Auditory Preferences of Children with Autism

Rana Tabrizi
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Advisors: Dr. Karen Pierce & Dr. Sarah Creel, Micah Bregman

ABSTRACT

Early diagnosis of an Autism Spectrum Disorder is a powerful tool used by families and researchers to improve the course of treatment and learn more about the causes of the disorder. The more broad we make our diagnostic procedures to include several sensory modalities in our inquiries, the more potential we have for creating a robust diagnostic process. The current study uses eye tracker methodologies to explore auditory preference in toddlers ages 13 to 45 months using a gaze-contingent display. Subjects are analyzed between and within three groups: ASD, typically developing, and language delay/developmental delay. Results show a trend with no statistical significance that mean preference for infant-directed speech when paired with repetitive music is greater for typically developing children than for children with an ASD. Results also show a trend that receptive language ability is negatively correlated with preference for infant-directed speech. Additional data must be collected in order to make conclusions about trends for a larger population.

INTRODUCTION

Social communication is one of many fundamental capacities that infants utilize during early development. When deficits in communication exist, a profound challenge may arise in interactions with surrounding individuals and the environment. One of the hallmark features of autism is this difficulty with communication, and with a rising prevalence of the disorder, researchers and families alike have become increasingly eager to find early diagnostic measures that pertain to the three main deficits of autism: reduced social interaction, deficits in communication, and "restrictive and/or repetitive interests and behaviors" (1).

As two of the hallmark features of autism, the study of abnormalities in social attention and repetitive interests and behaviors has been crucial to exploring the causes of the disorder. Scientists have discovered that while abnormalities in social attention may manifest themselves later in life, their prevalence can be seen as early as a child's first year (3). This fundamental observation highlights the importance of studying infant development; by exploring social attention and repetitive interests and behaviors in toddlers, we increase the likelihood of diagnosing autism during the first few years of life, therefore making the potential impact of treatment considerable.

Much of the current body of research has focused upon the visual domain. If researchers seek to find early diagnostic measures that are as robust as possible, however, they may look to include other sensory modalities such as the auditory domain in their investigations. Interestingly, parents often rely on audition and social attention to facilitate language development in children early on in life through a phenomenon called "infant-directed speech." Because children with autism have difficulties with social

attention, the study of this speech may be a key to informing our understanding of language difficulties associated with the disorder.

This unique speech formerly known as “motherese” is characterized by an “exaggerated intonation” thought to aid language development (2). Importantly, infant-directed speech has been characterized not only by its social and emotional saliency, but also by the degree to which it attracts the attention of the infant. Because one of the functions of infant-directed speech is to draw social attention to language and affect, preference for this speech provides a unique and natural lens through which to study the typicality of the development of social attention in infants. Fernald and Kuhl have shown that, when given the choice, typically developing four-month-olds prefer to listen to motherese as opposed to adult conversational speech (2). Because of known deficits in the realm of social communication within the autistic population, there is reason to hypothesize that preference patterns for infant-directed speech will vary from that of typically developing infants. Kuhl and colleagues show evidence of this in their 2005 study with 2-4 year olds; toddlers with ASD showed a preference for non-speech analog signals as opposed to infant-directed speech, which differed from the preferences of typically developing (TD) toddlers. In the current study, I aimed to see if differences in preference for infant-directed speech versus “monotone speech” between ASD and TD groups extends to an even earlier time period of thirteen months, in hopes of yielding a diagnostic measure even earlier on in life.

If children with ASD are hypothesized to show less of a preference for infant-directed speech, then what might they show more of a preference for? Lai and colleagues have shown that functional systems in the brain that process speech and song are more

engaged in reaction to song in children with ASD than in typically developing children (4). In the second part of my paradigm, I have explored whether this preference translates into the behavioral domain by studying preference for music. Studies by Pierce and colleagues have given us reason to integrate exploration of the third criteria of autism (restrictive interests and repetitive behaviors) into this part of the paradigm as well. In their 2011 study, Pierce and colleagues stated that children with autism "often prefer to attend to visual repetition," as manifested in their preference to look at geometric images when contrasted with more social images of children doing yoga (5). In order to see whether this preference for visual repetition also translates into the auditory domain, I have made the musical stimulus of the second paradigm a repetitive sequence.

In order to carry out such investigations, a methodology must be used to measure preference. Several of the aforementioned studies used head-turn in order to accomplish this, however in order to improve the ease of potential replication, other methodologies are useful to explore. Eye tracking technology is an effective medium in gathering data, theoretically, from participants of varying functional abilities and ages (5). Additionally, Klin and colleagues have proven that a preferential looking design geared towards infants is a reliable method of exploring indicators of autism early in life (6). Using the auditory mode as an accessible domain of study, markers of social attention deficits and repetitive and restrictive behaviors have been studied in a fresh light. The methodological challenges of testing preference in infants have been approached by utilizing an innovative gaze-contingent display. Such an approach allows eye fixation on certain images to activate specific auditory stimuli (in this case infant-directed speech and musical excerpts), to measure toddler preference.

Purpose

By measuring preference for infant-directed speech and repetitive music, this study aims to find patterns of differences in auditory preference between toddlers with an ASD and those who are typically developing. Firstly, the designed eye tracking paradigm aims to examine the degree to which toddlers with autism prefer infant-directed speech. Additionally, the study will explore the degree to which they prefer repetitive musical stimuli in comparison with typically developing toddlers, or toddlers with different developmental delays. The aim of finding patterns of response within either of these domains is to use these behavioral markers in tandem with other assessment tools to structure a more robust group of diagnostic measurements of autism.

APPROACH AND METHODS

Participants

The study was conducted using a group design: 116 toddlers between the ages of 13-45 months were tested. Following each eye tracker session, the children received their diagnoses. Data from children meeting criteria for an Autism Spectrum Disorder (ASD) were placed in one group, children with a language or developmental delay (LD or DD) were placed in another group, and children who were typically developing (TD) comprised the third group, with children not meeting any of these criteria in a fourth group. At risk subjects were gathered using a population-based screening method used in pediatrician offices, known as the 1-Year Well-Baby Check-Up Approach (K.P., C. Carter, PhD, M. Weinfeld, PhD, D., R.H., R. Bjork, MD, N. Gallagher, BA, unpublished data, 2006-2009). This screening method is used to recruit infants at risk for an ASD, LD,

and DD from the age of twelve months, while the TD controls are gathered from community referrals. Each of the subjects was administered a variety of tests within several two-hour sessions which include the Autism Diagnostic Observation Schedule-Toddler Module (ADOS-T) and the Mullen Scales of Early learning (7). These standardized assessments were administered by psychologists who determine the status of the subjects' diagnoses.

Apparatus, Stimuli, and Procedure for Data Acquisition

APPARATUS

The machine utilized for this paradigm is a Tobii T120 eye tracker, which uses infrared light sources and cameras in tandem with a 17-inch-thin film transistor monitor. The eye tracking machine uses corneal reflection to record the eye position of the infants at a frequency of 120 Hertz. In order to create the gaze-contingent display, the software E-Prime 2.0 and E-Prime Extensions for Tobii were utilized to work in tandem with the eye tracker. Data was collected through the E-Prime software, and subsequently extracted and analyzed to observe potential effects in the tested population.

STIMULI

The research paradigm consisted of two portions; the first consisted of a trial period during which the infant is familiarized with the concept of gaze-contingent display. Two similar images of the same animal are projected onto the screen. Each image is associated with a respective auditory sample throughout the entirety of the experiment (one image is paired with infant-directed speech while the other is paired with monotone speech);

fixation of the infant on an image causes one of two distinct sound files to play. During the trial period, the display is not yet gaze-contingent. Each image appears alone while an excerpt of its sound file plays with the aim of allowing the child to learn the association between the image and the auditory stimulus. It is important to note that the images differ only slightly, in the shape of the hat they are wearing, so that the preference for the auditory stimuli is measured rather than preference for the images that are associated with them.

Following the trial period in the first paradigm, fixation on one image activated infant-directed speech, while fixation on the other image activated monotone speech, or speech lacking "exaggerated intonation." Both samples were recorded by the same female volunteer who spoke the same text, and both speech samples were fixed for loudness through Audacity audio-editing software.

During the second half of the experiment, children were presented with a different set of images, this time with the purpose of measuring preference for repetitive musical stimuli. In an identical design to the first portion of the paradigm, children's eye-gaze activated distinct stimuli following a trial period. One image caused an excerpt of infant-directed speech to be played (the same speech sample from the first paradigm), while the other image caused a repetitive musical stimulus to be played. The musical stimulus was written and recorded using Finale Notation software, and was characterized by the repetition of the first three tones of a major scale, with a consistent synthesized piano timbre and rhythm. Both samples were again fixed for loudness through Audacity audio-editing software. Each child was only run on one of the two paradigms, as not to expose a single child to the same infant-directed speech sample twice in the same session.

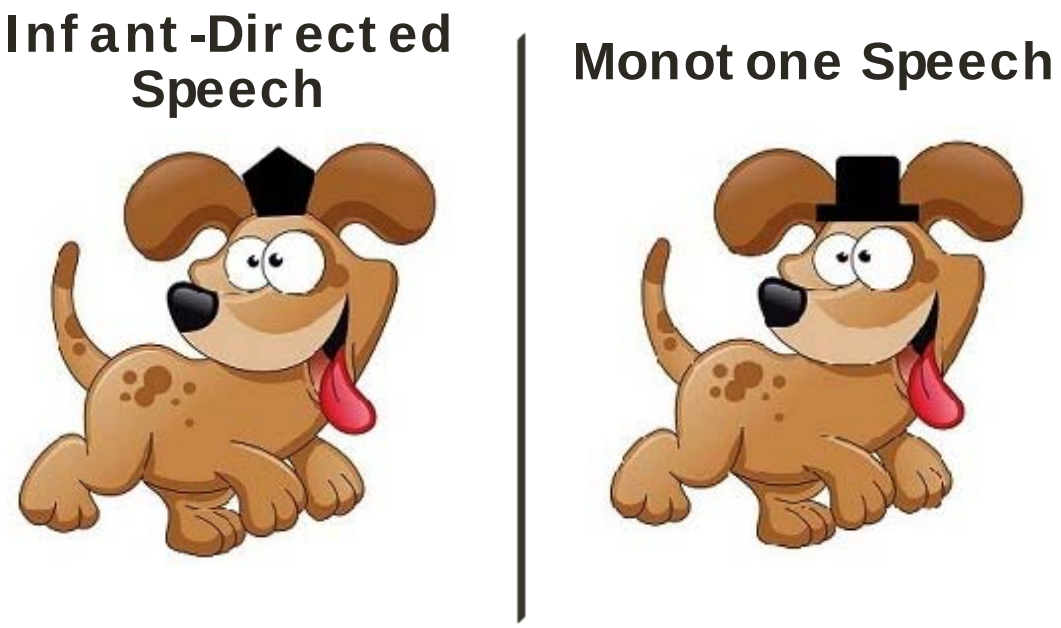

Figure of Stimuli Paradigm 1: Images presented to the subjects during the experiment. Fixation on either image activates the corresponding sound file (for clarity, the type of auditory stimulus is indicated here above the image)

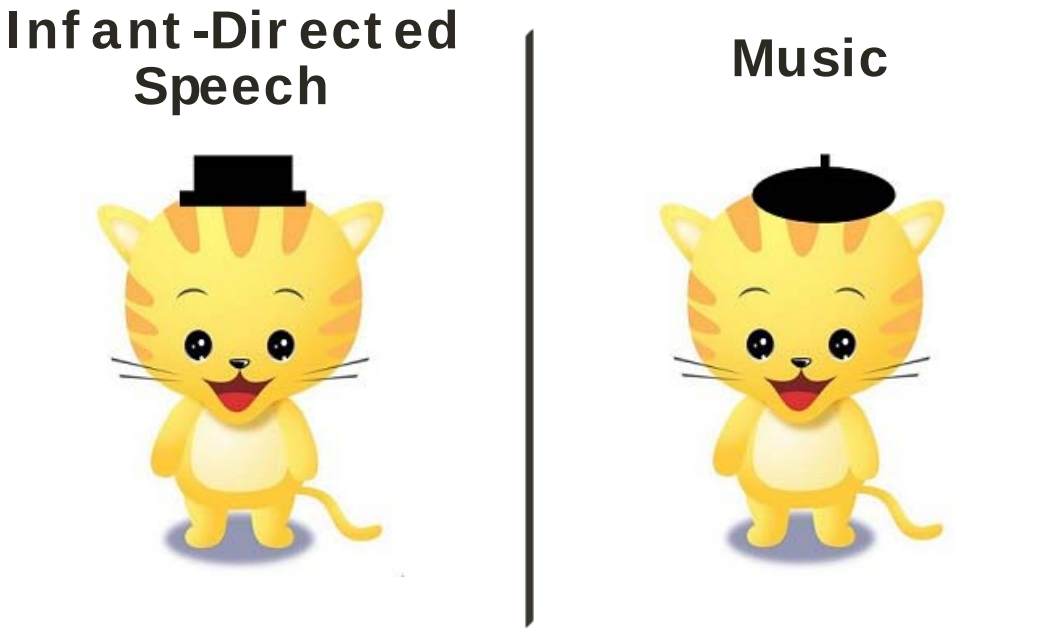

Figure of Stimuli Paradigm 2: Images presented to the subjects during the experiment. Fixation on either image activates the corresponding sound file (for clarity, the type of auditory stimulus is indicated here above the image)

PROCEDURE

Infants were placed on the laps of their parents, 60 cm from the eye tracking machine. Parents were informed of standardized instructions to follow during the running of the paradigm. Firstly, the infants' eyes were calibrated with the presentation of a red spot at five different locations on the eye tracking screen. If the quality of the calibration was poor the procedure was repeated, and if the quality failed to improve then the experiment would be terminated. A "live tracker" was used by the experimenters to view the location of the subjects' eyes for proper positioning before calibration began (5).

RESULTS

Fixation data was calculated using a 35-pixel radius filter. Percentage of fixation time served as the primary dependent variable for the paradigm. Before statistical tests were done data were excluded, in part for the following reasons: amount of total looking time was less than fifty percent of the experiment time; subjects did not fall into a category of ASD, LD, or DD; or the child was fussy. Following exclusion, the following subject totals remained: Paradigm 1 (N=16, ASD=4 subjects, Controls=7 subjects, LD/DD=2 subjects, Other=3 subjects), Paradigm 2 (N=39, ASD=10 subjects, Controls=12 subjects, LD/DD=5 subjects, Other Diagnoses=12 subjects).

In order to compare fixation time between the tested groups, a one-way analysis of variance was used. As expected, controls showed greatest mean looking time for infant-directed speech, followed by LD/DD, followed by ASD. These results were trending but not statistically significant. Correlations were also calculated between infant-directed speech and several clinical scores from the subjects' diagnostic sessions. Across all

groups, no statistical significance was found for correlations between preference for infant-directed speech and the following measures: expressive language scores, restrictive and repetitive behavior scores, and early learning composite scores/developmental quotient.

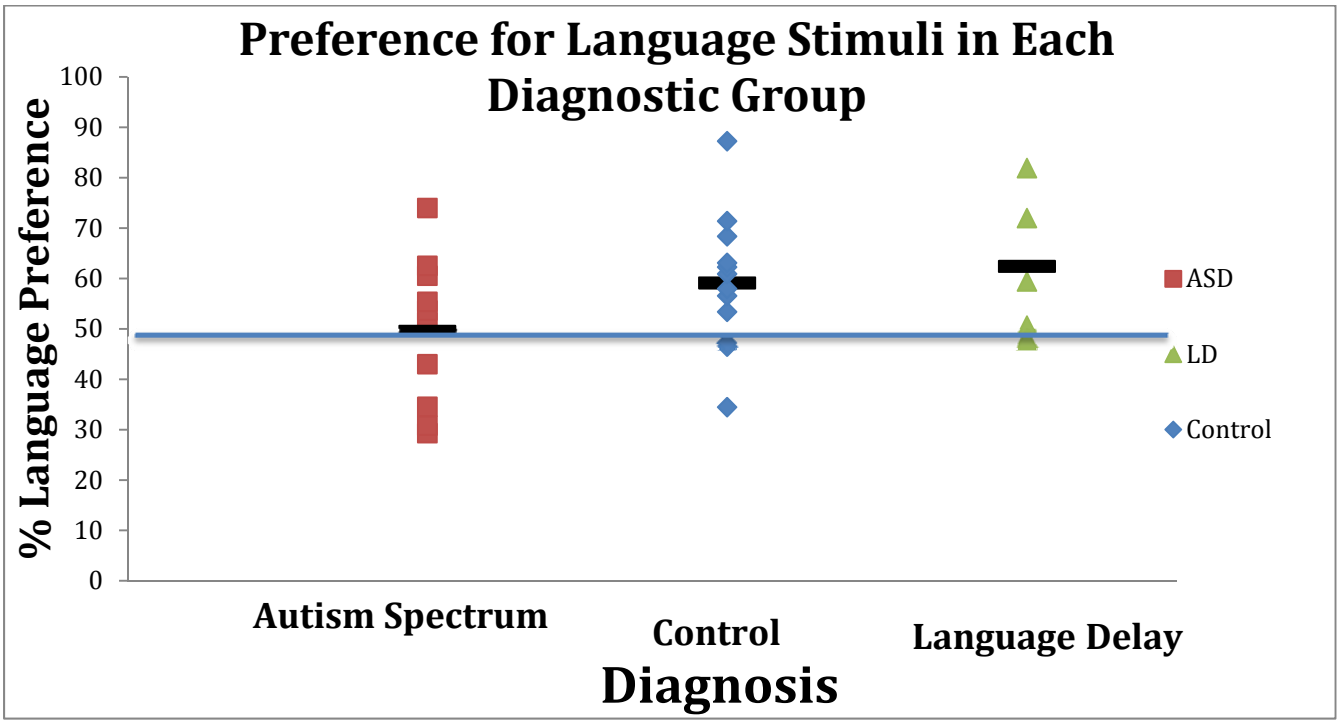

Figure: Analysis of diagnosis against percent language preference. Controls show highest preference, followed by toddlers with a LD/DD, followed by toddlers with ASD. Results are trending, but do not show statistical significance.

Contrary to my hypothesis, within the ASD group there was a trend in negative correlation between preference for infant-directed speech and receptive language scores on the Mullen Scales of Early Learning, although this result was not statistically significant. For the ASD group, r=-.68, P=.06. For the control group, r=.40, P=.25.With the gathering of more data, more concrete results may be able to be made, although it is apparent that there is a different correlation between groups when comparing receptive language scores to preference for infant-directed speech.

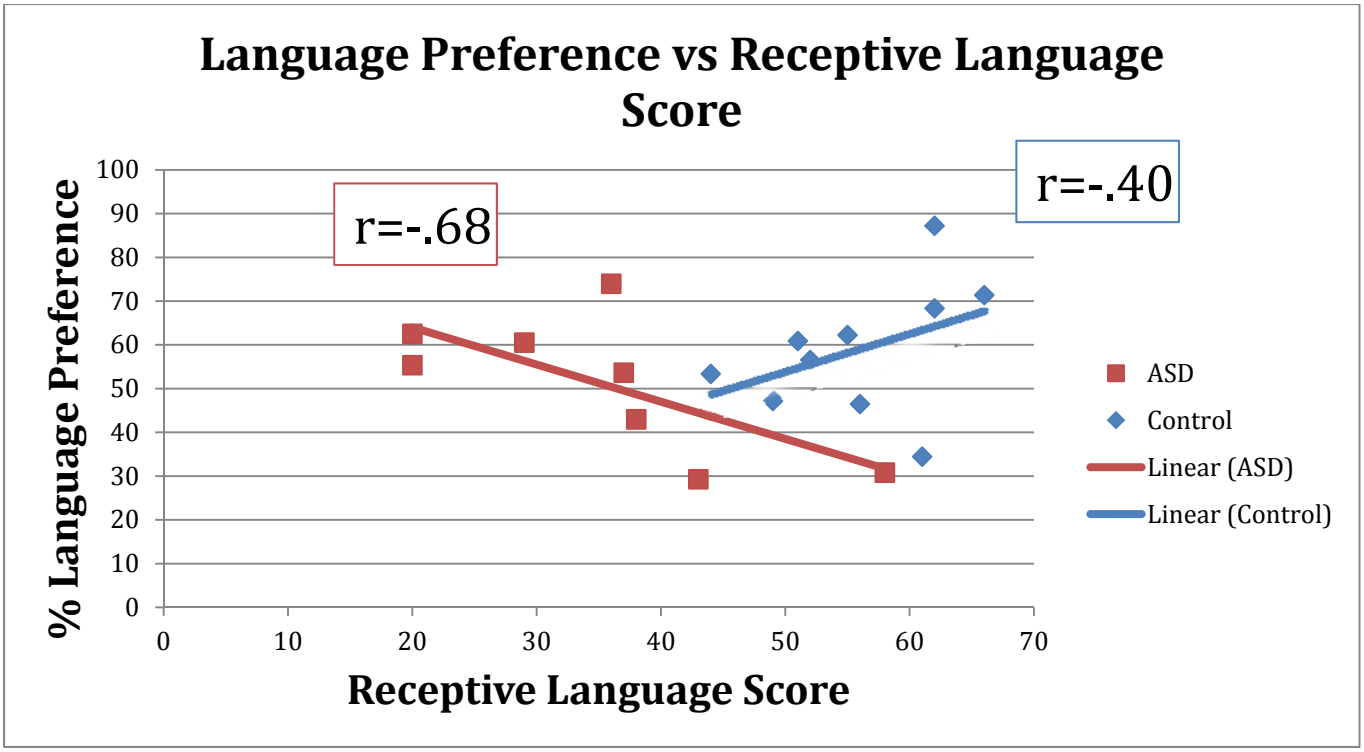

Figure: A trend shows a negative correlation between receptive language scores and percent language preference in toddlers with ASD. No trend is seen in this correlation in the typically developing (control) group.

DISCUSSION

As hypothesized, there was a trend in greater preference for the musical stimuli in the ASD group than the control and LD/DD groups. Should this pattern emerge as statistically significant in a larger sample size, then there may be further investigation into this paradigm as a distinguishing factor between groups for diagnostic measures.

The correlational studies show that receptive language is negatively correlated with preference for infant-directed speech. Although the results within the ASD group were contrary to my hypothesis, it is advantageous to note that there may be a noticeable difference between the two groups in their correlation between preference and R_L scores. If a similar pattern emerges in a larger subject pool, then these eye tracking

paradigms may guide further research to explore why differences in these preferences may occur, and may inform further diagnostic procedures. By studying two of the principal features of autism through the auditory domain in infancy, we may be one step closer to foreseeing a deviation in development through diagnosis, which may lead to the slowing or altering of the progression of the disorder through specialized treatment.

References

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