Georgia State University
ScholarWorks @ Georgia State University

Psychology Honors Theses

Department of Psychology

1-6-2009

The Effect of Auditory Sensory Abnormalities on Language Development in Young Children with Autism Spectrum Disorder

Melissa Tatyana Nikolic

THE EFFECT OF AUDITORY SENSORY ABNORMALITIES ON LANGUAGE DEVELOPMENT IN YOUNG CHILDREN WITH AUTISM SPECTRUM DISORDER

by

MELISSA NIKOLIC

Under the Direction of Diana Robins, PhD

ABSTRACT

Autism Spectrum Disorder (ASD) is a developmental disorder characterized by atypical development in the domains of social, emotional, language and cognitive functioning in the first few years of life. Research indicates an associated phenomenon of sensory processing abnormalities in the ASD population (Baker, Lane, Angley, & Young, 2008), and specifically auditory domain (Tecchio et al., 2003) which may relate to language deficits (Baranek, David, Poe, Stone & Watson, 2006). This study researched the effect of auditory sensory abnormalities on language in young children with ASD (n = 118), specifically receptive and expressive language and prosody. A specific subdomain of auditory abnormalities, sensory seeking, was found to be predictive of expressive language (β = .30, p=.009), perhaps due to a focus on auditory stimuli to the exclusion of expressive language interaction. There was no significant effect for receptive language (β = .16, p=.16) and prosody (β = -.09, p=.493).

INDEX WORDS: Autism, Sensory Abnormalities, Auditory, Language, Expressive, Receptive, Prosody, Children

THE EFFECT OF AUDITORY SENSORY ABNORMALITIES ON LANGUAGE DEVELOPMENT IN YOUNG CHILDREN WITH AUTISM SPECTRUM DISORDER

An Honors Thesis

Presented in Partial Fulfillment of Requirements for Graduation with
Undergraduate Research Honors, Georgia State University

2008

by

Melissa Nikolic

____
Dr. Diana Robins, Honors Thesis Director

____
Dr. Robert Sattelmeyer, Honors Program Director

____
Date

THE EFFECT OF AUDITORY SENSORY ABNORMALITIES ON LANGUAGE DEVELOPMENT IN YOUNG CHILDREN WITH AUTISM SPECTRUM DISORDER

by

MELISSA NIKOLIC

Honors Thesis Director: Dr. Diana Robins
Honors Program Director: Dr. Robert Sattelmeyer

Electronic Version Approved:

Honors Program
Georgia State University
December 2008

ACKNOWLEDGEMENTS

I would like to foremost acknowledge the excellent mentorship of Dr. Diana Robins, without whom this work would not have been possible. I offer my profound thanks to Dr. Robins for her patience, encouragement and support. I would also like to offer my great appreciation to Lisa Wiggins for her statistical support and feedback. Thank you to Lauren Stites and Jamie Zaj for their support and encouragement. Lastly, I thank my family and friends whose support means the world to me.

TABLE OF CONTENTS

LIST OF TABLES

Introduction

History

Autism was first defined by Leo Kanner in his monumental clinical description of children with "autistic disturbances of affective contact" (Kanner, 1943 as cited in Volkmar & Klin, 2005). The features of Kanner's description of autistic disorder, validated empirically, are social isolation, resistance to change and dysfunction in communication (Volkmar & Klin, 2005). In 1980, the designation of Pervasive Developmental Disorder (PDD) was added to the Diagnostic and Statistical Manual of Mental Disorders – edition III (American PsychiatricAssociation, cited in Cohen & Volkmar, 1997). Recently PDD has become more commonly referred to as Autism Spectrum Disorders (ASD; Eaves, Ho, & Eaves, 1994; Paul, Chawarska, Fowler, Cicchetti, & Volkmar, 2007). This term came to encapsulate the various developmental disorders characterized by difficulties in the domains of social, emotional, language and cognitive functioning in the first few years of life (Volkmar, 2005). Social interaction is impaired in nonverbal communication, eye contact, facial expression and body posture, the lack of developed relationships with peers, limited spontaneous gestures, pointing, showing objects of interest, and impaired emotional reciprocity. Communication impairments include delay or lack of language, expressive and receptive, repetitive use of language, and lack of make-believe play. Stereotyped behaviors include restricted patterns of interest and intense focus on particular interests, rigid adherence to routines and repetitive motor behavior (i.e. flapping hands). By the revised edition of the DSM-III-R, in 1987, autism was seen as the model of PDD, as the most thoroughly defined disorder under the PDD umbrella. In 1994 PDD-NOS (Pervasive Developmental Disorder-Not Otherwise Specified) was added to the DSM-IV, in addition to Childhood Disintegrative Disorder, Asperger's Disorder and Rett's Disorder (Cohen, 1997). Although variations in symptomatology occur within the ASD umbrella, social impairment is the defining characteristic across the spectrum (Paul, 2007). The prevalence rates for PDD in England are 1 in 166 children (Chakrabarti & Fombonne, 2005) and in the United States it is 1 in 150 children (CDC, 2007). In this paper ASD will refer to the pervasive developmental disorders of autism, Aspergers Syndrome and PDD-NOS.

Sensory Abnormalities

The question of sensory abnormalities in children with ASD has been discussed since the outset of clinical observations into the disorder (Kanner, 1943 as cited in Volkmar & Klin, 2005). The theory of Sensory Integrative Dysfunction was offered by Jean Ayres (Ayres, 1972, as cited in Schaaf et al., 2005) to explain her observations of children with learning disabilities who experienced difficulties in "processing and integrating sensory information" (Schaaf et al., 2005). Ayres theorized about the potential relationships between sensory input, including visual, auditory and tactile, and how the brain receives and integrates this information resulting in behavioral output (Schaaf et al., 2005). She additionally related sensory issues to children with ASD (Ayres & Tickle, 1980). From a neuroscience perspective the brain integrates information via input, perception, processing and output of stimuli. Environmental stimuli enter the brain (input via afferent neurons), are perceived and processed (interneurons in neural systems) and a response is produced (output via efferent neurons). It is within the sensory-specific neural systems that a stimulus is perceived and processed.

Today the phenomenon of sensory abnormalities in individuals with ASD has been documented by numerous researchers (Baker, Lane, Angley, & Young, 2008; Baranek, Boyd, Poe, David & Watson, 2007; Dunn, Myle, & Orr, 2002; Kern et al., 2006; Leekam, Nieto, Libby, Wing & Gould, 2007; Liss, Saulnier, Fein, & Kinsbourne, 2006; Rogers, Hepburn, & Wehner, 2003;). Dunn (2002) looked at the patterns of sensory patterns in children (n=42) with Asperger Syndrome (AS) and a typical developing control group (n=42). A group comparison design was employed utilizing the Sensory Profile (Dunn, 1999), a parent report, to quantify sensory processing. The Sensory Profile, a validated measure, consists of 125 questions related to sensory events occurring in a typical day. It measures sensory processing, behavioral and emotional responses, modulation and hypo/hyperresponsiveness to events. Dunn (2002) found that children with AS had problems with auditory processing and poor modulation (i.e. emotional reactivity).

Rogers (2003) utilized the Short Sensory Profile (Dunn, 1999) and compared the sensory processing of four different groups of children (Autistic Disorder, Fragile X syndrome, developmental delay and typical development). Mean age for the developmentally challenged groups was 31 months and typically developing 19 months, in order to have an approximate mental age match between the groups. Rogers (2003) found that children with autism and fragile-X had significantly higher scores then the other two groups in 5 of the 7 sensory domains (auditory filtering, stimulation and visual/auditory sensitivity, tactile sensitivity, taste/smell sensitivity, movement sensitivity, low energy/weak and underreactive/seeks stimulation and visual/auditory sensitivity). Children with autism also had significantly higher scores in tactile sensitivity and auditory filtering.

Leekam (2007) utilizing the Diagnostic Interview for Social and Communication Disorders, found over 90% of the autism group studied exhibited sensory abnormalities, with only 6% of the group not being affected by these abnormalities. The strengths of these three studies are the use of matching control subjects. The Leekam (2007) study additionally performed parent interviews by clinicians who did not know the diagnosis of the subjects.

Hyperresponsiveness to sensory stimuli was found in young children with autism, resulting in an aversion or avoidance of new sensory experiences (Baranek, Boyd, Poe, David & Watson's, 2007).

For a literature review in support of autism and sensory abnormalities see Iarocci and McDonald (2006) and for a critical review see Rogers and Ozonoff (2005). The basic premise behind the Rogers and Ozonoff critique is that there are too few studies into sensory abnormalities and those that exist are flawed methodologically. In short, they lack the rigor of other endeavors. A major issue cited is that research utilizing parent surveys can be flawed based on parent memory and interpretations. Also, they question the choice of controls for the studies. The best choice, to establish characteristics specific to autism, is to match equivalent age and IQ scores. They take issue with older experimental designs with questionable measure reliability and validity. They also make the point that small sample size makes generalizability difficult. Additionally, Rogers and Ozonoff (2005) state that auditory processing of stimuli is not the same as sensory reception of the stimuli.

Auditory Processing and Abnormalities

Auditory deficit may provide some of the first signs of autism in young children (Baghdadli, Picot, Pascal, Pry, & Aussilloux, 2003). Deficits in auditory processing can vary in origin. Research into auditory processing in individuals with ASD has utilized techniques measuring event-related potentials (ERP). ERP measures the level of activity in the auditory cortex, auditory association areas and those areas that process memory and other higher order cognitive processes (Bomba, 2004). ERP also measures sound intensity and frequency (Ceponiene, Lepisto, Shestakova, Vanhala, & Alku, 2003). The more intense the sound waves produced by strong vibrations, the louder the sound (Carlson, 2008). Frequencies of different vibrations, measured in hertz (Hz) or cycles per second, allows for the distinction between sounds to be made.

Abnormalities in processing of auditory information have been found to occur in children with ASD (Minshew, 1996; Tecchio, Benassi, Zappasodi, Giallorieti, Palermo, et. al. 2003). ERP studies have found specific abnormalities related to atypical sound reception and discrimination (Jansson-Verkasol et al., 2005), auditory sensory memory (Tecchio et al., 2003) and lack of mismatch negativity (MMN) in preschool children with ASD (Kuhl, Coffey-Corina, Padden & Dawson, 2005), specifically in children with more severe symptoms. Kuhl (2005) hypothesized that this may be due to central auditory deficits impacting the ability to process speech changes. Hypotheses for auditory processing abnormalities implicate auditory cortex functioning (Lincoln, Courchesne, Harms, & Allen, 1995) or temporal cortex dysfunction (Ferri, Elia, Agarwal, Lanuzza, Musumeci, et al, 2003). O'Riordan and Passetti (2006) suggest that the same elements which make auditory discrimination in people with autism more acute may also produce negative reactions from certain sounds. Their study did replicate previous research supporting the "enhanced" auditory discrimination of stimuli in autism. Hyperacusus (oversensitivity towards certain auditory stimuli) has also been found in children with autism (Rosenhall, Nordin, Sandstrom, Ahlsen, & Gillberg, 1999; Khalfa et al., 2004). Khalfa (2004) surmises that "disordered loudness processing" could have a relationship to atypical behavior and electrophysiological abnormalities.

Language

Auditory sensory abnormalities in ASD is an important research topic as there is a proposed link to language problems (Baranek, David, Poe, Stone & Watson, 2006). Acoustic input also plays an important role in language processes (Aydelott, 2006). One of the first signs of autism that parents seek out assistance for is delayed language (Lord & Paul, 1997; De Giacamo & Fombonne, 1998; Chawarska et al., 2007). Late speech onset was found in 41 of 101 children with high-functioning PDD (Sturm, Fernell, & Gillberg, 2004). Kjelgaard and Tager-Flusberg (2001) make the point that the study of language problems is crucial to understanding autism.

This study will look at receptive language, prosody and expressive language. Receptive language is defined as the "ability to comprehend or understand the meaning of words or sentences heard" (Cantwell & Baker, 1987, p. 15). Prosody is defined as "melodic features of speech, superimposed on the ongoing stream of speech, which signal differences in meaning" (Cantwell, 1987, p. 15), including pitch, the voice's frequency/tone during speech, and stress, increase in emphasis on syllables (Cantwell, 1987). Expressive language (expression) is defined as the "process of formulating ideas into words and sentences in accordance with the set of grammatical and semantic rules of the language" (Cantwell, 1987, p 12).

The typical trajectory of language development is seen in the following progression, at 12-15 months expressive vocabulary is 10 words. By 18 months that number is up to 100, on average, and 300 words by 24 months. That number is tripled just a year later (Tager-Flusberg, Paul & Lord, 2005). For receptive language vocabulary at 12-15 months, on average, is 50 words. At 18 months that vocabulary has increased six times that amount to 300 words (3 times the amount of expressive vocabulary) and by 36 months the vocabulary comprehended is 900 words. By 6 years old the average child will have a receptive vocabulary of 8,000 words (Tager-Flusberg, 2005).

Expressive language ability has been found to be a predictor of functioning in children with ASD (Lord & Paul, 1997). Both expression and comprehension are impaired in ASD (Fein et al., 1996; Kjelgaard & Tager-Flusberg, 2001; Rapin & Dunn, 2003). However, the test measures utilized may influence scores of language ability (Kjelgaard &Tager-Flusberg, 2001).

Prosody enables the speaker to use expressive language to facilitate enhanced meaning in communication (Paul, Augustyn, Klin, & Volkmar, 2005). Prosody also allows for the ability to perceive pitch is an auditory nervous system function supporting to recognize voices, perceive prosody of speech, recognize environmental sounds and acquire language (Tramo, 2005). A common feature in ASD speakers is abnormal prosody (Sheinkopf, Mundy, Oller, & Steffens, 2000; Paul, 2005).

Sensory Abnormalities: A Potential Autism Subgroup

Empirical evidence suggests that a subset of individuals with ASD have sensory abnormalities. Autism is a heterogeneous disorder that much like a puzzle requires the fitting together of multiple empirical pieces. This heterogeneity makes the identification of causal relationships, linking of symptoms to dysfunction within the brain problematic (Waterhouse, Fein & Modahl, 1996). However the heterogeneity of ASD also indicates possible points of etiological origin (Le Couteur et al., 1996). One hypothesis indicates subgroups that are genetically different and clinically separate (Le Couteur, 1996). Establishing ASD subgroups is an important line of research when looking at possible genetic causes for autism (Battaglia & McMahon, 2006; Keller & Persico, 2003; Tager-Flusberg, 2006). Symptoms represent varied expression from the same genetic predisposition (Carey & Gottesman, 1981 as cited in Le Couteur, 1996). A language impairment subgroup of ASD has been proposed by Tager-Flusberg (2006) called Autism and Language Impairment (ALI). Among the impairments observed in this potential subgroup are vocabulary processing, syntax and semantics. Likewise, the phenomena of sensory integration and processing constitute a compelling line of research into a possible subgroup of ASD (see Reynolds & Lane, 2007).

Another line of inquiry into subgroups is establishing comorbidity with ASD (Cohen, 1997; Zafeiriou, Ververi, & Vargiami, 2007). Comorbidity is the phenomena of two or more disorders occurring in the same person (Comer, 2008). Although sensory abnormalities are not a diagnostic criterion for ASD there may be a comorbid relationship between the two.

Aims

This study aims to contribute to the research into the etiology of autism by looking at the role of auditory sensory abnormalities on language in young children with ASD. Auditory sensory abnormalities are atypical responses to auditory stimuli. Due to the heterogeneity of language deficits in autism (Kjelgaard, 2001) evaluating possible predictors of language functioning in ASD is an important research topic. Therefore, it is hypothesized that auditory sensory abnormality in young children with ASD will primarily negatively affect receptive language and prosody, and secondarily negatively affect expressive language.

Method

Participants

Included in this study was a sample of 118 children age approximately 2 years. There were a total of 93 males and 25 females (reflecting the reported ratio of four males for every one female). Ethnicities represented consisted of White (n=89), Hispanic/Latino (n=8), African American or Black (n=4), Asian or Pacific Islander (n=4), Native American (n=1), White/Puerto Rican (n=1) and unidentified (n=11).

Subjects were originally seen at the University of Connecticut clinical study, researching the early detection of autism utilizing the Modified Checklist for Autism in Toddlers (M-CHAT;

Robins, Fein & Barton, 2001). Children enrolled in the study showed a risk for ASD. Information about subjects was acquired via archival data set from this clinical study. A diagnosis of ASD was required for inclusion in this study. Participants were diagnosed with Autistic Disorder (n=63), PDD NOS (n=43) and Autism Spectrum Disorder, low mental age, n=12).

Instruments

Sensory Profile. The Sensory Profile (Winn, 1999) is a parent/caregiver survey with 125 questions used to assess sensory processing ability and performance of children with disabilities, including autism (Kientz & Dunn, 1997). The questions are divided into eight categories: auditory, visual, taste/small, movement, body, position, touch, activity level and emotional/social. For each question a five-point Likert scale is used to establish a sensory profile:1 = always (child engages in activity 100% of the time when provided the opportunity), 2 = Frequently (75% of the time), 3 = Occasionally (50% of the time), 4 = Seldom (25% of the time) and 5 = Never (child never behaves in this manner, when presented with the opportunity). Lower scores indicate typical sensory processing skills whereas higher scores indicate more pronounced sensory impairment (Kientz, 1997). For this study only auditory sensory items were utilized from the Sensory Profile.

Mullen Scales of Early Learning: AGS Edition. The Mullen Scales of Early Learning: AGS Edition (MSEL:AGS; Mullen, 1995) tests for cognitive functioning and can be administered with children from birth to 68 months. Two domains were utilized from the MSEL:AGS Receptive Language and Expressive Language. The Receptive Language scale measures decoding of verbal input with the aim of minimizing output skills by requiring the child to respond by pointing (Mullen, 1995). Half of the tasks are intrasensory (only auditory information presented), testing auditory discrimination and linguistic conceptualization (Mullen, 1995). The rest of the tasks are intersensory (both auditory and visual information presented), evaluating auditory and visual comprehension and memory (Mullen, 1995). According to Mullen (1995) failure in the Receptive Language scale is a result of problems deriving linguistic meaning from language. Auditory discrimination and vocal motor skills are also necessary to assess expressive language skills (Mullen, 1995). Mullen (1995) also acknowledges that problems with linguistic structures, even with auditory reception skills intact, may impact expressive language performance. Specifically, he mentions possible problems with syntax (Mullen, 1995). T-scores are used for the scale with a 90% or 95% confidence interval (Mullen, 1995).

Some issues regarding the MSEL:AGS have been raised. According to Dumont, Cruse, Alfonso and Levine (2000), there are inadequacies in the standardization sample. Although the sample included 1849 children, only gender approximated the population of the US. Race/ethnicity, community size and socioeconomic status did not appear to correspond with the U.S. population estimates (according to 1990 Census data; Dumont, 2000). Specifically, Caucasians were overrepresented whereas Hispanics and African-Americans were underrepresented. Standardization is influenced by these issues but the sample from this study falls very close to those used in the MSEL:AGS, along these racially disproportionate lines, implying test validity for this study. Similarly rural communities were underrepresented with urban communities subsequently overrepresented (similar to the sample for this study).

Another issue with the MSEL:AGS are the norm tables. According to Dumont (2000) some of the norms were collected 15 years ago and others were collected more recently, resulting in an overestimation in cognitive ability from data collected pre-1988 (Flynn, 1984 as cited in

Dumont, 2000). The problem is that although the internal consistency reliability coefficients of the Early Learning Composite (ELC, all four scales totaled) are adequate, the test-retest reliability coefficient are unavailable and therefore do not address the reliability of the ELC over time (Dumont, 2000). However, since this study is not looking at the ELC, only two individual language components, this may not pose as serious an issue when compared to data retrieved from the entire ELC. This may especially be true as the MSEL:AGS is used to assess "distinct abilities" (Mullen, 1995, p.9). Considering the aim of this study is to look at discrete skills the MSEL:AGS (Mullen, 1995) may be advantageous with unifying theoretical approaches.

Autism Diagnostic Observation Schedule (ADOS). The ADOS (Lord, Rutter, DiLavore, & Risi, 1999) was developed specifically to test social-communicative functioning in people with ASD. It is used as a diagnostic tool for ASD. The ADOS (Lord, 1999) includes four modules to be used with children and adolescents of differing levels of expressive language. Therefore it is up to the clinician or researcher to choose a module based on the particular issues that clients present regarding communication and social interaction impairment beyond expressive language deficits (Klein-Tasman, Risi, & Lord, 2007), ultimately differentiating between issues with language and socio-communicative ability. For this study only Module 1 was utilized were utilized. Module 1 is for pre-verbal/single word language ability (Lord, 1999). In addition to confirming diagnosis, one item (A3), which evaluates prosody, was extracted and included as a dependent variable. Item three in Module 1 measures "Intonation of Vocalizations or Verbalizations", applying to all vocalizations or verbalizations, (Lord, 1999). Item three Module 1 has a rating scale of 0 (Normal intonation), 1 ("little variation in pitch and tone" with occasional flat, exaggerated or peculiar intonation), 2 ("Odd intonation or inappropriate pitch and stress", and/or flat, mechanical tone that is very apparent) and 8 (not enough vocalization for an intonation assessment) (Lord, 1999).

Procedures

Children were screened at local pediatrician offices for developmental delays, utilizing the M-CHAT (Robins, Fein, Barton, & Green, 2001). All children were diagnosed by a Clinical Psychologist or Developmental Pediatrician using clinical judgment based on the Autism Diagnostic Interview – Revised (Rutter, Le Couteur, & Lord, 2003), Autism Diagnostic Observation Schedule (Lord, 1999) and the criteria listed in Diagnostic & Statistical Manual, 4th Edition (APA, 1994). Also required were the performance of the Sensory Profile (Dunn, 1999) and Mullen Scales of Early Learning (Mullen, 1995).

Data Analysis

Linear Regression.

Linear Regression analyses were performed to test whether auditory abnormalities predicted language outcomes. The average auditory abnormality score was the independent variable in the first linear regression analysis. Three composite variables created from items that were significantly correlated on the Sensory Profile were the independent variables in the second linear regression analysis (see Tables 4, 5 & 6). These composite variables were auditory filtering, auditory sensitivity, and sensory seeking and were created from the following items on the Sensory Profile (see Appendix I; Dunn, 1999): items 3, 4 and 5 (auditory filtering), items 1 and 2 (auditory sensitivity) and items 6, 7 and 8 (sensory seeking). Dependent variables were expressive and receptive language raw scores from the Mullen Scales of Early Learning (Mullen, 1995) and prosody from the ADOS 1 (Lord, 1999).

Binary Logistic Regression.

Binary Logistic Regression Analysis was utilized to balance the floor effects for Mullen expressive (n=42) and receptive language (n-51) T-scores $\leq$20. Mullen language T-scores $\leq$30 were assigned a 0 reflecting below average language ability, and a score of 1 was assigned to Mullen language T-scores >30, indicating average/above average language ability. Zero was assigned to prosody scores indicating abnormal production (scores of 1 and 2 on the ADOS 1 item 3) and 1 was designated for normal prosody (scores of 0 on the ADOS 1 item 3).

Results

Linear Regression

Mean values were used to account for subjects who had incomplete auditory sensory scores on the Sensory Profile (Dunn, 1999), instead of removing subjects who had missing data. Auditory averages were then designated as the independent variable (see Table 1). The dependent variables were Mullen Receptive Language raw scores (n = 99), Mullen Expressive Language raw scores (n = 97) and ADOS 1 Prosody scores (0, 1 and 2, n = 64).

Table 1
Descriptives for Dependent Variable average Auditory Score and Independent Variables Expressive, Receptive Language and Prosody

	N	Mean	SD	Ranges
Sensory Profile Average Auditory Scores	118	.750	.797	1.25-4.88
Mullen Receptive Language	99	13.8	5.43	3-31
Mullen Expressive Language	97	13.6	5.28	4-34
ADOS 1 Prosody	64	3.49	.694	0-2

Linear regression analyses were performed to test whether average scores on the auditory abnormality domain of the Sensory Profile predicted language outcomes. The data did not support the hypothesis that auditory sensory abnormalities predict receptive language (β = -.08, p = .41), expressive language (β = .45, p = .56), or prosody (β = -.13, p = .15).

Table 2
Predictive Value of Auditory Sensory Abnormalities on Language Domains

Dependent Variables	B	SE	F	P-Value	B
Receptive Language	-.659	.796	.686	.410	-.084
Expressive Language	.459	.785	.342	.560	.459
Prosody	-95.2	66.2	.289	.153	-.132

Note. R^2= .007 for Receptive Language, R^2 = .004 for Expressive Language and R^2 = .005 for Prosody. Auditory Sensory Item score averages were utilized as the independent variable.

Separate linear regression analyses were performed to test whether three composite variables, auditory filtering (items 3, 5, and 4 on the Sensory Profile), auditory sensitivity (items 1 and 2 on the Sensory Profile), and sensory seeking (items 6, 7, and 8 on the Sensory Profile), predicted language outcomes. These three composite variables were established from a correlation matrix (see Table 3). Dependent variables were Mullen Receptive Language raw scores (n=78), Mullen Expressive Language raw scores (n=76) and ADOS 1 Prosody scores (n=52). The data represented continuous variables.

Twenty-seven subjects were excluded from this sample (n = 91) as a result of any missing Sensory Profile items. Only subjects with all eight auditory sensory items completed were included.

Table 3
Correlation Matrix for the three composite variables, Auditory Filtering, Auditory Sensitivity and Sensory Seeking

	Sensory Survey Item 1	Sensory Survey Item 2	Sensory Survey Item 3	Sensory Survey Item 4	Sensory Survey Item 5	Sensory Survey Item 6	Sensory Survey Item 7	Sensory Survey Item 8
Sensory Survey Item 1								
Sensory Survey Item 2	.537**							
Sensory Survey Item 3	.267*	.310**						
Sensory Survey Item 4	.366**	.333**	.650**					
Sensory Survey Item 5	.275**	.230*	.587**	.476**				
Sensory Survey Item 6	.258*	.033	.202	.138	.129			
Sensory Survey Item 7	.147	-.008	.027	-.029	.040	.712**		
Sensory Survey Item 8	.134	-.055	.144	.058	.093	.256*	.207*	

Auditory Filtering corresponds to items 3, 5, and 4 on the Sensory Profile (Dunn, 1999), Auditory Sensitivity corresponds to items 1 and 2 on the Sensory Profile (Dunn, 1999) and Sensory Seeking corresponds to items 6, 7, and 8 on the Sensory Profile (Dunn, 1999).

Results indicate that sensory seeking was predictive of expressive language ability (β = .30, p=.009), but not receptive language ability (β = .16, p=.16) or prosody (β = -.09, p=.493). Auditory filtering and auditory sensitivity did not predict any language outcomes (see Tables 4, 5 & 6).

Table 4
Predictive value of Auditory Filtering, Auditory Sensitivity and Sensory Seeking on Expressive Language

Dependent Variables	Independent Covariates	B	Standard Error	Beta	Significance
Expressive Language	Auditory Filtering	.206	.197	.126	.300
	Auditory Sensitivity	-.294	.243	-.146	.231
	Sensory Seeking	.581	.215	.303	.009

$R^2 = .115$ for Expressive Language. Linear Regression analyses were performed utilizing the total scores from the independent covariates Auditory Filtering, Auditory Sensitivity and Sensory Seeking auditory sensory scores from the Sensory Profile (Dunn, 1999).

Table 5
Predictive value of Auditory Filtering, Auditory Sensitivity and Sensory Seeking on Receptive Language

Dependent Variables	Independent Covariates	B	Standard Error	Beta	Significance
Receptive Language	Auditory Filtering	.013	.223	.007	.954
	Auditory Sensitivity	-.313	.274	-.143	.256
	Sensory Seeking	.336	.242	.160	.169

$R^2 = .040$ for Receptive Language.

Table 6
Predictive value of Auditory Filtering, Auditory Sensitivity and Sensory Seeking on Prosody

Dependent Variables	Independent Covariates	B	Standard Error	Beta	Significance
Prosody	Auditory Filtering	-.045	.040	-.178	.267
	Auditory Sensitivity	.080	.050	.252	.114
	Sensory Seeking	-.030	.043	-.099	.493

$R^2 = .066$ for Prosody.

Binary Logistic Regression

Twenty-seven subjects were excluded from this sample (n = 91) as a result of any missing items, from the eight auditory items, on the Sensory Profile (Dunn, 1999). Dependent variables were Mullen Receptive Language t-scores, Mullen Expressive Language t-scores and ADOS 1 Prosody scores (see Table 7).

Table 7
Binary Logistic Regression Descriptives

	N	Abnormal/Below Average Scores	Normal /Above Average Scores
Sample Total	91		
Mullen Receptive Language	78	61	13
Mullen Expressive Language	76	62	14
ADOS 1 Prosody	52	23	28

Language scores below 30 on the Mullen and 1 or 2 on the ADOS 1 were considered abnormal/below average. Language scores above 30 on the Mullen and 0 on the ADOS 1 were considered normal/average.

Binary Logistic Regression analysis was utilized to test whether the total auditory abnormality score and auditory sensitivity composite scores predicted below average expressive and receptive language scores and abnormal prosody. T-scores of ≤30 on the Mullen were defined as below average; raw scores of 1 or 2 on the prosody item on the ADOS were considered abnormal (see Table 7). Results indicated that auditory sensory abnormalities did not predict any language outcomes (see Table 8).

Table 8
Binary Logistic Regression Analyses indicating Average or Below Average Language Scores

Dependent Variables	Model parameter				
	SE	Wald χ^2	*df*	*P*-value	Exp (B)
Receptive Language t-score	.053	.199	1	.655	.977
Expressive Language t-scores	.056	1.024	1	.312	1.059
Prosody	.047	.121	1	.728	.984

Language scores above 30 on the Mullen (1995) are considered normal and under 30 abnormal.

Discussion

This study looked at the relationship between auditory sensory abnormalities and language in children with Autism Spectrum Disorder, specifically the hypothesis that auditory sensory abnormalities negatively affects primarily receptive language and prosody and secondarily expressive language in young children with Autism Spectrum Disorder. The findings of this study suggest that auditory sensory abnormalities negatively affect expressive language when auditory subscales were utilized, supporting part of the hypothesis. When three composite variables, auditory filtering, auditory sensitivity and sensory seeking, were established by a correlation matrix (see Table 3), from the eight auditory items on the Sensory Profile (Dunn, 1999), sensory seeking was found to predict expressive language (β = .30, p=.009). Sensory seeking and expressive language were positively correlated with lower sensory seeking scores, 1 being severely impaired and 5 being not impaired at all, predicting lower scores of expressive language on the Mullen (see Table 4).

Expressive language was not predicted by overall auditory abnormalities (β = .45, p = .56) subscales, and auditory sensory abnormalities had no statistically significant effect on receptive language (β = .16, p=.16) and prosody (β = -.09, p=.493).

The findings suggest that auditory sensory seeking has a negative effect on expressive language. There is evidence suggesting that young children engage frequently in joint attention with their mothers between 15 to 18 months of age (Carpenter, Tomasello, & Nagell, 1995). This attention to a caregiver is mediated by caregiver vocalization. Auditory sensory seeking behavior, observed in a subset of children with ASD, suggests that particular auditory stimuli attract these children potentially at the expense of other attentional interactions, important for language learning, which may otherwise strengthen expressive language. It is also beneficial to look at specific areas of the brain where expressive language is processed, i.e. anterior parietal and lateral frontal cortex (Towle et al., 2008), in order to understand the mechanisms involved in auditory sensory seeking and expressive language. There is also evidence suggesting that during expressive speech receptive language areas of the brain, i.e. superior temporal lobe, are deactivated. This may give some indication as to why receptive language is not affected by auditory sensory seeking. Expressive language impairment may lessen the impact on receptive language, due to a reduced deactivation.

A limitation of this study is that auditory sensory abnormalities were established from information on a parent questionnaire. The concern with parent questionnaires is the accuracy of parental observations; parents may either under- or over-estimate various behavior. Also, in the Mullen Scale of Early Learning floor effects made the analysis less conclusive. When T-scores were utilized the effects of a large number of language scores <20 resulted in difficulties interpreting the relationship between language and auditory sensory abnormalities. Greater sensitivity in measures is necessary to obtain more meaningful results of the potential predictive value of auditory sensory abnormalities on expressive and receptive language in young children with ASD.

Some suggestions for future research include studying auditory processing of stimuli at the neural level utilizing fMRI studies and animal modeling of the mechanisms involved in selective auditory processing. It would also be advantageous to do longitudinal studies to establish whether early expressive language deficits, correlated with auditory sensory abnormalities, continue throughout development.

Future research would additionally benefit from the inclusion of the Sensory Profile in the diagnostic process in order to understand more fully the extent of sensory abnormalities in ASD. Expanding the scope of the study to include the predictive value of auditory sensory abnormalities on social behavior would further elucidate the role of sensory abnormalities in ASD, beyond the language component.

Treatment can also be informed by the findings that suggest auditory sensory seeking behavior negatively affects expressive language. By screening for and treating auditory sensory abnormalities clinicians may be able to improve the outcome of expressive language treatment.

The phenomenon of sensory abnormalities in people with ASD has been supported by research (Baker, et al., 2008; Baranek, et al., 2007; Dunn, et al., 2002; and Kern, et al., 2006), and specifically auditory abnormalities (Jansson-Verkasol, et al., 2005, Minshew, 1996, & Tecchio, et al., 2003). The effect of auditory sensory abnormalities on language has implications for the treatment of the disorder and also understanding its etiology. By studying auditory sensory abnormalities clinicians are better able to plan effective, individualized treatment and research can be informed by emerging information leading to a greater understanding of ASD.

REFERENCES

American Psychiatric Association (1994). *Diagnostic and Statistical Manual of Mental Disorders (ed. 4).* Washington, D.C: American Psychiatric Association.

Aydelott, J, Dick, F, Mills, D.L. (2006). Effects of acoustic distortion and semantic context on event-related potentials to spoken words. *Psychophysiology, 43*, 454-464.

Ayres, A.J., Tickle, A.S. (1980). Hyper-responsivity to touch and vestibular stimuli as a predictor of positive response to sensory integration procedures by autistic children. *American Journal of Occupational Therapy.* 34, 375-381.

Baghdadli, A., Picot, M.C., Pascal, C. Pry, R., & Aussilloux, C. (2003). Relationship between age of recognition of first disturbances and severity in young children with autism. *European Child and Adolescent Psychiatry. 12.* 122-127.

Baker, A.E.Z., Lange, A., Angley, M.T., & Young, R.L. (2008). The relationship between sensory processing patterns and behavioural responsiveness in autistic disorder: A pilot study. *Journal of Autism and Developmental Disorders, 38,* 867-875.

Baranek, G.T., Boyd, B.A., Poe, M.D. Fabian, J.D., & Watson, L.R. (2007). Hyperresponsive sensory patterns in young children with autism, developmental delay, and typical development. *American Journal of Mental Retardation, 112,* 233-245.

Baranek, G.T., David, F.J., Poe, M.D., Stone,W.L., & Watson, L.R. (2006). Sensory experiences questionnaire: discriminating sensory features in young children with autism, developmental delays, and typical development. *Journal of Child Psychology and Psychiatry. 47*(6), 591-601.

Battaglia, A., & Carey, J.C. (2006). Etiologic yield of autistic spectrum disorders: A prospective study. *American Journal of Medical Genetics Part C: Seminars in Medical Genetics, 142C,* 3-7.

Bomba, M.D., & Pang, E.W. (2004). Cortical auditory evoked potentials in autism: a review. *International Journal of Psychophysiology., 53,* 161-169.

Cantwell, D.P., & Baker, L. (1987). *Developmental Speech & Language Disorders.* New York, N.Y: The Guilford Press.

Carey, G., & Gottesman, I. (1981). What is a case?: the problem of definition in psychiatric community surveys. In J.K. Wing, P. Bebbington, & L.N. Robins (Eds.), *Defining cases by genetic criteria* (pp. 29-41). London: Grant McIntyre.

Carpenter M, Nagell K, Tomasello M. (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development,* 63, V-143.

Carlson, N.R. (2008). *Foundations of Physiological Psychology.* Boston, MA: Pearson Education Inc.

Ceponiene, R. Lepisto, T., Shestakova, A., Vanhala, R., Alku, P., Naatanen, R. & Yaguchi, K. (2003). Speech-sound-selective auditory impairment in children with autism: They can perceive but do not attend. *Proceedings of the National Academy of Sciences of the United States of America. 100*(9), 5567-5572.

Center for Disease Control 2007, Autism Information Center. Frequently asked questions – prevalence. Retrieved January 11, 2008, from http://www.cdc.gov/ncbddd/autism/faq_prevalence.htm

Chakrabarti, S., & Fombonne, E. (2005). Pervasive developmental disorders in preschool children: confirmation of high prevalence. *American Journal of Psychiatry, 162,* 1133-1141.

Chawarska, K., Paul, R., Klin, A., Hannigan, S., Dichtel, L.E., Volkmar, F. (2007). Parental recognition of developmental problems in toddlers with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 37,* 62-72.

Cohen, D.J., & Volkmar, F.R. (1997). Diagnosis and Classification. In J,D. Cohen, & F.R. Volkmar (Eds.), *Handbook of autism and developmental disorders* (pp. 1-3). New York, NY: John Wiley & Sons, Inc. (2nd edition?)

Comer, R.J. (2008). *Fundamentals of Abnormal Psychology.* New York, N.Y: Worth Publishers.

De Giacomo, A., & Fombonne, E. (1998). Parental recognition of developmental abnormalities in autism. *European Child and Adolescent Psychiatry, 7,* 131-136.

Dumont, R., Cruse, C.L., Alfonso, V., & Levine, C. (2000). Mullen scales of early learning: AGS Edition. *Journal of Psychoeducational Assessment, 18,* 381-389.

Dunn, W. (1999). *Sensory Profile.* San Antonio, TX: Psychological Corporation.

Dunn, W., Myles, B.S., & Orr, S. (2002). Sensory processing issues associated with asperger syndrome: a preliminary investigation. *American Journal of Occupational therapy, 55,* 97-102.

Eaves, L.C., Ho, H.H., & Eaves, D.M. (1994). Subtypes of autism by cluster analysis. *Journal of Autism and Developmental Disorders, 24,* 3-22.

Fein, D., Allen, D.A., Aram, D.M., Dunn, M.A., Morris, R., Rapin, I., & Waterhouse, L. (1996). Overview and Conclusions. In I. Rapin (Ed), *Preschool children with inadequate communication* (pp. 214-228). High Holborn, London: Mac Keith Press.

Ferri, R. Elia, M., Agarwal N, Lanuzza, B, Musumeci, S.A., & Pennisi, G. (2003). The mismatch negativity and the P3a components of the auditory event-related potentials in autistic low-functioning subjects. *Clinical Neurophysiology. 114,* 1671-1680.

Iarocci, G., & McDonald, J. (2006). Sensory integration and the perceptual experience of persons with autism. *Journal of Autism and Developmental Disorder, 36*(1), 77-90.

Jansson-Verkasol, E., Kujala, T. Jussila, K., Mattila, M.L., Moilanen, I., Naatanen, R., Suominen, K., & Korpilahti, P. (2005). Similarities in the phenotype of the auditory neural substrate in children with Asperger syndrome and their parents. *European Journal of Neuroscience, 22*(4), 986-990.

Just, M.A., Cherkassky, V.L., Keller, T.A. & Minshew, N.J. (2004). Cortical activation and synchronization during sentence comprehension in high-functioning autism: evidence of underconnectivity. *Brain, 127,* 1811-1821.

Keller, F., & Persico, A.M. (2003). The neurobiological context of autism. *Molecular Neurobiology, 28,* 1-22.

Kern, J.K., Trivedi, M.H., Garver, C.R., Grannemann, B.D., Andrews, A.A., Savla, J.S., Johnson, D.G., Mehta, J.A., Schroeder, J.L. (2006). The pattern of sensory processing abnormalities in autism. *Autism, 10,* 480-494.

Khalfa, S., Bruneau, N, Roge, B., Georgieff, N., Veuillet, Adrien, J.L., Barthelemy, C, & Collet, L. (2004). Increased perception of loudness in autism. *Hearing Research, 198,* 87-92.

Kientz, M.A., & Dunn, W. (1997). A comparison of the performance of children with and without autism on the sensory profiles. *American Journal of Occupational Therapy. 51,* 530-537.

Kjelgaard, M.M., & Tager-Flusberg, H. (2001). An investigation of language impairment in autism: Implications of genetic subgroups. *Language and Cognitive Processes, 16,* 287-308.

Klein-Tasman, B.P., Risi, S., & Lord, C.E. (2007). Effect of language and task demands on the diagnostic effectiveness of the autism diagnostic observation schedule: The impact of module choice. *Journal of Autism and Developmental Disorders. 37,* 1224-1234.

Kuhl, P.K., Coffey-Corina, S., Padden, D., & Dawson, G. (2005). Links between social and linguistic processing of speech in preschool children with autism: behavioral and electrophysiological measures. *Developmental Science, 8,* F1-F12.

Le Couteur, A., Bailey, A., Goode, S., Pickles, A., Robertson, S., Gottesman, I., & Rutter, M. (1996). A broader phenotype of autism: The clinical spectrum in twins. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 37,* 785-801.

Leekam, S.R., Nieto, C., Libby, S.J., Wing, L., & Gould, J. (2007). Describing the sensory abnormalities of children and adults with autism. *Journal of Autism and Developmental Disorders. 37*(5), 894-910.

Leyfer, O.T., Folstein, S.E., Bacalman, S., Davis, N.O., Dinh, E., Morgan, J., Tager-Flusberg, H., & Lainhart, J.E. (1996). Comorbid psychiatric disorders in children with autism: interview development and rates of disorders. *Journal of Autism and Developmental Disorders, 36,* 849-861.

Lincoln, A.J., Courchesne, E., Harms, L., & Allen, M. (1995). Sensory modulation of auditory stimuli in children with autism and receptive developmental language disorder: event-related brain potential evidence. *Journal of Autism and Developmental Disorders*, *25*, 521–539.

Lord, C. & Paul, R. (1997). Language and communication in autism. In J,D. Cohen, & F.R. Volkmar (Eds.), *Handbook of autism and developmental disorders* (pp. 195-225). New York, NY: John Wiley & Sons, Inc.

Lord, C., Rutter, M., DiLavore, P.C., & Risi, S. (1999). *Autism Diagnostic Observation Schedule.* Los Angeles, CA: Western Psychological Services.

Minshew, N.J. (1996). Brief report: brain mechanisms in autism: Functional and structural abnormalities. *Journal of Autism and Developmental Disorders. 26*(2), 205-209.

Mullen, E.M. (1995). *Mullen Scales of Early Learning.* Circle Pines, MN: American Guidance Service, Inc.

O'Riordan, M., & Passetti, F. (2006). Discrimination is autism within different sensory modalities. *Journal of Autism and Developmental Disorders, 36.* 665-675

Paul, R., Augustyn, A., Klin, A., & Volkmar, F.R. (2005). Perception and production of prosody by speakers with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 35,* 205-220.

Paul R., Chawarska, K., Fowler, C., Cicchetti, D., & Volkmar F. (2007). "Listen my children and you shall hear": auditory preferences in toddlers with autism spectrum disorders. *Journal of Speech, Language and Hearing Research, 50,* 1350-1364.

Rapin, I., & Dunn, M. (2003). Update on the language disorders of individuals on the autistic spectrum, *Brain & Development, 25,* 166-172.

Reynolds, S., & Lane, S.J. (2007). Diagnostic validity of sensory over-responsiveness: a review of literature and case reports. *Journal of Autism and Developmental Disorders, 38,* 516-529.

Robins, D.L., Fein, D., & Barton, M.L., & Green. (2001). The modified checklist of autism in toddlers: an initial study investigating the early detection of autism and pervasive developmental disorders. *Journal of Autism and Developmental Disorders, 31,* 131-144.

Rogers, S.J., Hepburn, S., & Wehner, E. (2003). Parent reports of sensory symptoms in toddlers with autism and those with other developmental disorders. *Journal of Autism and Developmental Disorders, 33,* 631-642.

Rogers, S.J., & Ozonoff, S. (2005). Annotation: what do we know about sensory dysfunction in autism? A critical review of empirical evidence. *Journal of Child Psychology and Psychiatry, 46,* 1255-1268.

Rosenhall, U., Nordin, V., Sandstrom, M., Ahlsen G., & Gillberg, C. (1999). Autism and hearling loss. *Journal of Autism and Developmental Disorders, 29,* 349-357.

Rutter, M., Le Couteur, A., & Lord, C. (2003). *Autism Diagnostic Interview-Revised.* Los Angeles, CA: Western Psychological Services.

Sheinkopf, S.J., Mundy, P., Oller, D.K., & Steffens, M (2000). Vocal atypicalities of preverbal autistic children. *Journal of Autism and Developmental Disorders, 30,* 345-354.

Sturm, H., Fernell, E., & Gillberg, C. (2004). Autism spectrum disorders in children with normal intellectual levels: associated impairments and subgroups. *Developmental Medicine and Child Neurology, 46,* 444-447.

Tager-Flusberg, H., Paul, R., & Lord, C. (2005). Language and Communication in Autism. In F.R. Volkmar, R. Paul, A. Klin, & D. Cohen (Eds.), *Handbook of autism and pervasive developmental disorders* (pp. 335-364). Hoboken, New Jersey: John Wiley & Sons, Inc.

Tager-Flusber, H. (2006). Defining language phenotypes in autism. *Clinical Neuroscience Research, 6,* 219-224.

Towle, V.L., Yoon, H.A., Castelle, M., Edgar, J.C., Biassou, N.M., Frim, D.M., Spire, J.P, & Kohrman, M.H. (2008). ECoG gamma activity during a language task: differentiating expressive and receptive speech areas. *Brain. 131.* 2013-2027.

Tecchio, F., Benassi, F., Zappasodi, F., Giallorieti, L.E., Palermo, M., Seri, S., & Rossini, P.M. (2003). Auditory sensory processing in autism: A magnetoencephalographic study. *Biological Psychiatry. 54*(6), 647-654.

Tramo, M.J., Cariana, P.A., Koh, C.K., Makris, N. & Braida, L.D. (2005). Neurophysiology and neuroanatomy of pitch perception: Auditory cortex. *Annals of the New York Academy of Sciences, 1060,* 148-174.

Volkmar, F.R., & Klin, A. (2005). Issues in the Classification of Autism and Related Disorders. In F.R. Volkmar, R. Paul, A. Klin, & D. Cohen (Eds.), *Handbook of autism and pervasive developmental disorders* (pp. 5-41).). Hoboken, New Jersey: John Wiley & Sons, Inc.

Waterhouse, L., Fein, D., & Modahl, C. (1996). Neurofunctional mechanisms in autism. *Psychological Review, 103,* 457-489.

Zafeiriou, D.I., Ververi, A., & Vargiami, E. (2007). Childhood autism and associated comorbidities. *Brain and Development, 29,* 257-272.

APPENDIX

Eight Auditory Items on the Sensory Profile (Dunn, 1999)

1. Responds negatively to unexpected or loud noises (i.e. vacuum cleaner, dog barking, hair dryer.

2. Responds negatively to noisy environments (e.g. shopping malls, crowded restaurant).

3. Is distracted or has trouble functioning if there is a lot of noise around.

4. Holds hand over ears.

5. Cannot work with background noise (e.g. fan, refrigerator).

6. Enjoys strange noises/seeks to make noise for noise sake.

7. Actively seeks loud environments (e.g. prefers noisy cafeteria to quiet classroom).

8. Holds hand over ears while vocalizing (e.g. humming, singing).