Published in final edited form as:

Cogn Process. 2017 May ; 18(2): 205–209. doi:10.1007/s10339-016-0787-0.

Auditory Preference of Children with Autism Spectrum Disorders

Lynn Gilbertson,

University of Wisconsin - Whitewater, Roseman Building Room 1016, Department of
Communicative Disorders, Whitewater, WI 53190, 262-472-5202

Robert A. Lutfi, and

Auditory Behavioral Research Lab, Department of Communication Sciences and Disorders,
University of Wisconsin, Madison, Wisconsin 53706

Susan Ellis Weismer

Department of Communication Sciences and Disorders, Language Processes Lab, Waisman
Center, University of Wisconsin, Madison, Wisconsin 53706

Abstract

Research on children with Autism Spectrum Disorders suggests differences from neurotypical children in the preference for ‘social’ versus ‘nonsocial’ sounds. Conclusions have been based largely on the use of head-turn methodology which has various limitations as a means of establishing auditory preference. In the present study, preference was assessed by measuring the frequency with which children pressed a button to hear different sounds using an interactive toy. Contrary to prior results, both groups displayed a strong preference for the highly social sounds. These findings have implications for approaches to language intervention and for theoretical debates regarding social motivation.

Keywords

Autism; Listening Preference; Children

Introduction

Early intervention has been shown to improve the prognosis of children with Autism Spectrum Disorders (ASD) (Rogers and Vismara, 2008); however, the most beneficial method of intervention remains unclear (Paul, 2008). Tapping into the auditory strengths and preferences of children with ASD may well lead to an improved option for early language intervention as audition bears great significance in verbal speech acquisition; a lingering challenge for about 30% of children with ASD (Tager-Flusberg and Kasari, 2013).

Recent research on children with ASD has suggested some fundamental differences from neurotypical (NT) children in both the perception of and attentional preference for different sounds (Eponien et al., 2003, Dawson et al., 1998, Klin, 1991, Klin 1992, Kuhl et al., 2005). Research on hearing preference comparing ASD and NT children has often revealed

differences in orienting to ‘social’ versus ‘nonsocial’ stimuli (Dawson et al., 1998; Dawson et al., 2004; Paul et al., 2007). This research has largely been carried out using a head-turn response methodology. Using this method, Dawson et al. (1998, 2004) observed that children with ASD had fewer head turns to all stimuli than two comparison groups; however, the difference was greater for the social stimuli. Paul et al. (2007), also using the head-turn response method, found evidence suggesting that children with ASD share a similar preference with NT and developmentally delayed (DD) children for child-directed speech compared to rotated speech. Again, however, the ASD preference appeared not to be as strong as for the other groups.

Though the head-turn method has been the most common means of measuring auditory preference in ASD populations, there are acknowledged difficulties associated with the interpretation of the results from this method (Werker et al., 1997). First, the method relies on an independent observer to judge accurately whether or not the child has oriented to a sound. This can be difficult especially in ASD children who, by diagnosis, display uncommon reactions to stimuli. Second, one of the ‘red flag’ signs of a child with ASD is a failure to respond or orient to speech (Landry, 2004). Not surprisingly then, children with ASD have been found to exhibit fewer head-turn responses than NT and DD children, making it more difficult to measure a true difference in preference for sounds in the ASD group. Finally, and most importantly, the head-turn method relies heavily on the assumption of a strong association between preference and orientation to a sound, when in fact the child’s orientation to sound may be elicited for a variety of reasons unrelated to preference (e.g. distraction, startle, or even annoyance).

There are two studies known to the authors that have attempted to deal with these problems. Kuhl et al. (2005) attempted to deal with the first criticism by having the head-turn of the child activate desired sounds. This method eliminated the need for an independent judge, but required that the child be trained over a period of time to activate the sounds. Their results nonetheless indicated a preference for non-speech over speech stimuli. Klin (1991, 1992) adopted an entirely different approach that eliminated the need for a head-turn response altogether. Children initiated sounds by pressing one of two buttons on a toy. Preference was then measured in terms of the relative frequency with which the child chose one sound over the other. In separate studies Klin had children choose between mother’s speech or superimposed voices, and a children’s song or a synthetic hum. Results indicated that the children with ASD had a lower preference for mother’s speech than NT and DD children, but all the children preferred the children’s song.

The interactive button-press method holds promise as a means of studying auditory preference in ASD children inasmuch as it deals effectively with the major limitations of the head-turn response methodology. In the present study, the interactive button-press method was used in an attempt to answer the following questions: (1) Do ASD children have a preference for social/speech sounds over nonsocial/machine sounds? and (2) Do ASD children differ from NT children in their preference for these sounds?

II. Methods

A button-press sound-play procedure was used to obtain an objective measure of relative preference for social and nonsocial sounds. The distinction between social and nonsocial sounds in the ASD research literature is very similar to the distinction that has been made in the psychoacoustics literature between biological and non-biological sounds (Lutfi, 2008). Biological signals, such as vocalizations and song, most often have prosody; they typically vary in both intensity and pitch. Non-biological signals, such as mechanical sounds, more often lack prosody; they are usually monotone repetitive signals that are either constant or lacking in pitch. To explore this distinction, four classes of auditory stimuli were investigated: prosodic speech (PS, e.g. Jim Carey saying “Hello baby”), monotone mechanical sounds (MM, e.g. alarm buzzer), monotone speech (MS, e.g. Arnold Schwarzenegger saying “I’ll be back”) and prosodic mechanical sounds (PM, e.g. coo-coo clock sound). Ten exemplars of each auditory class (40 sounds altogether) were selected.¹

The acoustic stimuli were triggered by a keypad with four large (4×4 inch) pads corresponding to the four classes of auditory stimuli. Each depression of a key produced a different exemplar of the four corresponding sound classes. The keys of the keypad were the same color, texture, and size to control for visual and tactile differences that might serve to confound the acoustic variable. At the beginning of each session, the administrator of the test pressed each of the four keys at random (using the principle of Latin square design) so that the child heard one exemplar of each of the four classes of sounds and the data was not influenced by order of presentation. After the initial activation by the test administrator, the child was then allowed to interact with the keypad and advance through the sounds as desired. The only cues or prompts that were given included a second repetition of the sounds at random and a second demonstration on how to operate the keypad. Roughly one third of the children in each group required a second demonstration. The acoustic preference of the child was measured by counting the frequency with which the child activated each sound.

Altogether thirty children participated in the study. Sixteen children with ASD (age 24–46 months, mean=31.2) were recruited from participants enrolled in the Toddler Talk Project (Ellis Weismer, PI and Gernsbacher co-PI) at the Waisman Center, University of Wisconsin-Madison. ASD diagnoses were determined using comprehensive diagnostic evaluations by an interdisciplinary team that included the Autism Diagnostic Interview-Revised (ADI-R) (Lord et al., 1994) and Autism Diagnostic Observation Schedule (ADOS) (Lord et al., 1999). The control cohort of fourteen NT children (24–47 months, mean = 32) were recruited from the University of Wisconsin-Madison daycare facilities. Based on parent report, these children had typical development and normal hearing.

III. Results

Figure 1 provides the number of button presses corresponding to each sound category for each child in the two groups (ASD gray boxplots, NT white boxplots). Not included in the figure are 4 ASD children who did not respond to any sounds, and one ASD child who gave

¹Sounds used in the study can be made available by the authors on request.

in excess of 170 button presses, significantly more than any other child. The total number of key presses can be seen to be much lower for the ASD group across all categories compared to the NT group. The range of total button presses for the ASD group was 1–78 presses and the mean was 20.9 presses ($SD=25.2$). The NT group had a range of 6–81 total button presses and a mean of 42.3 presses ($SD=24$). Table 1 summarizes the total number of key presses (N_C) for each sound category for the NT and ASD groups for the data displayed in Figure 1. Since the N_C are distributed as multinomial frequencies, the multinomial distribution was used to compute the probability of the obtained N_C conditioned on different hypotheses H_i regarding the data (see Winkler and Hayes, 1975). The first hypothesis evaluated was the conclusion of Dawson and colleagues (1998, 2004), Kuhl et al. (2005), and Klin (1991, 1992) that there is a difference between the auditory preferences of the ASD and NT groups. We tested the null H_0 to this hypothesis by estimating the multinomial distribution for the NT group from the N_C for this group and computing the probability that the N_C for the ASD group was sampled from the same distribution as the NT group. The resultant probability $p(N_{C\text{ ASD}}|H_0) = 0.2977$ did not provide strong support for a difference in preference between the two groups. The same conclusion was drawn when the test was run including the 4 non-performers (0 button presses) and the one star-performer (greater than 170 button presses) in the ASD group ($p=0.2819$). The second hypothesis evaluated was that there are differences in the preference for sound categories within each group. The probability of the obtained N_C under the null to this hypothesis was $p(N_C|H_0) = .0089$ for the ASD group and $p(N_C|H_0) = .0024$ for the NT group, supporting the hypothesis of an existing preference for certain sounds. For both groups the most preferred sound category was the prosodic speech.

IV. Discussion

Consistent with past head-turn studies, the current study found a robust difference in the total number of responses between the ASD and NT groups – a result that attests to the strong methodological challenges of working with a heterogeneous ASD population. Unlike the head-turn studies, however, the current study found no strong difference between the ASD and NT groups in sound preference. We offer two possible explanations for the differences in these studies. First, the speech stimuli used in the present study may have been perceived as more “novel” by the children than those used in past studies. By using speech sounds that were unfamiliar to the children, a degree of interest and curiosity might have been generated leading to more interaction. A child participating in any of the aforementioned studies, for example, would be very familiar with the sound of their mother’s voice and find it easier to ignore the sound and continue with a more engaging activity rather than turning their head to find the location of the sound produced. Indeed, children with ASD have an exceptional ability to resist distraction and remain fixated on their current task (Gernsbacher et al., 2008; Venker, 2016). Using a speaker that the children have not heard before could have created more interest for the ASD group and motivated them to interact with the key pad.

An alternative interpretation for the difference in results across studies relates to the differences in methodology used. The studies by Dawson and colleagues (1998, 2004) and Paul et al. (2007) involved the subjective evaluation of the child’s orienting behavior, the

head-turn method. This method assumes that a child's orientation to a sound reflects their preference for that sound. However, as previously noted, multiple motivations could underlie a child's orientation, especially one that behaves atypically in social settings. The current study builds on the Klin (1991, 1992) interactive button-press method to provide a more objective measure of auditory preference. The interactive button-press method allows a child to actively select sounds of their own choosing, which most likely reflects their preference for those sounds. The method, moreover, eliminates the need for an independent observer's judgment regarding whether or not a child has oriented to the sound. Additionally, this active selection method eliminates the necessity of interacting with another person to elicit speech sounds. Although the initial activation and demonstration was completed by a member of the research team, subsequent sounds were produced without the need for a conversational partner. This de-coupling of prosodic speech sounds from the social situation may have allowed the children with ASD to expose the true acoustic preference without the influence of the interpersonal interaction.

The current study provides a behavioral paradigm for directly assessing the auditory preference of children with ASD for social versus nonsocial stimuli. Within the framework of social motivation research, findings from this study also could be viewed as contributing to our understanding of 'social seeking' in children with ASD by measuring the effort that they will expend (in this case, the number of button presses) in order to hear particular stimuli. Prior research by Dubey et al. (2015) has examined the social seeking component of social motivation by allowing adults with ASD to select movies of social (direct/averted) gaze versus nonsocial stimuli comprised of common objects. Analogously, the paradigm in the present study can be seen as an initial attempt to explore preference or social motivation in the auditory domain. Our findings of similar auditory preferences for the NT and ASD groups across social and nonsocial stimuli do not align with the social motivation theory of autism (Chevalier et al., 2012), however, further research is warranted prior to making broader theoretical interpretations.

With the increased prevalence of autism and the heightened awareness among parents, caregivers, and professionals (Chakrabarti and Fombonne, 2005), there is a greater need for therapeutic strategies that take into consideration the unique auditory preferences and abilities of the child with ASD. Through the utilization of the button-press task the current study encourages the development of a wider range of effective language-training programs for children with ASD. More specifically, the data suggests that language development in both NT and ASD children may be facilitated by using colorful and playful speech sounds to engage the child's interest.

Acknowledgments

This research was supported by NIDCD grants R01 DC001262 and R01 DC007223, and a University of Wisconsin Madison Hildale Undergraduate/Faculty Research Fellowship.

References

- eponien R, Lepistö T, Shestakova A, Vanhala R, Alku P, Näätänen R, Yaguchi K. Speech–sound-selective auditory impairment in children with autism: they can perceive but do not attend. *Proceedings of the National Academy of Sciences*. 2003; 100(9):5567–5572.
- Chakrabarti S, Fombonne E. Pervasive developmental disorders in preschool children: confirmation of high prevalence. *American Journal of Psychiatry*. 2005; 162:1133–1141. [PubMed: 15930062]
- Chevallier C, Kohls G, Troiani V, Brodtkin ES, Schultz RT. The social motivation theory of autism. *Trends in cognitive sciences*. 2012; 16(4):231–239. [PubMed: 22425667]
- Dawson G, Meltzoff A, Osterling J, Rinaldi J, Brown L. Children with autism fail to orient to naturally occurring social stimuli. *Journal of Autism and Developmental Disorders*. 1998; 28:479–485. [PubMed: 9932234]
- Dawson G, Toth K, Abbott R, Osterling J, Munson J, Estes A, Liaw J. Early social attention impairments in autism: social orienting, joint attention, and attention to distress. *Developmental Psychology*. 2004; 40:271–283. [PubMed: 14979766]
- Dubey I, Ropar D, de C Hamilton AF. Measuring the value of social engagement in adults with and without autism. *Molecular autism*. 2015; 6(1):1. [PubMed: 25705365]
- Gernsbacher M, Sauer E, Geye H, Schweigert E, Goldsmith H. Infant and toddler oral-and manual-motor skills predict later speech fluency in autism. *Journal of Child Psychology and Psychiatry*. 2007; 49:43–50. [PubMed: 17979963]
- Gernsbacher M, Stevenson J, Khandakar S, Goldsmith H. Why does joint attention look atypical in autism? *Child Development Perspectives*. 2008; 2:38–45. [PubMed: 25520747]
- Klin A. Young autistic children's listening preferences in regard to speech: a possible characterization of the symptom of social withdrawal. *Journal of Autism and Developmental Disorders*. 1991; 21:29–42. [PubMed: 1828067]
- Klin A. Listening preferences in regard to speech in four children with developmental disabilities. *Journal of Child Psychology and Psychiatry*. 1992; 33:763–769. [PubMed: 1376327]
- Kuhl PK, Coffey-Corina S, Padden D, Dawson G. Links between social and linguistic processing of speech in preschool children with autism: behavioral and electrophysiological measure. *Developmental Science*. 2005; 8:9–20.
- Landry R. Impaired disengagement of attention in young children with autism. *Journal of Child Psychology and Psychiatry*. 2004; 45:1115–1122. [PubMed: 15257668]
- Lord, C., Rutter, M., DiLavore, P., Risi, S. *Autism Diagnostic Observation Schedule*. Los Angeles, CA: Western Psychological Services; 1999.
- Lord C, Rutter M, Le Couteur A. Autism Diagnostic Interview-Revised: A revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *Journal of Autism and Developmental Disorders*. 1994; 24:659–685. [PubMed: 7814313]
- Lutfi, RA. Sound Source Identification. In: Yost, WA., Popper, AN., editors. *Springer Handbook of Auditory Research: Auditory Perception of Sound Sources*. New York: Springer-Verlag; 2008. p. 19-28.
- Paul R. Interventions to improve communication in autism. *Child and Adolescent Psychiatric Clinics of North America*. 2008; 17:835–856. [PubMed: 18775373]
- Paul R, Chawarska K, Fowler C, Cicchetti D, Volkmar F. Listen my children and you shall hear: auditory preferences in toddlers with autism spectrum disorders. *Journal of Speech, Language, and Hearing Research*. 2007; 50:1350–1364.
- Rogers S, Vismara L. Evidence-based comprehensive treatments for early autism. *Journal of Clinical Child & Adolescent Psychology*. 2008; 37:8–38. [PubMed: 18444052]
- Tager-Flusberg H, Kasari C. Minimally verbal school-aged children with autism spectrum disorder: The neglected end of the spectrum. *Autism Research*. 2013; 6:468–478. [PubMed: 24124067]
- Venker CE. Spoken word recognition in children with autism spectrum disorder: The role of visual disengagement. *Autism*. 2016 published Online First. 1362361316653230.
- Werker J, Polka L, Pegg J. The conditioned head turn procedure as a method for testing infant speech perception. *Early Development and Parenting*. 1997; 6:171–178.

Winkler, RL., Hays, WL. Statistics: Probability, Inference, and Decision. New York: Holt, Rinehart, and Winston; 1975. p. 223-224.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Figure 1.

Filled symbols give the number of button presses for each child in each group (ASD gray boxplots, NT white boxplots) corresponding to each sound category (MM: Monotone-Machine, PM: Prosodic-Machine, MS: Monotone-Speech, PS: Prosodic-Speech). Not included are 5 children from the ASD group, one who gave in excess of 170 button presses and four others who did not respond.

Table 1

Distribution of Key Presses Per Sound Category

Group	Monotone Machine	Prosodic Machine	Monotone Speech	Prosodic Speech
ASD	51 (22%)	53(23%)	58 (25%)	68 (30%)
NT	137 (23%)	145 (25%)	127 (21%)	183 (31%)

Total number of ASD and NT key presses for each sound category from Figure 1. Numbers in parenthesis indicate corresponding percentage of key presses.