Summer 2010

Word learning in children with autism spectrum disorders: the role of attention

Allison Frances Bean
University of Iowa

WORD LEARNING IN CHILDREN WITH AUTISM SPECTRUM DISORDERS: THE ROLE OF ATTENTION

by

Allison Frances Bean

An Abstract

Of a thesis submitted in partial fulfillment of the requirements for the
Doctor of Philosophy degree in Speech and Hearing Science in
the Graduate College of
The University of Iowa

July 2010

Thesis Supervisor: Professor Karla K. McGregor

ABSTRACT

Attention impairments are well documented in children with autism spectrum disorders (ASD). Under associative accounts of early word learning, the attention impairments in children with ASD preclude them from developing effective learning strategies. In this study we examined whether children with ASD utilize the same attention cues for learning as their unaffected receptive-vocabulary mates. In a word-learning task, we asked: 1) whether hearing novel and attention-grabbing words cued children to shift their attention to the speaker, and 2) whether the children followed the gaze of the speaker to determine the speaker's focus of attention. We taught novel words in two conditions. One condition provided maximal social-attention scaffolding; the examiner followed the focus of the child's attention. The other was less scaffolded; the examiner directed the child's attention to the target using eye gaze. We manipulated the number of objects present during teaching, two versus four, to examine the effect of non-social attention scaffolding with scaffolding here defined as a reduction in distractions.

Fifteen-children with ASD (ages 36-91 months) were matched to fifteen unaffected children (ages 16-92 months) on the basis of receptive vocabulary (RVM group). The ASD group's performance differed from the RVM group's performance on one measure: shifting attention to the speaker upon hearing a novel or attention-grabbing word on the initial trial. On all other measures, the ASD group's performance did not significantly differ from the RVM group's performance. Although there was not a significant effect of condition, closer analysis revealed that in the RVM and ASD groups, only the consistent-gaze followers' performed better than chance on the word-learning tasks. We hypothesize that, when all else is equal, providing a label does not make the target distinct enough to support word-referent pairings for children who are not consistently attending to the speaker. Overall, the ASD group demonstrated greater within group variability in their attention than the RVM group. Gaze following was variable across (and within) the ASD group. The within subject variability suggests some children with ASD are slow to appreciate eye gaze cues in unfamiliar contexts.

Abstract Approved: ____
Thesis Supervisor

____
Title and Department

____
Date

WORD LEARNING IN CHILDREN WITH AUTISM SPECTRUM DISORDERS: THE ROLE OF ATTENTION

by

Allison Frances Bean

A thesis submitted in partial fulfillment of the
requirements for the Doctor of
Philosophy degree in Speech and Hearing Science in
the Graduate College of
The University of Iowa

July 2010

Thesis Supervisor: Professor Karla K. McGregor

Graduate College
The University of Iowa
Iowa City, Iowa

CERTIFICATE OF APPROVAL

PH.D. THESIS

This is to certify that the Ph.D. thesis of

Allison Frances Bean

has been approved by the Examining Committee
for the thesis requirement for the Doctor of Philosophy
degree in Speech and Hearing Science at the July 2010 graduation.

Thesis Committee: ___________________________________
Karla K. McGregor, Thesis Supervisor

____
Bruce Tomblin

____
Amanda Owen

____
Larissa Samuelson

____
Julie Gros-Louis

To my mom and dad whose support has been invaluable.

Genius is nothing but continued attention.

Claude Adrein Helvetius

ACKNOWLEDGMENTS

I would like to thank all of the people who made this project possible. In particular I would like to thank my advisor, Karla McGregor, for all of the help and support she provided throughout this process and the members of the Word Learning Lab especially Elizabeth Walker, Derek Stiles, Nichole Eden, Amanda Berns, Ulla Grube, Stephanie Cain, Alison Bahnsen, Sara Stuck and Gwyneth Rost. In addition, I would like to thank Nina Capone and Jessica Horst for all of their helpful feedback and comments. I would also like to thank Teresa King, David Bean, John Sykes and Stephanie Haas for providing feedback on earlier drafts of this dissertation. Most importantly, I would like to thank all of the families who participated in this research study. Without them this project would not have been possible.

ABSTRACT

Attention impairments are well documented in children with autism spectrum disorders (ASD). Under associative accounts of early word learning, the attention impairments in children with ASD preclude them from developing effective learning strategies. In this study we examined whether children with ASD utilize the same attention cues for learning as their unaffected receptive-vocabulary mates. In a word-learning task, we asked: 1) whether hearing novel and attention-grabbing words cued children to shift their attention to the speaker, and 2) whether the children followed the gaze of the speaker to determine the speaker's focus of attention. We taught novel words in two conditions. One condition provided maximal social-attention scaffolding; the examiner followed the focus of the child's attention. The other was less scaffolded; the examiner directed the child's attention to the target using eye gaze. We manipulated the number of objects present during teaching, two versus four, to examine the effect of non-social attention scaffolding with scaffolding here defined as a reduction in distractions.

Fifteen-children with ASD (ages 36-91 months) were matched to fifteen unaffected children (ages 16-92 months) on the basis of receptive vocabulary (RVM group). The ASD group's performance differed from the RVM group's performance on one measure: shifting attention to the speaker upon hearing a novel or attention-grabbing word on the initial trial. On all other measures, the ASD group's performance did not significantly differ from the RVM group's performance. Although there was not a significant effect of condition, closer analysis revealed that in the RVM and ASD groups, only the consistent-gaze followers' performed better than chance on the word-learning tasks. We hypothesize that, when all else is equal, providing a label does not make the target distinct enough to support word-referent pairings for children who are not consistently attending to the speaker. Overall, the ASD group demonstrated greater within group variability in their attention than the RVM group. Gaze following was

variable across (and within) the ASD group. The within subject variability suggests some children with ASD are slow to appreciate eye gaze cues in unfamiliar contexts.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

Attention plays a critical role in children's development. Impairments in attention place children at a disadvantage when developing social, cognitive, and language skills (Allen & Courchesne, 2001). Language deficits in individuals with autism spectrum disorders (ASDs) are most likely influenced by concomitant attention impairments (e.g., Dawson, 2008). Evidence for this relationship comes from studies examining the influence of attention on language learning. In young children with ASD, following multiple attention directing cues has been positively associated with fast mapping and vocabulary acquisition (McDuffie, Yoder, & Stone, 2006a). Further, inattentive behaviors, such as looking away from tasks, have been associated with poor language development (Bopp, Mirenda, & Zumbo, 2009). In this study, we examined the effect of attention on word-learning performance under varying levels of social and non-social attention scaffolding.

Background

ASDs are biologically based neurodevelopmental disorders defined by impairments in social interactions and communication in the presence of restricted, repetitive, and stereotyped patterns of behavior (American Psychiatric Association, 1994). Attention impairments are not a defining feature of ASD; however, they are well documented within the ASD population (e.g., Ames & Fletcher-Watson, 2010; Burack, 1994; Jarvinen-Pasley & Heaton, 2007; Kaland, Smith, & Mortensen, 2008). It is hypothesized that these early differences in attention have a cascading effect on development by creating atypical developmental trajectories (Dawson, 2008; Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998; Dawson et al., 2004).

Attention deficits limit or otherwise alter active engagement in early social interactions, thus limiting social and linguistic learning opportunities (Doussard-Roosevelt, Joe, Bazhenova, & Porges, 2003; Lord, Merrin, Vest, & Kelly, 1983).

Engaging in reciprocal social interactions is important because it supports the development of more complex behaviors, such as joint attention (for a review see Dawson, 2008), an area identified as a "pivotal skill" in ASD because of its relationship to later language and social outcomes (Charman, 2003).

Joint attention is defined as coordinating attention with another person, with the awareness that this attention is shared (e.g., Tomasello, 1995). "Coordinating attention" is manifested behaviorally as following another person's eye gaze to the object that the person is observing. "Awareness that attention is shared" is manifested as subsequently alternating gaze between the object and the person. At its most basic level, engaging in an episode of joint attention requires the capacity to process information from two visual fields, your own and the other person's (Mundy, Sullivan, & Mastergeorge, 2009). Given the social nature of joint attention, gazing at the same object as another person in the absence of alternating eye gaze is not considered indicative of joint attention (e.g., Carpenter, Nagell, & Tomasello, 1998). In this study we measured gaze following rather than gaze alternation. Therefore, for the purpose of this dissertation, the phrase *coordinating attention* will be used rather than joint attention because it is a more precise reflection of the measured behavior.

Coordinating attention with the speaker is an effective word-learning strategy because it enables children to learn words without being directly taught (e.g., Baldwin, 1995; Mundy et al., 2009; Tomasello, 1995). By the age of two years, children are so efficient at coordinating attention with the speaker, they learn words as well through overhearing as direct address (Akhtar, Jipson, & Callanan, 2001; Shneidman, Buresh, Shimpi, Knight-Schwarz, & Woodward, 2009). Given that most language learning takes place in unstructured social interactions (e.g., Hoff, 2003; Tomasello, Kruger, & Ratner, 1999), the capacity to coordinate attention supports efficient language learning. Deficits in the ability to coordinate attention is a powerful early diagnostic indicator of ASD (e.g., Mundy & Crowson, 1997) and is predictive of language outcomes in children with ASD

(Bono, Daley, & Sigman, 2004; Charman, 2003; Landa & Garrett-Mayer, 2006; Mundy, Sigman, & Kasari, 1990).

Although children with ASD demonstrate deficits in coordinating attention, the learning environment can be modified to facilitate episodes of coordinated attention; this modification is termed scaffolding. “Scaffolding” refers to the act of providing a learner with the support necessary to accomplish a task that cannot be accomplished independently (e.g., Vygotsky, 1962; Wood & Wood, 1996). Scaffolding attention is a valuable technique for improving language learning (e.g., Booth, McGregor, & Rohlfing, 2008; Capone & McGregor, 2005; McGregor, Rohlfing, Bean, & Marschner, 2008). Due to the social deficits inherent to ASD, it is important to determine whether scaffolding the attention of children with ASD facilitates word learning.

Purpose of the Study

This research study was designed to examine the effect of coordinating attention on word-learning performance in children with ASD. Because most children with ASD are inefficient word learners we investigated whether children with ASD utilize similar attention cues as their receptive-vocabulary mates. We specifically examined: 1) whether hearing novel and attention-grabbing words cued children to shift their attention to the speaker, and 2) whether the children followed the gaze of the speaker to determine the speaker’s focus of attention. Given the documented impairments in coordinating attention in individuals with ASD, we expected most of the children with ASD would not follow the speaker’s gaze. Therefore, we examined whether providing varying levels of scaffolding improved word learning. We manipulated both the way we taught the novel word and the number of objects present in the environment. We taught novel words in two conditions. One condition provided maximal social-attention scaffolding: the examiner followed the focus of the child’s attention. The other was less scaffolded: the examiner directed the child’s attention to the target using eye gaze. Additionally, we manipulated the number of objects present during teaching, two versus four, to examine the effect of non-social attention scaffolding with scaffolding here defined as a reduction in distractions.

Significance

Word learning is frequently targeted in intervention for children with ASD and concomitant language impairments with mixed results (D. K. Anderson et al., 2007; Goldstein, 2002; Harris, 2007). We hypothesize that these mixed results may be attributed to a variety of factors including 1) the attention skills of the child receiving intervention and 2) the match of scaffolding provided during intervention with the child's developmental level. The current research makes significant contributions to our knowledge of word-learning performance in children with ASD by considering the effect of scaffolding on task performance.

This is the first study to examine how attention affects word learning using conditions modeled after two commonly used intervention approaches, discrete-trial training and naturalistic intervention. Discrete-trial training consists of massed-teaching episodes in which the examiner directs the child's attention. Naturalistic intervention entails following the focus of the child's attention and creating teaching opportunities around the child's interest. In this study, children were taught words in two conditions. In the directing attention condition, the examiner used eye gaze to direct the child's attention to an object. In the following attention condition, the examiner followed the child's attention. The results of this study will add to a growing body of literature examining the relationship between coordinating attention and word learning in children with ASD (McDuffie et al., 2006a; McDuffie, Yoder, & Stone, 2006b).

CHAPTER 2: LITERATURE REVIEW

Attention is the process of selectively concentrating on one aspect of the environment to the exclusion of other information present. More specifically, it is the allocation of processing resources (J. R. Anderson, 2005). The zoom-lens model of visual attention posits that the scope of attention varies (Eriksen & St James, 1986; Eriksen & Yeh, 1985). This is because not all information in the environment may be processed simultaneously and individuals must select where to allocate their attention in a manner similar to a spotlight highlighting a region in space. The information in the selected area is processed at the expense of the other information in the environment (Posner & Petersen, 1990). The scope of attention is adjusted in size with regards to the amount of information deemed to be relevant. Attention to less information results in fast and precise processing, whereas a wider scope of attention enables processing of multiple stimuli at the cost of efficiency (Eriksen & St James, 1986; Eriksen & Yeh, 1985).

Associative accounts of early word learning theory posit that individuals learn where to allocate their attention through experience. Individuals originally attend to a wide range of information in the environment. As they learn what cues are relevant, their focus of attention is narrowed resulting in faster and more precise processing of the information. Attention impairments are not a defining feature of ASD; however, they are well documented within the ASD population (e.g., Burack, 1994; Jarvinen-Pasley & Heaton, 2007; Kaland et al., 2008; Maestro et al., 2002). Differences in attention have been documented in infants as young as six months who were later diagnosed with ASD as compared to those without a diagnosis (Maestro et al., 2002). Joint attention, in particular, has been a widely researched area (Mundy & Newell, 2007).

Joint attention, or coordinating attention with another person, may be divided into two categories: initiating joint attention (IJA) and responding to joint attention (RJA). IJA refers to “the use of gestures and eye contact to direct others’ attention to objects, to events, and to themselves" (Mundy & Newell, 2007, p. 2). RJA refers to the ability to coordinate attention with another person by following their attention cues, such as gesture and eye gaze. RJA is hypothesized to be an involuntary system that prioritizes orientation towards "biologically meaningful" stimuli (Mundy & Newell, 2007). In contrast, IJA is hypothesized to control goal directed attention allocation (Mundy & Newell, 2007). Comparative research has demonstrated that chimpanzees demonstrate of RJA but not IJA (e.g., Carpenter & Tomasello, 2005). Together these findings have led researchers to suggest that IJA and RJA reflect distinct but interacting process (Mundy & Newell, 2007). Recent theoretical accounts of ASD highlight the role of attention impairments in the developmental trajectory. Associative accounts of early word learning posit that general learning strategies emerge from lower level attention processes (L. Smith, 2000b). Within this theoretical framework, the general attention and language deficits characteristic of individuals with ASD are related. That is, basic attention impairments disrupt the emergence of general learning strategies resulting in language deficits. This research study focuses on children's ability to use attention cues provided by the speaker to engage in episodes of coordinated attention during word learning.

Associative Accounts of Early Word Learning

Modern associative learning theory posits that tracking statistical regularities supports the development of predictions and expectations, which leads to the appropriate allocation of attention during learning (Kuhl, 2004; L. Smith, 2000a, 2000b). The capacity to track statistics for the purpose of language learning emerges early in development. By 6 months of age, infants begin to associate highly frequent words with their referents (Tincoff & Jusczyk, 1999) and by eight months they learn word-like units on the basis of transitional probabilities (Gomez & Gerken, 1999; Saffran, Aslin, & Newport, 1996).

Development of the shape bias illustrates how the statistics present in children's environments create general learning strategies. Use of shape as a cue for object kind emerges over the course of development. Children's early vocabularies are principally comprised of count nouns that name solid objects that share a specific shape (e.g., balls are usually round). From an early age, the statistics present in young children's vocabulary support shape as a reliable cue for object kind (Gershkoff-Stowe & Smith, 2004; Samuelson & Smith, 1999; L. Smith, 2000b). Between the ages of 17 and 21 months, as children's productive vocabularies increase, they show increased attention to shape. However, they do not consistently generalize labels on the basis of shape (Gershkoff-Stowe & Smith, 2004). It is not until around the age of 24 months, when children attain a productive vocabulary of at least 150 count nouns, that children generalize labels on the basis of shared shape alone (Samuelson & Smith, 1999; L. Smith, Jones, Landau, & Gershkoff-Stowe, 2002).

In a longitudinal training study, children who had not developed a shape bias were given intensive naming experiences. One group was taught nouns from categories typical of those that children learn early in development. The other group was taught nouns from atypical categories (non-solid substances). The children who were taught the typical noun categories developed a shape bias and showed accelerated vocabulary growth, whereas the other group did not (Samuelson, 2002). Thus, the statistics present in children's environment are sufficient to support development of a learning strategy, the strategy of generalizing names to new exemplars on the basis of shape. Development of this strategy, in turn, facilitates language acquisition.

A word-learning study by Shneidman and colleagues (2009) demonstrates how differences in children's environments yield differences in children's allocation of attention and, ultimately, in their strategy development. In their study, they compared how well 20-month-old children learned words that were overheard versus directly addressed to them. They were particularly interested in whether children's allocation of attention during word learning and children's daily experiences outside of the laboratory predicted word learning success.

Investigators had parents report the number of hours their child spent with one adult, more than one adult and no other children, and all other waking hours. They used this information as a measure of children's daily experiences. The investigators hypothesized that children who spent more waking hours with more than one adult would be better able to monitor adults' attention and, as a result, would perform better in the overhearing condition than children without this experience.

Children in the experiment were randomly assigned to the overhearing or direct address condition. Results revealed no effect of condition; that is, children learned words equally well via overhearing and direct address. In the direct address condition, children spent an equal amount of time looking at the people and the target object. No significant relationship was found between children's daily experience and word learning in this condition. In the overhearing condition, children looked longer at the people in the interaction and less at the target object. A positive correlation was found between the amount of time children watched the people in the interaction and word learning. A negative correlation was found between the amount of time children watched the target object and word learning. With regards to daily experience, a positive correlation was found between the time spent with multiple adults and word learning. These findings provide evidence that children's experiences influence their allocation of attention during learning and, subsequently, the learning strategies they develop.

In summary, under associative accounts of early word learning the input children receive influences their allocation of attention and, subsequently, the development of learning strategies. In typical language development, most word learning takes place during unstructured social interactions where parents spontaneously refer to new objects (Hoff, 2003; Tomasello et al., 1999). As a result, children learn to actively coordinate their attention with the speaker. To coordinate attention with another person, children must develop the capacity to "consider information about one's visual attention in parallel with information about visual attention of other people" (Mundy et al., 2009, p. 2). A complex relationship exists between general attention, the capacity to use attention cues provided by the speaker to coordinate attention, and general word learning in typical language development.

Word Learning

Acquisition of a new word requires creation of 1) a word-form representation, 2) a semantic representation, 3) a receptive link, and 4) an expressive link (Gupta & Tisdale, 2009). Word learning involves fast mapping and word retention (also referred to as slow mapping). Fast-mapping is the initial stage of word learning. First documented in three- and four-year-old children, fast mapping describes the initial link (or map) formed between a word and its referent after minimal exposures (Carey, 1978). Children become successful in fast-mapping tasks around the age of 18 months, approximately the same age that a rapid increase in vocabulary acquisition is observed (Dickinson, 2008; Golinkoff, Hirsh-Pasek, Bailey, & Wenger, 1992).

A close relationship exists between coordinating attention (frequently measured by gaze following) and early vocabulary development (Brooks & Meltzoff, 2008; Carpenter et al., 1998); coordinating attention enables accurate fast mapping. In principle, fast mapping may be divided into two steps: 1) coordinating attention with the speaker and 2) forming a link between the word and referent. Following the speaker's eye gaze creates the coordinated attention necessary for word learning.

The Development of Gaze Following

Following the speaker's focus of attention creates the episodes of coordinated attention that enable children to learn vicariously through others (Moore, 2008). A variety of cues indicate a person's focus of attention, including eye gaze. Eye gaze rarely occurs in isolation and is most often accompanied by other behaviors such as head turn. Thus, the term “gaze following” actually refers to the behavior of tracking gaze and head (or associated body) movements. Eye gaze is such a robust cue; magicians routinely use it to misdirect attention during magic tricks. Audience members are less likely to observe a magician’s sleight of hand if the magician looks away from the location where the “to-be-concealed event” is occurring (Kuhn, Tatler, & Cole, 2009; Kuhn, Tatler, Findlay, & Cole, 2007).

Gaze following emerges over the course of development and is supported by the maturity of general attention skills. These skills include the capacity to 1) shift attention between multiple stimuli, 2) respond to different spatial locations, and 3) understand that the appearance of interesting objects is predictable from adult behavior (Corkum & Moore, 1995). When adults establish eye contact with six-month-olds or use infant-directed speech to gain the their attention, six-month-old infants follow the adults’ gaze to visible objects (Corkum & Moore, 1995; Senju & Csibra, 2008). Between the ages of eight- and ten months, infants begin gaze following to objects outside of their immediate visual field. Eight-month-old children follow gaze when provided with feedback and ten-month-old children consistently follow gaze in the absence of feedback (Moore, 2008).

The capacity to maintain periods of sustained attention to multiple stimuli (i.e., a caregiver and object) in different visual fields emerges around the age of 12-months (Bakeman & Adamson, 1984). Twelve-month-old children access and use an adult’s gaze to find targets in complex spatial layouts (e.g., behind barriers) (Moore, 2008). However, it is not until the age of 18 months that children become adept at shifting attention between multiple stimuli. By this age, children have become sophisticated gaze followers, as demonstrated by a decision not to follow an adult’s head turn when presented with incongruent head and gaze orientation (Adamson & Chance, 1998).

Gaze Following in the Service of Word Learning

To create a word-referent pairing, children's attention must be drawn to the target object in such a way that it is made distinct from other objects. Although young children, are aware of gaze from an early age, it is not until the age of two years that eye gaze alone supports word learning (Hollich et al., 2000). At the age of 12 months, children are sensitive to eye gaze but require additional overlapping cues to support word learning. By the age of 19 months, children follow eye gaze during word-learning tasks, but their word-referent pairings are fragile. Hollich and colleagues (2000) found that when the spatial location of the target was changed between teaching and test, the 19-month-old children did not "conclusively" demonstrate word learning. In the same task, the 24-month-old children created a robust word-referent pairing that was not disrupted by changes in spatial location (Hollich et al., 2000). Twelve-month-old children are more successful word learners when presented with multiple overlapping cues, because these cues make the referent sufficiently distinct to support word-referent pairings. One cue that children attend to is words.

Words (object labels) alone do not increase 12-month-old children's attention to target objects (Hollich et al., 2000) but do increase 18-month-old children's attention to target objects (Flom & Pick, 2003; Hollich et al., 2000). By the age of 24-months, labels act as a cue for children to coordinate their attention with the speaker. This facilitates word learning across a variety of contexts including overhearing (Akhtar et al., 2001). Table A1 summarizes the relationship between general attention, gaze following, and word learning.

In summary, development of general attention skills increases word learning proficiency and decreases the influence of extrinsic factors (Hirsh-Pasek, Golinkoff, & Hollich, 2000). However, children begin learning language before the attention system fully develops. Caregivers scaffold children's attention to make this possible (Siller & Sigman, 2002).

Social Attention Scaffolding

The term “scaffolding” refers to the act of providing a learner with the support necessary to accomplish a task that cannot be accomplished independently (Vygotsky, 1978; Wood & Wood, 1996). For example, adults may alternate their own eye gaze between the child and the target object to scaffold the child’s attention to the target object. Scaffolding is beneficial when 1) the task is too difficult for the child and 2) the scaffolding provided is developmentally appropriate. Consider a study in which children ages five-, seven-, nine- and 12 months participated in two teaching conditions. In the joint attention condition, the examiner alternated eye gaze between the child and target while talking about the object. The examiner’s alternating eye gaze scaffolded attention by continuously redirecting the child’s attention to the target object. In the other condition, the examiner alternated gaze between the target and ceiling. Investigators found that seven- and nine-month-old children looked at the object longer in the joint attention condition. There was no effect of condition for the 5- and 12-month-old children (Cleveland, Schug, & Striano, 2007; Striano, Chen, Cleveland, & Bradshaw, 2006). Placed within a developmental framework, these results are unsurprising. Children do not follow adults’ gaze to visible objects until the age of six-months. By the age of 12-months, children are skilled gaze followers. The varying responses to scaffolding within this experiment support the perspective that scaffolding must be developmentally appropriate to be beneficial.

The ability of mothers and children to initiate and maintain episodes of coordinated attention is predictive of the children’s subsequent language growth (Brooks & Meltzoff, 2008; Carpenter et al., 1998). Children do not develop the attention skills necessary to independently coordinate attention for word learning until the age of 18 months. Before this age, mothers use following-in to ensure episodes of coordinated attention. Following-in is accomplished by talking about objects and events that are the focus of the child’s attention (Bakeman & Adamson, 1984). Early in development, the tendency of mothers to follow children's attention accounts for more than half of the variance in their language comprehension and production (Carpenter et al., 1998). This relationship weakens over time as children's attention-following skills develop and they take advantage of cues present in the environment.

Children's experiences influence the effectiveness of follow-in as a scaffold for language development. Take for example the different experiences of children raised by Mexican-immigrant versus American caregivers. Mexican-immigrant caregivers use an attention-directing interaction style with their young children, whereas most American caregivers use an attention-following interaction style. When American and first-generation Mexican toddlers (15-20 months) were taught novel words in an attention-directing style and attention-following style over a two-week period, the Mexican-immigrant children learned more words in the attention-directing style than the attention-following style in the first week. Although no differences were found in vocabulary learning in the American children, there was an overall trend that they learned more words in the attention-following style than the Mexican-immigrant children (Vigil, Tyler, & Ross, 2006). Previous researchers have suggested that an attention-following interaction style is optimal for facilitating vocabulary acquisition (e.g., Tomasello & Farrar, 1986); however, the results from this study indicate the attention regulation style children experience most often is the most beneficial for word learning. Different interaction styles may support different allocation of attention.

Non-social Scaffolding: The Influence of Distracters

The physical environment also influences the attention demands of the task. Non-target stimuli, or distracters, placed in close spatial proximity to the target object place additional demands on the attention resources of the child, thus diminishing the efficiency of attention (Enns & Girgus, 1985). The attention demands of the task may be manipulated by changing the number of distracters present. Two-and three-year-olds perform better when one, rather than three, distracters are placed in the test environment (Akhtar et al., 2001; Golinkoff, 1992; Golinkoff, Mervis, & Hirsh-Pasek, 1994; Heibeck & Markman, 1987). However, distracters are less likely to interfere with performance when attention is scaffolded (Burack, 1994).

Extra objects in the environment do not always distract; they can sometimes scaffold. For example, when a novel word is heard in the context of a known and unknown object, children infer that the word refers to the unknown object. The attention demands of the task are decreased because attention to social cues (e.g., eye gaze) is no longer necessary (Markman, 1990; Markman & Wachtel, 1998; Preissler & Carey, 2005).

In summary, the emergence of attention skills mediates what cues children use for word learning and whether the cues draw adequate attention to the target to enable word-referent pairing. Proficient word learners demonstrate the capacity to shift attention between multiple stimuli, use cues to coordinate attention with the speaker, and ignore distracters present in the word learning environment. Whereas the first two skills emerge by the age of 18 months, it is not until 24-months of age that children's learning becomes less influenced by extrinsic distracters. Social (e.g., talking about objects that are the focus of the child's attention) and non-social scaffolds (e.g., decreasing the number of distracters present) facilitate word learning in children who have not fully developed the attention capacities necessary for proficient word learning. Given their attention problems, children with ASD might benefit from such scaffolds.

Autism Spectrum Disorders (ASD)

Awareness of ASD has increased exponentially over the past decade due to increased media coverage and a rapidly expanding body of research (C. Johnson & Myers, 2007). First described by Kanner in 1943, it was not until 1980 that ASD was officially recognized within the *Diagnostic and Statistical Manual of Mental Disorders, Third Edition* (DSM-III). Diagnostic boundaries have changed over time and continue to remain a topic of debate (Bailey, Phillips, & Rutter, 1996; C. Johnson & Myers, 2007; Volkmar, Chawarska, & Klin, 2004). The DSM-IV uses the broad term ASD to encompass three Pervasive Developmental Disorders– autistic disorder, Asperger syndrome and pervasive developmental disorder – not otherwise specified (PDD-NOS; American Psychiatric Association, 1994). The validity of these as separate conditions remains a topic of dispute (Volkmar, Chawarska et al., 2004). Within this dissertation the term ASD encompasses the three Pervasive Developmental Disorders defined in the DSM-IV.

The core features of ASD are impairments in social interactions and communication in the presence of restricted, repetitive, and stereotyped patterns of behavior (APA, 1994). Although ASD has a strong genetic basis, with approximately 30 different genes implicated, its exact cause remains unknown (Hughes, 2008; C. Johnson & Myers, 2007). There is a recurrence risk of approximately 5-6% when there is an older sibling with ASD and a higher risk still when there are at least two children with ASD (Asherson & Curran, 2001; Risch et al., 1999; Smalley, 1997; Volkmar, Lord, Bailey, Shultz, & Klin, 2004). The best estimate of the current prevalence of ASD in the United States, Europe, and Canada is approximately 6 per 1000 with male-to-female ratios ranging from 2:1 to 6.5:1 (for a review see Fombonne, 1999; C. Johnson & Myers, 2007).

Parents of children later diagnosed with ASD often become concerned about their children's development around 15-24 months of age. In typically-developing children vocabulary development is initially slow. Fifteen-month-old children have an average expressive vocabulary size of 10 words. This is followed by a vocabulary burst (Fenson et al., 1994). The average expressive vocabulary size increases to 100 words by the age of 18 months and increases to over 300 words by the age of 24 months (Stoel-Gammon, 1998). In contrast, many children with ASD fail to begin saying words, learn a few words but never develop any further, or lose earlier acquired words (for a review see Tager-Flusberg, Paul, & Lord, 2005; Volkmar, Lord et al., 2004).

A limited number of longitudinal studies have documented language development of children with ASD. One reported half of the children developed at least some language skills (receptive vocabulary > 23 months) by the age of 10 years (Lord & Schopler, 1989). Another study found 72% of the children showed at least some language by the age of 13 years (Sigman et al., 1999). Children with ASD who go on to develop a more extensive vocabulary are often slow to develop words and word combinations, and speak very little until late in the preschool years (for a review see Paul, 2007; Tager-Flusberg et al., 2005). Anderson and colleagues (2007) documented growth patterns of children with ASD who participated in a longitudinal study from the age of two to nine years. Investigators found the pattern of change was related to children's nonverbal age equivalent and joint attention skills at age two.

Numerous studies have documented a positive relationship between language development and the capacity to engage in episodes of coordinated attention in children with ASD (e.g., Bono et al., 2004; Charman, 2003; Mundy et al., 1990). The ability to coordinate attention with another person is a powerful early diagnostic indicator of ASD (e.g., Mundy & Crowson, 1997). Moreover, differences in this ability are prognostic indicators for cognitive, language, and social development (Charman, 2003; Landa & Garrett-Mayer, 2006; Mundy et al., 1990). In fact, the ability to engage in coordinated attention is more predictive of language outcomes than the amount of intervention received (Bono et al., 2004). Impairment in coordinated attention is a hallmark of ASD and, as such, is frequently targeted in intervention. It is hypothesized the deficits in coordinating attention may be the result of general attention impairments.

Attention Impairments in ASD

Children and adults with ASD demonstrate fluctuating responsiveness to visual and auditory stimuli (Courchesne, Lincoln, Kilman, & Galambos, 1985), abnormalities in integrating incoming stimuli (Hermelin & O'Connor, 1970), and difficulty orienting attention. Orienting is particularly impaired in response to social stimuli and in tasks that require the individual to disengage from one stimulus and shift attention to another (for a review see Allen & Courchesne, 2001; Casey, Gordon, Mannheim, & Rumsey, 1993).

Typical children demonstrate a preference for social over non-social stimuli from birth, but children with ASD demonstrate significantly reduced selective attention to social stimuli (Hainline, 1978; Haith, Bergman, & Moore, 1977; M. H. Johnson, Dziurawiec, Ellis, & Morton, 1991; Mayes, Cohen, & Klin, 1993). Deficits in attention to social stimuli emerge early in development (Maestro, Casella, Milone, Muratori, & Palacio-Espasa, 2000; Volkmar, Chawarska et al., 2004; Werner, Dawson, Osterling, & Dinno, 2000) and include a failure to spontaneously orient to naturally occurring social stimuli in the environment. Investigators found toddlers with ASD exhibited attention patterns that were the “complementary opposite” of their unaffected and developmentally-delayed peers (Swettenham et al., 1998). The unaffected and developmentally-delayed toddlers looked more often and for longer durations at people, frequently shifting attention between social and non-social stimuli (i.e., people and objects). The toddlers with ASD looked more often and for longer durations at objects and less often and for shorter durations at people. In addition, they switched attention less between social and non-social stimuli (Swettenham et al., 1998). How would this play out in naturalistic environments? One salient example is that children with ASD do not consistently respond to their own names (Dawson, Meltzoff, Osterling, Rinaldi et al., 1998).

When children with ASD do attend to a social partner, they tend to manifest qualitatively different behaviors than their unaffected peers. For example, when watching a video of an adult looking directly into the camera while playing social games, such as peek-a-boo, unaffected and developmentally-delayed children fixated their attention on the adult’s eyes, whereas children with ASD fixated their attention on the adult’s mouth (Jones, Carr, & Klin, 2008). Under associative accounts of early word learning, these differences in the allocation of attention should alter the learning strategies children develop.

Gaze Following in Children with ASD

One of the earliest signs of ASD is a failure to establish a pattern of mutual gaze, which emerges early in typical development (Adamson, 1996; Volkmar & Mayes, 1990). Over 90% of parents report gaze abnormalities in their affected children (Carter, Davis, Klin, & Volkmar, 2005; Volkmar, Cohen, & Paul, 1986). Although children with ASD allocate their attention differently and demonstrate gaze abnormalities, they are sensitive to the directional information conveyed in eye gaze. However, eye gaze is not a privileged cue for children with ASD. When unaffected children are presented with arrow or eye-gaze cues, they show greater cueing in response to eye gaze. Children with ASD demonstrate equivalent performance when provided with arrow and eye-gaze cues (Chawarska, Klin, & Volkmar, 2003; Kylliäinen & Hietanen, 2004; Senju, Tojo, Dairoku, & Hasegawa, 2004; Vlamings, Stauder, van Son, & Mottron, 2005).

In another study, researchers found preschool children with ASD followed eye gaze to targets less than the developmentally-delayed children. However, the decrease in attention following was not limited to eye gaze. The children with ASD also followed non-social attention cues provided by an inanimate train less than the developmentally-delayed children. Even though the children with ASD did not use the attention cues provided, they were faster at orienting to the targets. The researchers hypothesized that the children with ASD relied on the presence of objects in their visual field to guide their attention rather than the social and non-social cues (Leekam, Lopez, & Moore, 2000).

Attention and Word Learning: Children with ASD

Most children with ASD, demonstrate a slow rate of vocabulary growth, rather than a rapid acceleration (for a review see Paul, 2007; Tager-Flusberg et al., 2005). Slow vocabulary development may be attributed, in part, to a failure to develop efficient learning strategies. Investigators have used word-learning studies to explore how children with ASD are learning language.

Children with ASD appear to develop learning strategies that do not require them to coordinate attention with the speaker. For example, children with ASD map novel words to unknown objects when presented with a familiar and unfamiliar object, (Preissler & Carey, 2005). In situations where they are presented with two unfamiliar objects that differ in saliency, the children with ASD map the novel word to the more interesting object (Parish-Morris, Hennon, Hirsh-Pasek, Golinkoff, & Tager-Flusberg, 2007). While successful in these contexts, children with ASD demonstrate poorer word-learning performance in tasks that require them to coordinate attention with the speaker.

Gaze Following and Word Learning

With regards to gaze following, research indicates children with ASD are capable of using the information contained in eye gaze to direct their attention to a specific location (Chawarska et al., 2003; Kylliäinen & Hietanen, 2004; Senju et al., 2004; Vlamings et al., 2005). However, children with ASD will use other cues in the environment when they are available (Leekam et al., 2000). Corkum and Moore (1998) posit that gaze following is learned from children’s experience. Because children with ASD orient to social stimuli less than their typically-developing peers, they have fewer opportunities to associate gaze following with a reward. As a consequence, children with ASD may be less likely to use the speaker’s gaze to coordinate attention with the speaker when a he or she labels an object.

In one widely used paradigm, investigators compared word-learning performance in two teaching conditions, follow-in labeling and discrepant labeling, that differ with regards to where the burden of coordinating attention falls (Baron-Cohen, Baldwin, & Crowson, 1997; Luyster, 2007; Preissler & Carey, 2005). In the follow-in labeling condition (in our study referred to as following attention) the examiner labeled the object of the child's attention focus, thus scaffolding an episode of coordinated attention. In the discrepant condition, no scaffolding was provided. The examiner labeled the target object when the child's attention was focused on the distracter object. Therefore, the child had to look up at the examiner when he or she heard the novel word, follow the examiner's gaze to determine the focus of the examiner's attention, and then map the word to the object that was the focus of the examiner's attention (Baron-Cohen et al., 1997; Luyster, 2007; Preissler & Carey, 2005).

Two studies reported that children with ASD performed like their language mates in the follow-in condition, but significantly worse than their language mates in the discrepant labeling condition (Baron-Cohen et al., 1997; Preissler & Carey, 2005). However, another recent study found comparable performance in the discrepant labeling condition (Luyster, 2007). Luyster (2007) attributes these discrepancies to the varying developmental levels of the ASD populations tested.

The use of gaze following for word learning by children with ASD appears to be related to their mental abilities (Baron-Cohen et al., 1997; Luyster, 2007; Preissler & Carey, 2005). Rather than being completely absent, gaze following may be more or less intact depending on mental age (see Leekam et al., 2000; Luyster, 2007; Nation & Penny, 2008). This suggests the attention impairments in children with lower mental ages impede the development of efficient learning strategies. In fact, children with ASD do demonstrate differences in the development of more complex word learning strategies. For example, they fail to use a shape bias as a basis for word extension (Tek, Jaffery, Fein, & Naigles, 2008). Subsequently, these children rely on using simple associations for word learning (Baron-Cohen, 1997).

Intervention Approaches to Scaffolding Attention for Language Learning

Two commonly used intervention approaches, discrete-trial training and naturalistic intervention, vary widely in terms of how the therapist creates the episodes of coordinated attention necessary for learning. In discrete-trial training therapists direct a child's attention to a target. In naturalistic intervention, therapists follow-in on the child's current focus of attention.

Discrete-Trial Training

Discrete-trial training has a long history in ASD intervention. Developed by Lovaas (1977), this was the first structured program to teach language to children with ASD. Drawing heavily on learning theory, therapists use massed-teaching episodes. Each trial has the same structure and targets specific responses. The rationale for using massed-teaching trials is based on the observation that the presentation of a specific stimulus evokes a response. This response is shaped over time through selective reinforcement and punishment (Lovaas, 1977). Teaching begins with the presentation of an antecedent stimulus used to elicit the targeted response (e.g., putting a ball on the table and saying *Give me the ball.*). If the child produces the targeted response, he or she is rewarded with a reinforcer. The reinforcer may or may not be functionally related to the targeted response (e.g., giving the child the ball to play with, or giving the child a preferred snack).

Single-subject and group-design studies have demonstrated the efficacy of discrete-trial training for teaching speech to nonverbal children with ASD and increasing vocabulary size in verbal children with ASD (for a review see Goldstein, 2002; Levy, Kim, & Olive, 2006; Rogers, 2006). Discrete-trial training is effective in establishing initial skills. Massed-teaching trials are useful in "rapidly establishing a new behavior pattern or in developing speed or fluency" (Warren and Kaiser, 1998 as cited by Rogers, 2006, p.146). Criticisms of this approach include the atypical teaching framework in which the main purpose of communication is omitted and, as a consequence, the opportunity to “associate new skills with functional real-life settings and communicative experiences is lost” (Rogers, 2006, p.146). Experts in the field recommend combining discrete-trial training with naturalistic intervention to foster spontaneity and generalization (e.g., T. Smith, 2001)

Naturalistic Intervention

Naturalistic intervention methods draw upon patterns of typical language acquisition. These approaches focus on creating episodes of coordinated attention by following-in on the child’s attention. While teaching, the therapist follows the child’s lead, by allowing him or her to choose the stimulus items. The stimuli are varied every few trials according to the child's interests. Teaching occurs within a play interaction and the teacher provides multiple cues and a natural reinforcer (e.g., the opportunity to play with the item) when the child produces the targeted response (Koegel & Koegel, 2006).

This approach has been successful in teaching nonverbal children to speak and in increasing vocabulary size in verbal children (for a review see Rogers, 2006). Strengths of this approach include the maintenance and generalization of targeted skills. Criticisms of this approach include reliance on single-subject studies to demonstrate efficacy (for a review see Delprato, 2001; Goldstein, 2002; Rogers, 2006). An additional criticism is that successful naturalistic intervention requires a highly trained therapist who can make decisions in the moment. Because efficacy studies have only used highly trained therapists, it is unclear whether this intervention approach can be effectively implemented by individuals who are not as highly trained (Rogers, 2006).

Given the poor attention capacities of children with ASD, some children with ASD may need scaffolding to support the coordinated attention necessary for learning. Children’s response to scaffolding may provide information about whether one intervention approach is better suited than another for teaching children at a specific developmental level.

Research Questions

This research study was designed to examine the role of attention in learning of children with ASD. We manipulated the attention scaffolding provided by the examiner and the object environment within a novel word-learning task. To determine whether children with ASD utilize similar attention cues for word learning as their typically-developing peers, we asked 1) whether hearing novel and attention-grabbing words cue the child to shift his or her attention to the speaker, and 2) whether the child follows the gaze of the speaker. To explore the effect of social and non-social attention scaffolding on learning, we taught novel words in two conditions. One condition provided maximal social-attention scaffolding: the examiner followed the focus of the child's attention. The other provided less scaffolding: the examiner directed the child's attention to the target using eye gaze. Additionally, we manipulated the number of objects present during teaching (two versus four). Because word learning is frequently targeted in intervention with mixed results, we hoped to gain insight on the performance of children with ASD under varying levels of scaffolding during the initial step in word learning (fast mapping).

Hypotheses and Predictions

Words act as attention cues for children. By the age of 24-months, hearing a novel word cues typically-developing children to shift their attention to the speaker (Akhtar et al., 2001). Words also act as attention cues for children with ASD, as demonstrated by their increased attention to objects that receive a verbal label (McDuffie et al., 2006b). Conflicting findings exist in the research literature regarding the use of novel words by children with ASD as a cue to shift attention to the speaker (Baron-Cohen et al., 1997; Luyster, 2007; Preissler & Carey, 2005). As a group, individuals with ASD demonstrate impairments in shifting attention (e.g., Dawson, Meltzoff, Osterling, Rinaldi et al., 1998).

We hypothesize that these impairments affect the ability of children with ASD to take advantage of cues in the environment that depend on shifting attention. Based on this hypothesis, it is predicted that the children with ASD will demonstrate significantly fewer looks to the examiner after hearing a novel word than their unaffected receptive-vocabulary mates.

Once a child has shifted his or her attention to the speaker, the child must follow the gaze of the speaker to determine his or her focus of attention (Akhtar et al., 2001; Baldwin, 1991; Baron-Cohen et al., 1997). Children with ASD demonstrate deficits in attention and coordinating attention (e.g., McDuffie et al., 2006b; Mundy et al., 1990). We hypothesize that attention impairments prevent children from achieving consistent gaze following. It is predicted that, as a group, the children with ASD will follow gaze less often than their unaffected receptive-vocabulary mates.

Adults scaffold coordinated attention by talking about objects and events that are currently the focus of the child's attention, thus creating episodes of coordinated attention (Carpenter et al., 1998). Children with ASD benefit from adults' use of follow-in strategies to scaffold attention (Siller & Sigman, 2002). We hypothesize that following-in on children's attention will improve word learning by scaffolding episodes of coordinated attention. It is predicted that children with ASD will perform better when the examiner provides attention scaffolding by talking about the object that is the focus of the child's attention. Because typically-developing children older than the age of 18 months do not rely on attention scaffolding, it is predicted that the unaffected receptive-vocabulary mates will perform equally well regardless of whether the examiner follows the child's attention or the child follows the examiner's attention. Overall, it is predicted that, as a group, the children with ASD will perform as well as their receptive-vocabulary mates when attention scaffolding is provided by the examiner during labeling and poorer than their receptive-vocabulary mates when no attention scaffolding is provided.

The environment itself influences word learning. Non-target stimuli, or distracters, placed in close spatial proximity to the target object add demands on the attention resources of the child, thus diminishing the efficiency of attention (Enns & Girgus, 1985). Children with ASD demonstrate significant deficits attending to social stimuli (Dawson, Meltzoff, Osterling, & Rinaldi, 1998; Dawson et al., 2004; Maestro et al., 2002; Mundy & Stella, 2000). Therefore, non-social scaffolding may be especially beneficial for children with ASD. We hypothesize that limiting the number of distracters in the environment will decrease the complexity of the word learning task. Because typically-developing children are aware of and use attention cues provided by the speaker, increasing the complexity of the learning environment will not affect learning to the same degree. It is predicted that the performance of the children with ASD will not differ from chance when there are four objects in the array and be above chance when there are only two objects in the array. We predict that the receptive-vocabulary mates will perform significantly better than chance regardless of the number of object in the array. (Table A2 provides a summary of hypotheses and predictions).

CHAPTER 3: METHODS

Participants

Participants with ASD were recruited by: (1) contacting preschools for children with ASD and speech-language pathologists who work with children with ASD and asking them to send informational letters home with their students, (2) posting informational flyers at venues targeting special-needs populations, (3) speaking to local ASD parent groups, and (4) sending informational emails about the study to employees at the University of Iowa.

Twenty-three children with ASD between the ages of three- and seven-years enrolled in the study. The *Autism Diagnostic Observation Schedule* (ADOS) was administered to confirm participants' diagnoses (Lord et al., 1990). Of the 23 participants enrolled, 8 children were excluded from data analysis. Four children were unable to independently complete the warm-up trials. One child was excluded for bilingualism. Due to illness, one child completed only the first visit. Therefore, the ADOS was never administered and his diagnosis could not be confirmed. Two children were excluded because the ADOS did not confirm the diagnosis. We report on the 15 children with a confirmed diagnosis of ASD who participated in the study.

The mean chronological age of the ASD participants was 59 months (range = 36-91 months). All of the ASD participants were male and all children but one received a clinical diagnosis of ASD prior to enrollment. All participants were monolingual English speakers who received services in English. Table A3 displays demographic information for the ASD group.

Receptive-vocabulary mates (RVM) were recruited by contacting families in the Iowa Collaboration on Child Language database and through local advertisements. The RVM group consisted of 15 children, nine male and six female, with a mean chronological age of 37 months (range = 16-92 months). The RVM group was significantly younger than the ASD group, *U*(30)= 51, p=.01. Table A4 displays demographic information for the RVM group.

The RVM group was matched to the ASD group according to raw scores on the *Receptive One Word Picture Vocabulary Test* (ROWPVT; Brownell, 2000). The raw scores of children in the ASD group and the RVM group were not significantly different *U*(20)= 48, p=.880. Five children with ASD could not complete the ROWPVT. These children were matched to the RVM group on the basis of words understood on the *MacArthur-Bates Communicative Development Inventory – Words and Gestures* (CDI; Fenson, 1989), *U*(10)=9, p=.463. Because two different measures of receptive vocabulary were used, percentiles were converted to z-scores to enable comparison. Years of maternal education was used as a measure of socio-economic status (SES). SES was not significantly different between the groups, *U*(28)= 76.5, p= .325.

Measures

(1) The *Receptive One Word Picture Vocabulary Test* (ROWPVT; Brownell, 2000) is a norm-referenced test of receptive vocabulary. The test displays four colored illustrations sequenced from right to left. All of the plates are numbered allowing the child to provide a pointing or verbal response.

(2) The *MacArthur-Bates Communicative Development Inventory – Words and Gestures* (CDI; Fenson et al., 1993) is a parent checklist of early receptive and expressive vocabulary, as well as nonverbal communicative skills. The *MacArthur-Bates Communicative Development Inventory –Words and Phrases* was administered, in addition to the CDI, to typically-developing children whose ages placed them outside of the CDI norms to determine whether the child's language fell within normal limits. This occurred for one child.

(3) The *Autism Diagnostic Observational Schedule* (ADOS; Lord, Rutter, & LeCouteur, 1999) is a semi-structured, standardized assessment of communication, social

interaction and play. During the assessment, the examiner uses a variety of social "presses" to elicit behaviors relevant to a diagnosis of ASD. Examiners choose the appropriate module based on the child's developmental level. A standardized diagnostic algorithm is calculated. Sub-scores from the communication and social domains are added together to create an algorithm total, with higher totals indicating greater abnormality. ADOS modules were administered by a trained examiner.

Stimuli

Stimuli consisted of 12 familiar objects, 120 unfamiliar objects (Appendix B) and five replacement unfamiliar objects. The set of familiar objects used for the warm-up included the following objects: dog, cat, duck, spoon, cup, bottle, shoe, bird, baby, shoe, block, and book. The unfamiliar objects were used for the novel word-learning task.

The 120 unfamiliar objects were subdivided into four groups. Each group contained a total of 30 unfamiliar objects: five sets of two unfamiliar objects and five sets of four unfamiliar objects. Each child saw up to 60 novel objects per visit, 20 of which were targets. The relatively large number of targets was possible because the task involved referent selection only; retention was not a goal. Target assignment was randomized across participants. Prior to the start of the experiment, parents were shown the novel objects and asked to identify objects for which the child had a label. Objects identified by the parent were replaced with an unknown object from the replacement set.

Forty novel words were used as labels for targets. To ensure that one set of words was not easier than another, we used words that been rated by adults on wordlikeness. Thirty adults rated the novel words on a five-point Likert scale, with a score of one being not wordlike and a score of five being very wordlike (Table A5).

Procedures

This study received approval from the University of Iowa Institutional Review Board. Recruitment of families was contingent upon either (1) parental contact or (2) prior parental indication of interest in future research participation (for those participants who were recruited through the Iowa Collaboration on Child Language database). When parents expressed interest in participation, details of the study were provided and parents were given the opportunity to ask questions about the study. To encourage participation, parents were given the option of scheduling the visits in the clinic or the home. Consent was obtained during the first visit.

Children in the RVM group completed two visits and children in the ASD group completed three visits. For both groups of children, the first two visits consisted of the experimental task and standardized language testing. The ADOS was administered to the ASD group on the third visit.

Procedures in the word-learning tasks were based on methods presented in Woodward, Markman and Fitzsimmons (1994) and Luyster (2007). Multiple objects were placed on a tray in front of the child. The examiner labeled the target object and used a neutral phrase (e.g, *Wow. Look at that.*) to draw attention to the distracter object(s). For all tasks described below, the orders of presentation, object placement, and object assignment (target versus distracter) were randomly assigned prior to administration for each child.

Each child participated in two conditions, one per visit, the order of which was randomized across participants. A total of up to 20 referent selection trials were administered per visit (10 trials with two unfamiliar objects and 10 trials with four unfamiliar objects). Each visit was organized as follows: warm-up, 10 teaching-testing trials (five trials with two unfamiliar objects and five trials with four unfamiliar objects), five minute break, and 10 additional teaching-testing trials (five trials with two unfamiliar objects and five trials with four unfamiliar objects). Testing, in which the child was asked to select the referent of the just-exposed novel word, immediately followed each teaching trial.

Warm-Up

Two familiar objects were placed on a tray. The child was instructed to place one familiar object in the bucket (*Put the duck in the bucket*.). If the child followed the instruction correctly, he or she was rewarded with verbal praise from the examiner. If the child's action was incorrect or the child did not respond, up to four additional teaching trials were administered. During the teaching trials, the examiner prompted the child by pointing to the target object and the bucket while repeating the instructions. If the child still did not respond or responded incorrectly, the examiner modeled the desired action (e.g., putting the duck in the bucket) and then verbally instructed the child again (e.g., *Now it's your turn. Put the duck in the bucket.*). After the completion of up to four teaching trials, five additional warm-up trials were administered. To ensure children's mastery of the task, children who did not follow the instructions independently on three of the five warm-up trials were excluded from the study (n=5).

Teaching Conditions

Teaching occurred immediately following the warm-up. Children participated in two conditions, one per day, designed to provide varying levels of attention scaffolding. The conditions differed in how the examiner introduced the novel word and are described below.

Directing Attention Condition

At the start of each trial, the two or four unfamiliar objects were placed on a tray out of the child's reach. The examiner looked at one object and either labeled the object, if it was the target (e.g., *Wow, look a modi. What a neat modi. Wow that's a modi*.) or used a neutral phrase to talk about the object, if it was a distracter (e.g., *Wow, look at that. That's neat. Wow that's cool*.). The examiner handed the object to the child immediately after she finished talking about the object. After five seconds the examiner took the object back from the child. This was repeated for every object on the tray.

Following Attention Condition

Again, at the start of each trial, the two or four unfamiliar objects were placed on the tray out of the child's reach. An object was determined to be the focus of the child's attention if he or she fixated his or her eye gaze on the object. The examiner handed the child the object that was the focus of his or her attention and either labeled the object, if it was the target (e.g., *Wow, look a modi. What a neat modi. Wow that's a modi.*) or used a neutral phrase to talk about the object, if it was a distracter (e.g., *Wow, look at that. That is neat. Wow that is cool.*), while the child handled the object. Like the directing attention condition, the child handled the object for five seconds. After she finished talking about the object, the examiner took it back from the child. This was repeated for every object on the tray.

If a child did not spontaneously shift attention to a new object, the examiner used a verbal prompt (i.e., *What else should we play with?*). If the verbal prompt was unsuccessful, the examiner removed the tray from the table, rearranged the objects and placed the tray back on the table. This enabled the examiner to break the child's focus of attention if he or she became fixated on an object.

In summary, the conditions were identical except that, in the following attention condition, the examiner followed the focus of the child's attention by giving the child the object that was the focus of his or her attention. The object was either named or talked about as the child held it. In the directing attention condition, the examiner looked at an object while she talked about it and then handed it to the child. The object was on the tray as the examiner either named or talked about it (Table A6).

Testing

Testing occurred immediately after each teaching trial. The examiner removed the tray from the table and rearranged the objects on the tray. The examiner placed the tray back onto the table and instructed the child to select the target (e.g.," *Put the modi in the bucket*."). One point was given for choosing the target.

Teaching and testing were discontinued if the child failed to respond on two consecutive trials or refused to participate in additional trials. Children needed to participate in at least five trials per teaching condition to have their results included (Balason & Dollaghan, 2002). To account for the unequal number of responses across participants, we computed a proportion score (correct response/ total trials).

Coding

All sessions were videotaped. The ELAN-Linguistic Annotator (ELAN) coding software was used to code children's looking behaviors. The purest measure of a child's use of a novel word as an attention cue is on the very first trial when he or she has not become familiar with the script used during the experiment. To examine whether children with ASD used novel or attention-grabbing words as a cue to shift attention to the speaker, we determined whether each child did or did not shift his or her attention to the examiner on the first trial of the directing attention condition.

Given that children who did not shift attention to the examiner on the first trial could come to do so on subsequent trials, we also computed children's mean gaze shifts to the examiner and children's mean gaze-following behavior on all subsequent trials involving two objects in the directing attention condition. Looks were not coded for the four-object trials due to difficulty in accurately discerning where the child looked when there were four objects in the array. Looks were not coded for the following attention condition because the examiner used a follow-in strategy to facilitate coordinating attention; therefore, in the following attention condition it was not necessary for the child to look at the examiner during teaching.

Coding began three seconds before the examiner said the novel word and ended when the examiner's hand came into view on the video recording. Coding ended at this time because the movement of the examiner's hand was judged to act as an attention cue. All videos were coded by a primary coder. A secondary coder coded 30 % of the videos. Reliability was calculated using Cohen's Kappa, k =.713. Agreement greater than .60 is considered acceptable and was used as a benchmark for reliability in another study that calculated looking behavior in children with ASD (McDuffie et al., 2006b; Mitchell, 1979). Therefore, this was considered an acceptable benchmark for reliability.

Mean gaze *shifting* was calculated by dividing the total number looks to the examiner by total number of trials completed. Mean gaze-*following* behavior was calculated as the total number of looks to the object following looks to the examiner divided by the total number of looks to the examiner. An example of the gaze-shift and gaze-following measurements is detailed in Table A7.

CHAPTER 4: RESULTS

Two broad aims were used as a guide in analyzing the results of the study: 1) describe the differences in word learning performance and coordinating attention between the ASD and RVM groups (between group); and 2) describe the influence of coordinating attention on the variables of interest within the ASD and the RVM group (within group). Between group analyses were conducted using an Analysis of Variance (ANOVA) and Mann-Whitney U tests. Within-group analyses were conducted using Mann-Whitney U tests and comparison to chance was conducted using independent sample t-tests. To further examine the relationship between coordinating attention and word learning, we ran exploratory Spearman rho correlations. Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS, 2008). All analyses were tested at alpha (α) = .05.

Between Group Analyses

Word Learning Performance

Subjects participated in a novel word-learning task under varying levels of social and non-social scaffolding. Each subject participated in two conditions, one providing maximal social scaffolding (following attention condition) and one providing less social scaffolding (directing attention condition). Within each condition, the number of objects in the learning environment was manipulated to make the task less (two objects) or more demanding (four objects). Because chance performance differed for the two- and four-object trials, we performed two univariate ANOVA's. One Group x Condition (2 x 2) univariate ANOVA was performed for the two-object trials and another was performed for the four-object trials (Figures 1 and 2). Group and Condition and were entered as independent variables. Word-learning performance was entered as the dependent variable. Children's word-learning scores were transformed, using an arcsine transformation, prior to analysis to account for the unequal number of trials across children.

In the two-object trials there was not a significant effect for Group $F(1, 115) = .22$, p=.64 ($\eta_p^2 = .007$) or Condition $F(1,115) = .16$, p=.69 ($\eta^2 = .005$). The children in the ASD, $t(14)=2.26$, p=.04, and RVM groups, $t(14)=2.30$, p=.01, performed significantly better than chance. The same pattern of performance was observed in the four-object trials. There was not a significant effect for Group $F(1, 41)=.02$, p=.8 ($\eta_p^2 = .001$) or Condition $F(1, 41)=1.27$, p=.27 ($\eta_p^2 = .04$). The children in the ASD, $t(14)=3.6$, p=.002, and RVM groups, $t(14)=3.72$, p=.002, performed significantly better than chance (Figure 1 and 2).

In addition, we ran two correlational analyses to determine whether performance across the conditions was related. In the RVM group performance in the directing condition was significantly correlated with performance in the following condition in the 2-object (p=.05) and 4-object (p=.01) trials. In the ASD group, performance in the following attention condition was marginally correlated to performance in the directing attention condition for the two- (p=.06) and four-object trials (p=.06).

Coordinating Attention

Two aspects of coordinating attention were measured; 1) whether children shifted their attention to the examiner when they heard a novel word and 2) whether they then followed the examiner's gaze to the named object.

Shifting attention upon hearing a novel word

The examiner used the same sentence frame to introduce the novel word for every teaching trial (i.e., the sequence *Wow, look a ___. What a neat ___. Wow that's a ____* was repeated on every trial). Therefore, it was determined that the purest measure of a child's use of a novel word as a cue to shift attention to the speaker was on the initial trial before children became familiar with the script. We determined whether each child did or did not shift attention to the examiner on the first trial of the directing attention condition.

In total, 85% of the children in the RVM group shifted their attention to the examiner when they heard a novel (n=5) or an attention-grabbing word (n=6). In the ASD, group 46% of the children shifted their attention to the examiner when they heard a novel (n=3) or an attention-grabbing word (n=3). A chi-square goodness of fit test revealed a significant difference in the number of children who shifted attention to the examiner in the RVM group as compared to the ASD group χ^2 (1, n=26), p=.04.

In addition, we determined whether shifting attention yielded accurate target selection at test. Four of the five children with ASD who shifted their attention to the examiner on the first trial selected the target object at test. Four of the seven children with ASD who did not shift attention to the examiner selected the correct object at test. In the RVM group, eight of the 11 children who shifted attention to the examiner on the first trial selected the target object at test. One of the two children who did not shift attention to the examiner on the first trial selected the correct object at test.

Following the examiner's gaze to a named object

Although, as compared to RVMs, the children with ASD did not shift their attention to the examiner upon hearing novel and attention-grabbing words on the initial trial, they may have come to do so as they became familiar with the experimental script. Therefore, to gain further insight into children's capacity to coordinate attention we calculated a mean gaze-shift score and a mean gaze-following score for each child on the two-object trials of the directing attention condition. Gaze following could not be coded for three children (2 ASD, 1 RVM) because of poor camera angles. Because we were interested in comparing looking behaviors between the ASD and RVM groups, children for whom looking data could not be coded and their matches were excluded from analysis (n=6).

There was not a significant difference between the groups for mean gaze shifts to the examiner, $U(23) = 81.5$, p=.898, or mean gaze-following behaviors, $U(23) = 74.0$, p=.608 (Figures 3 and 4). On average, the children in the ASD group looked at the examiner 1.18 times per teaching trial; those in the RVM group looked 1.31 times. The children in the ASD group followed the examiner's gaze to the target object an average 44% of the time and children in the RVM group followed the examiner's gaze to the target object an average 52% of the time.

Word Learning Performance and Gaze Following

RVM Group

The RVM group was divided into consistent- (n=8) and inconsistent- (n=5) gaze followers. Children defined as consistent-gaze followers had a mean gaze-following score greater than or equal to 50%. That is, when they looked at the examiner they followed her gaze to the target at least 50% of the time. We compared the fast-mapping performance of the consistent- and inconsistent-gaze followers to chance. Because teaching condition was not significant, conditions were collapsed. The consistent-gaze followers performed significantly above chance in the two-object trials in the following attention condition, $t(7) = 6.80$, $p < .001$ and directing attention condition $t(7)=2.23$, p=.06. In addition, the consistent-gaze followers performed significantly above chance in the four-object trials in the following $t(7)= 2.78$, p=.028 and directing attention conditions, $t(7)=2.37$, p=.05. Performance of the inconsistent-gaze followers in the two-object trials was significantly below chance in the following attention condition, $t(4)=-3.89$, p=.018 and did not differ from chance in the directing attention condition, $t(4)=.302$, p=.778. Their performance did not differ from chance in the four-object trials in either the following, $t(4)=.504$, p=.64 or directing attention condition, $t(4)=.331$, p=.76.

Given the individual differences in gaze following and subsequent word learning within the RVM group, we pursued additional analyses at the level of the individual participant. Specifically, we documented initial gaze shifting, gaze following, and subsequent word learning in the directing attention condition as well as word learning performance in the follow-in condition per individual child (see Table A8).

Examination of Table A8 reveals that of the 11 children who shifted their attention on the initial trial, eight were consistent-gaze followers in subsequent trials. These children demonstrate word learning that was significantly better than chance on the 2-and 4-object trials in both conditions. Of the two children who did not shift their attention to the examiner on the initial trial, neither went on to consistently follow the examiner's gaze on subsequent trials. The inconsistent-gaze followers' scores were not better in the follow-in than the directing attention condition. However, examination of individual participants revealed that two participants, 14T and 25T, performed better in the following attention condition. These participants were both 25 months of age and demonstrated good attention patterns throughout the experiment. One participant received the following attention condition on the first visit the other on the second.

ASD Group

Five children in the ASD group were consistent-gaze followers and eight children were inconsistent-gaze followers. The consistent-gaze followers performed at a level above chance in the two-object trials for the following attention condition, $t(4)=3.72$, $p=.02$, but not the directing attention condition, $t(4)=1.84$, $p=.14$. They performed significantly above chance in the four object trials in both the following, $t(4)=8.70$, $p=.001$, and directing attention conditions, $t(4)=4.27$, $p=.013$. The performance of the inconsistent-gaze followers did not differ from chance in the two-object trials in either the following , $t(7)=.-3.62$, $p=.728$, or directing attention conditions, $t(7)=.95$, $p =.37$. . This same pattern was observed in the four-object trials in the following, $t(7)=1.26$, $p=.25$, and directing attention conditions, $t(7)=2.14$, $p=.07$.

As per the RVM group, we describe further individuals differences in Table A8. Of the six children who shifted their attention to the examiner on the initial trial, two were consistent-gaze followers in subsequent trials. Of the seven children who did not shift their attention to the examiner on the initial trial, three went on to demonstrate consistent-gaze following in the subsequent trials. Three of the consistent-gaze followers had language scores that fell within one standard deviation of the mean. In addition, one participant, 14A, appeared to benefit from the following attention condition.

Correlations

We used a Spearman's *rho* correlation to further explore the relationship between coordinating attention and vocabulary learning. Vocabulary was measured using two tests (CDI and ROWPVT). Vocabulary percentiles were transformed into z-scores to enable vocabulary to be entered into the model. We assigned a vocabulary percentile of one to the children with ASD who were given the CDI. The CDI is normed on children up to 18 months of age. The children with ASD who were given the CDI were all at least three years of age. Given the difference between the age of the children with ASD and the population the CDI was normed on, a percentile of one was deemed an accurate reflection of the children's current receptive vocabulary level. The variables entered into the model were vocabulary (z-scores), gaze following, two-object word learning performance, four-object word learning performance, chronological age, and age of diagnosis. For the RVM group, age of diagnosis was not entered into the model (Table A9).

For the ASD group, gaze following was significantly correlated with two-object word learning performance, four-object word learning performance, and vocabulary ($p<.01$). Performance was not correlated with chronological age or age of diagnosis. For the RVM group, gaze following was significantly correlated with chronological age ($p< .05$) and two-object word learning performance ($p<.01$). Gaze following was not correlated with four-object word learning performance or vocabulary. However, chronological age was correlated with two- and four-object word learning performance ($p<.01$).

In summary, novel and attention-grabbing words acted as a robust cue to shift attention to the speaker on the initial trial for more of the children in the RVM group than the ASD group. Although the majority of children with ASD did not initially use novel or attention-grabbing words as a cue to shift attention to the speaker, some demonstrated consistent-gaze following on subsequent trials. As a result, the overall mean gaze shifts to the examiner and mean gaze-following behavior did not differ between the groups.

The word-learning performance of the ASD group did not differ from the RVM group. Use of a follow-in strategy did not improve word learning performance for either group. In addition, the number of objects present did not influence word-learning performance. Both the ASD and RVM groups performed above chance in the two- and four-object trials. Closer analysis revealed that this pattern was driven by the consistent-gaze followers in each group. The consistent-gaze followers in both groups performed above chance in the two- and four-object trials, whereas the inconsistent-gaze followers' performance did not differ from chance in either the two- or four-object trials. Table A10 provides a summary of the results.

CHAPTER 5: DISCUSSION

General Discussion

This research study was designed to examine the role of attention in word learning in children with ASD. Engaging in episodes of coordinated attention facilitates word learning by increasing attention to the object and, subsequently, increasing the likelihood of word-referent pairing. To actively coordinate attention, children must shift their attention to the speaker at the appropriate time and use attention cues provided by the speaker, such as eye gaze. Given the limited knowledge that we have regarding word learning in children with ASD, we examined only the initial stage of word learning, fast mapping.

In this study, ASD and RVM children participated in two novel word-learning tasks that differed in the way the novel word was introduced and where the burden of coordinating attention fell. In the directing attention condition, the examiner used eye gaze to direct the child's attention to the target object. Success in this condition relied on the child's capacity to coordinate attention with the examiner. In the following attention condition, the examiner followed-in on the focus of the child's attention. Because the examiner followed-in on the child's attention, word learning success relied on the child's capacity to pair the label with the object in their hand. In addition, we manipulated the number of objects present in the word learning environment, two versus four, to examine the effect of distracters on word learning.

ASD Group

One of the goals of this study was to determine whether the ASD group utilized the same cues for learning as the RVM group. To determine this we compared whether children 1) shifted their attention to the speaker when they heard novel or attention-grabbing words and 2) followed the speaker's eye gaze. We were interested in these behaviors because they support efficient learning. Shifting attention to the speaker and following his or her eye gaze to determine the speaker's focus of attention enables children to learn without being directly taught. Because gaze draws attention to the target object it should make the target object distinct enough to support word-referent pairing. The ASD group's performance differed from the RVM group's performance on one measure: shifting attention to the speaker upon hearing a novel or attention-grabbing word on the initial trial. This was the most stringent measure of whether novel words cued children to shift attention. On all other measures, the ASD group's performance did not significantly differ from the RVM group's performance. However, the ASD group demonstrated greater within group variability in their attention than the RVM group.

Novel Words

We examined whether children shifted their attention to the speaker when they heard novel or attention-grabbing words, a behavior observed in typically-developing children as young as 24-months (Akhtar et al., 2001). As compared to the RVM group, fewer children in the ASD group shifted their attention to the examiner when they heard a novel or attention-grabbing word on the first trial.

We examined whether shifting attention influenced performance on the initial trial. Four of the five children with ASD who did shift their attention to the examiner selected the target object at test. This compares to four of seven children who did not shift attention (a number that coincides closely to chance). The same pattern of results held for the RVM group. Eight of the eleven children who did shift attention to the examiner selected the target at test, whereas one of the two children who did not shift attention selected the target object at test. These results illustrate how cues in the environment, such as novel and attention-grabbing words, support attention shifts, and ultimately word learning, in children.

The finding that the ASD group differed from the RVM group on initial gaze shifts, but not mean gaze shifts or gaze following indicates that some of the children in the ASD group altered their behavior over the course of the experiment. Two of the children in the ASD group responded to novel and attention-grabbing words as a cue to shift attention and were consistent-gaze followers. This behavior pattern suggests relatively intact attention for these participants. Three of the children did not shift attention on the initial trial but were consistent-gaze followers on subsequent trials. The behavior pattern of these children suggests that general attention impairments may have prevented them from shifting their attention to the speaker on the initial trial. We hypothesize that these children used the input they received during the experiment (i.e., the script) to develop predictions and expectations about the examiner's behavior and used this information to alter their behavior and develop an efficient word-learning strategy. Four children shifted attention on the initial trial but demonstrated inconsistent attention shifting on the remaining trials. We hypothesize these children shifted attention to the examiner on the initial trial because of the novelty of the task. These children failed to develop a learning strategy and, as a result, their word-learning performance did not differ from chance. Four of the children did not shift their attention on the initial trial and did not become consistent even though they experienced the experimental script multiple times. The performance of this group suggests general attention impairments impeded them from developing an efficient word learning strategy.

In summary, the children with ASD demonstrated four patterns of performance 1) poor attention throughout, 2) initially good attention that decreased on subsequent trials, 3) initially poor attention that improved on subsequent trials, and 4) good attention throughout. In contrast, the RVM group demonstrated three patterns of performance 1) poor attention throughout, 2) initially good attention that decreased on subsequent trials, and 3) good attention throughout.

Compared to the ASD group, the RVM group demonstrated less variability. In addition, the children in the RVM group who demonstrated inconsistent and poor attention shared a specific characteristic, age. Three of the four children were of only 16-

20 months of age suggesting the patterns of attention were being driven by general development. This conclusion is supported by the significant relationship observed between performance on 2- and 4-object word learning tasks and chronological age in the RVM group. Unlike the RVM group, age did not appear to be driving attention patterns in the ASD group. Instead, a significant relationship was observed between gaze following, vocabulary and word-learning performance. These findings led us to hypothesize that differences in attention in the ASD group are related to the disorder itself.

The manifestation of the disorder in conjunction with experience may have influenced whether or not children shifted their attention to the examiner at the appropriate time. Under associative accounts of early word learning, we hypothesized that the experience of the majority of ASD participants prior to the experiment did not support the development of novel and attention-grabbing words as a cue to shift attention. Because only responses on the first trial were considered, this was a stringent measure of whether novel and attention-grabbing words act as a cue to shift attention to the speaker. Most of the children with ASD in this experiment were receiving speech and language intervention. As such, their learning experiences are inherently different than the children in the RVM group. The experiences of the children with ASD during intervention may not support the emergence of novel words as a cue to shift attention to the speaker.

However, three of the children went on to follow gaze consistently on subsequent trials. This suggests that they used the input they received during the experiment to alter their behavior and came to appreciate gaze and use it as a cue for learning. The group of children who shifted attention on the initial trial but demonstrated inconsistent gaze-following on subsequent trials may have needed additional scaffolding during the experiment in order to come to appreciate gaze and use it in the service of word learning.

In the future we can apply a paradigm akin to Smith and Yu (2008) to explore whether children with ASD use cross-trial experiences to learn words. If children with

ASD are using the input they receive to guide learning, we can examine whether providing gaze cues in conjunction with more salient cues, such as touch, facilitates coordinated attention for learning. More importantly, if everything else is held constant, we can examine whether children with ASD learn to consistently follow eye gaze over the course of an experiment if the more salient cue is slowly removed over multiple trials. In addition, we can examine whether manipulating the input children receive during the experiment alters their learning strategies over the course of the experiment. Studies using reaction time measures may provide further insight into whether attention impairments in the children with ASD results in slower attention shifting, which makes it *appear* as though the children with ASD are responding to different cues or whether they are in fact *using* different cues.

The fourth group of children did not shift attention on the initial trial and remained inconsistent-gaze followers on subsequent trials. For children who demonstrate this attention pattern future research will explore whether the experiment itself influences the allocation of attention. For example, the discrepant and follow-in labeling paradigm may be modified to examine whether children with ASD and significant attention impairments shift their attention to the speaker if the speaker is holding an unknown referent and the child is holding a known referent as compared to the current protocol wherein only unknown referents are present.

In summary, novel and attention-grabbing words failed to act as a cue to shift their attention to the speaker for the majority of children with ASD. Failure to shift attention to the speaker at the appropriate time places children with ASD at a disadvantage for learning language during unstructured social interactions. An additional consequence of failing to shift attention is that children with ASD have less experience with the cues provided during unstructured social interactions. In this experiment some of the children benefited from the input provided during the experiment, using it to develop an efficient learning strategy. However, over half of the children with ASD did not. For these children learning strategies may need to be explicitly taught (Jacobs, 2003).

Coordinating Attention

Whether or not children shifted their attention to the examiner on the initial trial was a stringent measure of attention behaviors. We used mean gaze following as a general measure of the behavior. Gaze following was of particular interest to us because of the deficits in social attention that characterize children with ASD and the importance of coordinating attention for word learning (e.g., Ames & Fletcher-Watson, 2010; McDuffie et al., 2006).

The mean gaze-shifts and gaze-following behaviors of the ASD group was equivalent to the RVM group. However, equivalent performance does not indicate intact attention skills. The majority of children with ASD failed to consistently follow the examiner's eye gaze. The average age of the inconsistent-gaze followers was 19.4 months (range= 16-27 months) in the RVM group and 57.8 months (range= 36-83 months) in the ASD group. The finding that the inconsistent-gaze followers in the ASD group were, on average, 38.4 months older than the inconsistent-gaze followers in the ASD group indicates that gaze following was impaired for the majority of ASD participants in the study. However, not all of the children with ASD were inconsistent-gaze followers. Five of the ASD participants followed the examiner's eye gaze consistently. Thus, we cannot conclude that coordinating attention was impaired across the group.

Coordinating Attention and Word Learning

Like previous research, these results demonstrate a significant relationship between coordinating attention (as measured by gaze following), word learning, and concurrent vocabulary among children with ASD. These findings highlight the importance of considering the attention skills in children with ASD. Coordinating attention has been identified as a pivotal skill to teach because improvement in coordinating attention results in improvement in areas not directly taught, including vocabulary. Although our findings are correlational and thus cause cannot be attributed, the findings from this study and McDuffie and colleagues (2006a) imply that targeting coordinated attention facilitates attention following, resulting in improved fast mapping and, in turn, vocabulary learning.

Scaffolding Word Learning

Given the deficits in coordinating attention widely reported in children with ASD, we anticipated that most of the children who participated in this study would not use the cues provided in this experiment to coordinate attention with the speaker. Therefore, we were interested in examining the effect of social and non-social scaffolding on word learning. Overall, limiting the number of distracters did not improve word learning performance. Gaze following, rather than the number of objects present, determined whether children's word-learning performance differed from chance. In addition, we examined the effect of social scaffolding on word learning. We examined whether following-in on the child's attention improved word-learning performance. However, neither group benefited from the follow-in strategy we used.

This finding conflicts with other findings in the literature. McDuffie and colleagues (2006) found that verbal labels increased attention to the target object in children with ASD. However, in that study, as a group the children with ASD showed less attention to the target than their receptive-vocabulary mates. Previous work showed children with ASD benefit from adult's use of follow-in strategies to scaffold attention (Baron-Cohen et al., 1997; Preissler & Carey, 2005; Siller & Sigman, 2002). These findings led researchers to suggest that word learning in children with ASD may be confined to situations where adults follow the child's current focus of attention and provide descriptive talking (McDuffie et al., 2006). Why then did our inconsistent-gaze followers fail to benefit from the follow-in scaffolding?

Closer inspection of the data suggests individual attention patterns in the capacity to take advantage of the scaffolding provided. The ASD group demonstrated four attention patterns performance 1) poor attention throughout, 2) initially good attention that decreased on subsequent trials, 3) initially poor attention that improved on subsequent trials, and 4) good attention throughout. The children with poor attention did not consistently attend to the examiner and, as a result, were unable to take advantage of the scaffolding provided. The second group of children may have attended to the examiner on the initial trial because of the novelty of the task. Although they attended to the examiner initially, we hypothesize that they used other cues for learning and, as a result, did not take advantage of the scaffolding. This was possible because of the design of the experiment. The directing attention condition was designed to measure whether children used the eye gaze of the examiner to determine the referent and, subsequently, create a word-referent pairing. In this condition the examiner handed the target object to the child shortly after it was named, thus the child could potentially map the word to the referent even if he or she never attended to the examiner. However, in this experiment the children handled both objects. As a result, only the verbal label in conjunction with the examiner's eye gaze differentiated the target from the distracter. We hypothesize that these children did not form a sufficient link between the word and referent because the only cue they used was the label itself. As a result, their word learning performance did not differ from chance. If this is the case, why did other studies find follow-in improved word learning for children with ASD?

Most studies examining the benefit of follow-in for teaching object names to children with ASD have used Baron-Cohen and colleagues (1997) follow-in versus discrepant labeling paradigm. Closer inspection reveals that their experiment differed from ours in one important way. In Baron-Cohen's experiment, the examiner held one object and the child held the other object. The speaker then talked about the object the child was holding as the child looked at it. The child was never given the opportunity to handle the other object. In our experiment, the children with ASD were given the opportunity to handle each of the objects. As a result, their experience with each object was identical with the exception that one object received a label. We propose that the presence of a verbal label may not have made the object distinct enough to support word-referent pairing. One reason that the label alone may have failed to promote word-referent pairing is because the children did not hear the label a sufficient number of times.

The children with ASD who participated in Luyster's (2007) novel word-learning task, which was modeled after Baron-Cohen's task, heard the novel word nine times as opposed to three times. In her study, the children were successful in both the follow-in and discrepant labeling conditions. The investigators attributed this success to the fact that their population was less impaired, however, it may be that increased exposure to the word may have also improved performance. Given that increased exposure facilitates word learning in young typically-developing children (e.g., Hollich et al., 2000) and children with SLI (e.g., Gray, 2000), it stands to reason the same effect may hold for children with ASD. It is possible that the children in this study could have created a more robust link if they heard more exposures. Future research may examine the effect of word exposure on learning.

Thus, the follow-in scaffolding that we provided may have been insufficient for the inconsistent-gaze followers' developmental level. That is, it did not make the target distinct enough to support word-referent pairing. Previous work with unaffected children found that scaffolding was beneficial when the task was too difficult for the child and the scaffolding was developmentally appropriate (Cleveland et al., 2007; Striano et al., 2006). Rather than solely using a follow-in strategy, children with ASD may need additional cues to highlight attention to the target.

However, not all of the children with ASD demonstrated impaired attention. One group of children with ASD was slow to take advantage of the examiner's gaze for learning, but learned to do so over the course of the experiment. These same children, made use of the follow-in scaffolding and performed above chance in the 2- and 4- object trials. A fourth group of children with ASD demonstrated good attention and word learning throughout. We hypothesize these children demonstrated good word learning in both conditions because the conjunction between gaze and labeling made the target distinct enough to support a sufficient link between the word and referent. Thus, coordinating attention by following-in on the child's focus, when everything else is equal, is only successful when children are aware of the other cues provided by the speaker or come to be aware of the other cues provided by the speaker through experience. For children who are not attending to the speaker, more salient cues may be needed in conjunction with follow-in to support word-referent pairing.

It may also be that the directing attention condition scaffolded performance for a particular set of children with ASD. The finding that there was a marginal correlation between word learning performance between the conditions provides indirect evidence that the children who were successful in the directing attention condition were not always the same children who were successful in the following attention condition. Therefore, rather than viewing these results as a failure to benefit from follow-in, the design of the directing attention may have scaffolded attention for some of the participants.

In summary, gaze following was variable across (and within) the children with ASD. Change in looking behavior by some of the ASD participants over the course of the experiment resulted in equivalent mean gaze-shifting and gaze-following between the ASD and RVM groups. The consistent-gaze followers coordinated attention with the examiner and, as a result, the verbal label in conjunction with the examiner's gaze cue made the target object distinct enough to support word-referent pairings. However, the majority of children in the ASD group were inconsistent-gaze followers and poor word learners. We hypothesize that the inconsistent-gaze followers failed to benefit from the follow-in, while holding everything else equal, because it did not make the target sufficiently distinct to support word-referent pairings. That is, for the inconsistent-gaze followers follow-in with more salient cues may be a more developmentally appropriate scaffold. This suggests that children require more than a verbal label to make a target distinct enough to support word-referent pairing. However, it is as likely that the directing attention condition scaffolded word learning for a subset of children with ASD negating any differences between the conditions.

The two teaching conditions used in this study were modeled after widely used intervention approaches, discrete-trial training and naturalistic intervention. The majority of children with ASD failed to take advantage of the follow-in scaffolding to coordinate attention. We hypothesize that this may have been because follow-in alone was not developmentally appropriate for these children. That is, holding the target while hearing the name was not sufficient to create a word-referent mapping. Clinically, this suggests that it is imperative to ensure the scaffold provided matches the child's developmental level and highlights the importance of making target objects distinct enough to facilitate word-referent pairings.

RVM Group

Children in the RVM group varied widely in their age. The youngest participant was 16 months and the eldest was 92 months. All of the children except two shifted their attention to the examiner when they heard novel and attention-grabbing words. This suggests that from a young age children understand novel and attention-grabbing words indicate an interesting object or event.

Given the wide age range, it is not unexpected that chronological age correlated with gaze following and word-learning performance. In addition, we see a correlation between word learning performance across conditions, such that those who performed well in the directing attention conditions also performed well in the following attention conditions in the two- and four-object trials. These correlations suggest that, despite the early emergence of these skills, refinements take place across the preschool years. In this experiment, we used gaze following as a measure of coordinated attention. Dividing children into consistent-and inconsistent-gaze followers enabled us to explore the influence of coordinating attention on word learning success. The consistent-gaze followers performed above chance in both conditions, whereas the inconsistent-gaze followers did not perform above chance in either the two- or four-object trials in the directing attention condition and the four-object trials in the following attention condition. The finding that the inconsistent-gaze followers in the RVM group performed below chance in the two-object trials in the following attention conditions suggests that the children may have been using a different strategy for these trials, such as choosing their favorite object. With the exception of one child, all of the inconsistent-gaze followers were under the age of two years.

The children under two-years of age demonstrated qualitatively different looking behaviors than the older participants. When the younger participants looked at the examiner, they frequently also pointed to one of the novel objects and alternated their eye gaze between the object of interest and the examiner. This behavior is typically indicative of requesting. Thus, it appears the younger children in the RVM group looked at the examiner for the purpose of requesting rather than for the purpose of coordinating attention with the speaker. Given this behavior during the directing attention condition, we would expect the children to perform significantly better when the examiner followed the child's attention.

Like the ASD group, the RVM children with poor attention and attention that decreased over the course of the experiment were poor word learners. We hypothesize that the children were using a strategy similar to the inconsistent-gaze followers in the ASD group. As a result, in the follow-in condition the verbal label alone did not make the target distinct enough to support robust word-referent pairing. In the following attention condition the child handled each object while the examiner talked about or labeled the object. The only difference between the target and distracter was that one received a verbal label, whereas, the other did not. Rearrangement of the objects between teaching and test prevented children from using spatial location to remember the word-referent pairing. Early word-referent pairings are extremely fragile and, as a result, small changes disrupt word learning. For example, when 12-and 19-month old children were taught a word but the location of the target was changed for testing, they did not “conclusively” demonstrate word learning (Hollich et al., 2000). However, the consistent-gaze followers in the RVM group did take advantage of the cues provided by the examiner and for these children the examiner’s gaze in conjunction with labeling made the target object distinct enough to promote sufficient word-referent pairing. As a result, the children’s word-learning performance was significantly better than chance in the 2- and 4-object conditions.

In summary, the poor word-learning performance of the inconsistent-gaze followers highlights the importance of gaze following for word learning success in directing attention (or overhearing) contexts. Because no other cues were provided, the gaze of the examiner was the only cue that made the target object distinct. However, consistent with previous research, the chance level performance of the inconsistent-gaze followers in the *following attention* condition suggests that labels alone may not make targets sufficiently distinct to facilitate word-referent pairing in very young children even when the adult takes the responsibility for coordinating attention. Future research can examine whether increasing the number of repetitions (e.g., Gray, 2000; Hollich et al., 2000), treating the target object differently (Akhtar, Carpenter & Tomasello, 1996; Samuelson & Smith, 1998), or using consistent spatial cues improves word learning performance of young typically-developing children in this task.

Limitations and Future Directions

This study provides interesting insight into the role of attention and word learning but has limitations. These limitations include the small sample size, the large age range, and the large range of abilities demonstrated by the participants. We did not do preference testing at the completion of each trial and, therefore, cannot determine whether the poor word learners were using a preference strategy for word-referent pairing. In addition, because we did not do mental age testing, we cannot determine whether gaze following in the children with ASD was related to their mental age.

Because this research study examined the initial stage of word learning, subsequent research may focus on retention and extension. In addition, future research can examine whether children with ASD use cross-trial experiences to learn words and whether manipulating input alters behavior over the course of an experiment. With regards to scaffolding, future research may examine whether increasing the number of exposures to the novel word and/or providing additional attention cues makes the target distinct enough to promote word-referent pairings for children with ASD with poor attention skills.

Summary

This study adds to a growing body of literature examining attention and learning in children with ASD. Like previous research, our results replicate evidence of a relationship between coordinating attention and word learning. Children who consistently followed the eye gaze of the examiner were better word learners. Gaze following was variable across (and within) the ASD group. The within subject variability suggests some children with ASD are slow to appreciate eye gaze cues in unfamiliar contexts. This is the first study to directly compare directing attention and following attention teaching styles using a within- subject study design. Our findings suggest that following children's attention is not sufficient to facilitate word learning in children who do not demonstrate consistent attention to the speaker. We hypothesize that although the follow-in strategy decreased the difficulty of the word learning task, when all else is equal, providing a label does not make the target distinct enough to support word-referent pairing for these children. However, children who demonstrate awareness of the speaker, or come to demonstrate awareness over the course of the experiment, are able to take advantage of labeling in conjunction with eye gaze to create robust word-referent pairings.

APPENDIX A: TABLES AND FIGURES

Table A1. Attention, gaze following, and word learning

Age	General attention	Gaze following	Word learning
4-5 mo.	Actively coordinate visual attention between objects and people	Emerging awareness of adults' eye gaze	
6 mo.	Emerging ability to shift attention between objects in the same visual field	Follow adults' eye gaze to visible objects when adults use direct gaze contact or infant-directed speech to gain infants' attention	
8 mo.		Consistently follow gaze when provided with feedback	
10 mo.		Consistently follow gaze in the absence of feedback	Tendency of mother to follow her child's attention accounts for more than half the
12 mo.	Maintain periods of sustained attention to multiple stimuli in different fields	Use adults' gaze to find targets in complex spatial layouts	variance in infant's language comprehension and production
14 mo.			Word learning strongly influenced by extrinsic factors
18 mo.	Adept at shifting attention between multiple stimuli	Sophisticated gaze followers – do not follow adult's head turn when presented with incongruent head and gaze orientation	Word learning continues to influenced by extrinsic factors but not to the same degree Fast mapping abilities emerging Beginning of vocabulary burst
24 mo.	Aware of variety of attention cues in the environment that may be used for word learning		Less influenced by extrinsic factors Successful in variety of word learning contexts including overhearing

Table A2. Hypotheses and Predictions

Hypothesis 1: Attention impairments affect the ability of children with ASD to take advantage of cues in the environment.

Prediction 1: Children with ASD will demonstrate fewer looks to the examiner after hearing novel and attention-grabbing words than the RVM children

Hypothesis 2: Attention impairments prevent children with ASD from achieving the developmental level necessary for consistent gaze following

Prediction 2: Children with ASD will follow gaze less than the RVM children

Hypothesis 3: Following in on children's attention will improve word learning by scaffolding episodes of coordinated attention

Prediction 3a: Children with ASD will perform better when the examiner provides attention scaffolding during labeling

Prediction 3b: The RVM group will perform equally well in both teaching conditions

Prediction 3c: The ASD group will perform like the RVM group in the following attention condition and worse than the RVM group in the directing attention condition

Hypothesis 4: Limiting the number of distracters in the environment will decrease the complexity of the word learning task.

Prediction 4a: Decreasing the complexity of the object environment will not effect word learning to the same degree for the RVM group. Children will perform above chance regardless of the number of objects in the array.

Prediction 4b: Performance of children with ASD will not differ from chance when there are four-objects in the array and will be significantly better than chance when there are two-objects in the array.

Table A3. ASD Demographic Information (N=15)

Participant ID	*Chronological Age (months)*	*Age of Diagnosis (months)*	*Maternal education (years)*	*Vocabulary (z-scores)*
2A	40	24	12	-2.33
3A	41		Not reported	-2.33
4A	36	29	10	-2.33
5A	81	30	14	2.05
8A	38	21	17	-1.48
9A	76	62	18	0.52
10A	83	45	21	-2.33
12A	81	24	18	-2.33
13A	61	43	16	-0.74
14A	46	27	20	-2.33
17A	91	67	18	1.75
18A	71	30	14	-2.33
19A	53	9	16	0.33
22A	53	31	16	-1.64
25A	38	19	Not reported	-2.33
Mean	59.27	34.42	16.15	-1.19
Range	36-92	21-67	10-21	-2.33-2.05
SD	19.53	14.67	3.08	1.59

Table A4. RVM Demographic Information (N=15)

Participant ID	*Chronological Age (months)*	*Maternal Education (years)*	*Vocabulary (z-scores)*
12T	25	18	-0.28
14T	53	21	0.20
15T	16	14	1.04
18T	16	18	-0.52
20T	18	18	-0.52
22T	27	14	-0.52
23T	18	20	-0.68
24T	46	20	1.65
25T	25	15	0.28
26T	27	16	-0.73
27T	55	16	0.61
29T	38	16	0.08
31T	83	18	0.08
33T	92	16	1.28
34T*	20	22	n/a
Mean	37.27	17.47	.14
Range	16-92	14-20	-0.68-1.65
SD	24.18	2.47	.76

* z-scores were based on receptive language, because the child fell outside of the age for the CDI: Words and gestures a z-score was not computed.

Table A5. Wordlikeness Ratings

Set A	**Set B**	**Set C**	**Set D**
prindle (4.41)	trumpetine (4.38)	rubid (4.29)	pennel (4.28)
bannifer (4.13	ballop (4)	diller (4.25)	toma (4.13)
hampent (3.84)	skiticult (3)	frescovent (4)	doppelate (4)
fennerizer (3.75)	glistow (3.88)	brasterer (3.84)	bannow (3.97)
penerriful (3.75)	nibe (3.69)	teebo (3.59)	contraponist (3.66)
mode (3.56)	reutteration (3.63)	stopograttic (3.38)	vope (3.63)
barrazon (3.56)	commeecitate (3.03)	dayboo (3.03)	commerine (3.9)
tayvock (2.81)	empliforvent (2.94)	blonterstaping (3)	loddernapish (2.5)
doyfe (2.53)	boono (2.63)	keefee (2.78)	vatchype (2.09)
chovagg (2.25)	tafflest (3.61)	woogalamic (2.38)	waetoo (2.47)

Table A6. Teaching Conditions

Following Attention condition	**Directing Attention condition**
All of the objects are placed on the table	All of the objects are placed on the table
Examiner waits for the child to look at an object Examiner **hands** the object to the child. While the child handles the object the examiner says: <u>Target object:</u> *Wow, look a modi. What a neat modi. Wow that's a modi.* or <u>Distracter:</u> *Wow, look at that. That's neat. Wow that is cool.*	Examiner looks at an object and says: <u>Target object:</u> *Wow, look a modi. What a neat modi. Wow that's a modi.* or <u>Distracter:</u> *Wow, look at that. That's neat. Wow that is cool.* Examiner **hands** the object to the child

Table A7. Example of gaze shifts and gaze following measurements

Trial	**Measurement**
1	*Wow, look a modi. What a neat modi. Wow, that's a modi*. Measurement begins — Measurement ends when examiner moves towards object Measure 1: number of looks to examiner Measure 2: number of looks to object following looks to examiner
2	*Wow, look a toma. What a neat toma. Wow, that's a toma*. Measurement begins — Measurement ends when examiner moves towards object Measure 1: number of looks to examiner Measure 2: number of looks to object following looks to examiner
….5	
TOTAL	1) total number of looks to examiner / total number of trials completed = mean gaze shifts 2) total number of looks to object following looks to examiner/ total number of looks to examiner = mean gaze-following behavior

Figure A1. 2- object trials word learning performance

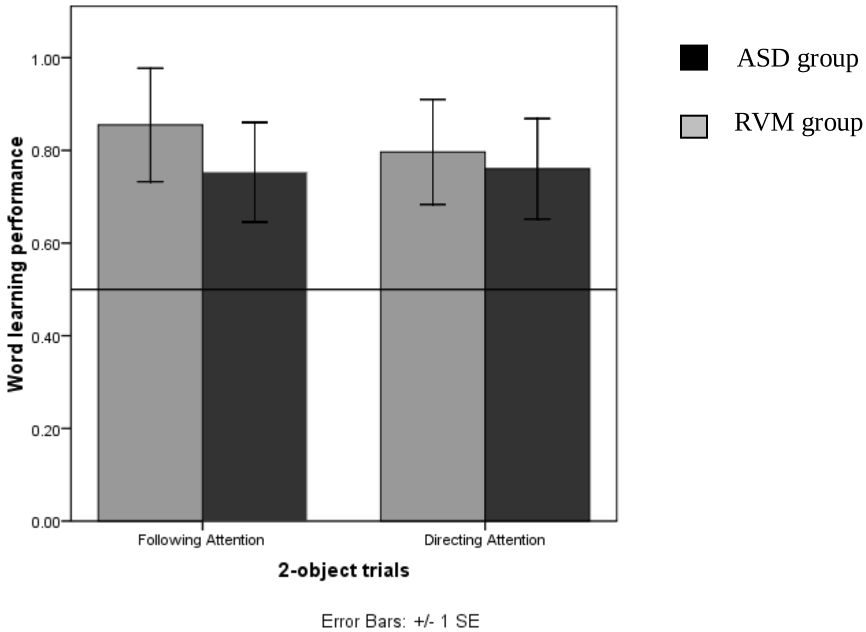

Figure A2. 4-object trials word learning performance

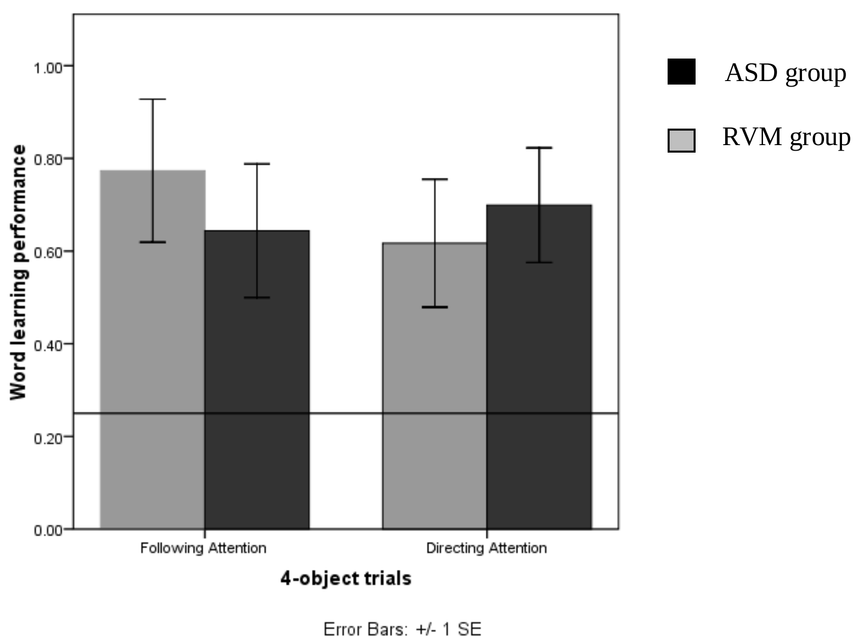

Figure A3. Mean gaze shifts group comparison

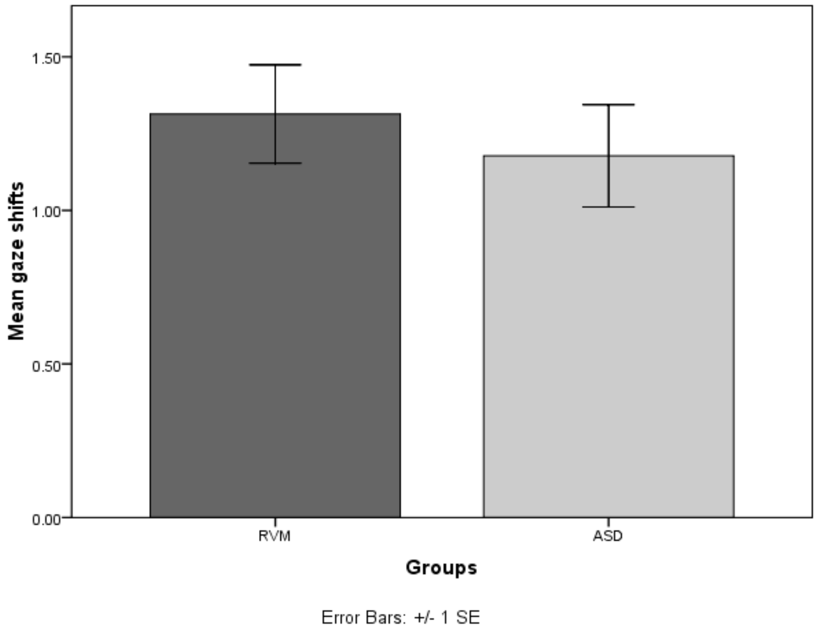

Figure A4. Mean gaze-following behaviors group comparison

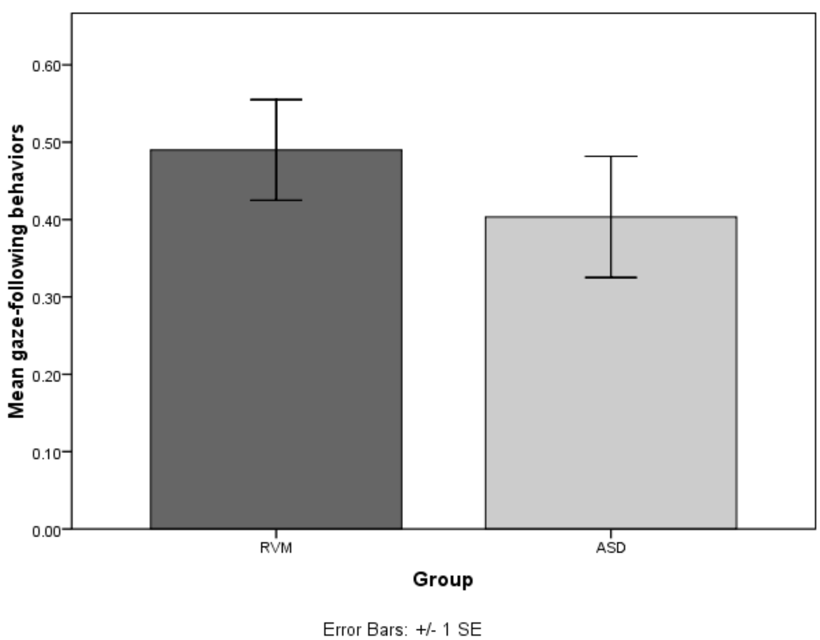

Table A8. Summary of participant's performance

		Directing Attention				***Following Attention***	
Patterns of attention to examiner	*Subject*	*2-object*	*4-object*	*Initial look to examiner (yes/no)*	*Consistent gaze following (yes/no)*	*2-object*	*4-object*
RVM							
Poor attention	20T	+ 10	+13	No	No	-20	+15
	34T	0	+15	No	No	-21	+8
Decreased over experiment	15T	20	-25	Yes	No	-25	-11
	18T	-20	-3	Yes	No	-6	-14
	26T	0	+20	Yes	No	-6	19
Good attention	12T	+17	0	Yes	Yes	+50	0
	14T	-10	-5	Yes	Yes	+30	+25
	22T	+27	+31	Yes	Yes	+25	+8
	23T	-17	-5	Yes	Yes	+6	+4
	25T	+10	+8	Yes	Yes	+40	+40
	27T	+50	+75	Yes	Yes	+39	+75
	29T	+30	+55	Yes	Yes	+40	+35
	33T	+50	+75	Yes	Yes	+50	+75
ASD							
Poor attention	2A	-10	-5	No	No	-17	0
	4A	+10	+25	No	No	-10	+75
	13A	+20	+15	No	No	+17	+4
	18A	-10	+19	No	No	+13	0
Decreased over experiment	10A	+33	+58	Yes	No	-17	+8
	12A	+10	+25	Yes	No	-10	+15
	22A	+10	-5	Yes	No	+10	+5
	25A	-17	-3	Yes	No	0	-40
Improved over experiment	8A	+18	+55	No	Yes	0	+10
	14A	-30	+5	No	Yes	+30	+55
	17A	+50	+45	No	Yes	+39	+75
Good attention	9A	+39	+65	Yes	Yes	+40	+65
	19A	+50	+65	Yes	Yes	+50	+65

*Scores on the 2- and 4-object trials were computed by subtracting the child’s score from chance

Table A9. Correlation Table

Measures	1	2	3	4	5	6
ASD Group						
1. gaze following	-	.701**	.771**	.781**	.363	.290
2. vocabulary		-	.903**	.664*	.335	.347
3. 2-object word learning performance			-	.753**	.326	.226
4. 4-object word learning performance				-	.538	.273
5. chronological age					-	.651*
6. age of diagnosis						-
RVM Group						
1. gaze following	-	.334	.748**	.424	.584*	n/a
2. vocabulary		-	.653**	.181	.394	n/a
3. 2-object word learning performance			-	.565*	.763**	n/a
4. 4-object word learning performance				-	.802**	n/a
5. chronological age					-	n/a

* Correlation is significant at the 0.05 level

** Correlation is significant at the 0.01 level

Table A10. Summary of Results

Experimental Measures	Group Comparison	Finding
Attention following		
Novel words as a cue	ASD < RVM	
Gaze Following	ASD = RVM	
Word Learning	ASD = RVM	
Condition	ASD = RVM	Following Attention = Directing Attention
Object number	ASD = RVM	two-object & four-object trials > chance

APPENDIX B: STIMULI

REFERENCES

Adamson, L. B. (1996). *Communication development during infancy*. Boulder, CO: Westview Pr.

Adamson, L. B., & Chance, S. E. (1998). Coordinating attention to people, objects, and language. *Transitions in prelinguistic communication, 7*, 15–37.

Akhtar, N., Jipson, J., & Callanan, M. A. (2001). Learning words through overhearing. *Child Development, 72*, 416-430.

Allen, G., & Courchesne, E. (2001). Attention function and dysfunction in autism. *Frontiers in Bioscience, 6*, 105–119.

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders (4th ed.)*. Washington, DC: Author.

Ames, C., & Fletcher-Watson, S. (2010). A review of methods in the study of attention in autism. *Developmental Review, 30*, 52-73.

Anderson, D. K., Lord, C., Risi, S., DiLavore, P. S., Shulman, C., Thurm, A., et al. (2007). Patterns of growth in verbal abilities among children with autism spectrum disorder. *Journal of consulting and clinical psychology*, *75*(4), 594-604.

Anderson, J. R. (2005). *Cognitive psychology and its implications*. New York, NY: Worth Publishers.

Asherson, P. J., & Curran, S. (2001). Approaches to gene mapping in complex disorders and their application in child psychiatry and psychology. *The British Journal of Psychiatry*, *179*(2), 122.

Bailey, A., Phillips, W., & Rutter, M. (1996). Autism: towards an integration of clinical, genetic, neuro-psychological, and neurobiological perspectives. *Journal of Child Psychology and Psychiatry*, *37*(1), 89-126.

Bakeman, R., & Adamson, L. B. (1984). Coordinating attention to people and objects in mother-infant and peer-infant interaction. *Child Development*, 1278-1289.

Balason, D. V., & Dollaghan, C. A. (2002). Grammatical morpheme production in 4-year-old children. *Journal of Speech, Language, and Hearing Research, 45*(5), 961.

Baldwin, D. A. (1991). Infant's contribution to the achievement of joint reference. *Child Development*, *62*, 875-890.

Baldwin, D. A. (1995). Understanding the link between joint attention and language. *Joint attention: Its origins and role in development*, 131–158.

Baron-Cohen, S., Baldwin, D. A., & Crowson, M. (1997). Do Children with Autism Use the Speaker's Direction of Gaze Strategy to Crack the Code of Language? *Child Development, 68*(1), 48-57.

Bono, M. A., Daley, T., & Sigman, M. (2004). Relations Among Joint Attention, Amount of Intervention and Language Gain in Autism. *Journal of Autism and Developmental Disorders, 34*(5), 495-505.

Booth, A. E., McGregor, K. K., & Rohlfing, K. J. (2008). Socio-pragmatics and attention: Contributions to gesturally guided word learning in toddlers. *Language Learning and Development, 4*(3), 179-202.

Bopp, K. D., Mirenda, P., & Zumbo, B. D. (2009). Behavior Predictors of Language Development Over 2 Years in Children With Autism Spectrum Disorders. *Journal of Speech, Language and Hearing Research, 52*(5), 1106.

Brooks, R., & Meltzoff, A. N. (2008). Infant gaze following and pointing predict accelerated vocabulary growth through two years of age: A longitudinal, growth curve modeling study. *Journal of Child Language, 35*(01), 207-220.

Brownell, R. (2000). Receptive one-word picture vocabulary test. *Novato, CA: Academic Therapy*.

Burack, J. A. (1994). Selective attention deficits in persons with autism: preliminary evidence of an inefficient attentional lens. *Journal of Abnormal Psychology, 103*(3), 535-543.

Capone, N. C., & McGregor, K. K. (2005). The Effect of Semantic Representation on Toddlers' Word Retrieval. *Journal of Speech, Language and Hearing Research, 48*(6), 1468-1480.

Carey, S. (1978). The child as a word learner. In M. Halle (Ed.), *Linguistic Theory and Psychological Reality*: MIT Press.

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*, 1-174.

Carter, A. S., Davis, N. O., Klin, A., & Volkmar, F. R. (2005). Social development in autism. *Handbook of autism and pervasive developmental disorders, 1*, 312–334.

Casey, B. J., Gordon, C. T., Mannheim, G. B., & Rumsey, J. M. (1993). Dysfunctional attention in autistic savants. *Journal of Clinical and Experimental Neuropsychology, 15*(6), 933-946.

Charman, T. (2003). Why is joint attention a pivotal skill in autism? *Philosophical transactions - Royal Society, 358*, 315-324.

Chawarska, K., Klin, A., & Volkmar, F. (2003). Automatic attention cueing through eye movement in 2-year-old children with autism. *Child Development*, 1108-1122.

Cleveland, A., Schug, M., & Striano, T. (2007). Joint attention and object learning in 5- and 7-month-old infants. *Infant and Child Development, 16*(3), 295.

Corkum, V., & Moore, C. (1995). The development of joint visual attention in infants. In C. Moore & J. Bruner (Eds.), *Joint attention: Its origins and role in development* (pp. 61-84). Hillsdale: Lawrence Erlbaum Associates.

Courchesne, E., Lincoln, A. J., Kilman, B. A., & Galambos, R. (1985). Event-related brain potential correlates of the processing of novel visual and auditory information in autism. *Journal of Autism and Developmental Disorders, 15*(1), 55-76.

Dawson, G. (2008). Early behavioral intervention, brain plasticity, and the prevention of autism spectrum disorder. *Development and Psychopathology, 20*(03), 775-803.

Dawson, G., Meltzoff, A. N., Osterling, J., & Rinaldi, J. (1998). Children with autism fail to orient to naturally occurring social stimuli. *Journal of Autism and Developmental Disorders, 28*, 479-185.

Dawson, G., Meltzoff, A. N., Osterling, J., Rinaldi, J., & Brown, E. (1998). Children with autism fail to orient to naturally occurring social stimuli. *Journal of Autism and Developmental Disorders, 28*(6), 479-485.

Dawson, G., Toth, K., Abbott, R., Osterling, J., Munson, J., Estes, A., et al. (2004). Early social attention impairments in autism: Social orienting, joint attention, and attention to distress. *Developmental Psychology, 40*(2), 271-282.

Delprato, D. J. (2001). Comparisons of discrete-trial and normalized behavioral language intervention for young children with autism. *Journal of Autism and Developmental Disorders, 31*, 315-325.

Dickinson, D. K. (2008). First impressions: Children’s knowledge of words gained from a single exposure. *Applied Psycholinguistics, 5*(04), 359-373.

Doussard-Roosevelt, J. A., Joe, C. M., Bazhenova, O. V., & Porges, S. W. (2003). Mother-child interaction in autistic and nonautistic children: Characteristics of maternal approach behaviors and child social responses. *Development and Psychopathology, 15*, 277-295.

Enns, J. T., & Girgus, J. S. (1985). Developmental changes in selective and integrative visual attention. *Journal of experimental child psychology(Print), 40*(2), 319-337.

Eriksen, C. W., & St James, J. D. (1986). Visual attention within and around the field of focal attention: A zoom lens model. *Perception & Psychophysics, 40*(4), 225-240.

Eriksen, C. W., & Yeh, Y. (1985). Allocation of attention in the visual field. *Journal of Experimental Psychology: Human Perception and Performance, 11*(5), 583-597.

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D. J., Pethick, S. J., et al. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development, 59*(5).

Fenson, L., Dale, P. S., Reznick, J. S., Thal, D., Bates, E., Hartung, J., et al. (1993). *MacArthur Communicative Development Inventories: User's guide and technical manual.* Baltimore: Brookes.

Flom, R., & Pick, A. D. (2003). Verbal encouragement and joint attention in 18-month-old infants. *Infant Behavior and Development, 26*(2), 121-134.

Fombonne, E. (1999). The epidemiology of autism: a review. *Psychological Medicine, 29*(04), 769-786.

Gershkoff-Stowe, L., & Smith, L. B. (2004). Shape and the first hundred nouns. *Child Development, 75*(4), 1098-1114.

Goldstein, H. (2002). Communication intervention for children with autism: A review of treatment efficacy. *Journal of Autism and Developmental Disorders, 32*, 373-396.

Golinkoff, R. M. (1992). Young Children and Adults Use Lexical Principles to Learn New Nouns. *Developmental Psychology, 28*(1), 99-108.

Golinkoff, R. M., Hirsh-Pasek, K., Bailey, L. M., & Wenger, N. R. (1992). Young children and adults use lexical principles to learn new nouns. *Developmental Psychology, 28*(1), 99-108.

Golinkoff, R. M., Mervis, C. B., & Hirsh-Pasek, K. (1994). Early object labels. *Journal of Child Language, 21*, 125-156.

Gomez, R. L., & Gerken, L. (1999). Artificial grammar learning by 1-year-olds leads to specific and abstract knowledge. *Cognition, 70*(2), 109-135.

Gupta, P., & Tisdale, J. (2009). Word learning, phonological short-term memory, phonotactic probability and long-term memory: towards an integrated framework.

Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1536), 3755.

Hainline, L. (1978). Developmental changes in visual scanning of face and nonface patterns by infants. *Journal of Experimental Child Psychology, 25*(1), 90-115.

Haith, M. M., Bergman, T., & Moore, M. J. (1977). Eye contact and face scanning in early infancy. *Science, 198*(4319), 853-855.

Harris, S. L. (2007). Behavioral and educational approaches to pervasive developmental disorders. In F. Volkmar (Ed.), *Autism and Pervasive Developmental Disorders* (Second ed.). Cambridge: Cambridge University Press.

Heibeck, T. H., & Markman, E. M. (1987). Word learning in children - An examination of fast mapping. *Child Development, 58*(4), 1021-1034.

Hermelin, B., & O'Connor, N. (1970). *Psychological experiments with autistic children*: Pergamon.

Hirsh-Pasek, K., Golinkoff, R. M., & Hollich, G. (2000). An emergentist coalition model for word learning: Mapping words to objects is a product of the interaction of multiple cues. In R. M. Golinkoff, K. Hirsh-Pasek, L. Bloom, L. Smith, A. L. Woodward, N. Akhtar, M. Tomasello & G. Hollich (Eds.), *Becoming a word learner: A debate on lexical acquisition*. Oxford: Oxford University Press.

Hoff, E. (2003). The specificity of environmental influence: Socioeconomic status affects early vocabulary development via maternal speech. *Child Development*, 1368-1378.

Hollich, G. J., Hirsh-Pasek, K., Golinkoff, R. M., Brand, R. J., Brown, E., Chung, H. L., et al. (2000). Breaking the language barrier: An emergentist coalition model for the origins of word learning. *Monographs of the Society for Research in Child Development*.

Hughes, J. R. (2008). A review of recent reports on autism: 1000 studies published in 2007. *Epilepsy and behavior, 13*(3), 425-437.

Jarvinen-Pasley, A., & Heaton, P. (2007). Evidence for reduced domain-specificity in auditory processing in autism. *Developmental Science, 10*(6), 786.

Johnson, C., & Myers, S. M. (2007). Identification and evaluation of children with autism spectrum disorders. *Pediatrics, 120*(5), 1183.

Johnson, M. H., Dziurawiec, S., Ellis, H., & Morton, J. (1991). Newborns' preferential tracking of face-like stimuli and its subsequent decline. *Cognition, 40*(1-2), 1-19.

Jones, W., Carr, K., & Klin, A. (2008). Absence of preferential looking to the eyes of approaching adults predicts level of social disability in 2-year-old toddlers with autism spectrum disorder. *Archives of general psychiatry, 65*(8), 946.

Kaland, N., Smith, L., & Mortensen, E. L. (2008). Brief report: Cognitive flexibility and focused attention in children and adolescents with asperger syndrome or high-functioning autism as measured on the computerized version of the Wisconsin card sorting test. *Journal of Autism and Developmental Disorders, 38*(6), 1161-1165.

Koegel, R. L., & Koegel, L. K. (2006). *Pivotal Response Treatments for autism: Communication, social and academic development*. Baltimore: Paul H. Brooks Publishing Co.

Kuhl, P. K. (2004). Early language acquisition: Cracking the speech code. *Nature Reviews, 5*, 831-843.

Kuhn, G., Tatler, B., & Cole, G. (2009). You look where I look! Effect of gaze cues on overt and covert attention in misdirection. *Visual Cognition, 17, 6*(7), 925-944.

Kuhn, G., Tatler, B. W., Findlay, J. M., & Cole, G. G. (2007). Misdirection in magic: Implications for the relationship between eye gaze and attention. *Visual Cognition, 99999*(1), 1-15.

Kylliäinen, A., & Hietanen, J. K. (2004). Attention orienting by another's gaze direction in children with autism. *Journal of Child Psychology and Psychiatry, 45*(3), 435-444.

Landa, R., & Garrett-Mayer, E. (2006). Development in infants with autism spectrum disorders: a prospective study. *Journal of Child Psychology and Psychiatry, 47*(6), 629-638.

Leekam, S. R., Lopez, B., & Moore, C. (2000). Attention and joint attention in preschool children with autism. *Developmental Psychology, 36*(2), 261-273.

Levy, S., Kim, A. H., & Olive, M. L. (2006). Interventions for young children with autism: A synthesis of the literature. *Focus on Autism and Other Developmental Disabilities, 21*(1), 55.

Lord, C., Merrin, D. J., Vest, L. O., & Kelly, K. M. (1983). Communicative behavior of adults with an autistic four-year-old boy and his nonhandicapped twin brother. *Journal of Autism and Developmental Disorders, 13*(1), 1-17.

Lord, C., Rutter, M., & LeCouteur, A. (1999). *Autism Diagnostic Observation Schedule (ADOS)*. Lost Angeles: Western Psychological Services.

Lord, C., & Schopler, E. (1989). The role of age at assessment, developmental level, and test in the stability of intelligence scores in young autistic children. *Journal of Autism and Developmental Disorders, 19*(4), 483-499.

Lovaas, O. I. (1977). *The autistic child: Language development through behavior modification*. New York: Irvington.

Luyster, R. J. (2007). *Word learning in children with autism spectrum disorders.* Unpublished Dissertation, The University of Michigan.

Maestro, S., Casella, C., Milone, A., Muratori, F., & Palacio-Espasa, F. (2000). Study of the onset of autism through home movies. *Psychopathology, 32*(6), 292-300.

Maestro, S., Muratori, F., Cavallaro, M. C., Pei, F., Stern, D., Golse, B., et al. (2002). Attentional skills during the first 6 months of age in autism spectrum disorder. *Journal of Amer Academy of Child & Adolescent Psychiatry, 41*(10), 1239.

Markman, E. M. (1990). Constraints children place on word meanings *Cognitive Science, 14*(1), 57-77.

Markman, E. M., & Wachtel, G. F. (1998). Children's use of mutual exclusivity to constrain the meaning of words. *Cognitive Psychology, 20*(2), 121-157.

Mayes, L., Cohen, D., & Klin, A. (1993). Desire and fantasy: a psychoanalytic perspective on theory of mind and autism. *Understanding Other Minds: Perspectives From Autism. Oxford: Oxford Medical Publications*.

McDuffie, A., Yoder, P., & Stone, W. (2006a). Fast-mapping in young children with autism spectrum disorders. *First Language, 26*(4), 421.

McDuffie, A., Yoder, P., & Stone, W. (2006b). Labels increase attention to novel objects in children with autism and comprehension-matched children with typical development. *Autism, 10*(3), 288.

McGregor, K. K., Rohlfing, K. J., Bean, A., & Marschner, E. (2008). Gesture as a support for word learning: The case. *Journal of Child Language*.

Mitchell, S. (1979). Interobserver Agreement, Reliability, and Generalizability of Data Collected in Observational Studies. *Psychological Bulletin, 86*, 379-390.

Moore, C. (2008). The Development of Gaze Following. *Child Development Perspectives, 2*(2), 66-70.

Mundy, P., & Crowson, M. (1997). Joint attention and early social communication: Implications for research on intervention with autism. *Journal of Autism and Developmental Disorders, 27*(6), 653-676.

Mundy, P., Sigman, M., & Kasari, C. (1990). A longitudinal study of joint attention and language development in autistic children. *Journal of Autism and Developmental Disorders, 20*(1), 115-128.

Mundy, P., & Stella, J. (2000). Joint attention, social orienting, and nonverbal communication in autism

In A. M. Wetherby & B. M. Prizant (Eds.), *Autism Spectrum Disorders* (Vol. 9, pp. 55-78). Baltimore: Paul H. Brooks Publishing Co.

Mundy, P., Sullivan, L., & Mastergeorge, A. M. (2009). A Parallel and Distributed Processing Model of Joint Attention, Social-Cognition and Autism. *Autism research: official journal of the International Society for Autism Research, 2*(1), 2.

Parish-Morris, J., Hennon, E. A., Hirsh-Pasek, K., Golinkoff, R. M., & Tager-Flusberg, H. (2007). Children with autism illuminate the role of social intention in word learning. *Child Development, 78*, 1265-1287.

Paul, R. (2007). Communication and its development in autism spectrum disorders. In F. volkmar (Ed.), *Autism and Pervasive Developmental Disorders* (pp. 129-156). Cambridge: Cambridge University Press.

Posner, M. I., & Petersen, S. E. (1990). The attention system of the human brain. *Annual review of neuroscience, 13*(1), 25-42.

Preissler, C. A., & Carey, S. (2005). The role of inferences about referential intent in word learning: Evidence from Autism *Cognition, 97*(B13-B23).

Risch, N., Spiker, D., Lotspeich, L., Nouri, N., Hinds, D., Hallmayer, J., et al. (1999). A genomic screen of autism: evidence for a multilocus etiology. *The American Journal of Human Genetics, 65*(2), 493-507.

Rogers, S. (2006). Evidence-based interventions for language development in young children with autism. *Social and communication development in autism spectrum disorders: Early identification, diagnosis, and intervention. New York: Guilford*.

Saffran, J. R., Aslin, R. N., & Newport, E. L. (1996). Statistical learning by 8-month-old infants. *Science, 274*, 1926-1928.

Samuelson, L. K. (2002). Statistical regularities in vocabulary guide language acquisition in connectionist models and 15-20-month-olds. *Developmental Psychology, 38*, 1016-1037.

Samuelson, L. K., & Smith, L. (1999). Early noun vocabularies: do ontology, category structure and syntax correspond? *Cognition, 73*(1), 1-33.

Senju, A., & Csibra, G. (2008). Gaze following in human infants depends on communicative signals. *Current Biology*, *18*(9), 668-671.

Senju, A., Tojo, Y., Dairoku, H., & Hasegawa, T. (2004). Reflexive orienting in response to eye gaze and an arrow in children with and without autism. *Journal of Child Psychology and Psychiatry, 45*(3), 445-458.

Shneidman, L. A., Buresh, J. S., Shimpi, P. M., Knight-Schwarz, J., & Woodward, A. L. (2009). Social Experience, Social Attention and Word Learning in an Overhearing Paradigm. *Language Learning and Development, 5*(4), 266-281.

Sigman, M., Ruskin, E., Arbelle, S., Corona, R., Dissanayake, C., Espinosa, M., et al. (1999). Continuity and change in the social competence of children with autism, Down syndrome, and developmental delays. *Monographs of the Society for Research in Child Development*.

Siller, M., & Sigman, M. (2002). The behaviors of parents of children with autism predict the subsequent development of their children's communication. *Journal of Autism and Developmental Disorders, 32*(2), 77-89.

Smalley, S. L. (1997). Genetic influences in childhood-onset psychiatric disorders: autism and attention-deficit/hyperactivity disorder. *The American Journal of Human Genetics, 60*(6), 1276-1282.

Smith, L. (2000a). Avoiding associations when it's behaviorism you really hate. In R. M. Golinkoff, K. Hirsh-Pasek, L. Bloom, L. B. Smith, A. L. Woodward, N. Akhtar, M. Tomasello & G. Hollich (Eds.), *Becoming a word learner: A debate on lexical acquisition* (pp. 169-174). New York, NY: Oxford University Press.

Smith, L. (2000b). How to learn words: An associative crane. *Breaking the word learning barrier*, 51–80.

Smith, L., Jones, S., Landau, B., & Gershkoff-Stowe, L. (2002). Object name learning provides on-the-job training for attention. *Psychological Science, 13*(1), 13-19.

Smith, T. (2001). Discrete trial training in the treatment of autism. *Focus on Autism and Other Developmental Disabilities, 16*(2), 86.

Stoel-Gammon, C. (1998). Sounds and words in early language acquisition: The relationship between lexical and phonological development. *Exploring the speech-language connection, 8*, 25–52.

Striano, T., Chen, X., Cleveland, A., & Bradshaw, S. (2006). Joint attention social cues influence infant learning. *European Journal of Developmental Psychology*, *3*(3), 289-299.

Swettenham, J., Baron-Cohen, S., Charman, T., Cox, A., Baird, G., Drew, A., et al. (1998). The frequency and distribution of spontaneous attention shifts between social and non-social stimuli in autistic, typically-developing, and non-autistic developmentally delayed infants. *Journal of Child Psychology and Psychiatry, 39*, 747-754.

Tager-Flusberg, H., Paul, R., & Lord, C. (2005). Language and Communication in Autism. In F. Volkmar, R. Paul, A. Klin & D. Cohen (Eds.), *Handbook of autism and pervasive developmental disorders -3rd Edition* (pp. 335-364). New York: Wiley.

Tek, S., Jaffery, G., Fein, D., & Naigles, L. R. (2008). Do children with autism spectrum disorders show a shape bias in word learning? *Autism research: official journal of the International Society for Autism Research, 1*(4), 208.

Tincoff, R., & Jusczyk, P. W. (1999). Some beginnings of word comprehension in 6-month-olds. *Psychological Science, 10*, 172-175.

Tomasello, M. (1995). Joint attention as social cognition. *Joint attention: Its origins and role in development*, 103–130.

Tomasello, M., & Farrar, M. J. (1986). Joint attention and early language. *Child Development, 57*(6), 1454-1463.

Tomasello, M., Kruger, A. C., & Ratner, H. H. (1999). Cultural learning. *Lev Vygotsky: Critical assessments, 4*, 101–143.

Vigil, D. C., Tyler, A. A., & Ross, S. (2006). Cultural differences in learning novel words in an attention-following versus attention-directing style. *Journal of Multilingual Communication Disorders, 4*(1), 59-70.

Vlamings, P., Stauder, J. E. A., van Son, I. A. M., & Mottron, L. (2005). Atypical visual orienting to gaze-and arrow-cues in adults with high functioning autism. *Journal of Autism and Developmental Disorders, 35*(3), 267-277.

Volkmar, F., Chawarska, K., & Klin, A. (2004). Autism in infancy and early childhood.

Volkmar, F., Cohen, D. J., & Paul, R. (1986). An evaluation of DSM-III criteria for infantile autism. *Journal of Amer Academy of Child & Adolescent Psychiatry, 25*(2), 190.

Volkmar, F., Lord, C., Bailey, A., Shultz, R. T., & Klin, A. (2004). Autism and pervasive developmental disorders. *Journal of Child Psychology and Psychiatry, 45*(1), 135-170.

Volkmar, F., & Mayes, L. C. (1990). Gaze behavior in autism. *Development and Psychopathology, 2*(1), 61-69.

Vygotsky, L. S. (1962). Thought and language. In. Cambridge, MA: Harvard University Press.

Vygotsky, L. S. (1978). Mind in Society: The Development of Higher Psychological Process. In M. Cole., V. John-Steirner & S. Scribner (Eds.). Cambridge, MA: Harvard University Press.

Werner, E., Dawson, G., Osterling, J., & Dinno, N. (2000). Brief report: Recognition of autism spectrum disorder before one year of age: A retrospective study based on home videotapes. *Journal of Autism and Developmental Disorders, 30*(2), 157-162.

Wood, D., & Wood, H. (1996). Vygotsky, tutoring and learning. *Oxford review of Education*, 5-16.