregor, 1998).

Pragmatic prosody carries social information that conveys the speaker’s intentions (VanLanker, Canter, & Terbeek, 1981; Winner 1988). The stress in pragmatic prosody can be used to call the listener’s attention to certain information within the conversation; this type of stress is typically referred to as emphatic stress (Bates & McWhiney, 1979; Haviland & Clark, 1974).

Affective prosody can denote an individual’s personal speaking style, as well as adjust changes in the vocal register based on whom the individual is speaking with (i.e. alterations in an individual’s speech when they interact with peers or someone of a higher social status). This type of prosody will vary from person to person. Affective prosody can also be used to carry the speaker’s general emotion in the context of the message being delivered (Bolinger, 1989; Hargrove, 1997).

Existing literature on prosodic characteristics in individuals with ASD.

Individuals who have been diagnosed with ASD and who are considered to be verbal may present with vast variability in the degree of impairment in prosodic features in speech. In the ASD population, there are recurring reports of atypical suprasegmental production. Researchers frequently hypothesize that individuals with autism spectrum disorders have deficits primarily in the pragmatic and affective subcategories of prosody. Therefore, deficits in this area have become a core feature of verbal individuals with ASD (Baltaxe & Simmons, 1985, 1992; Fay &

Schuler, 1980; Ornitz & Ritvo, 1976; Paul, 1987; Pronovost, Wakstien, 1966; Rutter & Lockyer, 1967; Tager-Flusberg, 1981). Speakers with ASD are often described as being monotonic, using aberrant stress patterns, and demonstrating deficits in the use of pitch and volume during speech (DeMyer et al, 1973; Kanner, 1971; Rutter & Lockyer, 1967; Simmons & Baltaxe, 1975). Landa (2000) and Tager-Flusberg (1981, 1995) documented that these prosodic deficits in individuals with ASD are typically in the pragmatic and affective prosody subcategories, and that these deficits are due in large part to the individuals' difficulties with social communication. As stated earlier, the overall purpose of prosody is to modulate and enhance the meaning of the spoken signal (Shriberg et al., 2001). McCann and colleagues (2007) indicate that within the limited body of literature discussing prosody and autism, contrastive stress has been a highly active area of research. In fact, McCann and Peppé (2003) reported that all studies which investigated this area found contrastive stress to be in deficit among individuals with autism. More specifically, the overall consensus of research indicates that the most commonly reported deviations in the speech of individuals with ASD are increased pitch range or pitch variation (Nadig & Shaw, 2011).

McCann, Peppé Gibbon, O'Hare, and Rutherford (2007) examined 31 children with high-functioning autism, as well as seventy-two typically developing children, in order to investigate the relationships between expressive and receptive language, phonology, pragmatics, and non-verbal abilities. The researchers were also interested in how prosody relates to these areas of communication, in which aspects of prosody are most impaired. Overall, the study found that children with autism presented with deficits in at least one aspect of language; expressive language was most commonly affected. All children with autism were observed to have difficulties with at least one prosody characteristic. The results identified a high correlation

between prosodic ability and expressive and receptive language. Compared to the typically developing children, the children with autism demonstrated significantly impaired prosodic skills (McCann et al., 2007).

In a series of three experiments, Grossman, Bemis, Skwerer and Tager-Flusberg (2010) examined perception of affective prosody, lexical stress perception, and lexical stress production in 16 children with high functioning autism (HFA). The researchers hypothesized that children with HFA would perform comparably with typically-developing peers on identifying prosodic contours of affective sentences with and without verbal content. They also hypothesized that children with HFA would perform at the same level as their typically-developing peers on tasks that required the use of lexical stress to determine the meaning of ambiguous word pairs. Finally, the researchers also hypothesized that the children with HFA, as discussed in previous literature, would exhibit quantifiable and subjective deficits in lexical stress production for ambiguous word pairs. The results of the study supported the researchers' hypotheses in that the children were observed to disambiguate word pairs with differentiated production of lexical stress patterns. The results also confirmed the researchers' third hypothesis, that the productions of lexical stress in the children with HFA were significantly divergent from those common to typically developing peers. With regard to the second hypothesis, the researchers analyzed pitch and intensity using PRAAT software to determine whether a quantifiable difference existed between groups in the assignment and production of lexical stress. They also reviewed whole-word duration using the PRAAT software. However, analysis of the data determined that no significant differences in pitch or intensity on first-syllable or second-syllable stress items existed between children with HFA and typically-developing peers. Perceptual study of the productions of the children with HFA found contrasting results, in which the children with HFA

were perceived as having long exaggerated pauses in between syllable productions, particularly when the stress was to be placed on the second syllable as identified by the significant group effect. The researchers in this study suggested that more research in this area was necessary in order to target differences in prosodic productions between elicited productions versus spontaneous productions.

In Shriberg et al. (2001), the authors summarized interpretations of grammatical versus affective or pragmatic aspects of prosody within ten studies. Of the studies examined, only three contained statistically significant differences within the category of grammatical prosody. However, all studies resulted in data suggestive of a significant difference in the pragmatic and/or affective prosody subcategories (Shriberg et al., 2001). In Shriberg and colleagues' study, 30 male participants with high functioning autism (HFA) or autistic syndrome (AS) provided speech samples, which were assessed with The Prosody-Voice Screening Profile. The results revealed a statistically significant difference existed between the HFA and AS speakers and the control group within the categories of phrasing, stress, pitch, and average resonance quality. However, the results also revealed *no* significant difference between the groups in the categories of rate, loudness, and overall quality. The researchers also used the PEPPER software suite to analyze the frequencies and types of consonant and vowel/diphthong errors in conversational speech. The PEPPER test includes six severity metrics. Although some of the individuals in the experimental groups received lower scores, overall there was no significant difference between the experimental groups and the control group in the frequency or types of errors observed (Shriberg et al., 2001).

Nadig and Shaw (2011) investigated acoustical and perceptual characteristics of prosody in 15 children with HFA and 13 typically-developing children, aged 8 to 14 years. Speech

samples were gathered through spontaneous conversation (outside of the initial conversation topic prompt), and short audio clips of utterances were extracted for analysis. The researchers used PRAAT software to determine mean pitch, maximum and minimum pitch, and duration of the clip. The results showed a significant difference between experimental and control groups with regard to pitch range, which was calculated as the difference between maximum and minimum pitch from the short conversation sample.

Nadig and Shaw (2011) also conducted a perceptual study in which raters, blind to the diagnosis of the speakers, gave perceptual ratings for the conversational speech samples. A seven-point scale was used to evaluate features of pitch, pitch changes, and speech rate. A four-point scale was also used to rate overall impressions of the speech. The results of the perceptual ratings suggested that the children with HFA were judged to be atypical significantly more often in prosody production compared to the control group. However, there were no significant differences in ratings of pitch variation, mean pitch, and speech rate across the two groups. The authors also attempted to determine whether the acoustic measurements and perceptual ratings of the speech samples were correlated. The pitch range was determined to not be significantly correlated between the acoustic and perceptual measures. For mean pitch, there was a modest statistical correlation between both measures, as well as a strong statistical correlation for speech rate. There was no statistically significant relationship between acoustic and perceptual measures of overall impressions of prosody.

Finally, John (2008) conducted a study which aimed to evaluate acoustical prosody characteristics in children with ASD. John collected speech samples from four participants with ASD and three typically developing individuals. The speech samples consisted of conversational speech, passage reading, and imitation. In an acoustic analysis, John evaluated normalized

amplitude of pre-stressed voiced stop consonants and normalized duration of word final fricatives using PRAAT software. The results revealed no statistically significant difference between the experimental and control groups for normalized amplitude of voiced stop consonants. Analysis of the results for the normalized duration of word-final fricatives also revealed no statistically significant difference between the groups.

John (2008) also conducted a perceptual analysis of the speech samples, in which raters evaluated seven prosodic characteristics (naturalness, voice quality, rhythm, intonation, fluency, loudness, and overall intelligibility) using a five-point Likert rating scale for each characteristic. Overall, there were statistically significant differences between the groups in ratings of naturalness, rhythm, intonation, fluency, loudness, and overall intelligibility. The only characteristic that showed no significant difference was voice quality. Due to the lack of significant differences between groups found in the acoustic study, it was not clear what acoustic information might have been the basis of the significant differences in ratings between groups in the perceptual study.

Rationale and purpose of current study. Published literature regarding prosodic characteristics in the speech of individuals with ASD has tended to focus on older individuals (older children, adolescents, and adults) who were relatively high-functioning and who lacked a significant language delay. The study conducted by Shriberg and colleagues in 2001 included participants with high-functioning autism and Asperger's syndrome, ranging in age from 10-49 years. The children included in the study by McCann et al. (2007) were aged 6-13 years and had been diagnosed with high-functioning autism. A study by John (2008) included individuals with varying severity of autism spectrum disorder (autism and Asperger's Syndrome) ranging in age from 9-25 years. Grossman et al. (2010) and Nadig and Shaw (2011) likewise completed their

experiments using school-age children and adolescents, with all participants with of high-functioning autism. It is clear that there exists a paucity of research concerning speech characteristics of very young children with a diagnosis of severe ASD.

The findings of these various studies are inconsistent with regard to whether or not significant differences in prosody present in individuals with ASD, compared to typically-developing individuals. John (2008) identified statistically significant differences in several perceptual ratings by raters blind to the speakers' diagnostic status, whereas Nadig and Shaw (2011) found no significant differences in perceptual ratings, other than overall perception of prosody production. Shriberg et al. (2001) completed an acoustic analysis of frequencies in conversational speech and found no significant difference between the experimental and control groups. Nadig and Shaw (2011) also conducted an acoustic analysis regarding measures of frequency; their results showed a significant difference between experimental and control groups in measurements of pitch range.

Thus, a review of the current literature of this topic demonstrates a need for further exploration of the prosodic characteristics in the speech of very young, language-delayed children on the severe end of the autism spectrum. Previous studies have focused on older children, adolescents, and adults rather than very young children. These studies have also concentrated on individuals with less severe forms of autism (i.e. high-functioning autism, Asperger's syndrome), and have not included individuals with more severe diagnoses combined with language delay. It is clear that additional investigation in these areas is needed to expand knowledge of this topic. The clinical implications of additional research in this area could include higher-quality diagnoses, assessments, and intervention procedures for young children with ASD. Findings from this study may also help clinicians formulate more accurate goals to

address expressive prosodic deficits. Again, individuals with autism often present with expressive prosodic deficits when participating in social communication exchanges. More knowledge in this area could help clinicians develop more effective treatment strategies to incorporate into clients' treatment plans.

The current study involved analysis of the speech of young children with ASD by focusing on acoustic and perceptual characteristics of prosody. More specifically, it used acoustic analysis to identify differences in the prosodic characteristics in children with ASD compared to typically developing controls. The study also aimed to explore whether listeners blind to the speakers' diagnosis could detect differences in the prosodic characteristics of young children with ASD, relative to typically developing, language-matched controls.

Research Questions

The research questions addressed in this study are as follows:

1. Are there reliable perceptual markers of the prosodic speech characteristics that differentiate children with ASD from typically developing children?
2. What acoustical properties are present in the speech of children with ASD that may give rise to those perceived group differences?

Method

Participants

The participants in this study were seven children with ASD between the ages of 38 and 93 months (5 males and 2 females) and seven language-age matched individuals with neurotypical development (control group) between the ages of 20 and 30 months old. The experimental and control groups of participants were matched on the expressive language age equivalency as obtained from prior administration of the Preschool Language Scale – 5th edition. All participants had been in prior studies at the Michigan State University Autism Laboratory. A parent or guardian for these individuals signed a form that allowed video recordings to be made rendered from the study in which they participated in to be used for future studies done at Michigan State University.

Inclusion criteria for the ASD group were: 1) under 8 years old; 2) history of autism spectrum disorder as confirmed by a previous diagnosis under the Autism Diagnostic Observation Scale-ADOS, Lord, Rutter, DiLavore & Risi, 1999 with scores on this assessment of 12 or higher; and 3) demonstrates at least six utterances that were a minimum of two words in length. Note that ADOS scores of 12 or higher are indicative of a diagnosis of “autism” and reflect more severe symptoms, as opposed to a diagnosis of “autism spectrum” which correspond to ADOS scores of 8-11 and reflect less severe symptoms. The control group of typically-developing children were matched on expressive language age equivalency scores on the Preschool Language Scale-4th edition (PLS-4) to scores of the ASD group. Moreover, they had no history or evidence of autism based on scores from a battery of formal cognitive, speech and language, and early social communication assessments, as well as informal social communication and observation measures. Some of these tests included the Bayley Scales of

Infant Development, Early Social Communication Scales, MacArthur Communicative Development Inventories, Mullen Scales of Early Learning, and Social Communication Questionnaires. In addition, their speech samples in the database included at least six spontaneous utterances (i.e.- these utterances were not imitated) that were minimally two words in length. The number of utterances used for the experimental group ranged from six to twelve per child. The number of utterances used for the control group ranged from seven to twelve.

Table 1 shows chronological age in months, PLS-4 expressive standard score, PLS-4 age equivalency in months, number of speech samples produced by each participant, ADOS raw score, mean length of utterance, and total number of syllables per participant. Independent-samples t-tests revealed no group differences on PLS-4 expressive language age equivalency ($M_{ASD} = 30.1$ mos, $SD = 4.4$; $M_{TD} = 31.9$ mos, $SD = 4.3$; $t(12) = .739$, $p = .474$). As expected, there were group differences in chronological age; ASD children were language-delayed relative to their chronological age and therefore older than their language-matched peers ($M_{ASD} = 55.6$ mos, $SD = 17.9$ mos; $M_{TD} = 24.9$ mos, $SD = 3.6$ mos, $t(12) = -4.457$, $p = .001$). Mean length of utterance was calculated using the speech transcripts included in the perceptual and acoustic studies. The average number of utterances per participant used for the experimental group was 9.14. The average number of utterances per participant used for the control group was 11.4. There were no group differences between the ASD group and the control matches ($M_{ASD} = 3.44$, $SD = 0.43$; $M_{TD} = 3.44$, $SD = 1.15$, $t(12) = 0.00$, $p = 1.00$). There were also no group differences in average number of syllables per sample between the ASD and control groups ($M_{ASD} = 3.3$, $SD = 0.57$; $M_{TD} = 3.1$, $SD = 1.1$, $t(12) = .280$, $p = .784$).

Table 1: Characteristics of Participants in the ASD and Typically-Developing (TD) Groups

Group	Participant	Chronological Age (months)	PLS Expressive Standard Score	PLS Expressive Age Equivalency (months)	Speech Files per Subject	ADOS Raw Score	Mean Length of Utterance	Avg. Syllables Per File
ASD	AlHa	57	63	32	8	20	3.4	3.2
	GrLo	38	91	33	10	14	3.2	2.7
	JaNe	53	73	35	12	16	4.3	4.1
	ReCa	53	64	32	7	18	3.3	3.5
	RyCh	93	50	23	7	12	3.1	3.3
	MiWo	53	78	31	11	14	3.7	3.5
	DaCi	45	70	25	9	16	3.1	2.2
TD	LeEl	28	129	40	12		6	5.4
	MoMa	30	112	32	11		3	2.7
	DoTr	26	118	35	12		3.5	3.2
	WiAl	20	124	29	12		3.1	2.5
	CoWa	22	124	29	12		2.8	2.3
	KaVa	26	106	29	9		2.8	3.7
	JuLa	22	124	29	12		2.9	2.7

Child speech samples

The speech samples from the ASD and TD groups were extracted from pre-existing video recordings of a parent-child interaction in which no therapy was provided. Each child's speech was transcribed from the video recordings by the researcher and one undergraduate research assistant. Their transcriptions were compared, and unintelligible utterances as agreed upon by both transcribers were excluded from the samples rated. To be included in the study, the utterance had to be at least two words in length, be spontaneous (i.e., not a direct imitation of what the parent just said), and perceived as fully intelligible by both transcribers. The audio was extracted from each audiovisual recording and then parsed into utterance clips using Audacity, a free audio-editing program. Utterances that had syntactic errors were included due to the chronological age of the participants. Young children between the ages of 20 months and 93 months may produce grammatical errors that are developmentally appropriate.

Perceptual Task

Raters. Eighteen undergraduate listeners were recruited through the SONA on-line experiment scheduling system through the College of Communication Arts and Sciences at Michigan State University. Prospective listeners were provided with a brief overview of the current study and the task that they would be performing. In the pre-screening process in the SONA system the listeners had reported an absence of speech/language/hearing deficits, and were native English speakers. These listeners were not provided any training before participating in the experiment. Before participating in the experiment, the listeners were asked to sign a consent form (see Appendix B) and given a copy of the form after the end of the experiment. After completing the experiment the listeners were asked a series of questions regarding whether or not they used any strategies to complete the task, attention during the task, and effort during the task. This study met guidelines for use of human subjects in research as set forth by the Institutional Review Board at Michigan State University. Further details regarding approval of this study can be found in Appendix A.

Procedures. The selected utterances were presented to listeners via headphones in a quasi-random order with the constraint that no more than two utterances from the same speaker were presented in a row and no more than three utterances from the same group (ASD or control) were presented in a row. The listeners were blind to the diagnosis of the speakers. The listeners were given a brief description of the meaning of ASD as well as the meanings of the concepts on the rating scale. For each sample, participants were asked to provide ratings of six attributes. For more details on the descriptions and instructions provided to the listeners please see Appendix D.

Perceptual ratings. The six ratings included: intelligibility, perceived age, speech rate, level of pitch, degree of animation, and certainty of ASD diagnosis. A six-point Likert rating

scale was developed for speech rate, level of pitch, degree of animation, and certainty of diagnosis. For speech rate, the listener was asked to judge of how slow or fast the speaker was talking; ratings were described as 1 corresponding to very slow to 6 corresponding to very fast. Listeners were asked to judge on how low or high the overall pitch sounded as appropriate for perceived age; ratings were described as 1 corresponding to very low to 6 corresponding to very high. Listeners were asked to judge on the degree of animation of the speech overall; ratings were described as 1 corresponding to not animated enough to 6 corresponding to too animated. Certainty of an ASD diagnosis was rated with 1 corresponding to certain no ASD diagnosis, to 6 corresponding to certain ASD diagnosis. Listeners were asked to indicate the percent words that were perceived as intelligible on a scale ranging from 1 to 100.

Listeners were provided with five practice speech clips on which to make ratings before the experimental portion began. Listeners were allowed to listen to the speech clip only once before giving their ratings. A transcript was shown on the screen while the speech clip was presented to the listener.

Acoustic Measures

Two measures were selected for the acoustic investigation, in order to shed light on possible acoustic bases for perceptual judgments that might show significant differences as a function of Diagnosis. The two measures derived from the speech samples for every child included (a) speech rate calculated as syllables per second and (b) global fundamental frequency (F0). The latter measure included the mean F0, minimum F0, maximum F0, standard deviation of F0, and F0 range. To measure speech rate, spectrograms and waveforms of the speech samples were analyzed using Praat (Boersma & Weenink, 2014) in order to mark the onset and offset of each speech syllable and pause. The spectrograms and waveforms were beneficial by providing a

visual representation of the sounds to more accurately identify the syllable boundaries. To measure F0, Praat's autocorrelation function was used with default parameter settings, and then pitch tracks were corrected by hand for accuracy.

Statistical Methods

The Statistical Package for the Social Sciences (SPSS) was used to analyze data from both the perceptual and acoustic measures. Independent-samples t-tests were generated for each characteristic, and *p*-values were reported for each test. The results of these analyses are discussed further in the following sections.

Results

A series of independent-samples t-tests were conducted with Diagnosis as the independent variable (consisting of two levels; ASD, TD), and dependent variables from the perceptual study (ratings of perceived age, perceived intelligibility, perceived speech rate, perceived pitch, perceived animation, and perceived diagnosis) and from the acoustic study (syllables, duration and syllables/second for both articulation rate and overall speech rate). The duration measure in overall speech rate included significant pauses (250 milliseconds or longer) between words within the utterance. Articulation rate was calculated with the duration of the pauses removed. In these analyses, equal variances were assumed.

Perceptual Analysis

Perceived pitch. Children from the ASD group were judged to be similar to the control group for perceived pitch ($M_{\text{ASD}} = 3.3$, $SD = 0.4$; $M_{\text{TD}} = 3.6$, $SD = 0.3$). This difference was not significant, $t(12) = 1.277$, $p = .226$.

Perceived speech rate. Children from the ASD group were judged to be similar to the control group for perceived speech rate ($M_{\text{ASD}} = 3.3$, $SD = 0.3$; $M_{\text{TD}} = 3.4$, $SD = 0.3$). The difference was not significant, $t(12) = 0.344$, $p = .736$.

Perceived age. Children from the ASD group were judged to be older ($M_{\text{ASD}} = 4.1$ years, $SD = 0.7$ years) than children in the control group ($M_{\text{TD}} = 3.2$ years, $SD = 0.2$ years). This difference was significant, $t(12) = -3.689$, $p = .003$.

Perceived intelligibility. Children from the ASD group were judged to be slightly more intelligible to the control group ($M_{\text{ASD}} = 80.3$, $SD = 14.4$; $M_{\text{TD}} = 75.6$, $SD = 4.6$). The difference was not significant, $t(12) = -.827$, $p = .425$.

Perceived degree of animation. Children from the ASD group were judged to be similar to the control group for perceived degree of animation ($M_{\text{ASD}} = 3.4$, $SD = 0.4$; $M_{\text{TD}} = 3.5$, $SD = 0.3$). The difference was not significant, $t(12) = .516$, $p = .615$.

Perceived diagnosis. Children from the ASD group were judged to be similar to the control group for perceived diagnosis ($M_{\text{ASD}} = 3.5$, $SD = 0.7$; $M_{\text{TD}} = 3.3$, $SD = 0.2$). The difference was not significant, $t(12) = -.633$, $p = .539$.

Acoustic Analysis

Articulation rate: syllables/second. Children from the ASD group were measured to be similar to the control group for articulation rate ($M_{\text{ASD}} = 2.6$ syll/sec, $SD = .34$; $M_{\text{TD}} = 2.7$ syll/sec, $SD = .37$). The difference was not significant, $t(12) = .513$, $p = .617$.

Speech rate: syllables/second. Children from the ASD group were measured to be similar to the control group for speech rate ($M_{\text{ASD}} = 2.4$ syll/sec $SD = .44$; $M_{\text{TD}} = 2.6$ syll/sec, $SD = .36$). The difference was not significant, $t(12) = .681$, $p = .509$.

F0 mean. Children from the ASD group had a lower overall f0 ($M_{\text{ASD}} = 310$, $SD = 42.6$) compared to the control group ($M_{\text{TD}} = 372.5$, $SD = 29.6$). The difference was significant, $t(12) = 2.950$, $p = .012$.

F0 maximum. Children from the ASD group were measured to have a lower overall maximum f0 ($M_{\text{ASD}} = 397.2$, $SD = 66.2$) compared to the control group ($M_{\text{TD}} = 462.1$, $SD = 30.1$). The difference was significant, $t(12) = 2.185$, $p = .049$.

F0 minimum. Children from the ASD group were measured to have a lower overall minimum f0 ($M_{\text{ASD}} = 235.1$, $SD = 32.3$) compared to the control group ($M_{\text{TD}} = 281.2$, $SD = 39.4$). The difference was significant, $t(12) = 2.223$, $p = .046$.

F0 range. Children from the ASD group were measured to have a similar overall f0 range compared to the control group ($M_{\text{ASD}} = 162.1$, $SD = 46.9$; $M_{\text{TD}} = 180.9$, $SD = 42.1$). The difference was not significant, $t(12) = .728$, $p = .480$.

F0 standard deviation. Children from the ASD group were measured to have a similar f0 standard deviation compared to the control group ($M_{\text{ASD}} = 45.5$, $SD = 15.9$; $M_{\text{TD}} = 50.3$, $SD = 12.2$). The difference was not significant, $t(12) = .592$, $p = .565$.

Discussion

Current literature investigating variables associated with autism has identified prosody as being an important distinguishing characteristic in the speech of children with autism. Previous studies have investigated possible distinguishing characteristics using older children, adolescents, and adults with high-functioning autism (considered less severe) as participants (Nadig & Shaw, 2011; McCann et al., 2007; Shriberg et al., 2001). Prior findings raise the question of whether differences in prosody would be present and identifiable for young children on the severe end of the autism spectrum diagnosis.

The purpose of this study was to investigate whether there is a reliable difference in prosodic characteristics of young children with a diagnosis of moderate to profound autism spectrum disorder compared to typically developing children. Multi-word utterances were extracted from the speech of children with ASD and typically-developing children. Listeners rated the multi-word utterances in perceived age, perceived intelligibility, perceived speech rate, perceived pitch, perceived degree of animation, and perceived degree of certainty of ASD diagnosis. An acoustic analysis was conducted to measure the global fundamental frequency and speech rate of both the ASD and control groups, in order to determine which acoustic characteristics in the speech might mediate perceptual differences in prosody identified between the children with ASD and typically-developing children.

The results of this study showed no significant difference between the children with ASD and the control group in ratings of two key prosodic attributes: perceived pitch and perceived speech rate. The results also revealed no significant group differences on mean ratings of degree of animation, certainty of ASD diagnosis, or perceived intelligibility. In fact, perceived intelligibility ratings were slightly higher in the ASD group ($M = 80.3$) compared to the TD

group ($M = 75.6$), indicating that listeners found the ASD group to be slightly more intelligible. However, results of perceived age indicated that listeners were able to reliably perceive the children as having different ages between the two groups. Moreover, ratings of perceived age were significantly correlated with the subject's chronological ages ($r = .569, p = .034$). These results are consistent with findings that listeners use voice characteristics of talkers in judgments of chronological age (Dilley et al., 2013).

The findings of the acoustic study did not show a significant difference in articulation rate or overall speech rate between the children with ASD and the control group. However, the results of the global fundamental frequency measurement revealed a significant group difference in that the participants in the ASD group had a lower global fundamental frequency than the control group. A significantly lower minimum and maximum fundamental frequency difference between groups was also observed. These significant differences in F0 most likely reflected the distinct difference between groups in chronological age, rather than the presence or absence of an ASD diagnosis. This interpretation is consistent with the result obtained here that listeners could not reliably determine ASD diagnosis. By contrast, listeners are able to perceive F0 differences associated with developmental age, and such differences influence judgments of perceived age (Dilley et al., 2013). The findings that listeners reliably identified children as having different ages between groups is consistent with the acoustic F0 differences found here and their causal effects in age perception as identified in previous research (e.g., Dilley et al., 2013; Harnsberger, Shrivastav, Brown, Rothman & Hollien, 2008).

However, the results of this study should be tempered by its small sample size. In this study, the substantial within-group variability may have contributed some non-significant findings, particularly given the sample size of $n = 7$ in each group. Considering that the project

had time limitations, there was no opportunity to recruit more subjects for each group. Consequently, there could be a difference between groups that was not reliably detected using *t*-tests.

Exploratory post-hoc analyses were done that excluded one participant who was an outlier with respect to chronological age (93 months). However, the statistical outcomes of the group comparisons on the dependent perceptual measures were very similar despite this participant's exclusion from the analyses. That is, the results were comparable to the previously-described analyses that had included all participants, with the exception that the group differences in perceived intelligibility became statistically significant ($t(11) = -2.413, p = .034$).

Clinical Implications

The results of this study suggest that the speech characteristics of very young children with ASD do not provide reliable perceptual cues to an ASD diagnosis on the measures examined. The findings of this study may indicate that prosodic speech characteristics alone are unlikely to be a sufficient early sign of an ASD diagnosis or suitable treatment targets.

The Autism Diagnostic Observation Scale evaluates performance in social affect through communication and reciprocal social interaction - as well as restricted and repetitive behavior. In the scoring booklet, there is a subsection titled "Intonation of Vocalizations or Verbalizations," which addresses whether or not the child has appropriate intonation, little variation to pitch; flat or exaggerated, odd intonation or inappropriate pitch and stress, and/or markedly flat and toneless vocalizations. Not all of the scored items are included in the final calculation of the classification score. The score for "Intonation of Vocalizations or Verbalizations" is one of the items excluded from the final total score. The findings of the current study suggest that the practice of not including prosodic components in the final score may be justified. This is due to

the finding that listeners could not reliably identify marked prosodic differences between the ASD group and its chronologically younger language-matched controls.

Research Implications

This study included several key components that enhanced its quality. The listeners in the perceptual study were blind to the diagnosis of the participants. This reduced the likelihood of bias in rating the speakers based upon predetermined knowledge as opposed to what they actually heard in the speech. The study included a language-age matched control group. This allowed for a comparison between the population of interest and typically-developing individuals. The participants were carefully selected to have a match based on expressive language age equivalency. This ensured that there was no significant difference on expressive language skills between the ASD group and controls. This study included more participants ($n = 14$) than a similar previous study (John, 2008), which only had a total of 7 participants.

A possible direction for future research would be to measure perceived pitch, speech rate, animation, intelligibility, and diagnosis on a larger group of individuals with ASD and their matched controls than was used in the present study. Analyzing a larger sample could ensure that results are appropriately representative of the population. Within-group variability should be controlled for participant age and the number of speech samples used per child. Future research should also probe an acoustic analysis on pitch by comparing the individuals with ASD to typically-developing controls that are matched on chronological age. This could control for differences in fundamental frequency measures that are related to age rather than ASD diagnosis.

Another potential direction for future work would be to conduct a longitudinal study examining parameters associated with prosody in individuals with ASD to see how prosodic speech characteristics change over time in this population. This may identify whether or not

possible prosodic deficits in individuals with ASD become more apparent as their expressive language abilities develop.

It may also be beneficial to do a similar perceptual study using professionals in the field of communication sciences and disorders. This could reveal whether or not professionals with more knowledge and experience with individuals with ASD could identify prosodic deviations that are less perceptible to listeners that lack expertise in evaluating speech.

The results of the perceptual experiment revealed that listeners could not reliably identify marked differences between the ASD group and controls in the probed characteristics except for perceived age. In the acoustic measures, there were no significant group differences in speech rate or articulation rate between groups. However, significant differences did occur between groups on mean, maximum, and minimum global fundamental frequency measures. The results of this study are inconclusive as to whether differences in prosodic characteristics exist between individuals with ASD and typically-developing individuals. In particular, the present study finds that within-group variability and exogenous factors may impact observed characteristics. Consequently, future research in this area should strive to examine larger sample groups and control for other factors that may cause within-group variability such as chronological age.

Concluding Remarks

The findings of this study suggest there are few reliable prosodic markers in the speech of young children with severe autism that can distinguish them from younger language-matched children who are typically developing. Such findings may influence the extent to which such markers can be useful for diagnosing and treating individuals with ASD.

APPENDICES

APPENDIX A: INSTITUTIONAL REVIEW BOARD APPROVAL LETTER

MICHIGAN STATE
UNIVERSITY

Initial IRB
Application
Approval

August 19, 2013

To: Laura Dilley
116 Oyer Speech and Hearing

Re: **IRB#** 13-518 Category: EXPEDITED 2.6, 2.7
Approval Date: August 19, 2013
Expiration Date: August 18, 2014

Title: Prosodic Characteristics of Young Children with Autism Spectrum Disorder

The Institutional Review Board has completed their review of your project. I am pleased to advise you that **your project has been approved**.

The committee has found that your research project is appropriate in design, protects the rights and welfare of human subjects, and meets the requirements of MSU's Federal Wide Assurance and the Federal Guidelines (45 CFR 46 and 21 CFR Part 50). The protection of human subjects in research is a partnership between the IRB and the investigators. We look forward to working with you as we both fulfill our responsibilities.

Renewals: IRB approval is valid until the expiration date listed above. If you are continuing your project, you must submit an *Application for Renewal* application at least one month before expiration. If the project is completed, please submit an *Application for Permanent Closure*.

Revisions: The IRB must review any changes in the project, prior to initiation of the change. Please submit an *Application for Revision* to have your changes reviewed. If changes are made at the time of renewal, please include an *Application for Revision* with the renewal application.

Problems: If issues should arise during the conduct of the research, such as unanticipated problems, adverse events, or any problem that may increase the risk to the human subjects, notify the IRB office promptly. Forms are available to report these issues.

Please use the IRB number listed above on any forms submitted which relate to this project, or on any correspondence with the IRB office.

Good luck in your research. If we can be of further assistance, please contact us at 517-355-2180 or via email at IRB@msu.edu. Thank you for your cooperation.

Sincerely,



Harry McGee, MPH
SIRB Chair

c: Brooke Ingersoll, Sara Cook



Office of Regulatory Affairs
Human Research
Protection Programs

Biomedical & Health
Institutional Review Board
(BIRB)

Community Research
Institutional Review Board
(CRIRB)

Social Science
Behavioral/Education
Institutional Review Board
(SIRB)

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www.humanresearch.msu.edu

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APPENDIX B: PARTICIPANT CONSENT FORM

Research Participant Information and Consent Form

You are being asked to participate in a research project. Researchers are required to provide a consent form to inform you about the study, to convey that participation is voluntary, to explain risks and benefits of participation, and to empower you to make an informed decision. You should feel free to ask the researchers any questions you may have.

Study Title: Prosody Characteristics in Young Children with Autism

Researcher and Title: Dr. Laura C. Dilley, Assistant Professor

Department and Institution: Communicative Sciences and Disorders, Michigan State University

Address and Contact Information: 116 Oyer Speech and Hearing, Michigan State University, East Lansing, 48824, ldilley@msu.edu

1. PURPOSE OF RESEARCH:

- You are being asked to participate in a research study aimed at learning more about human communication.
- You have been selected as a possible participant in this study because you have expressed an interest in participating and you meet our inclusion criteria of being a member of the MSU community with relevant native English or non-English language background.
- From this study, we hope to learn more about how the acoustic properties of speech permit spoken language to be perceived and understood. This data is useful for better understanding how spoken language is perceived and produced.
- In the entire study, approximately 30 people are being asked to participate.
- Your participation in this study will take between 15 minutes and 2.5 hours.
 - THE ESTIMATED AMOUNT OF TIME TO COMPLETE THIS STUDY IS ____ MINUTES.
- If you are under 18, you cannot participate in this study.

2. WHAT YOU WILL DO:

- If you agree to participate, then any of the following may happen.
- You may be asked to listen to sounds (e.g., speech or speech-like noises) or look at words or pictures on a computer screen, and make simple responses.
 - For example, you may be asked to say whether you heard a particular word, to respond whether you could tell two words or speech-like sounds apart, to transcribe the words that you heard, to speak or repeat a sentence, to name or click on a picture, or to do a similar task.
 - Responses will be made either by providing a written response, by pushing buttons and/or typing on a special response device or computer mouse/keyboard, or by making a verbal response.
- You may be asked to speak words or phrases. The words or phrases that you are asked to speak may either be scripted (i.e., written on a page or computer screen) or unscripted.
 - If speaking is required in this study, then your speech may be recorded for the purpose of acoustic analysis of the produced sounds and/or for generating materials for subsequent speech perception experiments. (See #5 for more information on recording.)
- After the study is over, you will be asked to fill out a form about your background and about the responses you gave during the study.
- The research findings are likely to be published in peer-reviewed research journals, and these are available to the public. The results of research study will not be provided to individual participants.

3. POTENTIAL BENEFITS:

- You will not directly benefit from your participation in this study. However, your participation in this study may contribute to understanding of how humans perceive and produce speech.
- The findings from this study will contribute to basic and applied science research on speech perception and production and may in turn help to direct future research on various speech-related disorders and speech-related technologies (e.g., automatic speech recognition by computer).

This consent form was approved by a Michigan State University Institutional Review Board. Approved 08/19/13 – valid through 08/18/2014. This version supersedes all previous versions. IRB # 13-518.

4. POTENTIAL RISKS:

- There are no foreseeable risks associated with participation in this study.

5. YOUR RIGHTS TO PARTICIPATE, SAY NO, OR WITHDRAW

- Participation in this research project is completely voluntary. You have the right to say no.
- Choosing not to participate or withdrawing from this study will not make any difference in benefits to which you are otherwise entitled.
- You may change your mind at any time and withdraw. If you withdraw before the experiment is completely over, you will be compensated with course credit or monetarily (as indicated below) commensurate with the amount of time you spent participating in the study.
- You may choose not to answer specific questions or to stop participating at any time.
- Whether you choose to participate or not will have no effect on your grade or evaluation.
- You will be told of any significant findings that develop during the course of the study that may influence your willingness to continue to participate in the research.

6. COSTS AND COMPENSATION FOR BEING IN THE STUDY:

- For participating in this study, you will receive the following form of compensation:
 - ☐ Course credit commensurate with time spent during study participation (2 Human Participation in Research credits per hour for offerings through the Psychology Department, or as outlined in course syllabus for offerings through the Department of Communicative Sciences and Disorders).
 - ☐ Monetary compensation at a rate of \$10/hr.
 - ☐ Volunteer (no credit or compensation)
- If monetary compensation is selected, payment for participation will take place within 3 weeks.

7. ALTERNATIVE OPTIONS

- If you are in a course taught by Dr. Laura Dilley, a research report may be performed in place of (rather than in addition to) research participation in order to earn research credits or extra credit. You are under no obligation to participate in this research study, and alternative options exist for being awarded course credit which do not involve study participation. These alternatives can be substituted without penalty. You are also free to choose whether you wish to receive course extra credit, research credits, or monetary compensation for participation.

8. CONTACT INFORMATION FOR QUESTIONS AND CONCERNS

If you have concerns or questions about this study, such as scientific issues, how to do any part of it, or to report an injury, please contact the researcher (Dr. Laura Dilley, 116 Oyer Speech and Hearing, Department of Communicative Sciences and Disorders, Michigan State University, ldilley@msu.edu, 517-884-2255).

If you have questions or concerns about your role and rights as a research participant, would like to obtain information or offer input, or would like to register a complaint about this study, you may contact, anonymously if you wish, the Michigan State University's Human Research Protection Program at 517-355-2180, Fax 517-432-4503, or e-mail irb@msu.edu or regular mail at 408 W. Circle Dr., Room 207 Olds Hall, MSU, East Lansing, MI 48824.

9. PRIVACY AND CONFIDENTIALITY:

- Your confidentiality will be protected to the maximum extent allowable by law.
- Data will be tracked and analyzed using a method that involves very low risk of revealing your identity.
- Each participant will be assigned an alphanumeric ID directly linked to your consent form which is identifiable only to investigators with access to consent forms and password-protected computer systems. This ID will be used for data coding and analysis.

This consent form was approved by a Michigan State University Institutional Review Board. Approved 08/19/13 – valid through 08/18/2014. This version supersedes all previous versions. IRB # 13-518.

- Your name appears on the consent form, which will be maintained in a secure filing cabinet, as well as on any reimbursement records or course rosters; your name will not appear elsewhere in our records. Reimbursement records and course rosters will not be directly linked to the alphanumeric ID.
- Throughout the project access to consent forms, reimbursement records, and course rosters will be limited to laboratory members, and access to data will be limited to authorized personnel. Authorized personnel include laboratory members (i.e., researchers and research staff), collaborators of Dr. Dilley, and the Institutional Review Board. Records will be stored in the Communicative Sciences and Disorders Department at MSU in secure filing cabinets accessible only to lab members for at least three (3) years after the end of the research project.
- The results of this study may be published or presented at professional meetings, but the identities of all research participants will remain anonymous.
- Check one box:
- Participants in this study:
 - ☐ will not be audio-recorded.
 - ☐ will be audio-recorded.
- If participants in this study are being audio-recorded, then being audio-recorded is a requirement of this study, and by consenting to this study, you consent to being audio-recorded.

10. DOCUMENTATION OF INFORMED CONSENT.

Your signature below means that you voluntarily agree to participate in this research study.

Signature

Date

You will be given a copy of this form to keep.

This consent form was approved by a Michigan State University Institutional Review Board. Approved 08/19/13 – valid through 08/18/2014. This version supersedes all previous versions. IRB # 13-518.

APPENDIX C: PROCEDURAL CHECKLIST

Part #: _____	Session: _____	Expt: _____	
Date: _____	Time: _____	Comptr: _____	Exprtr: _____

PROCEDURAL CHECKLIST - BEFORE START OF EXPERIMENT

FORMS:

- _____ You have removed the following forms from the file cabinet in **Oyer B1**.
- _____ 2 consent forms

COMPUTER:

- _____ Log-on to the computer [**Username: Dilly Research User, Password: MSUlab**].
- _____ **DO NOT:**
- _____ -**DO NOT** change the start-up settings (these are pre-set).
- _____ -**DO NOT** unplug the Ethernet cables (computers are unable to connect to the Internet).
- _____ -**DO NOT** change any screen settings (e.g. screen saver, power, etc.).
- _____ Make sure the **VOLUME** is set between the lines 1 & 2 (double click sound icon on taskbar).
- _____ Make sure all programs are **SHUT DOWN**.
- _____ Make sure the **HEADPHONES** are plugged in to the back of the computer tower.
- _____ Double-click the "**A&P**" folder on the desktop.
- _____ Double-click the "**Experiment**" folder in the **Prosody and Autism** folder.
- _____ Double-click the E-Run experiment
- _____ Enter the **Participant Number**: number and click **OK**.
- _____ Enter the **Version Number** (A&P_1 or A&P_2) click **OK**.
- _____ Confirm that you have correctly entered the Participant # and Session # and click **RUN**.

PARTICIPANT:

- _____ The participant has been asked to **TURN OFF** his/her cell phone and is seated at the computer. The participant should leave all personal items on the floor next to his/her desk.
- _____ Place the **Experiment in Progress** sign on the run room door.
- _____ Read the following to the participant:
- _____ **For this experiment, you will hear a number of speech clips over headphones. After each speech clip, we would like you to make a series of judgments about the speaker. Please know that your participation is voluntary and you may stop at any time if you feel your rights have been violated."**
- _____ Have the participant sign the **CONSENT FORM**.
- _____ Read the following to the participant:
- _____ **There will be one practice block with five speech clips like those in the actual experiment followed by a screen asking if you have any questions. Please use this time to clarify any questions you have before continuing on to the experimental block. The experimental portion will consist of 7 blocks with a one minute break in between each.**
- _____ **If you understand the instructions and have no questions at this time, please press the space bar to continue to the practice block.**
- _____ Ask the participant to put on the **HEADPHONES**. There is an **R** on the Right side and an **L** on the Left side.
- _____ **During the practice trials**, make sure the participant is performing the task correctly (see below).
- _____ Once complete, make sure the participant does not have questions.
- _____ -Check that the participant is typing answers to the practice questions.

WHILE THE EXPERIMENT IS RUNNING: REMAIN IN THE ROOM AND VIGILANT FOR THE DURATION OF THE EXPERIMENT!

RUNBOOK / FORMS:

- ___ In the runbook, fill out the first page information for the participant you are running. This includes the **Participant Number, Version Number, Experimenter, Date, Time** and **Computer**.

AFTER THE EXPERIMENT IS COMPLETE

COMPUTER:

- ___ Press the **F12/spacebar/enter** to exit E-Prime.

B&S Strategies:

- ___ Double-click the **"A&P Followup"** folder on the desktop.
- ___ Double-click the **"B&S"** folder in the **"A&P Followup"** folder.
- ___ Select **B&S_ A&P Followup**.
- ___ Enter the **Participant Number**:
- ___ Enter the **Version Number (A&P_1, A&P_2)** and click **OK**.
- ___ Confirm that you have correctly entered the Participant # and Version # and click **RUN**.
- ___ Press the **F12/spacebar/enter** to exit E-Prime.

AFTER ALL FORMS ARE COMPLETE

- ___ **Take the participant into the hall!** Give the participant a **BLANK** copy of the **CONSENT** and **DEBRIEFING**. Those are the participants' to keep. Briefly explain to the participant the main hypotheses for the experiment and the big picture scientific question (this is part of the educational component required by MSU).
- ___ **MAKE SURE TO THANK THE PARTICIPANT BEFORE HE/SHE LEAVES.**
- ___ Put the signed **Consent Form** in the correct folder in the filing cabinet in **Oyer B-1**.
- ___ There will be **TWO** new files in the **P&A** folder (an .edat file and a .txt file) within the experiment folder. They will be labeled with the **Name of the Experiment, Participant Number** and **Version Number**. Drag both of these new files into the **DATA** folder.
- ___ There will be **TWO** new files in the **B&S** folder (an .edat file and a .txt file) within the experiment folder. They will be labeled with the **Name of the Experiment, Participant Number** and **Version Number**. Drag both of these new files into the **DATA** folder.
- ___ **Wipe down** each computer with an antibacterial wipe and make sure the room is as neat (or neater) than when you came in.

OTHER:

- ___ Make sure the new data files for the experiment and the B&S survey are in the correct folder.
- ___ Copy the experiment data to the share drive (SHARE > PROJECTS > OTHER > PROSODY AND AUTISM > DATA)
- ___ **DO NOT** shut down the computer (this will automatically happen at midnight).
- ___ Shut down the computer monitor.
- ___ Any technical problems or other concerns have been documented in the **Comments** section.
- ___ **Make sure to give the participant CREDIT on the SONA system**

Comments:

APPENDIX D: AUTISM & PROSODY EPRIME INSTRUCTIONS

Autism & Prosody Instructions

INTRO

Thank you for participating in this study!

Press SPACE to begin.

For this experiment, you will hear a number of speech clips over the headphones. The speech clips are from a variety of children at different ages with varying language abilities. After each speech clip, we would like you to make a series of judgments about the speech you hear. These questions will include intelligibility (percentage of how intelligible the speaker is speaking), perceived age (how old do you think the speaker is), speech rate (how quickly or slowly the speaker is speaking), pitch (how high or low the speaker is speaking), animation (how animated or unanimated did the speech sound), and Autism diagnosis (how certain are you to whether the speaker has an autism diagnosis or typically developing). The transcript of the speech clip will be displayed on the screen while the clip is playing over the headphones.

Please press SPACE to continue.

Autism spectrum disorder is a neurodevelopmental disorder that is characterized by communication difficulties, social impairments, and restricted, repetitive, or stereotyped patterns of behavior. It is called a “spectrum” disorder because autism varies widely in the severity and symptoms that manifest. Many children with autism require intensive speech and language therapy to assist in the development of their communication skills.

Many children with autism have speech characteristics that sound different compared to a child of typical development. These differences can be heard as: an increase in speech rate, reduced production or overproduction of animation within the speech, and abnormally high or abnormally low pitch in the speech overall.

There will be one practice block with five speech clips similar to those in the actual experiment followed by a screen asking if you have any questions. Please use this time to clarify any questions you have before continuing on to the experimental block. The experimental portion will consist of 7 blocks of 20 trials with a one minute break in between each block.

If you understand the instructions and have no questions at this time; please press the space bar to continue to the practice block.

Are you ready?

Press SPACE to begin.

PRACTICE TRIALS

1. Assess the percentage of the utterance that is intelligible overall.

Scale: 1 = very unintelligible to 100 = very intelligible

2. How old do you perceive the speaker to be?

Enter in the perceived age in years and months

3. Assess the rate of speech of the speaker overall

Scale: 1 = very slow to 6 = very fast

4. Assess the level of pitch as appropriate for perceived age

Scale 1 = very low to 6 = very high

5. Assess the degree of animation of the speech overall.

Scale: 1 = not animated enough to 6 = too animated

6. Assess the certainty that the speaker has an Autism diagnosis.

Scale: 1 = certain no Autism diagnosis to 6 = certain Autism diagnosis

EXPERIMENTAL TRIALS

Now you will start the experimental trials. Please let the experimenter know now if you have any questions

Press SPACE to begin

BREAK TRIALS

You will now have a short break.

Please continue to answer the questions as you have practiced.

Press SPACE to continue.

LITERATURE CITED

LITERATURE CITED

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