# RAPID WORD LEARNING IN PREVERBAL CHILDREN WITH AUTISM

By

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A dissertation submitted to the Graduate Faculty in Psychology in partial fulfillment of the requirements for the degree of Doctor of Philosophy,
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# Abstract

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This dissertation is concerned with the theoretical and applied problems raised by the communicative impairment of individuals diagnosed with autistic disorder. Autistic disorder is characterized by significant social impairments (e.g. lack of eye contact). Although making eye contact (joint attention) is critical to word learning, very few studies have looked at early word learning among autistic children. Symptoms of autism also include atypical patterns of behavior and attention (e.g. focusing on partial or irrelevant features of an object context). Previous research has not assessed how these nonsocial impairments in autism impact word learning. This dissertation will focus on the contributions of *both* social *and* cognitive attention impairments in autism. This is the first study to assess the rapid word learning abilities of preverbal children with autism.

This dissertation relates the language delay/deficit characteristic of autism to two word learning models from the literature on typical language development ("gaze-following" and "fast mapping"). This dissertation included an assessment and a training intervention. In the assessment, 15 preverbal children with autism demonstrated significantly lower scores on word learning tests in both fast-mapping and gaze-following conditions as compared to 10 typically developing children and 5 language-matched children with mental retardation. In the intervention, 10 children participated in two (counter-balanced) programs designed to teach fast-mapping and gaze following while 5 children participated in the non-training control group. Post-test scores indicated that participants in the training groups demonstrated significant improvements in both fast-mapping and gaze-following scores, whereas participants in the control group did not. This dissertation is the first study to approach training rapid word learning strategies in children with autism.

Impairments in the two primary word-learning strategies ("gaze-following" and "fast mapping") are interpreted within the context of the two models of autism ("impaired theory of mind" and "weak central coherence"). The implications of the assessment and intervention are discussed in terms of future research and training interventions.

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This dissertation would not have been possible if it wasn't for the guidance and support from my advisors, Dr. Katherine Nelson and Dr. Vicki Sudhalter.

Through her book "Language and the Mediated Mind" and her class on Evolutionary Psychology, Dr. Nelson introduced me to a way of viewing research from a multidisciplinary approach: incorporating social, cognitive and evolutionary theories into more cohesive and precise models of language development. The breadth and depth of Dr. Nelson's knowledge of language development has offered insight and perspective at every step of my dissertation process. It was an honour working with her.

I first saw Dr. Sudhalter give a lecture on autism to a parent support group. Not only did she speak with unparalleled grace and charisma, but her reputation commanded a standing ovation. I remember thinking "I want to be like her when I grow up". As a clinical intern I admired how Dr. Sudhalter would treat every parent and child with compassion and dignity without sugar-coating the difficult reality of autism. Dr. Sudhalter has guided me through academic, career

and personal crises with her generous advice and comfort. She has been my academic mother and my personal role model.

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# CHAPTER I. INTRODUCTION

Autistic Disorder (AD) is a developmental disability that significantly affects language acquisition. The constellation of symptoms characterizing "autistic disorder" offers a unique guide to help researchers navigate the complex waters of language development. Profound social impairments may exist in AD without comparable cognitive impairments, giving the illusion of functional dissociation. Consequently, autistic disorder allows researchers to gain insight into the relative role social processing plays in overall language development. The label "autistic" was coined to highlight the asocial tendencies (e.g. aloofness) observed in the clinical population (Kanner, 1943). Consequently, emphasis has been given to the social aspects of the disorder. Previous research has focused on how the social impairments in AD affect word learning. Research has not yet evaluated how nonsocial symptoms of AD affect word learning. By comparing social and linguistic word learning strategies in preschoolers with AD, this dissertation explores the uncharted territory of how symptoms in both domains impair word learning. This dissertation is the first to study the linguistic strategy "fast-mapping" in a population of preschoolers with AD, and the first to compare social and linguistic word-learning strategies in a population of children with AD and children with mental retardation.

Word learning is an important point of departure because it is the foundation of language development. Further, impairments in word learning may have cascading effects on the development of subsequent language functions. Word learning, however, is not a unified concept. There are many different types of words (i.e. nouns, proper nouns, adjectives, verbs) that children learn in many different contexts (i.e. activities, eavesdropping, watching TV, school lesson). This study focuses on how children learn nouns labeling people, places or things (i.e.

welder, stadium, record) in a 1:1 interaction with an adult who incidentally introduces the new words during a picture-pointing game. It focuses on nouns for several reasons. First, the focus is on single-trial word learning (i.e. fast-mapping) and nouns are easier to depict via a single photo card than are adjectives or verbs. Second, preschoolers with AD may have difficulty participating in interactive activities where a verb could be incidentally introduced because of their severe social impairments. Third, children's vocabulary consistently contains a greater proportion of nouns than other word classes (Bornstein & Cote, 2004). Finally, nouns are generally learned before verbs and other word classes (Gentner, 1982; Bates, 1982; Slobin,1985).

## Overview of the Dissertation Sections

The introduction reviews previous research in the fields of autism and language development that supports two possible sources for the word learning impairment in AD. Section 1 outlines the delayed and atypical language characteristics of AD, specifying how an impaired ability to establish reference may contribute to semantic errors. Section 2 provides an overview of the "emergent coalition model" of lexical development. Lexical development is discussed in terms of social word-learning skills (i.e. gaze-following) in Section 3 as well as in terms of linguistic word-learning skills (i.e. fast-mapping) in Section 4. The method of treating the language symptoms of AD through applied behavior analysis is presented in Section 5. Section 6 summarizes the purpose and goals of the investigation.

The Pilot study tested a single word-learning assessment and intervention method on a small group of children with autism. Chapter II (the pilot study) includes an assessment and an intervention section; each with a method, results and discussion sub-section.

The comparison study expanded on the pilot study by including two word learning assessments and interventions and by comparing test performance of children with autism to

control groups (children with mental retardation and typically developing children). Chapter III (the comparison study) also includes an assessment and an intervention section; each with a method, results and discussion sub-section.

Chapter IV (the general discussion) seeks to explain the results of the pilot and comparison studies. The results are interpreted in terms of symptoms in section 1 by comparing the Impaired Theory of Mind model (section 2) to the Weak Central Coherence model (section 3) of autism. Section 4 explains how both models of autism could account for the word-learning impairments evidenced in the assessment results. Section 5 concludes the dissertation with a brief summary and suggestions for future research.

## I.1 Language Impairments in Autism

The most obvious indication of language impairment in children with AD (CAD) is a delay or lack of the development of spoken language. Before the expansion of early intervention programs, prognostic studies estimated that only 50% of CAD ever became verbal (Prizant, 1983). Today, as many as 85% of CAD (who participate in early intervention programs) learn to use speech as a primary mode of communication (Koegel, 2000; McGee, Daly, & Jacobs, 1994). The majority of CAD who become verbal do so by age 6 (see review by Wilkinson, 1998). Consequently, the preschool years may be considered as a "critical period" in language development for CAD, as they are for typically developing children. This dissertation focuses on how receptive language develops in preschool CAD during the transition between preverbal and verbal communication to identify variables contributing to their severe language delay.

What is it about AD that sabotages the natural course of language development? It is difficult to accurately assess the receptive language in preverbal CAD because they often do not understand simple testing directions. As a result, much of what is known about language

development in AD comes from research on older or higher-functioning CAD because they are more likely to be verbal. Analyzing the language impairments found in verbal CAD offers insight into how AD may interfere with preverbal language development.

## General Language Impairments in Autistic Disorder

CAD demonstrate pragmatic language impairments (i.e. comprehending conversational themes (Baltaxe, 1977 ; Curcio & Paccia, 1987), difficulty maintaining a conversation and forming narratives) that limit their ability to hold successful conversations (Jackson, Fein & Wolf, 2003). Adolescents and adults with AD demonstrate significantly lower scores than peers on pragmatic language tests (measures of humor, inference, metaphor and indirect request comprehension) that require using context cues to interpret language (Loveland et al, 1990; Ozonoff & Miller, 1996; Rumsey & Hanahan, 1990).

Autistic speech sounds different from standard conventional speech. Specifically, CAD have difficulties with prosody. They do not apply the appropriate stress or intonation necessary to emphasize meaning or affect. They appear to have problems modulating the volume and pace of their speech for different listeners and situations (Sabbagh, 1999). Typically developing infants are sensitive to prosodic cues for parsing words in ongoing speech. These cues may be essential in early word learning (Jusczyk, Luce, & Charles-Luce, 1994; Jusczyk, Cutler, & Redanz, 1993). Verbal CAD will often produce parsing errors by blending several words into one. For example, CAD learning simple "I want ___ please" sentences often overgeneralize the use of "want" or "please" as prefixes or suffixes of specific words. In this case, they label a picture of cookies as a "cookiesplease" or a "wantcookies".

Pronoun reversal, once considered to be indicative of an “impaired sense of self”, is a common characteristic in autistic language (see review in Wilkinson, 1998). Pronoun reversals

(e.g. using"I" vs. "you") are now considered to be evidence of a difficulty in shifting referents relative to the context, a general problem that may make establishing reference in learning words very difficult (Wilkinson, 1998). CAD are impaired in their ability to take the context and point of view into consideration before they decide which pronoun to use, as illustrated by their impairments comprehending other diectic words ("here" vs. "there") commonly used to orient listener's attention to referents (Wilkinson, 1998). Problems with diexis may impair word learning when the speaker labels an object from a distance (e.g. in ostensive situations).

It is important to make the distinction between the language delay and language disorder associated with AD. Symptoms of AD include a language delay in that developmental milestones (e.g. pointing, speech, reading) are reached significantly later than for typically developing peers. Symptoms of AD also include a language disorder. Once the milestones are reached, CAD continue to have problems not evident in language age-matched peers.

The language delay in autism may not affect all domains of language (i.e. phonology, syntax, semantics, pragmatics) in the same way. Some studies have reported syntax and phonology developing on time while pragmatic and semantic domains were delayed (Tager-Flusberg, 1981, 1989; Dunn, Gomes, Sebastian, 1996) even though the sequence of skill development within these domains was reportedly typical (Bartolucci, et al, 1976; Tager-Flusberg, 1985; Waterhouse & Fein, 1982). Impaired verbal IQ and delayed vocabulary are not accounted for by mental retardation alone in that nonverbal mental age is significantly higher than verbal mental age-matched peers; Tager-Flusberg, 1985).

Research shows that even high-functioning (non- mentally retarded) CAD demonstrate fluent articulate speech while still demonstrating pragmatic impairments in conversational turn-taking (e.g. topic maintenance) and semantic impairments such as overly literal interpretation and use of

words (Dewey & Everard, 1974; Moreno & Donellan, 1991). The pattern of impairment appears to be a dissociation of the form (language structure) and function (language use) (Tager-Flusberg, 1994). This asynchrony contributes to the "atypical" sound of autistic speech. The fact that an adult with AD uses complex grammar and sophisticated phrasing stands in stark contrast to his use of invented words and poor conversation skills (Volden & Lord, 1991). This asynchrony is apparent in receptive language as well. Language comprehension studies have demonstrated a tendency of CAD to indiscriminately focus on syntactic over semantic content, even when the semantic interpretation was a logical impossibility (Paul, Fischer & Cohen, 1988; Tager-Flusberg, 1981). A deficient semantic processing system suggests that there may be an underlying impairment in learning, understanding and using words.

## Semantic Language Impairments

CAD have notable delays in the onset and later pace of vocabulary development (Lord, Rutter, & Le Couteur, 1994; Volden & Lord, 1991; Thal, Marchman, Stiles, & Aram, 1991). A peculiar symptom emerges in later autistic speech, namely atypical word use, that offers insight into what could be causing this language delay. One of the diagnostic features of AD is the presence of stereotyped, repetitive and idiosyncratic language in speech (APA, 1994). Deviant word use & unusual utterances (described as "metaphoric" or "unconventional"), not readily attributable to delay, have been well-documented in the literature (Baltaxe & Simmons, 1977; Baron-Cohen, Baldwin, & Crowson, 1997; Bosch, 1970; Cantwell et al, 1978; Cohen, 1978; Kanner, 1943; Volden & Lord, 1991). Although many of the language behaviors exist early in typical child development (e.g. semantic over-extension, echolalia), these atypical lexical patterns are distinctive in AD because of their frequency and persistence through adolescence (Wilkinson, 1998); even when other symptoms of AD diminish (Simmons & Baltaxe, 1975).

"Idiosyncratic use of language" is the use of conventional words or phrases in personal/unconventional ways to convey specific meanings (Volden & Lord, 1991, pg. 111). This usage is distinguishable from "creative" original language in that the meaning of the unconventional words is derived from a *personal* frame of reference (inaccessible to anyone but the autistic speaker) and therefore does not serve as functional communication. It is difficult to quantify the number of these unconventional words CAD have in their vocabulary, let alone try to decipher the specific personal meaning that the child has associated with each word. It is sufficient to say that the unconventional words have a specific meaning *to the child* that is not tied to the socially accepted, agreed-upon definition. Temple Grandin, a successful writer and professor diagnosed with AD, recounts in her autobiography how she used to use the word "prosecutor" as an exclamation whenever her kite fell (Grandin, 1996, p 24-25 ). To her, the event of "falling kite" was associated with an unknown word she had overheard while watching her kite fall. Grandin claims that she could not figure out what the word was referring to, so she made up a meaning from her point of view.

A classical example of a semantic error comes from a case study reported by Kanner (1973). The case study describes a boy with AD listening to his mother reciting nursery rhymes (Figure 1). As she said, "Peter, Peter, pumpkin-eater", she dropped a saucepan. The loud crash of the pan instantly engaged the boy's attention. From then on, every time he saw a saucepan he would say "peter-eater". The child had mapped the phrase "peter-eater" to the object "saucepan" incorrectly, making a *semantic mapping error* (Kanner, p 46, 1973).

***Figure 1.***


A <u>semantic mapping error</u> is a consistent use of an incorrect word/phrase to refer to a specific object/event/action. Semantic mapping errors occur when a child defines a word based on a private/original frame of reference.

Typically developing children (TDC) also occasionally make semantic mapping errors, however these errors decrease as children get older and their vocabularies increase. Conversely, as CAD get older and develop larger vocabularies, they have a tendency to make *more* semantic errors (Volden & Lord, 1991). Unlike the semantic errors produced by typically developing children, these are *not* generally related (semantically or phonologically) to the correct conventional word (Volden & Lord, 1991). CAD appear to have problems understanding the

very concept of semantic conventionality- that words have socially agreed-upon definitions. Without conventionality, we would not be able to assume we understood to what concept a word was referring, words would be random and ambiguous.

The word learning impairment inherent in AD is more than just a developmentally delayed vocabulary. The language delay includes (or is possibly caused by) a deviant approach to learning new words. Impaired verbal IQ and delayed vocabulary are not accounted for by mental retardation alone (i.e. nonverbal mental age is significantly higher than verbal age-matched peers; Tager-Flusberg, 1985). Whereas children with mental retardation (CMR) may require more frequent exposures to a single new word before they learn its meaning, CAD might learn the wrong meaning for a new word (but learn it on the *first* exposure). This type of impairment is more complicated to correct, because it is impossible to assess which words were learned incorrectly until the child uses them erroneously. If CAD include too many incorrect words in their vocabulary, the semantic errors could cause contradictions and confusion, leading to cascading effects in later language development and a significant reduction in their conventional functional vocabulary. Anecdotal examples and assessment estimates do not convey the developmental element of semantic errors. From a Developmental Psychology perspective, the genesis of semantic errors needs to be analyzed. This requires experiments that expose CAD to new words in controlled laboratory conditions. To date, only one experiment (Baldwin, Baron-Cohen & Crowson, 1997) has taken this approach. This experiment suggested that CAD were not using the same strategies to learn words as typically developing or mentally retarded peers.

What happens if CAD do not have the necessary word-learning strategies? It has been suggested that typically developing infants adopt a conservative strategy of ignoring new words

altogether (rather than risk the linguistic implications of mapping the wrong meaning to a word) until they are able to distinguish referential from non-referential acts (Baldwin, Baron-Cohen & Crowson, 1997). Mervis & Bertrand (1994) tested two groups of toddlers (15 months and 22 months) on their ability to pick out which novel object in a set corresponded to a recently introduced new word. Both groups of toddlers were able to indicate objects corresponding to words they knew. The younger toddlers not only were unable to indicate objects corresponding to recently introduced words, but they did not indicate any of the objects in the set. The younger toddlers appeared to be ignoring the new words rather than risk making an incorrect response or guess (Mervis & Bertrand, 1994). If CAD form new word-object associations using the wrong strategy, they would be faced with false starts, contradictions, and confusion. Over time, they could lose motivation for vocabulary acquisition altogether, turning to more predictable aspects of the environment (refer to discussion in Baron Cohen, Baldwin and Crowson, 1997).

## I.2 Emergent Coalition Model of Word Learning

Infants usually begin learning words around 12 months of age. In experimental contexts at this age, typically developing children (TDC) require a great deal of converging evidence or frequent repetitions (Hollich et al, 2000; Goldfield & Reznick, 1990) and longer durations of exposures before they are able to make the necessary associations (Hollich et al, 2000; experiment 9).

Between 18 and 24 months, TDC appear to start learning words quickly (a few new words/day) and independently (without direct definitions) (Carey & Bartlett, 1978; Mervis & Bertrand, 1994). This qualitative shift has been referred to as a "word burst" and considered to be a critical period in lexical development (Goldfield & Reznick, 1990; Mervis & Bertrand, 1995). Toddlers from 16-20 months shift their word learning abilities from novice to expert levels,

becoming more independent of "infant directed speech" and flexible enough to learn words in many different conditions. Several developmental skills have been proposed to cause this growth spurt including the child's insight that language is symbolic (Dore, 1978), the ability to categorize by multiple traits (Mervis & Bertrand, 1994; Gopnik & Meltzoff, 1986), the onset of word learning constraints (Behrend, 1990; Golinkoff, et al 1992) or the ability to establish reference by gaze-following (Baldwin, 1994). Preschoolers can learn new words on the basis of a *single* quick incidental exposure (Dollaghan, 1985; Heibeck & Markman, 1987).

Although rapid word learning can occur by using only social or non-social cues, most real-life contexts include access to both sorts of cues. There is evidence that children can use both social (gaze-following) and and nonsocial (fast-mapping) methods simultaneously to learn words (Jaswall & Markman, 2001). The task of the novice word learner is to gather and evaluate cues from both social and nonsocial sources, considering only the most relevant bits of information when they make their final interpretation of the new word. Hollich et al (2000) delineated a hybrid theory, incorporating social and nonsocial perspectives into a unified framework (Table 1).

**Table 1:** The Emergent Coalition Model of Word learning:

| |
|---|
| 1) Children cull information from all of the multiple inputs that are available. |
| 2) Inputs from multiple sources are differentially weighted over development |
| 3) As children develop, new strategies emerge to guide subsequent word acquisition. |

The Emergent Coalition model is a constructivist account of word learning. It suggests that children are predisposed to make certain hypotheses over others. After these hypotheses are established, the child develops more specific and more efficient strategies based on their

experience with the world. In this way, domain specific principles (i.e associating a new word with the most novel object in a set) can emerge from domain general mechanisms (i.e. predisposed attention to novelty). The emergence of the higher-order domain specific word learning strategies is based on guided distributional learning. Children are sensitive to a wide range of cues and events in the world around them. Children are also sensitive to the frequency of the co-occurrence of these cues. Frequency can compensate for subtlety in correlations to guide predictions about what to attend to in future experiences (Hollich et al, 2000, p 25). Computing the reliability of cues in making reliable mappings shifts the balance from weighting some cues more heavily (e.g. perceptual salience) to weighting others (e.g. speaker's eye gaze).

When processing cues, children assign different weights to different cues based on their previous experience (i.e. relevance of the clue) and their cognitive ability (i.e. confidence in their own perception of the clue). Rapid word learning is the product of the strength of the available cues (i.e. frequency, timing, salience) the type of available cues (e.g. animacy, prosody, syntax, eye gaze) and the weight children assign to those cues (e.g. emphasize eye gaze more than animacy). For example, an 18 month-old boy may not be skilled enough in gaze-following to infer the referent of a novel word, so he does not place much emphasis on eye gaze. He might place more weight on novelty and therefore use mostly nonsocial strategies (i.e. fast-mapping) to learn words. By itself, neither eye gaze nor novelty would be sufficient for the 14 month-old to establish reference. By referring to both sources of input, the boy can compensate for his undeveloped strategies and successfully establish reference. The Emergent Coalition model acknowledges that the multiple sources of language input develop individually but within a synchronized network. This model makes the important point that neither attention, nor social,

nor semantic cues, by themselves are sufficient for word learning to progress at its rapid pace (Hollich et al, 2000).

There are two defining concepts in the emergent coalition model that should be delineated. The first is the concept of "emergence". According to this model, word learning skills emerge when certain developmental milestones are achieved. There is a correlation between the onset of the fast-mapping skill and the acquisition of a 50 word vocabulary ( Mervis & Bertrand, 1994). One could interpret this correlation as suggesting that fast-mapping automatically emerges as a result of achieving a vocabulary threshold that allows novice word-learners to establish a predictable relationship between labels and objects. Such an interpretation is tautological because one could also argue that fast-mapping causes children to learn independent of repeated exposures to words and therefore to acquire more than 50 words in their vocabulary. The key to disentangling the relationship between the fast-mapping skill and early lexical acquisition is to look at how vocabulary develops before the development of the fast-mapping skill in individual cases.

If one were to apply the theory that a 50 word vocabulary is necessary for the fast-mapping skill to emerge, then ABA preschoolprograms would continue teaching CAD through rote vocabulary drills until they learned 50 words and they would be expected to begin fast-mapping automatically. The problem with this program is that it may make the children dependent on others to learn words. What happens if the child does reach the 50 word threshold and still does not fast-map? The assumption that fast-mapping automatically emerges is based on TDC who have no difficulties establishing reference in pre-lexical contexts. No research has been reported on fast mapping in CAD. AD causes several attention impairments that may directly impair fast-mapping. Pilot research for this dissertation found that some preschoolers

with AD had more than 50 words in their receptive vocabulary, but still were not able to pass fast-mapping tests. Children were either not fast-mapping at all (not noticing new words) or they were only partially fast-mapping to establish immediate reference (but not retaining the mapped word for subsequent use). There is a clear relationship between fast-mapping and "breaking the word barrier" into a working vocabulary. Fast-mapping, however, is not the only skill involved .

The second defining concept in the emergent coalition model is "coalition". The idea that children learn words by consulting a coalition of cues precludes any assumption that inferential word learning (i.e. fast-mapping) occurs without respect to ostensive word learning (i.e. gaze-following). Children use whatever information is readily available, from a coalition of accessible sources (gestures, activity context, prosody, object context, etc). Based on a coalition model, if there is clear evidence that ostensive word learning is impaired in AD it is logical to assume that inferential word learning should also be affected.

One of the most important concepts in the emergent coalition model is that social and nonsocial word learning skills develop symbiotically. The strength of a developing reference skill in one domain stengthens the development of reference skills in the other domain by offering clarification and verification that a novel word is referring to a particular referent. By distributing the sources of information, children can successfully learn words in many situations with subtle or complex referential cues. For example, a child who overhears his mother talking about a thermos as she leaves the room may see her head turn but not her eye gaze. The child uses the head turn to figure out the "thermos" is in the general direction of the table. The child sees many objects on the table that could be labeled, but only one that is novel. The child assumes that this novel object is the thermos, but he is still not quite sure. Later, his father says "where is that thermos ?" while searching for something. The child hears his father say "here it

is !" as he picks up the novel object and stops searching. The child is now confident that this particular object is the referent of "thermos".

In the above example, the child used a social clue (gaze-following) for the initial search, a nonsocial clue (novelty) for clarification and a pragmatic clue for verification. Individually, none of the sources of information were enough to interpret the new word. Taken as a "coalition" of coordinated information, the child was able to pool subtle and unclear evidence to map the word. This conceptualizes social and nonsocial domains not as partisan competitors, but as a network outsourcing research to each other depending on the available information and the developmental capabilities in a given context or time. From this perspective, decreased performance in one domain would directly affect the overall word learning performance and indirectly compromise performance of the associated domains. Furthermore, it would decrease the security of the word learning process, making the child less confident of an initial word-object map and more reliant on subsequent repetitions and more obvious indications of reference.

## Problems with the Social v. Nonsocial Distinction

Earlier language theories separated the processing of social and nonsocial reference cues into different models of word learning, emphasizing either the role of social processing (“gaze-following”) or the role of nonsocial attention mechanisms (“fast-mapping”). The Emergent-Coalition Model has offered a more comprehensive view of word learning by accepting both social and nonsocial theoretical perspectives. Unfortunately, unifying the models into a theory is much easier than unifying them into a controlled experiment. When working with a population with symptoms of stimulus over-selectivity and hyper-arousal (e.g. AD), it is not feasible to focus on more than one skill at the same time without creating confounds, especially if some of

the skills (fast-mapping) have never been studied in this population. Furthermore, separating social and nonsocial word learning skills may help parse out the relative contribution of the social and nonsocial symptoms of AD. In this dissertation, social and nonsocial skills will be studied separately. It is important to note that contrasting the different theoretical models is merely a methodological distinction.

The real differences are much harder to disentangle. The development of social and nonsocial skills is a very coordinated process that is never separated in either the child's external or internal environment. For example, cognitive concept formation relies heavily on the principle of conventionality which is realized by social experience. Children organize lexical meaning into categories based on form (based on nonsocial perception) and function (based on social observations). Many nonsocial word-learning strategies rely on a basic understanding of relational categories. Research on the evolution of language suggests that the human ability to understand relational categories emerged from the nonhuman primate ability to understand third party social relationships. Tomasello (2003) suggests that the cognitive skill of conceptualizing categories may emerge first with social experience in infancy. In this case, nonsocial skills (i.e. fast-mapping) may emerge from early social skills (i.e. face-to-face shared attention) early in the second year.

Babies (12-18 month-olds) who spent more time in joint attentional activities with their mothers had larger vocabularies (Tomasello & Todd, 1983), suggesting that children's ability to construe others' perspectives emerges from their parent's ability to take their perspective . There is both correlational and experimental support for the hypothesis that mothers who used their language in attempts to follow into their child's attention had children with larger vocabularies than mothers who used language to direct the child's attention to something new (Tomasello &

Farrar, 1986). Children's nonsocial perception/attention can influence social functioning if it is qualitatively different from their parents. Parents would not be able to perspective-take as well for children who perceive differently. This is commonly reported by people working with AD :

> "I don't know why my child spaces out. Most of the time, I can't figure out what he is paying attention to and I can't get him to look at me. Is it something on the outside he hears or sees or something on the inside like a seizure or headache?" – Parent of CAD
>
> " I wish I could just experience the world like he does for an hour so I could figure out what is distracting him" – Special Education teacher

Therapists in the field may develop an "autistic" theory of mind to interpret behavior changes:

> "Whenever an airplane flies overhead he stops focusing and starts grimacing, this lasts five minutes after the plane sound is gone" – Behavior therapist
>
> "He closes his eyes whenever he hears a loud sound and covers his ears when the light is too bright" – ABA supervisor

Social and nonsocial skills have a symbiotic and coordinated relationship in language development. Though they may be studied separately, they may never be assumed to be independent of their mutual influence.

## I.3 The Social Model of Word Learning

When a new word is introduced, there are a variety of cues available that help to indicate what the word is naming. The most obvious cues can usually be found by focusing on either the speaker or the nameable objects. In reality, children shift their attention between both the speaker and the objects in a given context to gather the most information. The principles that

guide attention to social and linguistic cues have been studied separately. In this section, social principles[1] will be discussed. Linguistic principles will be discussed in section four.

The social-pragmatic theories emphasize how social principles guide word learning. Social-pragmatic theories assert that children's knowledge of people's goals and purposes limits their interpretations of novel words and directs them to the most likely *intended* meaning (e.g. Carpenter et al, 1998 ; Baldwin, 1991, 1994 ; Lucariello & Nelson, 1985). This perspective holds that language is an inherently social phenomenon because it is both intersubjective and perspectival (Nelson, 1996). Language is intersubjective because language users know they share the use of their language with others who speak it. Language is perspectival because different words and phrases embody different ways a situation may be construed for differrent communicative purposes (Tomasello, 2003). Language can only be used and comprehended by people who can engage in some level of intersubjectivity and take other speakers' perspectives. These prerequisite communicative skills are thought to emerge from more general social skills present in neonates and specific to human development. Essentially, Tomasello's theory (2003) is that shared activities lead to focusing attention on the same objects. In order to interact with a person and these objects, the actor must look at both the objects and at the eye gaze of the other actors to determine what objects will be acted on (this insight may be based on basic associations between eye gaze and objects). Once the actor is monitoring the eye gaze of his partner, he is establishing immediate reference. The actor is increasingly able to make more associations between his partner's behavior and subsequent actions on objects so that he can predict from antecedent behavior what the consequent action might be. He incorporates these predictions into his memory of previous interactions in order to establish delayed reference. Over time, the actor

[1] The term lexical principles usually refers to nonsocial models. To preserve parallel structure in this thesis, it will be used to refer to social word learning. It is not meant to imply a constraint or a strategy as has been implied by previous models.

starts to incorporate these associations into his personal experience (feelings, goals, intentions) so that he can predict his partner's feelings, goals and intentions (theory of mind).

At birth, human infants look at human faces over other perceptual patterns (Fantz, 1963). This early preferential attending to faces enables nonverbal interactions that lay the foundation for conversations. These 'protoconversations' are social interactions in which the parent and infant focus their attention on one another in a face-to-face manner (involving looking, touching, and vocalizing) in ways that serve to express and share basic emotions in clear turn-taking structure (Trevarthen, 1979). Protoconversations are a universal feature of adult-infant interaction (Trevarthen, 1993, Keller, Scholmerich & Eibl-Eibesfeldt, 1988). In addition to protoconversations, basic imitation begins in early infancy. Soon after birth human babies increase the frequency of their own natural repertoire of behaviors ( e.g. tongue protrusions, mouth openings and head movements) in the presence of a matching stimulus (Meltzoff & Moore, 1989). This imitation becomes increasingly refined with practice and enables older babies to imitate sounds and gestures in early communicative attempts. The genesis of communication begins with these early gestures/sounds through the well-rehearsed and coordinated efforts between parent and child. The theory of ontogenetic ritualization (Tomasello et al, 1997) proposes that a communicatory signal is created by 2 organisms shaping each other's behavior in repeated instances of a social interaction (i.e. baby trying to crawl up/reach mom by raising arms leads to the baby raising his/her arms to communicate 'pick me up').

Young infants (~ 6 mos) are able to interact with either objects or people in a dyadic fashion. As they get older (~ 9 mos ) they start to interact triadically in that they can coordinate their interactions with objects and people simultaneously resulting in a referential triangle of child adult and object. It is this triangulation that enables the dominant social principle which

underlies word learning, joint attention (see Moore & Dunham, eds., 1995) Between the ages of 9-12 mos, infants begin to flexibly and reliably look where adults are looking (gaze following) and use this information as social reference points (social referencing). Shortly thereafter infants begin to direct adult attention by gesturing and showing behaviors (Gomez, Sarria & Tamarit, 1993) eventually replacing the indexical gestures with symbolic words.

After they learn how to engage in joint attention, infants begin to reproduce adult intentional actions on outside objects which opens up the possibility of acquiring the conventional use of tools and artifacts which is the basis of cultural learning (see Tomasello, 2003 for review). Children acquire language within a social dyad, deriving meaning from ongoing discourse contexts and retaining the new words most relevant to their personal pursuits. The meaning of a particular word is bound by context, conventionality and the mutual shared experience between the speaker and listener. Through social experiences children learn what speakers are likely to notice and name in a given context. By observing how others use objects, children learn the conventional use of objects. These mental representations develop into symbolic representations of object categories and eventually linguistic representations outlining the conventional use of words. The realization that words have one-to-one, predictable and conventional relationships to objects is the first milestone to word learning. It is what some nonsocial lexical models refer to as "the principle of conventionality" (Golinkoff, et al 1994). The principle of conventionality emerges from social interactions and predictable social scripts. Some theorists have proposed that communication evolved from a sohpisticated form of imitation involving the representation of an object or event through action for an audience (Donald, 1991; Tomasello, 2003). The ability to imitate required the ability to represent an event while integrating a model of the self (Donald, 1991 ; Deacon, 1997). The ability to

interpret an imitated act required the ability to detect the intention of another person's activities (see Baron-Cohen, 1996, for review).

## Gaze-following to Learn Words

The social environment that supports language acquisition is pregnant with lexical information. The activity context, the prosody, the social script, the shared history, the cultural conventions, the facial expressions, the emotional tone and a myriad of other resources are available to the child. This dissertation focuses on the social skill of gaze-following not only because it has been well-documented by previous research on preschool word learning, but also because gaze-following deficits are a defining symptom of AD. By the end of their second year, typically developing toddlers start learning new words by entering into joint attention with a mature language user (Bruner, 1983; Brown, 1956; Tomasello, 1992, 1995). This dissertation focuses on the social theory of how children establish reference to learn new words by "gaze-following".

According to Baldwin, social referencing strategies are acquired in a developmental sequence (1993). In Baldwin's study, 16 month-old infants will only map words to objects that are at the center of their own attention. Although at 14 months, infants readily use speaker's attention cues to coordinate joint focus, they do not establish a stable link between new words and the objects of the speaker's focus. Infants under 16 months required several exposures to a new word and its object referent to verify an association before they retained it. By 20 months, toddlers readily looked at speaker's eyes when they heard new words (Baldwin, 1993).

A deficit in joint attention is one of the earliest symptoms of AD. A joint attention deficit would likely interfere with the ability to follow speaker's direction of eye gaze, limiting the ability to establish reference in the presence of a new word. One study has measured the

implications for the autistic joint attention deficit in word learning by assessing how verbal CAD (age 7-11) used speaker's eye gaze to learn words (Baldwin, Baron-Cohen & Crowson, 1997). Children took a series of rapid (i.e. single trial) word learning tests requiring them to follow the speaker's direction of eye gaze to figure out which of 2 novel toys was being labeled. In the "follow-in labeling" condition, the experimenter labeled the novel toy at which the child was already looking. In the "discrepant labeling" condition, the experimenter labeled the novel toy that the child was not looking at. After a delay, the children were given a retention test to see if they remembered any of the new words they had been exposed to.

CAD performed on par with controls (typically developing and mentally retarded) at remembering words labeled during the "follow-in " condition. In "discrepant labeling" conditions, only 29.4% of CAD passed as compared to 70.6% of children with mental retardation and 79% of the typically developing children (Baldwin, Baron-Cohen & Crowson, 1997).

The children in this study showed a significant impairment in their ability to use the speaker's direction of eye gaze to interpret the referent of a novel word. When they heard the new word, they failed to disengage their attention long enough from their own focus (toy) to consult the ostensive cues in the environment. Not only did they not remember the correct word, but they also associated the word with the wrong object because they were employing the incorrect (listener's direction of gaze) strategy (Baron-Cohen, Baldwin & Crowson, 1997). This study was the first to illustrate the genesis of semantic errors in AD. Gaze-following is a crucial clue, but it is not the only variable contributing to the autistic word-learning impairment.

## I.4 The Linguistic Model of Word Learning

Section 3 discussed how social principles guide word learning. This section will discuss linguistic principles by shifting focus away from the speaker and towards the objects in a word-

learning context. Although language generally occurs in a social context, there are many nonsocial cues which children regularly use to learn words. In many situations, the social information is occluded, confusing or ambiguous. Children with attention deficits (or children busy with another activity) may not be focusing on what the adult is doing when they hear a new word. If the child also cannot ask questions to clarify "which one ?" or "what was that ?" they may have to use other resources to figure out the object being named. The conundrum of reference is that it is not feasible for a child to logically consider all of the possible things in the environment that a new word could be naming the instant they hear the word for the first time. To solve the conundrum of reference, researchers have proposed that children develop principles (Clark & Hecht, 1983; Markman, 1987; Hall & Waxman, 1993) that support word learning. These lexical principles are basically guidelines that help children make practical assumptions about where to look for the referent of a new word when they hear one (Markman, 1991). Lexical principles guide children's assumptions concerning the likely forms and functions of language; preventing them from entertaining logically possible but practically improbable hypotheses (Clark, 1987; Golinkoff, et al 1992 ; Markman, 1989; Mervis & Bertrand, 1994).

Linguistic theories emphasize how these nonsocial cues can also be used to establish reference. The linguistic theories assert that children use knowledge of how different words (e.g. plurals) link to different categories or types of objects (e.g. several similar objects). This knowledge limits their search space for novel referents, directing them towards the linguistically relevant interpretation of new words (Markman, 1989; Mervis et al , 1994; Waxman, 1991). These accounts are formulated in terms of assumptions based on linking specific linguistic notions, (nouns, count-nouns, proper nouns) and kinds of meaning (taxonomic, whole object). This dissertation will focus on the linguistic theory of how children establish reference to learn

the name for a nameless new object by comparing it to previously named familiar objects through a process called "fast-mapping".

## Fast-mapping to Learn Words

When a child identifies a new word, it is as if they create a "meaning" file to save whatever information is immediately available about the word. Each subsequent encounter with the word provides some additional information that is then stored in the file, refining and extending the meaning of the word. Some aspects of word meaning are conventional (apples are fruit), some are culturally-embedded (as American as apple pie), some are shared with others (in October my family goes apple-picking) and some are personal (apples make me happy because they remind me of my family). Developing a full understanding of the meaning of a new word is a process that can take a lifetime and never be completed. To avoid philosophical debates of "essence" and "meaning", this dissertation will focus on the initial step in word-learning.

When children hear a new word, they first try to establish reference (figure out what object/action the word is labeling). Establishing reference is the necessary first step to learning a new word (see Bloom, 2000 for discussion). Fast-mapping is the strategy children use to establish reference by storing some information about the meaning of a novel word based on a single incidental exposure to its referent (Carey & Bartlett, 1978; Golinkoff et al, 1994; Golinkoff; Heibeck & Markman, 1987; Mervis & Bertrand, 1994; Woodward, Markman, & Fitzsimmons, 1994). Carey and Bartlett (1978) proposed that whenever children encounter a novel word, they draw upon the linguistic and nonlinguistic context for a quick, initial, partial understanding of the word's meaning. This partial understanding allows them to immediately identify the referent in the initial context and infer something about its conventional meaning (Carey, 1978). Although the meaning is confined to the initial reference context, it is stored for

future reference (Carey & Bartlett, 1978). In order to meet the qualifications of fast-mapping as defined in the literature, the word learning must be fast (a few exposures) and inferred (not explicitly taught) based on contextual information (see reviews by Wilkinson Dube & McIlvane, 1996, 1998). Some research has suggested that infants as young as 13 months can *fast-map* given 4 direct exposures to novel word object (Kay-Raining Bird & Chapman 1998). The fact that the initial exposures were direct means the infants were not fast "mapping" (i.e. association based on inference). Other studies claim that 9-11 month old infants can fast-map given 24 exposures to a novel word-object in an engaging enough teaching situation (Oviatt, 1980). The fact that infants could not make this inference on the first few exposures means they were not "fast" mapping (i.e. association based on a single or relatively few exposures). The ability to fast-map is not evident in infants under 16 months[2] (Mervis & Bertrand, 1994).

Carey & Bartlett (1979) first studied how children learn new labels for objects through the process of fast-mapping. Carey & Bartlett defined the fast-mapping ability as including both a reference and a memory component skill. The *reference* skill involved the ability to establish reference between a new word and object when the word is initially introduced. The *memory* skill involved the ability to remember the association long enough to recognize the corresponding object when the word is subsequently re-introduced. In the fast-mapping reference test, children were exposed to a novel object (i.e. white plastic circle) in a set of 3 familiar objects (i.e. ball, apple, pen) while being introduced to a new word (i.e. "koob"). Children passed the fast-mapping reference test if they were able to indicate which of the objects in the set was labeled (i.e. by pointing to the white plastic circle when asked to "point to the koob"). In the fast-mapping memory test children were exposed to the same novel object from

[2] Individual differences in fast-mapping performance are documented, but the majority of infants are not able to reliably pass fast-mapping tests until they are 16 months or older.

the reference test (i.e. white plastic circle) in a set of 2 or more novel objects (dumpling press, corkscrew, tire gauge). Children passed the memory test if they were able to recognize which novel object in the set is asociated with the previously exposed new word (i.e. pointing to the plastic circle when asked to "point to the koob").

Subsequent research has found that the fast-mapping ability is present in TDC (Golinkoff et al, 1992; Heibeck & Markman, 1987; Hutchinson, 1986; Dollaghan, 1985) as young as 18 months old (Mervis & Bertrand, 1994). Preschoolers are able to fast-map new words via eavesdropping ( Akhtar, Jipson & Callanan, 2001) and even watching television (Rice & Woodsmall, 1988). The fast-mapping ability is not significantly impaired in children with specific language impairment (Rice, Buhr & Nemeth 1990; Dollaghan, 1987), Down syndrome (Chapman et al, 1990; Mervis & Bertrand, 1995) or mild/severe mental retardation (McIlvane, Dube & Green, 1992; Mc Ilvane & Stoddard, 1981 ; Wilkinson & Green, 1998).

Age does not appear to affect the fast-mapping ability once it has developed (Markson & Bloom, 1997). In fast-mapping (matching-to-sample) tests, all children (over 2 years MA) select the unnamed comparison as the target for new names (Dollaghan, 1985; Golinkoff et al, 1992; Markman, 1989). Language impairments seem to affect the ability to remember mapped words later but not the ability to initially establish reference as evidenced by children with language delay (exposed to new words during a television program) remembered fewer of these new words than age-matched peers (Rice, Buhr & Nemeth, 1990).

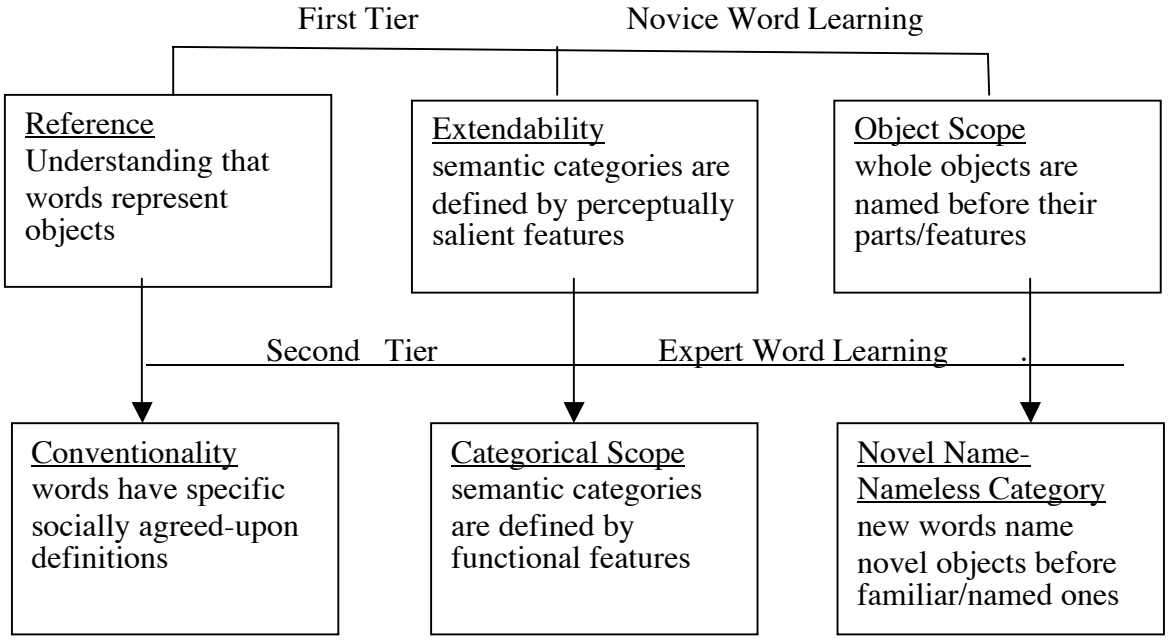
The phenomenon of fast-mapping is not limited to words (Markson & Bloom, 1997; Wilkinson, Dube & McIlvane, 1998). Matching-to-sample tasks, like those used in most fast-mapping assessments, can be conducted without words as samples. Animal cognition research refers to this inferential strategy (i.e. learning by exclusion) that spontaneously appears in

matching-to-sample tests as “emergent matching”. Emergent matching has been found using gestural matching-to-sample tasks in populations of dolphins (Herman, 1980), sea lions (Schusterman & Kreiger, 1984) and more recently a border collie (see discussion by Bloom, 2004).

In the emergent matching paradigm, new object names were introduced by pairing a novel and unnamed object with an old previously named object. Under these conditions, animals learned to rapidly associate the unfamiliar gesture with the unfamiliar object (immediate, almost errorless performance) (Schusterman & Kreiger, 1984).

Several linguistic strategies have been proposed to explain rapid word learning (Waxman & Kasowski, 1990; Markman, 1989; Merriman & Bowman, 1989; Markman & Hutchinson, 1984; Clark & Hecht, 1983). Golinkoff organized these linguistic strategies into a 2-tier framework (Golinkoff et al, 1994). The first tier of strategies are the “apprentice set”, providing a foundation for novice word learning. They include the reference, extendability and object scope. As children learn more words, their word learning strategies change (Hollich et al, 2000). The second tier of word learning strategies emerges from the first tier, helping children shift their status from novice to expert word learners. The “expert word learning” strategies include conventionality, categorical scope and the novel name-nameless category strategy (see Figure 2).

***Figure 2.*** Golinkoff's Lexical Principle[3] Framework :




The Novel name-nameless category (N3C) strategy is based on the knowledge that speakers are more likely to refer to salient items in the environment (Mervis & Bertrand, 1994). The novel name-nameless category strategy is the assumption that novel words map to unnamed categories of objects. Central to this assumption is the claim that the introduction of novel words primes a *search* for a novel object. The difference between this strategy and the similar Mutual exclusivity assumption is that mutual exclusivity claims that children consider the label for each object *before* inferring which one has no label. Mutual exclusivity (Markman & Wachtel, 1988) is also more of a constraint which discourages children from assigning a new name (mutt) to an already named object (dog).

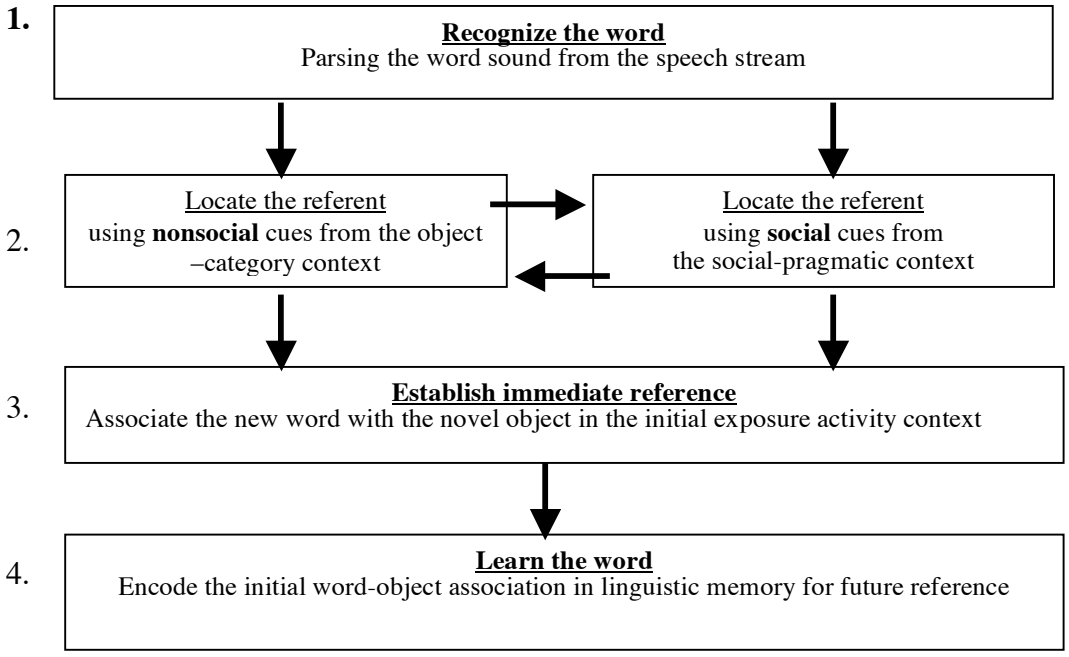
Lexical strategies are acquired in a developmental sequence. Children have acquired all first tier strategies between 11-13 months. The second tier strategies emerge later (16-20

[3] Lexical "Principle" is Golinkoff's term for inferential strategies contributing to rapid word learning.

months). Given identical objective input, infants who have available only the earliest principles are likely to make incomplete inferences about the referent or extension of a particular word than would toddlers who have available more advanced strategies (Mervis & Bertrand, 1994).

All of the lexical strategies work in concert with each other, leading to qualitative changes in vocabulary. Lexical acquisition during the period where the child has only the first 3 principles has a slow and deliberate look (Golinkoff et al, 1994; Mervis & Bertrand, 1993; 1994) requiring simple definitions and repeated exposures (Dromi, 1987). Once all 6 principles are in place, children are able to learn a new object word based on a single exposure (Hutchinson, 1986). Mervis & Bertrand (1994) assessed the language abilities of infants (13-20 mos.) before and after they acquired the N3C strategy. The results demonstrated a positive correlation between the presence of the N3C strategy (i.e. fast-mapping) and vocabulary size.

***Figure 3.*** Steps to Learning a New Word:



Fast-mapping requires the mastery of several component skills (see Figure 3). First, the child must be able to parse the novel word from the speech stream. This requires attention to linguistic cues (ie: prosody, phonology, word class, function words, syntax). Second the child must be able to locate the referent object from the ambiguous environment. Rapid word learning requires attention to object cues (ie: form/function, animacy, perceptual salience, novelty) and/or social cues (i.e. eye gaze, head turn, body posture, gesture) to establish joint reference. The third step in rapid word learning is to immediately associate the novel word with its object referent. Finally, the child must encode this association into memory based on this single exposure (Rice, Buhr, & Nemeth, 1990). It is step 2, the establishment of reference, on which this dissertation will focus.

## I.5 Justification for a Training Program

AD is a disorder that has no known etiology and no cure. Applied behavior analysis (ABA) offers the most effective treatment for decreasing the symptoms of AD. CAD who graduate from ABA preschools are more likely to be mainstreamed into regular elementary schools than mental-age matched children who graduate from alternative (e.g. TEACCH) preschools (Howard, 2004 ; Lovaas, 1987). One of the most important prognostic indicators of later performance in young CAD is language ability (Schreibman, 1988). Studies estimate as many as 85% of CAD who begin ABA (Lovaas, 1977) intervention by age 5 can learn to use speech as a primary mode of communication (Koegel, 1995; McGee, Daly, & Jacobs 1994).

ABA is a method for teaching CAD the basic skills that develop naturally in TDC. For example, a typically developing 13 month old can imitate basic gestures (clapping, waving, raising hands) but many CAD cannot imitate until they participate in an ABA imitation program,

and they must be taught each basic gesture. The ABA approach breaks down a complex task (i.e. fast-mapping) into simple components (i.e. parsing word, identifying novelty, searching set of objects) that can be worked on individually. The therapist provides contingent reinforcement and prompts associated with each skill to scaffold the ability from the lowest level (full prompting) to the highest level (verbal correction) until the child masters the task independently. Data is recorded to monitor progress ( number of successes and level of prompts used for trials).

This dissertation uses a behavioral(ABA) method to train CAD to use social (gaze-following) and nonsocial (fast-mapping) strategies to establish reference to learn words based on a single exposure. Support for the contention that social word learning skills can be trained comes from previous successful training programs designed to teach joint attention and theory of mind skills (Sweettenham, 1996; Hadwin, Baron-Cohen, Howlin and Hill, 1997). Support for the contention that nonsocial word learning skills can be trained comes from previous successful training programs designed to teach object discrimination and relational categories using ABA prompting to reduce stimulus over-selectivity in matching-to-sample tasks (Dube & McIlvane, 1999). The Matching-to-sample task is widely used in special education classrooms to teach relations between spoken words/symbols and objects/pictures (Dube & McIlvane, 1999). A matching-to-sample task is the basis for the fast-mapping assessment.

A matching-to-sample format incorporating methods of Applied Behavior Analysis was adapted to previous gaze-following (Baldwin, Baron-Cohen & Crowson, 1997) and fast mapping (Mervis & Bertrand, 1994) assessments to create two comparable assessment tests and training programs.

Word learning in natural contexts may be too complex for CAD because they have difficulty with complex tasks (requiring a high degree of interplay and plasticity of inhibitory processes, parallel computational strategies and simultaneous considerations of many possible

solutions) (McClelland, Rumelhart, & Hinton, 1986; Mesulam, 1990). Tasks with well-defined rules that do not require much processing flexibility should be easier (Ciesielski & Harris, 1997). Therefore language may improve if children are taught new rules to deal with complexity of word learning in an ABA format (discrete trials, repeated instructions, controlled word stimuli).

The children in this study represent the moderate-low functioning portion of the AD population (with moderate mental retardation and no speech). If the intervention is effective, it could provide a means to increase independent word-learning in this population of CAD.

## I.6 Purpose of this Dissertation

This dissertation focuses on the earlier (i.e. preverbal) stages of language development in an effort to identify word-learning skills that may be impaired in autism. Two putative sources of impairment (gaze-following and fast-mapping) were identified from word learning studies on typically developing children. Both gaze-following and fast-mapping skills play vital roles in independent word learning. Several symptoms of AD may compromise both gaze-following and fast-mapping skills. There are two reasons why it is important to study both gaze-following and fast-mapping skills in CAD. First, we must determine whether these skills are impaired in AD so that we have a better understanding of what causes the language impairments in autistic development. Second, we must evaluate both skills in relation to each other in typical and atypical children so that we have a better understanding of the relative contributions of these skills to typical language development. This dissertation includes an *assessment* to evaluate the gaze-following and fast-mapping skills in CAD as compared to children with mental retardation and typically developing children.

The necessary next step to the identification of new symptoms is to design an intervention to treat the symptoms. A specialized gaze-following and/or fast-mapping

intervention should be offered to children who demonstrate impairments. The efficacy of the intervention should be evaluated to determine if children with similar impairments could potentially benefit from it. This dissertation includes an *intervention* designed to teach both gaze-following and fast-mapping using principles of applied behavior analysis.

This dissertation has two studies. The Pilot study involves a fast-mapping assessment and intervention in a small group of CAD. The Dissertation study involves both gaze-following and fast-mapping assessments and interventions for a larger group of CAD with control groups.

# CHAPTER II. PILOT STUDY

A pilot study was conducted to study fast-mapping in preverbal CAD. The pilot included an assessment and an intervention segment. The assessment segment measured the fast-mapping ability using a modified version of Mervis & Bertrand's fast-mapping test (1994). The intervention section measured the efficacy of a training program which incorporated ABA prompts and reinforcements (see Lovaas, 1977) into the fast-mapping assessment test format.

## II.1 Pilot Assessment

### Method

#### Participants

Five preschoolers (4 boys, 1 girl) diagnosed with AD via the AD Diagnostic Interview or the AD Behavior Checklist participated in this study. Their mean choronological age was 4 years, 5 months (*range* = 3 ;11-5 ;11). None of the children had a history of other neurological disorders. None of the children were taking medication. All of the children attended the same ABA preschool for children with autistic disorder where they received 1:1 speech therapy at least one hour a week.

At the onset of this study, the children had not developed communicative speech. Children 1 and 3 (the girl) could not verbalize at all. Children 4 and 5 were echolalic (did not speak except to echo words/phrases spoken by others). Child 2 could approximate some phonemes (ex: "tuh" for T.V.). All of the children could reliably point to indicate answers in a picture-pointing task, however only two of the children pointed spontaneously to communicate. Receptive vocabulary estimates were based on speech therapy inventories, teacher reports and a picture pointing assessment administered by the experimenter. All 5 children had less than 30

object nouns in their receptive vocabularies. Three (of the original 8 volunteers) were dropped because their receptive vocabularies were too large (est. over 100).

Materials

An individualized set of photo cards was created for each child (see appendix I) to supplement the professional set used in the speech therapy program (Photo Cue Cards, PRO-ED © 1985). All supplement cards were standardized in size (3" x 5"), color corrected and laminated to match the professional set.

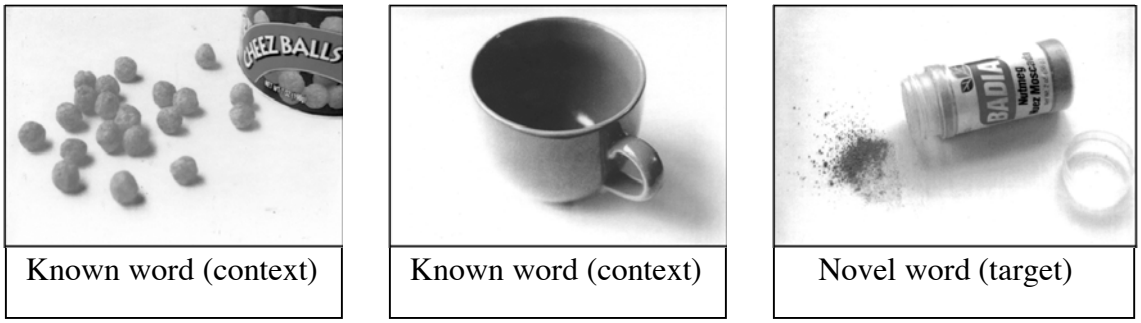
The noun cards were pre-tested on the children to create a word list for the fast-mapping assessment. Each child had his or her own individual word list separating the 100 noun cards into 3 categories (see Table X). The first category of cards was the known noun cards. *Known* stimuli were 20-30 photo cards depicting well-known words that the child was always able to indicate correctly in pre-test trials. The second category was the novel target noun cards. *Novel* target stimuli were 30 photo cards depicting novel words that the child was *not* able to indicate correctly in any pre-test trials. The set of novel target cards corresponded to the words introduced in the training program. The rest of the noun cards served as *distractor* noun cards (control stimuli). These distractor cards depicted novel words that would not be referred to throughout the program. For example, the experimenter never used the word "parasail" during the sessions so that the photo of a parasail could be used as a novel control.

Fast-mapping Reference Assessment Procedure

The fast-mapping reference tests were designed to assess each child's ability to associate a novel word with a novel object (photo) in the absence of social cues. Three assessment sessions were conducted over the course of a week. The children were given one opportunity to

learn each of the 30 target novel words during these sessions. The experimenter started out each Fast-mapping Reference test by placing 3 stimulus cards on the table in front of the child (Fig. 4). Two *known* cards (eg. cheezeballs & cup) were placed in a row with one *novel target* card (eg. nutmeg). Each child was instructed to point to the *novel target* card (e.g. "Point to the nutmeg"). The experimenter provided only a nonspecific gesture cue to the table while looking directly at the child. The experimenter did not look at any of the cards until the child had made a final selection (so as not to provide social cues). After 10 seconds, regardless of the child's response, the experimenter picked the cards up from the table and placed another set of cards (2 randomly chosen known cards and a different unknown card) on the table for the next trial. To prevent position bias, the *novel target* card was placed in the set pseudo-randomly. Children were reinforced for attention and sitting but not for correct responses

***Figure 4.*** Example of a Fast-mapping Reference trial:




| Known word (context) | Known word (context) | Novel word (target) |
|---|---|---|

[The experimenter looks at the child and instructs him "point to the nutmeg"].

To maintain attention to the specific word in the instructions, children were asked during control trials to point to a familiar object card (in the presence of the novel card).

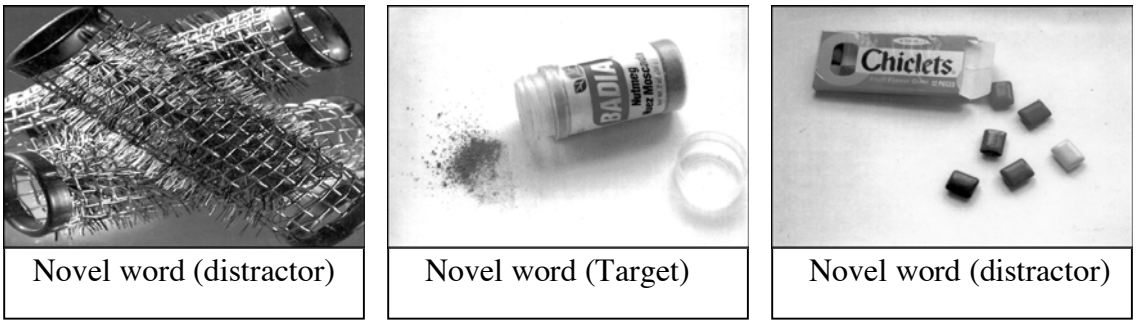
The assessment test consisted of 10 fast-mapping and 5 control trials per day over the course of 3 days. The reference test score was the percentage of words indicated correctly out of the total number of words that were exposed. In addition to determining the initial fast-mapping ability, the assessment tests served as a baseline for the subsequent training program.

Fast-mapping Memory Assessment Procedure:

The day after a novel target word was exposed, it was tested in a memory trial. If the word was remembered in the first memory trial, it was tested twice more over the course of the week. The novel target card was presented in a set with two distractors (novel control word cards). There were no known cards that the child could use to infer the association. Children were instructed to point to photos corresponding to previously exposed novel words (Fig. 5).

The purpose of the fast-mapping memory tests was to determine whether the association between the novel word and object was encoded as linguistic information so the next time the child heard that novel word, they would look for its specific corresponding photo (and not just any novel photo). The memory tests also assessed whether the child was fast-mapping to learn words (not just to pass the immediate "matching to sample" task). To prove that the child was fast-mapping to learn words, the memory tests required that the child picked a referent photo out of a set where the only indication of reference was the word itself. To control for response inconsistencies related to AD, three memory trials were given (over the course of a week) for each word introduced in fast-mapping sessions. The memory test score was the percentage of words (from the total exposed) indicated correctly in all three memory trials.

***Figure 5.*** Example of a Memory Test Trial:




[The experimenter looks at the child and instructs him "point to the nutmeg"].

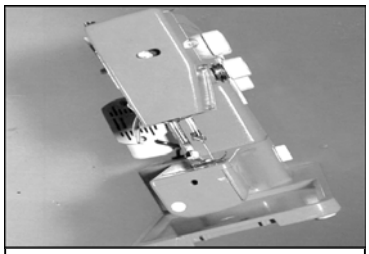
It is possible that the child could point to the *most novel* card in a given set to pass memory trials. To prevent children from being able to use this strategy, control trials included 2 novel target cards (learned in previous trials) in a set with 1 novel distractor card so that children were forced to choose correctly between the 2 novel targets (Figure 6).

***Figure 6.*** Example of a Control Memory Trial:

*Wednesday (If 'Record' was introduced on Monday and 'Nutmeg' on Tuesday)*


Novel word (Target)

Novel word (distractor)



Novel word (distractor)

[The experimenter looks at the child and instructs him "point to the Record"].

## Results

In the baseline, all of the children scored at or below chance level (chance = 33%) on fast-mapping tests (scores ranged from 13%-33%). None of the children could fast-map (Table 2) novel words to objects before training.

**Table 2.** Estimated Vocabulary and Fast-mapping Test Scores

| Child # | Est. # Object nouns in vocabulary | Baseline Fast-mapping score (based on 30 trials) | |
|---|---|---|---|
| 1 | 27 | 23% | 7 |
| 2 | 19 | 20% | 6 |
| 3 | 29 | 33% | 10 |
| 4 | 20 | 23% | 7 |
| 5 | 19 | 13% | 4 |
| Mean | 22.8 | 22.7% | 6.8 |

# Discussion

The children who participated in the assessment had fewer than 30 object nouns in their receptive vocabularies when they were first were assessed. Their speech therapy programs focused on rote learning and vocabulary drills using photos or objects in simple pointing tasks. Initially, the children were "pre-verbal" in that they did not use speech spontaneously to communicate. All 5 of these children performed at or below chance levels on the fast-mapping tests, suggesting that they were not yet fast-mapping to learn words.

The severity of the atypical and delayed language of AD varied as much as the other symptoms among the children diagnosed. It is likely that the fast-mapping ability varies similarly throughout the population. Three of the original 8 children who volunteered to participate in this study were dropped because their language functioning level was signficantly higher than the others (i.e. spontaneously used speech to communicate, spoke in full sentences at least once a day). Upon assessment, their receptive vocabularies were significantly larger than the other 5 (i.e. more than 100 nouns in their receptive vocabulary). As many of their known words were not explicitly taught, it was suspected that these children already had attained the fast-mapping ability. Their speech therapist administered a 10 trial fast-mapping test in the presence of the experimenter. All three of the children responded above 80% accuracy without fast-mapping training. The inability to fast-map may be restricted to those individuals with AD who have more severe language impairments (i.e. moderate-low functioning).

# II.2 Pilot Intervention

## Method

### Participants

Participants who performed at or below chance levels (33%) during the assessment were candidates for the training program. The same five children who participated in the assessment particpated in the training program.

### Fast-Mapping Intervention Procedure

The purpose of the training program was to scaffold the child's ability to fast-map by prompting them to attend to relevant object-context cues during the presentation of novel words. The training program utilized a reinforcement theory paradigm implementing methods of applied behavior analysis. The fast mapping testing procedure was used as a format to create the training program. First, the fast-mapping strategy was made more obvious, by slowing down the pace while increasing the number of exposures to each novel word presented. Second, attention and response behaviors were shaped through contingent reinforcement. Third, the complex "fast-mapping" behavior was broken down into simple component skills. Each skill was worked on individually through a prompt hierarchy. The experimenter started with the lowest prompt (most assistance) and worked her way up the hierarchy to the highest prompt (least assistance) necessary for the child to choose the target card. The highest prompt made the new word more salient in the instructions. The lowest prompt also made the new word salient while offering additional prompts to make the novel photo the most salient card in the set (Table 3). Prompts were systematically faded from most (spatial) to least (verbal) prompting (see Figure 7) over the course of the training sessions.

**Table 3.** Fast-mapping Hierarchy of Prompts:

| | | |
|---|---|---|
| Independent | The child points to the card with **No** prompting | Speaker looks directly at child and says "Point to the spools" |
| Verbal- | needs prompt to parse new word from speech stream and identify it as new | Speaker repeats instructions slowly "Point to *spools*" Emphasizing the new word |
| Hint- | Needs prompt to look at each card in the set and identify the known cards as a context | Speaker tells child to point to each of the known cards "point to cheeseballs…point to cup" and then repeats instructions "Now, point to *spools* " |
| Spatial- | Needs prompt to look at the novel word and separate it from the set | Speaker identifies each of the context cards "this is cheeseballs… this is cup" while moving them out of the child's reach and then repeats "Point to spools" |

Figure 7. Fast-mapping Prompts


Prompts were recorded after every trial. The number of independent (i.e. unprompted) correct responses was recorded as the session score. Ten training sessions were conducted over the course of 3* weeks (Tuesday-Friday) for each of the three training periods (**Table 4**). To ensure the children could maintain what they learned during training, there were two periods of non-training intervals after each training period. During these intervals, no fast-mapping training

nor contingent reinforcement for fast-mapping was provided (two months after 1st period, one month after second).

**Table 4. Assessment and Training Schedule**

| Test 1 | Training Period 1 | Non-training Period 1 | Follow-up Mem Test | Test 2 | Training Period 2 | Non-training period 2 | Training Period 3 | Test 3 |
|---|---|---|---|---|---|---|---|---|
| 3 days | 10 days | 60 days | 3 days | 3 days | 10 days | 30 days | 10 days | 3 days |

Memory Tests

Initial Memory Test

To evaluate the efficacy of the fast-mapping intervention to teach word-learning, Memory tests were given within a week after the initial fast-mapping exposure to novel words[4] Because words were being introduced every day, daily memory tests were incorporated into the intervention sessions. Each session started with three memory test trials targeting words that had been exposed during the days before.

The memory test in the intervention program utilized the same method and scoring as the memory test in the assessment test.

Long-Term Memory Test

To test the permanence of the word-object associations encoded during fast-mapping exposures, three sessions of memory tests were given two months after the initial training program (after the first non-training interval). Each session included a single memory trial for each of the words introduced in the first training period. The score was the percent of words indicated correctly in *all three* of these sessions.

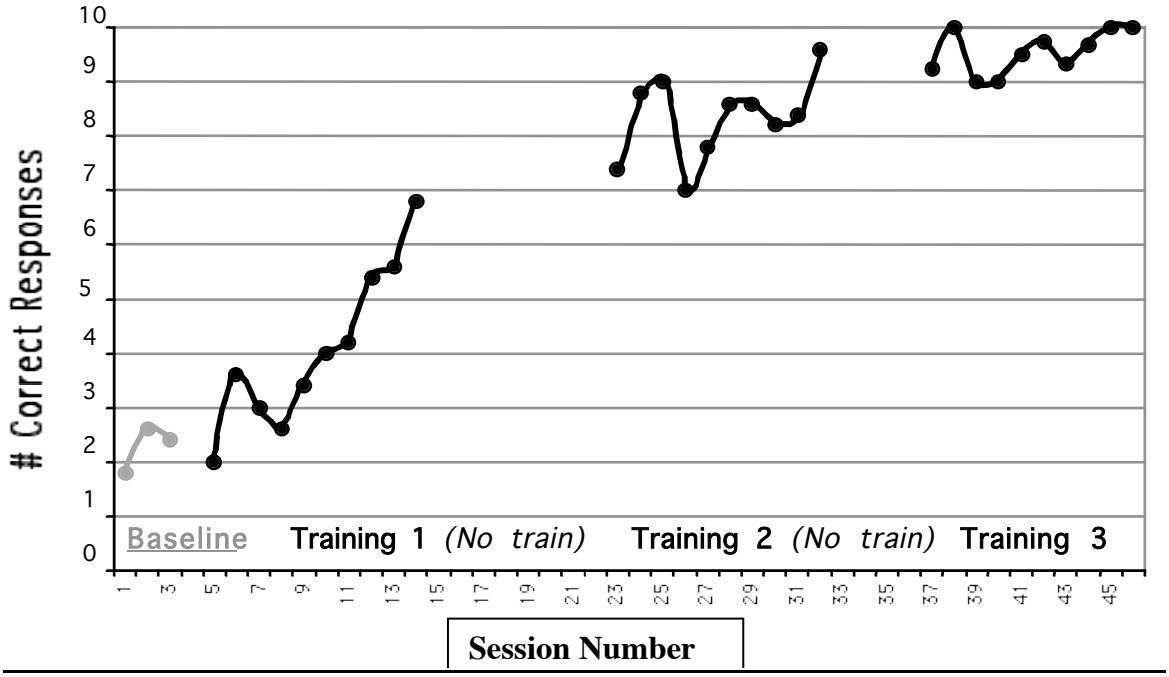
[4] Memory tests were only conducted while the training program was in effect (not during extinction periods).

# Results

## Fast-mapping Reference Scores

The fast-mapping intervention was effective at improving fast-mapping scores for all five children. Before training, CAD scored below chance (< 33%) on fast-mapping assessments. After training, CAD scored at or above the mastery (> 90%) level. The average fast-mapping session scores (i.e. number of unprompted correct responses per session) for all children increased significantly over the course of the intervention program (see Figure 8).

***Figure 8.*** Average Fast-mapping Session Scores




A t-test for dependent scores was used to analyze the difference between the scores for the last three training sessions and the scores for the first three (baseline) sessions. The statistical analysis indicated that all of the children' fast mapping raw scores (table 4) were significantly better than baseline (mean d= 22.2, $p<0.001$). A Pearson product correlation with respect to all

five children was conducted to analyze the statistical relationship between fast-mapping scores and the number of days each child participated in the training program. The length of time in the training program predicted the fast-mapping performance score (Table 5) as indicated by a significant correlation between training day and number of correct responses ($r = 0.775 – 0.863$, $p<0.01$). This indicates that the intervention affected the ability to fast-map.

**Table 5.** Fast-mapping session scores for each training period :

| Child # | Baseline 30 words (30 trials) | | Period 1 10 words (100 trials) | Period 2 10 words (100 trials) | Period 3 10 words (100 trials) |
|---|---|---|---|---|---|
| 1 | 23% | 7 | 54% | 79% | 96% |
| 2 | 20% | 6 | 42% | 84% | 95% |
| 3 | 33% | 10 | 43% | 87% | 100% |
| 4 | 23% | 7 | 55% | 95% | ** |
| 5 | 13% | 4 | 9% | 67% | 92% |
| Mean | 22.7% | 6.8 | 40.6% | 82.4% | 95.7% |

** *Child 4 moved to another country after period 2 was completed*

Although mapping session scores did improve during the eight and four week non-training intervals, the average improvement was not significant, indicating that the effects of the training intervention were long-lasting. The ability to fast-map as taught during the intervention could be maintained in the absence of training for at least 2 months.

Initial Memory Test Scores

Fast-mapping not only involves establishing reference but also storing this association in *linguistic memory* for future reference. The fast-mapping test assessed their ability to make this immediate association, but not their ability to encode it into the child's developing receptive vocabulary.

Three initial memory tests were administered for each novel target word. A strict response criteria was used ; only words that the child was able to indicate in *all three* initial

memory tests were considered to be "correct". This reduced the probability of a "chance" correct response from 33% to 3.7%. A t-test for independent samples was conducted to analyze the difference between the actual memory performance scores for each child and the level of performance that could be expected by chance (3.7%). The scores (average for all levels = 57%) on initial memory tests (Table 6= raw scores for each level) given within a week of the initial fast-mapping exposure was significantly better than chance performance ($p<0.01$).

**Table 6.** Words remembered from each training period

| Child # | Period 1<br>10 words<br>(30 trials) | Period 2<br>10 words<br>(30 trials) | Period 3<br>10 words<br>(30 trials) |
|---|---|---|---|
| 1 | 20% | 50% | 80% |
| 2 | 30% | 40% | 90% |
| 3 | 30% | 80% | 80% |
| 4 | 50% | 60% | ** |
| 5 | 0 | 80% | 90% |
| Mean | 26% | 62% | 85% |

** *Child 4 moved out of the country after Period 2 was completed.*

A Pearson product –moment correlation was conducted to analyze the relationship between the average fast-mapping reference scores and memory scores for each level. Fast-mapping scores were highly correlated with memory scores ($r= 0.679$-$0.907$, $p<0.001$) for four of the five children. As fast-mapping performance improved over the course of the training levels, so did performance on memory tests. This suggests that the children used fast-mapping as a strategy to both *locate* the referent of the novel word and also to *encode* the novel word-object association into their receptive vocabularies.

Follow-up Memory Test

A follow-up memory test was administered at the end of the first non-training interval. All of the children were able to remember 50-70% of the words they had fast mapped in training for 2 months without subsequent exposure. Unlike the initial memory test, the follow up

memory test only included one trial for each word (because the length of the test exceeded their attention span), thus increasing chance from 3.7% to 33.0%. A t-test for independent samples was used to measure the difference between follow-up memory performance scores and chance performance. Follow-up memory test scores for all children (mean = 63%) was significantly better than chance ($p<0.001$). This suggests that the children were able to retain an association between a word and a specific object (photo) that they based on a single exposure even in the absence of an ostensive indication or a direct definition.

## Discussion

Before the training intervention, none of the children could pass a fast-mapping test. After completing the training program, all five children demonstrated the ability to fast-map a novel word to a novel photo. Furthermore, memory tests given within a week of each word exposure demonstrated a word learning effect for all children.

The two non-training intervals were included into the design to determine if the same rate of improvement that occurred during the 4 weeks of training would continue in the absence of training. The scores showed no significant improvement when training was removed. This indicates that the fast-mapping ability was the result of the training program and not other factors (e.g. age, other speech therapy, ABA experience).

It is difficult to determine whether the children were able to use fast-mapping to learn words outside of the experimental task. Teachers and speech therapists reported an increase in overall word learning within the classroom for all children following the second training period. Without a control group, however, we cannot determine whether this increase was the result of another variable.

The only direct evidence of fast-mapping happened accidentally with child 3. When child 3 was reinforced, the experimenter held open a reinforcer box with 10 compartments and said "what do you want?". Child 3 had recently learned to say "I want _____ please" sentences in speech therapy. He said "I want M&M's please". The experimenter replied by saying "I'm sorry. There are no M&M's today. Would you like something else?". Child 3 replied "I want somethingelse please" as he reached for a novel candy that had just been added to the box that day (licorice bite). Child 3 enjoyed the new candy so much that he requested it the next day (before the reinforcer box was open) by saying "I want somethingelse". Although this was a mapping error, he made it by assuming that a new term "somethingelse" referred to a new object (licorice) because he knew the names of all the other objects in the reinforcer box (M&Ms, skittles, cheeseballs, raisins, pretzels, cheerios). This shows that other strategies are involved in the interpretation of what is relevant to map to a word. Rigid matching-to-sample tasks do not teach the child how to decipher referential from non-referential acts. With only one word learning strategy, the vocabulary is still vulnerable to semantic errors. However, this example shows that the child was using fast-mapping to learn words outside of the training condition.

Attempts at trying to create a more naturalistic mapping situation failed. At first, the experimenter used objects instead of picture cards in a mapping task. All of the CAD were able to use objects in fast-mapping and memory tests as well as they used photos. When the experimenter moved the set of objects off of the experimental table-top and onto the floor at the other end of the room, all of the CAD went back to performing at chance levels. Apparently, when the task required that the CAD first listen to the directions and then walk 10 feet to retrieve the object, it became too complicated.

Considering the complicated issue of generalization, one might question the decision to use photo cards of objects as opposed to actual objects in assessment and training. Physical features that signify novelty may be more salient in a 3D object than in its 2D representation. A pilot study was conducted on five CAD ages 47-58 months (mean 44 months) using objects instead of photo cards. The results of this pre-pilot assessment test agreed with the results of the pilot assessment; none of the CAD demonstrated the ability to fast map better than chance. The scores from the pre-pilot training program were inconsistent because the children related to the objects in the set differently. CAD had no trouble using objects to indicate the words that they knew. However, when presented with a new word they would grab whichever object was the most interesting to them at the time. The CAD from the pilot would then explore the object in an unconventional manner (mouthing, flapping, banging it) even if the object was familiar. Therefore, differences in object characteristics that could distract the child had to be controlled.

Although the 3D form and practical function of objects are inherent in the real world of word learning, the 2D visual features illustrated in the photo cards were sufficient to begin the fast-mapping intervention. By the end of the second training period, all of the CAD in the pilot were able to use objects and photos interchangeably. After CAD learn to fast-map with photos, they may begin a generalization program using more natural objects and interactions.

Previous data indicate CAD have impaired *social* word learning strategies (Baldwin, Baron-Cohen, & Crowson, 1997). Data from this pilot study demonstrated evidence of impairment in *linguistic* word learning strategies. The comparison study was planned to expand the assessment to include both fast-mapping and gaze-following tests and to compare performance between CAD to CMR and TDC groups. The follow-up intervention was designed to train both fast-mapping and gaze-following skills to strengthen rapid-word learning skills.

# CHAPTER III. COMPARISON STUDY

## III.1 COMPARISON ASSESSMENT

The Dissertation study was an expansion of the Pilot study incorporating additional measures and controls. Like the Pilot study, the Dissertation study was segmented into assessment and intervention parts. There were three primary differences between the Assessment section in the Pilot study and the Dissertation study. The Dissertation study included three additional standardized tests, a larger sample of CAD and two control groups (typically developing children and children with mental retardation).

There were four differences between the intervention section in the Pilot study and the Dissertation study. The Dissertation study included two interventions to train *both* word learning strategies (fast-mapping and gaze-following), three generalization measures, a post-test and a follow-up parent interview.

### Method

#### Participants

Three groups of children participated in the comparison assessment. The CAD group consisted of 15 preschoolers diagnosed with AD. The mean chronological age of the CAD group was 4 years, 4 months (*range* 3;5-4;11). The CMR group consisted of 5 preschoolers diagnosed with mental retardation (not on the autistic spectrum). The mean chronological age of the CMR group was 3 years, 11 months (*range* 3.5-4.10). The TDC group consisted of 10 typically developing preschoolers with no discernable diagnosis. The mean chronological age of the TDC group was 3 years, 1 month (*range* 2.1-3.9). None of the children had any other physical or

psychological diagnosis (i.e. epilepsy) nor were they taking any medication. All of the children spoke English as their only language.

The CAD Group met the DSM-IV diagnostic criteria for AD, verified by the Autism Diagnostic Interview (Lord, 1999). Children in the CAD group were enrolled in one of two ABA preschools (AMAC or Eden II) specializing in the treatment of AD. Both preschools incorporated applied behavior analysis (ABA) and at least 1 hour of 1:1 speech therapy (per week) in each individual child's treatment program. The CAD group had significant receptive and productive language delays as estimated by the Vineland Adaptive Behavior Scale (Vineland) and the Peabody Picture Vocabulary Test (PPVT). All of the CAD were classified as "preverbal" because they did not demonstrate daily spontaneous use of words to communicate.

The CMR group consisted of five mental-age matched peers diagnosed with mental retardation. Children in the CMR group were enrolled in an special education preschool (AHRC Blue feather). All of the CMR were classified as "preverbal", though two occasionally used words spontaneously (but not reliably). The preschoolers who participated in the CMR group were selected to match the language functioning level of the CAD group. There was a 1 :1 match between the five children in the CMR group and five of the preschoolers from the CAD group. Three language measures were used in this selection: Therapist/teacher interview, Vineland Adaptive Behavior scale (Vineland) and a Peabody Picture Vocabulary test (PPVT). First, the experimenter interviewed teachers and speech therapists to choose candidates who were preverbal (did not spontaneously produce words to communicate on a daily basis). Parents of selected preschoolers participated in an interview that included the Vineland. Preschoolers whose Vineland language age fell within the range of the CAD group (10-16 mos) were selected for the assessment. In the initial assessment, the selected preschoolers participated in the PPVT

to verify language level and to compare picture-pointing abilities (skills required for the experimental assessment). Parents of children in the CAD and CMR roups also participated in the Autism Diagnostic Interview (ADI). The ADI was used to verify that children in the CAD group did meet the diagnostic criteria for AD and that children in the CMR group did not.

Children were selected for the CAD group if they met the diagnostic criteria for AD (scores above the cutoff) and for The CMR group if they did not (scores below the cutoff). Four of the original volunteers were omitted from the CMR group because their ADI scores were within the AD range.

The TDC group consisted of 10 typically developing (2-3 year old) preschoolers. All children in the TDC group were enrolled in one of two preschools affiliated with local colleges (CUNY, Columbia). Children who participated as typically developing controls were chosen if they had at least 6 months of experience in a preschool and they were able to reliably point to photos corresponding to known words. As such, no children under the age of 2 were admitted in the study. The purpose of the TDC group was to show the performance in preschoolers who were not diagnosed with AD or MR. The typically developing control group could not be mental-age matched to the CMR and CAD groups (MA range 11-16 months) because they would be too young to reliably participate in the picture-pointing tasks. As such, the TDC group consisted of the youngest preschool children who could reliably point to words they knew.

Initially, there were an equal number of volunteers (15) for the three groups. Assessment tests and parent interviews were used to select children for The CMR group who were most comparable to the children in the CAD group. Ten volunteers were omitted from The CMR Group because they displayed some symptoms of AD or their language age was significantly

higher than the CAD group or they lived in bilingual families. Similarly, five volunteers were omitted from the TDC group because they lived in bilingual families.

Materials

The Autism Diagnostic Interview was used to assess children in the AD and CMR group. The Vineland Adaptive Behavior Scale and the Peabody Picture Vocabulary test were used to assess children in all three diagnostic groups. Additionally, children participated in two non-standardized experimental tests. The Fast-mapping and Gaze-following assessments used a standard set of 200 3"x5" color photo cards (Photo Cue Cards, PRO-ED © 1985). Additional cards (20) were created to supplement the standard set for generalization tests. Supplementary cards were standardized in size and color (via photoshop) to match the professional set. Small objects (80) were chosen for generalization tests (refer to Appendix B).

Assessment Procedure

Noun Assessment

For each child a list of well-known and novel words was compiled based on parent/teacher report and verified with a simple picture-pointing task. The card set contained photos of both high –frequency (i.e. cup, book, chips) and low-frequency words (i.e. riveter, stadium, loom). To verify that the high-frequency words were familiar and the low frequency words were not, children participated in a picture-pointing activity.

Based on the vocabulary questionnaire, each child had a list of *known* and *novel* nouns. The experimenter verified this list by directly assessing each child using a standard noun card set in a simple picture-pointing task similar to the PPVT. In known word trials, 3 photos representing *known* nouns were placed in a set. In novel word trials, the 3 photos represented reportedly novel nouns. In both trials the child was instructed to point to the named photo. Each

word was presented in 3 trials to the child over the course of 3 sessions. Only the words the child indicated in all three trials qualified as *known words*. Conversely, only the words the child did not indicate in any trials qualified as *novel words*. Each child had an individual list of 10-40 known noun photos. A general set of novel nouns was compiled depicting words that none of the children could indicate in the assessment tests (see sample set in Table 7 ; see Appendix A for full list). From this set, 140 target photos were chosen (30=pre-test, 30 = post-test, 40 = experimental, 40 = picture-different picture and picture to object generalization tests). These photo sets were divided randomly into fast-mapping and gaze-following sets. The remaining 100 photos were used as novel distractor cards. All objects used in generalization tests were verified in the same pointing test.

**Table 7**. Examples of Stimulus Photos from each Category:

| Known | Novel (target) Fast-mapping | Novel (target) Gaze-following | Novel (control) |
|---|---|---|---|
| Balloons | Mill | Coffee | Airport |
| Bathroom | Record | Stadium | Bank |
| Book | Chef* | Tailor | Binoculars |
| Candy | Tennis court | Weightlifter | Bowling alley |
| Cake | Flashlight | Golfer | Flower-pot |
| Chips | Loom | Laundromat | Gas attendant |
| Cookie | Hotel | Tractor | Globe |
| Cup | Taxi | Welder | Faucet |
| Ice cream | Arcade | Photographer | Toaster-oven |
| Pizza | Canopener | Violin | Swiss-army knife |
| Popcorn | Barber | Typewriter | Snail |
| Pretzels | Pharmacy | Astronomer | Shoe-store |
| Fries | Trailer | Kettle | Window-washer |
| Soda | Secretary | Electrician | Uniform |
| T.V. | Riveter | Construction | Vacuum |

For each child, a reward list of was compiled by the teacher of the child's favorite toys/foods/activities (see appendix ). These items was kept on –hand during the assessment procedure to reinforce proper attention and participation.

Standardized Tests

Three Standardized tests were administered to the children in each of the 3 groups: the Autism Diagnostic Interview (Lord, Rutter & LeCouteur, 1999), the Vineland Adaptive Behavior scale[5] (Sparrow, Balla & Chichetti, 1984) and the Peabody Picture Vocabulary test (Dunn & Dunn, 1981). The ADI is structured into 3 symptom sub-domains (communication, socialization, stereotypic behaviors). The ADI determines that a child meets the criteria for AD if their score falls above a standardized cutoff score, however, scores on the ADI are not sensitive to estimating the severity of AD. The Vineland is a structured interview scale that evaluates the acquisition of developmental milestones in four skill domains (communication, daily living, social and motor). The Vineland offers a standardized age equivalent for each of the sub-domains based on average functioning levels. The PPVT is a standardized picture-pointing test administered to the children. Unlike the Vineland, which measures both receptive and expressive communication, the PPVT measures only receptive language. The PPVT also offers an estimated language age, however, the lowest estimable age is 2 years (the age at which TDC can reliably be expected to point to words they know)[6]. As such, the PPVT scores can be compared to each other as an estimation of the lexical picture pointing ability, but they cannot be compared to the Vineland as a reliable estimation of language age.

Upon completion of this test battery, the children participated in two experimental assessments designed to measure their ability to learn novel words in a single trial (in gaze-following and fast-mapping conditions). The assessments made a functional distinction between immediate contextual reference (match a novel word with its corresponding object) and

[5] The ADI and Vineland tests were administered during a parent interview either in the lab or at their homes.
[6] Though their mental age was under 2 years, children in Groups 1 and 2 had mastered pointing to known words in card sets in preschool prior to being selected for the study.

subsequent retention (remember a novel word– photo association after a delay). Therefore, both experimental assessments included reference and memory trials.

Fast-mapping Reference Test

The Dissertation study used the same fast-mapping reference assessment as was used in the Pilot study (see method on page 36-37). Each novel word card was presented in a set with two known word cards. The experimenter used only nonspecific gestures to instruct the child, providing no social clues (i.e. eye-gaze) to indicate which was the target word. Children were reinforced for attention and sitting but not for correct responses (refer to Figure 4 on page 37). The raw score was the number of trials in which the child made a correct response.

Memory trials in the Dissertation study were the same as memory trials in the Pilot study. Just like the Pilot trials, experimental trials presented previously introduced words in a set with two novel words while control trials presented previously introduced (target) words in a set with a novel word and another previously introduced (distractor) word. All words introduced in the reference trials were tested in memory trials (refer to Figures 5 and 6 on pages 37-38).

Four sessions consisting of ten trials each were conducted over the course of four days. Days one and three were reference trials. Days two and four were memory trials targeting the words exposed during days one and three. The children were given one reference and one memory trial for each of the novel words in the word list. Each testing session started with 3 warm-up (control) trials to verify that children were paying attention and understood the directions. Additional control trials were used if the child's attention lapsed from the activity for longer than 10 seconds or if the child got up from his/her seat.

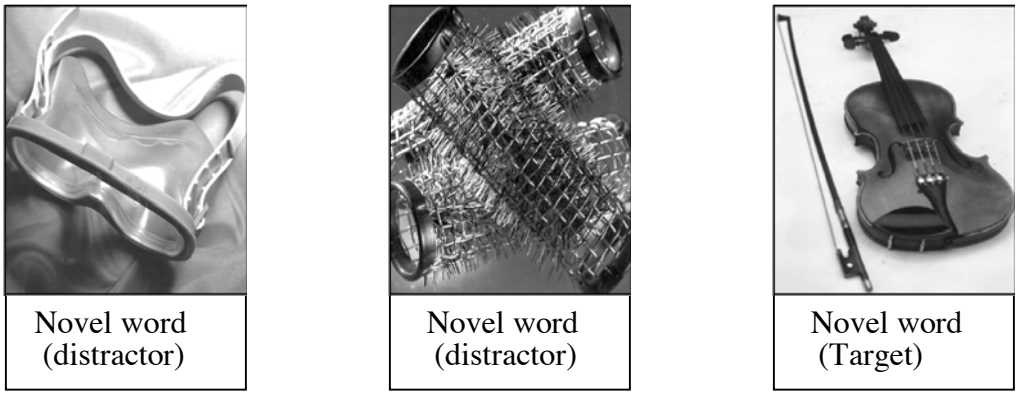
Gaze-following Reference Test

The Gaze-following assessment is based on a study assessing single trial word learning and gaze-following using two-item sets of novel objects (Baldwin, Baron-Cohen, Crowson, 1997). The gaze-following assessment was modified for consistency with the fast-mapping test by using a three-item set of novel photos. Like the fast-mapping assessment, gaze-following reference was measured using a matching-to-sample task. Unlike the fast-mapping assessment, all three of the cards in the experimental set were novel (so that there were no contextual cues for the children to refer to). Once the cards were set on the table (5" apart) the experimenter looked at the child while saying "Point to the…" and then looked directly at one of the cards as she named it "violin". The experimenter continued to stare at the card until the child responded. NO other gestures, body movements or other physical indications of the card were provided. In experimental trials, the sample was a novel word in a set of novel words. In control trials the sample was a familiar word in a set of equally familiar words. Control trials were only used to verify the child was attending to the cards and following instructions. The score was the percentage of experimental trials in which the child made a correct response.

The experimenter started out each reference test by placing 3 stimulus cards on the table in front of the child. Two novel word cards (eg. Pilot and bank) were placed in a row with the novel target card (eg. violin). The child was instructed to point to the novel target card (e.g. "Point to the violin"). As the experimenter said the novel word, she looked directly at one of the cards with exaggerated eye gaze. After 3 seconds of eye gaze directed at the target card, the speaker looked up at the child. After 10 seconds, regardless of the child's response, the

experimenter picked the cards up from the table and placed another set of cards (2 randomly chosen novel distractor cards and a different novel target card) on the table for the next trial (Figure 9). To prevent position bias, the novel target card was placed in the set pseudo-randomly. Children were reinforced for attention and sitting but not for correct responses.

***Figure 9.*** Example of a Gaze-following Reference trial:




[The experimenter looks at the target card and instructs "point to the violin"].

The Memory test for gaze-following was identical to the fast-mapping memory test. The difference between the gaze-following reference and memory tests was the provision of eye contact. While the experimenter looked directly at the target card in reference trials, she looked ***only*** at the child during memory trials until the child responded.

Reliability of Scoring

Some sessions were videotaped to ensure the reliability of the assessment scores. Nine children in the CAD group and four children in the CMR group were taped on a Sony digital Mini DV recorder. All of their sessions were recorded. All 14 tapes of the assessment sessions were viewed by the experimenter and compared to the transcribed data. The gaze-following and fast-mapping scores recorded in the data sheets were 100% consistent with the performances recorded on the videotapes.

Assessment Timeline

The entire comparison assessment program took 10 days to complete (Table 8).

| Day # | Assessment type |
|---|---|
| 1 | Teacher interviews, class observation |
| 2 | Parent interviews (ADI, Vineland) |
| 3 | Introductory session (play activity) |
| 4 | PPVT |
| 5-6 | Vocabulary test (verify novel vs known) |
| 7 | Fast-mapping reference test |
| 8 | Fast-mapping memory test |
| 9 | Gaze-following reference test |
| 10 | Gaze-following memory test |

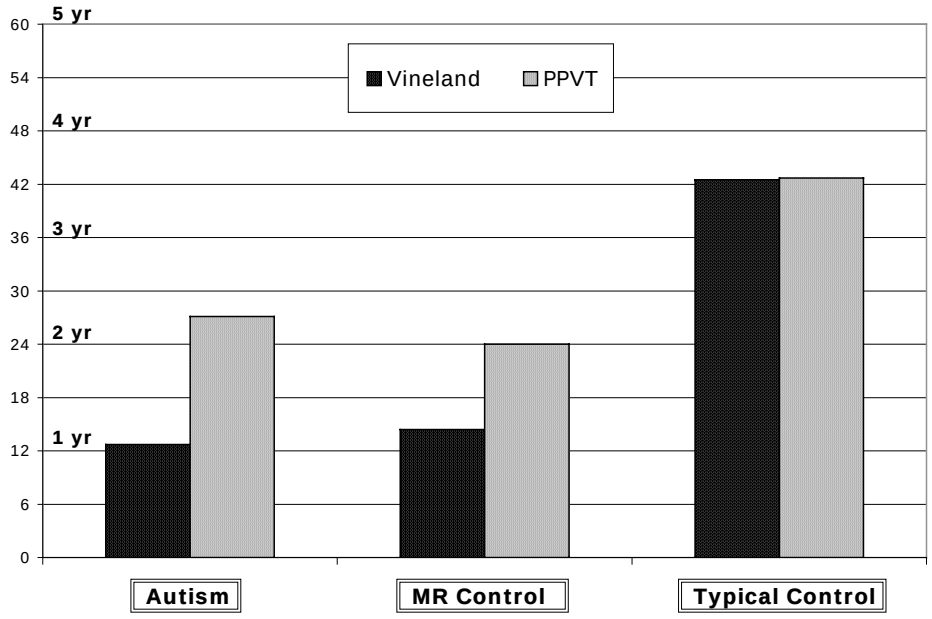
## Results

Preschoolers participating in the assessment were pre-selected into three groups based on diagnostic categories (the CAD group, the CMR group, the TDC group). Preschoolers whose Vineland and PPVT language ages fell within the range of the CAD group were selected for the assessment. The mean Vineland language age for the CAD group was 1 year, 1 month (*range*= 0;10-1;6, SD=2) and for the CMR group was 1 year, 2 months (*range*= 1; 0-1;4, SD=2). The mean PPVT language age for the CAD group was 2 years, 3 months (*range* = 1;10-3;0, SD=4.4) and for the CMR group was 2 years (*range*= 1;10-2;1, SD=1.4). The high correlation (0.97, p<

0.05) between the Vineland and PPVT language measures suggests that the parents' reports of language functioning was consistent with their children's actual language abilities.

There was no significant difference in the Vineland communication scores ($F=2.92$, $p < 0.104$) or the PPVT language scores ($F=2.23$, $p < 0.153$) between the CAD or CMR groups, but the TDC group had signficantly higher scores on both assessments (Figure 10).

***Figure 10.*** Estimated Language age for All Groups :

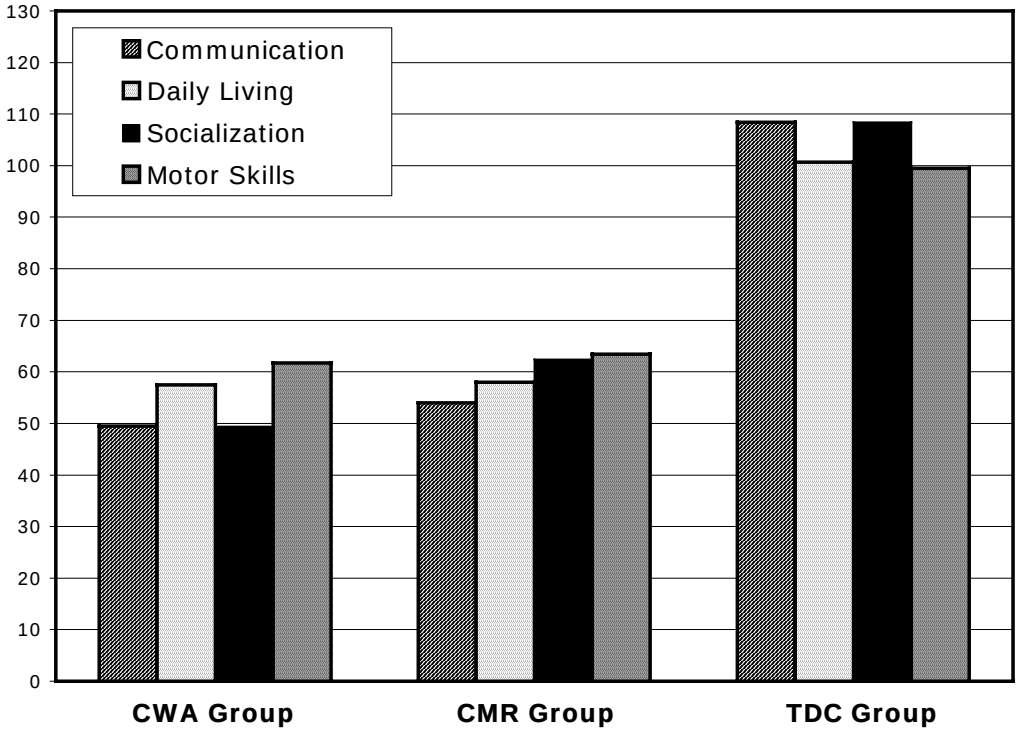



As expected, the children in the CMR group performed better on the social sub-domain of the Vineland than the children in the CAD group. Across the other domains (communication, daily living, motor) there was no significant difference in scores (Figure 13), indicating that the groups were highly comparable.

The children in the TDC group scored significantly higher than the CAD and CMR groups on the PPVT and across all Vineland Sub-domains (Figure 11), indicating that the TDC group test results did not show any significant developmental delay.

The greatest within-group variability for Vineland and PPVT scores was found in the TDC group. For both the CAD and the CMR group, Vineland composite scores (42-65) and PPVT standard scores (41-64) were within the Low range. The TDC group's Vineland composite scores (76-130) and their PPVT standard scores (74-124) ranged from low-average to high, showing a more even distribution than the CAD and CMR groups.

***Figure 11.*** Vineland Sub-domain Scores for All Groups:



The ADI verified that the 5 children in The CMR group did not meet the criteria for AD while all 15 children in the CAD group did meet the criteria for AD (see Table 9).

**Table 9.** ***Autism Diagnostic Interview Scores***

| Child # | The CAD Group (Autistic Disorder) | | | The CMR Group (Mental Retardation) | | |
|---|---|---|---|---|---|---|
| | Social-ization | Commun-ication | Stereo-typies | Social-ization | Commun-ication | Stereo-typies |
| cutoff = | **10** | **7** | **3** | **10** | **7** | **3** |
| 1 | 33 | 16 | 8 | 6 | 5 | 0 |
| 2 | 34 | 14 | 7 | 4 | 4 | 0 |
| 3 | 36 | 11 | 8 | 3 | 1 | 0 |
| 4 | 28 | 10 | 5 | 3 | 6 | 2 |
| 5 | 27 | 12 | 8 | 8 | 6 | 2 |
| 6 | 19 | 8 | 5 | | | |
| 7 | 30 | 12 | 9 | | | |
| 8 | 32 | 14 | 4 | | | |
| 9 | 31 | 18 | 5 | | | |
| 10 | 33 | 12 | 7 | | | |
| 11 | 15 | 12 | 4 | | | |
| 12 | 34 | 11 | 12 | | | |
| 13 | 35 | 14 | 8 | | | |
| 14 | 34 | 16 | 8 | | | |
| 15 | 15 | 10 | 7 | | | |
| Mean: | 29.1 | 12.7 | 7 | 4.8 | 4.4 | 0.8 |

*Score meets criteria for diagnosis of AD*

Fast-mapping Reference Test

An analysis of variance for reference test scores by diagnostic group found a significant between-group difference in fast-mapping performance, F (2, 27) =101.92, $p < 0.0001$. The fast-mapping scores for the CAD group (26%) were significantly below those of the CMR group (80%) and the TDC group (93%). The TDC group performed significantly better on fast-mapping tests than The CMR group ($d=2.00$, $p<0.05$).

A t-test for independent measures determined that the CAD group score was not significantly above chance (mean difference =-1.07, $p= 0.075$). The fast-mapping test scores were significantly above chance for the CMR (mean difference= 7.00, $p< 0.001$) and TDC (mean difference = 9.00, $p< 0.001$) groups. All but three of the children in the CAD group scored at or below chance level (chance = 33%) on fast-mapping tests (*range* 13%-33%, SD= 14.2%). Two of the children scored slightly above chance (40%), but the difference was not significant. These scores indicate that most of the children in the CAD could not fast-map novel words to objects before the intervention. Only child 3 scored significantly above chance (Table 8). All of the children in the CMR and TDC groups scored significantly above chance on fast-mapping tests (Figure 12).

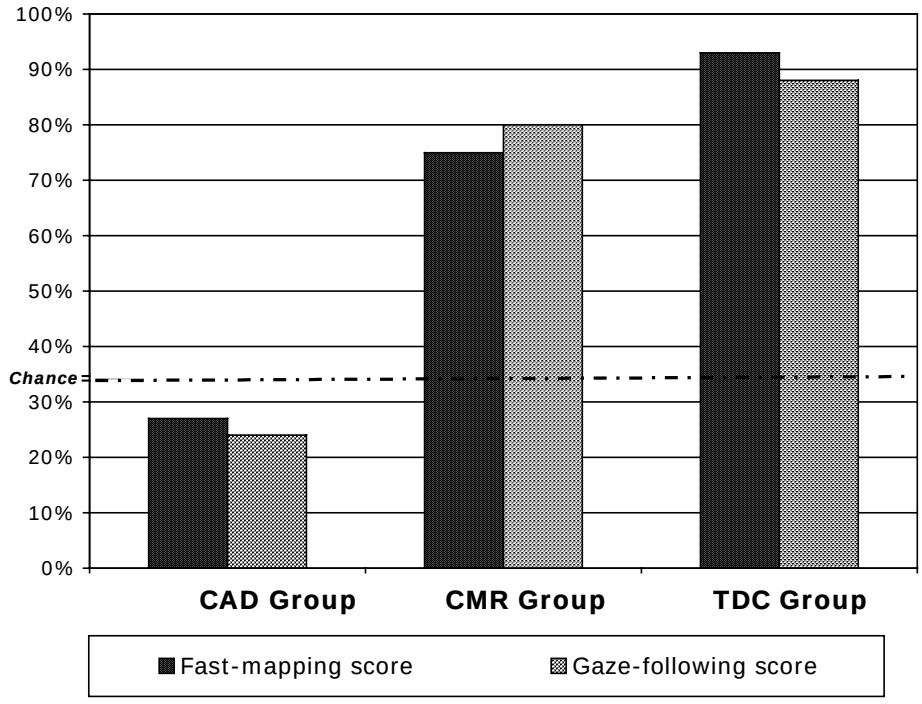
Gaze-Following Reference Test

An analysis of variance for reference test scores by diagnostic group also found a significant between-group difference in gaze-following performance, F (2, 1.42) =132.4, $p < 0.0001$. The gaze-following scores for the CAD group (24%) were significantly below those of the CMR (80%) and the TDC groups (88%). The TDC group performed slightly better on gaze-following tests than The CMR group, but this difference was not signficant.

A t-test for independent measures determined that the CAD group scores were all significantly below chance (mean difference= -1.40, p= 0.004). The gaze-following test scores were significantly above chance for the CMR (mean difference = 7.00 , p< 0.001) and TDC (mean difference = 8.20, p< 0.001) groups.

All of the children in the CAD group scored at or below chance level (chance = 33%) on gaze-following tests (*range*= 0%-33%, SD= 10.3%). These scores (table 10) indicate that all of the children could not use gaze-following to map novel words to objects before the training intervention. All of the children in the CMR and TDC groups scored significantly above chance on gaze-following tests. Therefore, none of these children needed to participate in the gaze-following portion of the training program (Figure 12).

***Figure 12.*** Average Reference Assessment Scores :



Fast-mapping v. Gaze-following**:**

Fast-mapping reference test scores were compared to gaze-following test scores. Average fast-mapping raw scores were slightly better than average gaze-following scores for the TDC group (0.08). There was no difference between average fast-mapping and gaze-following raw scores in the CMR group, and the difference in the CAD group raw scores (0.33) was not signficant (see Table 10).

**Table 10.** Scores on Fast-mapping and Gaze-following Reference Tests:

| | CAD Group | | CMR Group | | TDC Group | |
|---|---|---|---|---|---|---|
| Child # | Fast-map Reference | Gaze-fol. Reference | Fast-map Reference | Gaze-fol. Reference | Fast-map Reference | Gaze-fol. Reference |
| 1 | 2 | 0 | 12 | 11 | 15 | 15 |
| 2 | 2 | 2 | 13 | 14 | 13 | 11 |
| 3 | 10 | 4 | 13 | 13 | 12 | 11 |
| 4 | 3 | 5 | 12 | 11 | 15 | 13 |
| 5 | 6 | 2 | 10 | 11 | 11 | 12 |
| 6 | 4 | 5 | | | 15 | 15 |
| 7 | 5 | 5 | | | 15 | 14 |
| 8 | 4 | 3 | | | 15 | 15 |
| 9 | 3 | 5 | | | 15 | 12 |
| 10 | 6 | 5 | | | 14 | 14 |
| 11 | 3 | 4 | | | | |
| 12 | 2 | 4 | | | | |
| 13 | 3 | 5 | | | | |
| 14 | 3 | 3 | | | | |
| 15 | 3 | 2 | | | | |
| Mean | **3.93*** | **3.60*** | 12.00 | 12.00 | 14.00 | 13.2 |
| SD | **2.13** | **1.54** | 1.41 | 1.41 | 1.48 | 1.62 |
| Mean (%) | **26.3%** | **24.0%** | 80.0% | 80.0% | 93.3% | 88.0% |
| SD (%) | **14.2%** | **10.3%** | 9.4% | 9.4% | 9.9% | 10.8% |

**** Indicates scores below chance (33% of 15 trials = 5.00)***

Fast-mapping Memory Test

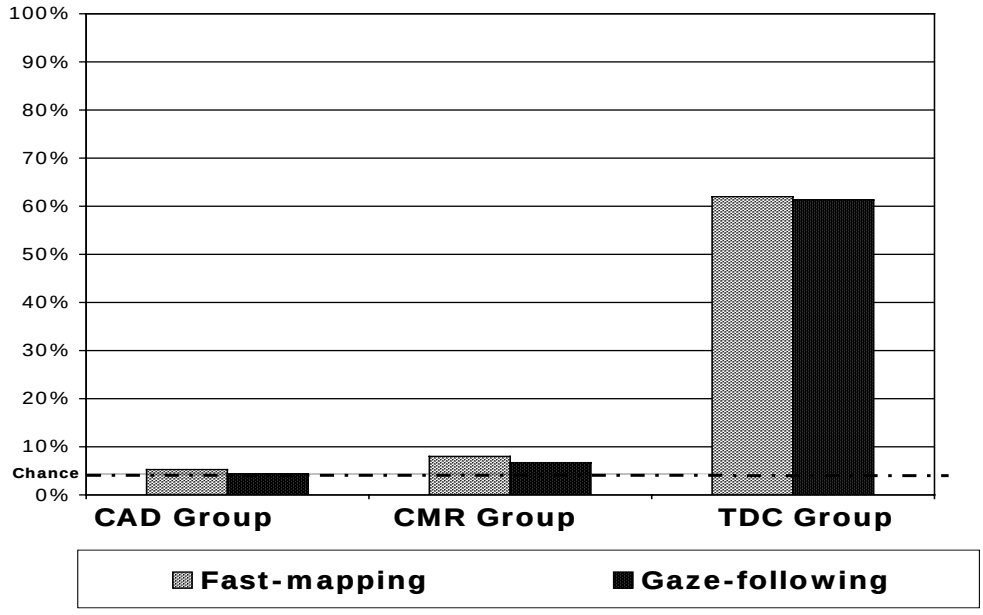
An analysis of variance for memory test scores by diagnostic group found no overall significant between-group difference in fast-mapping memory performance. There was a difference in performance on fast-mapping memory tests when you combined the CAD with the CMR group and compared them to the TDC group $F(1, 27)=55.15, p < 0.0001$. The memory scores (Figure 13) for the CAD (5.3%) and CMR (8.0%) groups were significantly below the TDC group (62.0%). There was no significant difference between the percentage of words remembered in the CAD and CMR groups, $F(1,18)=0.211, p=0.65$. This suggests that children diagnosed with MR (with or without AD) were unable to remember words introduced in a fast-mapping context upon subsequent exposure. The memory scores were represented as the percentage of words remembered from the total list of words introduced. Most of the children in the CAD group, however, were not able to remember any of the words. The only child in the CAD group who demonstrated memory (47%) was the one who passed the fast-mapping test (child 3). By contrast, all children in The CMR group remembered at least 1 word. To pass a memory test, the child had to choose the word in all 3 of its set permutations (left, middle, right). Therefore, the probability of a chance correct response was 3.7% (0.33 x 0.33 x 0.33). On fast-mapping memory test, the TDC group performed significantly above chance (mean difference= 8.70, $p< 0.001$), The CMR group slightly above chance (mean difference= 0.40, $p= 0.032$), while the CAD group did not perform above chance (Figure 13).

Gaze-following Memory Test

An analysis of variance for memory test scores by diagnostic group found no overall significant between-group difference in memory performance. There was a significant

difference when children with mental retardation were *pooled* into one group and compared to the TDC group, $\underline{F}\ (1, 27)=77.5, p < 0.0001$. The memory scores (Figure 13) for the CAD (5%) and CMR (7%) groups were significantly below the TDC group (61%). There was no significant difference between the percentage of words remembered in the AD and CMR groups, suggesting that children with mental retardation (with or without AD) were unable to remember words introduced in a gaze-following context upon subsequent exposure. Average scores for the CAD and CMR groups are significantly below those of the TDC group (70.9%). Gaze-following memory tests were not significantly above chance for the CAD and CMR groups. Gaze-following memory tests were significantly above chance for the TDC group (mean difference=8.6, p< 0.001).

***Figure 13.*** Average Memory Assessment Scores**:**



Fast-mapping v. Gaze-following

Fast-mapping memory scores were compared to gaze-following memory scores. There was no significant difference in memory scores between fast-mapping and gaze-following conditions. Mean fast-mapping memory raw scores were marginally better (0.2) than mean gaze-following memory scores in the TDC group and gaze-following memory scores were marginally better (0.1) than fast-mapping memory scores in the CMR group. There was no difference between fast-mapping and gaze-following memory scores in the CAD group (see Table 11).

**Table 11.** Scores on Fast-mapping and Gaze-following Memory Tests:

| Child # | **CAD Group** | | **CMR Group** | | **TDC Group** | |
|---|---|---|---|---|---|---|
| | Fast-map Memory* | Gaze-fol. Reference* | Fast-map Memory* | Gaze-fol. Reference* | Fast-map Memory* | Gaze-fol. Reference* |
| 1 | 0 | 0 | 2 | 2 | 11 | 10 |
| 2 | 0 | 1 | 1 | 1 | 10 | 8 |
| 3 | 7 | 4 | 1 | 2 | 9 | 7 |
| 4 | 1 | 2 | 1 | 0 | 12 | 11 |
| 5 | 1 | 2 | 1 | 0 | 4 | 6 |
| 6 | 0 | 1 | | | 9 | 10 |
| 7 | 0 | 0 | | | 9 | 13 |
| 8 | 0 | 0 | | | 13 | 13 |
| 9 | 0 | 0 | | | 10 | 7 |
| 10 | 3 | 0 | | | 6 | 7 |
| 11 | 0 | 0 | | | | |
| 12 | 0 | 0 | | | | |
| 13 | 0 | 0 | | | | |
| 14 | 0 | 0 | | | | |
| 15 | 0 | 0 | | | | |
| Mean | 0.8* | 0. 67 | 1.2* | 1* | 9.3* | 9.2* |
| SD | 0.19 | 1.17 | 0.43 | 1.01 | 0.27 | 0.26 |
| Mean (%) | 5.3% | 4.4% | 8.0% | 6.7% | 62.0% | 61.3% |
| SD (%) | 1.3% | 7.8% | 2.9% | 6.7% | 17.8% | 17.1% |

***Signficantly above chance level ; chance is 0.6 (4% of 15 words=0.60).***

Scores on fast-mapping and gaze-following Reference tests were highly correlated with each other (0.93, $p < 0.05$), as were scores on fast-mapping and gaze-following Memory tests (0.92, $p < 0.05$). There was a slightly lower correlation between Reference and Memory scores in the fast-mapping (0.72, $p < 0.05$) and gaze-following (0.83, $p < 0.05$) tests (see Table 12).

**Table 12.** ***Correlations between Reference and Memory test scores***

| | Fast-mapping Reference test | Fast-mapping Memory test | Gaze-following Reference test | Gaze-following Memory test |
|---|---|---|---|---|
| F-M ref test | 1.00 | 0.72 | 0.93 | 0.70 |
| F-M mem | 0.72 | 1.00 | 0.78 | 0.92 |
| G-F ref test | 0.93 | 0.78 | 1.00 | 0.83 |
| G-F mem | 0.70 | 0.92 | 0.83 | 1.00 |

A Pearson product moment correlation was used to compare scores on the descriptive assessments to the experimental (fast-mapping and gaze-following) assessments to determine what variables were most related. The ADI and Vineland assessments were highly correlated to each other in their communication (-0.78, $p < 0.05$) and social (-0.83, $p < 0.05$) sub-domains[7]. *Between* groups, the ADI was highly correlated to fast-mapping and gaze-following reference tests for the CAD and CMR groups. ADI scores were more highly correlated to fast-mapping and gaze-following reference tests than Vineland scores. *Within* groups, however, there was no significant correlation between the ADI scores and the reference/memory test scores. The reason for this is that the ADI score is used dichotomously (above or below the diagnostic threshold number) and therefore cannot be interpreted as a scale. Vineland scores were more highly correlated to both memory tests than ADI scores. Fast-mapping and gaze-following reference test scores were equally correlated (-0.92, $p < 0.05$) to the ADI communication scores.

[7] The correlations were negative because higher ADI scores indicate more severe AD symptoms while higher Vineland scores indicate higher adaptive functioning levels.

# Discussion

The purpose of the dissertation assessment was to determine if social and nonsocial word learning skills are impaired in preschoolers with AD. The hypothesis was that both social and nonsocial skills would be significantly impaired and that these impairments directly contributed to the severe language impairment characteristic of AD. Preschoolers were chosen for this study because they are old enough to participate in the experimental task (picture-pointing) but young enough to still be within their critical period of language development (2-6 years old). Preverbal children were chosen because they were more likely to have severe language impairments across the board, including social and nonsocial word learning deficits.

The assessment section focused on whether CAD would be able to learn words based on a single exposure in both a fast-mapping and a gaze-following condition.

| Assessment Questions |
| --- |
| 1) Would CAD pass fast-mapping and joint-attention tests? |
| 2) Would the CAD group perform on par with the MR and Typical groups? |
| 3) Did performance vary between gaze-following and fast-mapping tests? |

***1) Would CAD pass fast-mapping and joint-attention tests?***

All of the CAD tested in the Pilot (5) and in Dissertation studies (15) performed at or below chance on both fast-mapping and gaze-following Reference tests. [8] Preverbal CAD did not pass either of these reference tests, whereas language-matched preverbal CMR did.

[8] Except child 3, who was able to pass the fast-mapping but not the gaze-following test.

***2) Would the CAD group perform on par with the CMR and TDC groups?***

Both CAD and CMR groups were preverbal and mentally retarded. Additionally, they had comparable Vineland scores across all domains of development. The only significant difference between the CAD and CMR groups was on their ADI scores. Only children in the CAD group were diagnosed with AD. The finding that the CAD group failed the same reference tests that the CMR group passed suggests that there is something about AD that impairs fast-mapping and gaze-following skills for which MR alone cannot account. The only children demonstrating impairments in reference tests were the CAD. In comparison, the CMR performed more similarly to the TDC on reference tests. In this study, 3-4 year CMR could establish reference (using both social and nonsocial context cues) as well as typically developing 2-3 year olds, but 3-4 year old CAD could not.

The CAD and CMR groups were not significantly different in Vineland or PPVT estimates of language functioning. There was some difference in social functioning as estimated by the average Vineland social sub-domain scores for the CAD group (49.5) and the CMR group (62.4). Even though both groups of children were preverbal, the CMR group was able to use their nonverbal social skills to interact with peers, play games, express emotions, share attention and communicate their wants. These children were much like their typically developing peers in their positive responses to the experimenter during non-testing interactions. The experimenter included several social probes to gauge children's interactive styles in different conditions including making silly faces, playing with action figures/Pez dispensers, demonstrative activities (3 ways to use silly putty), hide and seek, action songs (itsy bitsy spider), and role-playing (giving child stimuli and letting them pretend to be the teacher). In comparison, the children in the CAD group showed no interest in silly faces, action figures, demonstrative activities or role-

playing games. Most of the children in the CAD group were only interested in hearing well-rehearsed action songs or playing with Pez dispensers. Children did not attempt to copy actions in the songs or sing along. The type of play children in the CAD group engaged in was limited and repetitive (i.e. lining up Pez dispensers, opening and closing dispensers, flicking Pez heads up and down, putting candy in and out) as compared to the children in the TDC group who acted out scenes such as superhero flying or planning a party (for the Spongebob Pez). The children in the CMR group had less sophisticated pretend play, but they did play chase and make animal noises with the various Pez characters. Socially, the CAD group was withdrawn, unresponsive and limited to rigid, stereotyped or self-stimulatory behaviors. Children in the CMR and TDC groups, by comparison, were very affectionate, responsive, and creatively playful.

In addition to social responsiveness, The CMR group made regular eye contact with the experimenter both inside and outside the experimental context. Despite their limited language, they were able to participate in several of the aforementioned non-experimental activities that required joint reference.

If CMR were establishing reference when they heard a new word, what accounted for their language delay? The children in the CMR group were able to map new words to novel objects immediately, but unable to remember the new words the next day. Children in the CAD group were unable to map the new words to novel objects in the first place. The similar language delay found in the CAD and CMR groups may be attributed to different causes. MR may impair the ability to remember new words whereas autistic disorder may impair the ability to establish reference. The children in the CAD group were diagnosed with both AD and MR, which may account for their similar poor performance on memory tests. It is also possible that their impairments in establishing reference compromised the confidence they had in the words they

did map, leading to poor memory performance. Whatever the case, MR alone did not seem to impair the ability to establish reference in the fast-mapping or gaze-following conditions. Future research should evaluate if repeated exposures to words improve memory scores in children with mental retardation who can establish reference using fast-mapping and gaze-following skills.

The presence of AD was controlled for (the CMR group) but not the presence of MR. Does AD only impair the ability to establish reference or does it impair linguistic memory as well? It is possible, however, that children with AD without MR may perform differently on reference tests. Recall the example of a CAD making a semantic error from the introduction (refer to page 8). The child mapped the new word ("peter-eater") to an incorrect object (saucepan) based on a single exposure. This mapping held without corroborating evidence from subsequent exposures. If linguistic memory was not impaired but reference was impaired, CAD may be more susceptible to these types of semantic mapping errors because they would map words incorrectly based on a single exposure. Future research should evaluate fast-mapping and joint-attention word learning in CAD who are not mentally retarded.

How might the reference impairments observed in the assessment affect language development? There are three possible developmental implications for these reference impairments. First, children who are unable to establish reference at all may get frustrated or ignore new words because they cannot make sense of them. Second, children who can establish reference partially may make enough errors so that they lose confidence in their ability to figure out the meaning of a new word. In these cases, children may require additional exposures or evidence to collaborate the initial mapping. Third, children who establish reference incorrectly may make semantic errors (mapping the wrong object to a new word). In these cases, children may be faced with conflicting information that would compromise the foundation upon which

early lexicon is built. This would not only compromise vocabulary, but it may compromise the acquisition of subsequent word learning skills. Whether the impairment is a lack of mapping, a partial mapping or an incorrect mapping, it would explain their decreased receptive language scores on the Vineland and PPVT assessments.

Although semantic errors may offer pivotal information about the mechanics of the reference impairment in AD, the introduction discussed the difficulties involved in studying the development of semantic errors in a preverbal population. The experimenter wrote down all semantic errors produced during the noun assessment. Most of the children in the CAD and CMR groups were completely nonverbal, so few errors were found.

One of the volunteers for The CMR group was omitted because he displayed autistic symptoms. Upon subsequent referral, he was diagnosed with Pervasive Developmental Disorder (PDD-NOS). Autism Spectrum Disorders include several diagnoses (AD, PDD-NOS, aspberger's disorder, Rhett's syndrome). During the initial assessments, the experimenter noticed he had a large (but not spontaneous) productive vocabulary. While showing him stimulus photos, he would verbally name the ones he knew. He produced several semantic errors in response to seeing photos of ambiguous or low-frequency photos. The experimenter wrote these errors down and tested him the next day. He produced the same semantic errors for the same cards the next day. Errors made by typically developing preschoolers showed consistent patterns of being either categorically or phonologically related to the correct word. In comparison, the errors made by the child with PDD-NOS were unrelated to the correct word. Most errors were nonsense words or semantic mapping errors (see Appendix D ).

The number of semantic errors in any given lexicon may be impossible to estimate, however, the types of errors may be equally informative. Given the difference in error types

found, it may be worthwhile to analyze the types and frequencies of errors made in response to productive vocabulary tests in verbal preschoolers with AD (or PDD-NOS) as compared to typically developing and developmentally delayed peers. If reference impairments cause semantic mapping errors, there should be a significant correlation between semantic error rates and gaze following/fast-mapping test scores.

***3) Did performance vary between gaze-following and fast-mapping tests?***

The final question of the assessment section concerned how fast-mapping compared to gaze-following performance. There was no significant difference in performance between fast-mapping and gaze-following within the CAD, CMR and TDC groups. There were some slight differences between gaze-following and fast-mapping tests, but not enough to achieve significance within this small child sample. The finding that CMR and TDC groups performed similarly on both tests may be a function of their age; previous research suggests fast-mapping emerges earlier than gaze following (Hollich et al, 2000). Future research should study the differences in fast-mapping and gaze-following as they emerge in different age groups in autistic and typical development.

It is difficult to disentangle the relative contributions of mental age and chronological age to the emergence of fast-mapping and gaze-following abilities. The mental age of the CMR (12-16 months) was younger than the age at which fast-mapping and gaze-following emerge in TDC. The CMR were able to establish reference in both conditions almost as well as their typically developing peers. They were unable, however, to remember the words the next day. The poor memory test scores may be the result of encoding problems associated with mental retardation. There is another possibility. TDC are able to engage in gaze-following long before they use this skill to learn words. Previous models of word learning (see Hollich et al, 2000)

have suggested that children require additional information to confirm a referent when they start using gaze-following to learn words and that there may be a period in development when gaze-following cues are not given as much weight as nonsocial cues. Consequently, children may be less confident of their word-object mappings. This lack of confidence may prevent them from associating a new word with an object on the first exposure, leaving them waiting for future exposures to confirm the word-object map before they incorporate it into their vocabulary. Because they were developmentally delayed, the CMR group may have still be in this transitional period of language development. This could explain their poor memory performance. If this were the case, these same children could be tested a year later to determine if their memory tests improved with age. Future research should compare fast-mapping and gaze-following memory scores in different age groups of children with mental retardation.

Some theorists suggest that fast-mapping naturally emerges as a result of children having learned 50 words. A certain threshold of words provides children with enough of a sample size that they become familiar enough with the correlations between words and object-categories that they confidently make default assumptions about new words and new object-categories. The results of the assessment did not support this threshold theory. Children in The CMR group had fewer than 50 nouns in their estimated vocabularies and yet they were able to fast-map as well as TDC with greater than 500 nouns in their estimated vocabularies. Amongst the CAD, six from the dissertation assessment and three from the pilot assessment had greater than 50 nouns in their estimated vocabularies and were still unable to fast-map. It is possible that the children with mental retardation were at a lower level of fast-mapping that allowed them to establish immediate reference but not to retain the mapped word for future reference. It cannot be assumed that once they learned 50 words their fast-mapping skill would not change qualitatively

allowing improved memory performance. However, these children were able to establish reference without knowing 50 nouns. This noun threshold may be an artifact of testing methods or correlation without causation. This dissertation found no evidence to suggest that fifty is the magic number from whence all word-learning skills emerge.

The children in the CAD group had the same 3-4 years of opportunity for social experience as children in the CMR group and an additional year of opportunity than the children in the TDC group. Unfortunately, they were unable to glean the same amount of information from their social or communicative experience because of their profound social impairments. They did not notice the correlation between speaker's direction of gaze and the referent of a new word because they were not making eye contact. They did not notice the correlation between a new word and novel objects in a set because they were not looking at all objects in a set at the same time. The information was there, it just was not salient to them. The only way for them to start learning words independently would be for these cues to become salient to them. This might have occurred naturally in their development, albeit with a significantly delayed onset. The intervention was designed to help make these cues more salient by introducing them with direct prompts in a controlled/predictable setting.

# III.2 Comparison Intervention

## Method

### Participants

The children from the assessment who did not pass fast-mapping or gaze-following reference tests participated in the intervention. The only children who qualified for the intervention were the children diagnosed with AD. All (15) children in the CAD group qualified to receive the gaze-following intervention (scores= 0%-33%). Most (14) of the children in the CAD group also qualified to receive the fast-mapping intervention (scores= 13%-40%)[9]. Because child 3 passed the initial fast-mapping assessment (score = 67 %), she did not participate in the fast-mapping intervention. She did not pass the gaze-following assessment (score = 27%), so she still qualified to participate in the gaze-following intervention.

The fast-mapping intervention was designed to teach children how to locate the one novel photo in a set by using the two known photos as context cues. The gaze-following training program was designed to teach children how to locate the novel target photo in a set of novel photos by following the speaker's direction of eye gaze. As described in the methods section, both programs used 10-trial sessions with backwards prompting and contingent reinforcements for each word introduced. Each program consisted of 20 sessions (introducing 20 words).

Fifteen CAD were randomly assigned to one of three groups based on the order of received permission slips. Participation in the two training programs was counter-balanced for order effects. Children in the F-G group received fast-mapping training first followed by

[9] *Two children were included who scored 40% (7% above chance) because the score did not achieve significance at the p< 0.05 level.*

gaze-following training. Children in the G-F group received gaze-following training first, followed by fast-mapping training. Children in the Control group received no training. There was a 2 week non-training interval in between training condition one and two where post-tests were administered for the training words.

The purpose of the training program was to try to scaffold the ability to use the two specified skills (fast-mapping and gaze-following) to learn words by prompting the CAD to attend to relevant cues during the presentation of novel words. The fast-mapping and gaze-following tests from the assessment were used as a baseline (pre-tests). After the training program was completed, post-tests were administered to evaluate change in performance. In addition to the comparable assessment test, generalization tests were included to determine if the children could apply the trained strategy to non-training stimuli.

Fast-Mapping Intervention

The fast-mapping intervention piloted in the pilot intervention was used in the comparison intervention (see method on page 42). The gaze-following intervention involved a similar methodology incorporating discrete trials, contingent reinforcement and hierarchical/backwards prompting into the format of the gaze-following assessment procedure. Similar to the fast-mapping intervention, each gaze-following skill was worked on individually through a prompt hierarchy (Table 3) which was systematically faded over the course of the training sessions (see page 41). For both interventions, prompts were recorded for each trial and the session score was the number of independent (unprompted) correct responses per session.

Gaze-Following Intervention

The gaze-following intervention focused on teaching children how to monitor the speaker's direction of eye gaze to locate the referent of a novel word. In order to pass the gaze-

following test, the child must parse the new word from the speech stream and identify it as novel and then immediately look at the speaker's eyes to figure out towards which object the speaker was looking. Social cues that children use in gaze-following were broken down into a hierarchy (table 13) from least (stare) to most (gesture) obvious with corresponding prompts (Figure 14).

**Table 13.** Gaze-following Hierarchy of Prompts:

| | | |
|---|---|---|
| Independent | The child points to the card with **No** prompting | Speaker looks directly at target and says "Point to chef" |
| Stare- | needs prompt to attend to the speaker's eye gaze and more time to follow the direction of gaze to the referent object | Speaker repeats instructions slowly "Point to chef" while exaggerating eye contact towards the object (staring at the object with wide eyes for 5 full seconds). |
| Posture- | needs a more obvious indication of speaker's intentional focus to draw attention to the direction of gaze | Speaker repeats instructions and stare, orienting her entire body so that her head is hovering directly over the target card. |
| Gesture- | Needs direct indication of speaker's intention, does not pay attention to eye gaze or body posture | Speaker says "Point to chef" while pointing to the target with finger 6" away from card |

Figure 14. Gaze-following Prompts :

Stare

"Point to chef"

Posture

"Point to chef"

Gesture

"Point to chef"

Twenty training sessions were conducted over the course of 5 weeks for both the fast-mapping and gaze-following interventions. Each 15-minute session included 3 memory, 10 training, and 4 control trials. Memory trials in the intervention used the same method as those in

the assessment. All of the reference training trials used the same method as the assessment trials (described pages 54-58) but included contingent reinforcement and prompts as described above.

All training sessions occurred during the school day in between classroom ABA sessions. For the first preschool, sessions were conducted in the classrooms[10]. For the second preschool, sessions were conducted in a separate room adjacent to the classroom. Before sessions, the experimenter asked teachers and therapists about extenuating circumstances that could influence performance (e.g. sickness, recent tantrum, potty training). If the teacher reported a significant change or if the child seemed reluctant (e.g. persistent tantrums, throwing cards, crying) the child did not participate that day. Most children stood up and grabbed the experimenter's hand as soon as she walked in the classroom.

Sessions were conducted on a short preschool table with 2 perpendicular chairs. The experimenter sat close enough to the child to physically prompt the child to stay seated. The experimenter oriented her posture to be directly facing the child. Cards were placed in a line parallel to the experimenter and child. Cards were kept in a box under the table. As they were used they were returned to stacks on the table photo side down (so as not to distract children). No other objects were on the table. The experimenter would start each session with 2 control trials to orient the child to the directions. If the child was very distracted, additional control trials were used until the child was participating. The experimenter then administered 3 memory trials for the words learned the previous sessions. Before the training began, the experimenter reminded the child about the reward "You are working for chips". The cards were placed on the table. If the child was not looking at the cards, the experimenter prompted the child by drawing an imaginary circle around each card with her finger. The experimenter also provided physical

[10] **To preserve the confidentiality of students not participating in the program, sessions in the classroom could not be videotaped, therefore only Preschool 2 sessions were videotaped.**

prompts to prevent the child from touching the cards until the instructions were given. The session trials then proceed exactly as the test trials did, except with the addition of prompts and reinforcement to help the child respond.

Control Group Program

To control for the possibility that test performance may be related to the children's familiarity with the experimenter, the experimenter participated in daily non-training activities with all of the control children. The experimenter greeted each of the children and participated with them in non-goal classroom activities (i.e. circle time, art projects, free play, outdoor recess) for the approximate equivalent of the training session duration.

Ongoing Memory Assessments

The same Memory test piloted in the pilot intervention (see page 39) was included in the comparison intervention. Just like the previous memory tests, each of the words that the children correctly identified (during the reference session) was tested in three memory trials during the following sessions. The memory tests served to determine whether children were able to recognize the photos they had mapped on previous days in either the fast-mapping or gaze-following condition.

Post-training Reference Test

Post-test measures were used to evaluate the efficacy of the training interventions. The fast-mapping and gaze-following scores from the assessment served as a pre-test. Upon completion of the training program, all children were given another set of fast-mapping and gaze-following tests (with new target words) which served as a post-test. If the intervention was effective, children in the F-G and G-F groups should have higher post-test scores than children in the control group who did not participate in the intervention.

One week after both of the training programs were completed, the children (both experimental and control) were given post-tests. The fast-mapping and gaze-following post-test in the comparison intervention evaluation utilized the same method as in the comparison assessment. Four sessions consisting of 10 trials were conducted over the course of 4 days. Days one and three were reference trials. Days two and four were memory trials targeting the words exposed during days one and three. The children were given one reference trial for each of the 10 novel words in the word list. Two control trials started the sessions and three were interspersed randomly between experimental trials. The words successfully chosen in the reference trials were tested in the memory trials. Each of the words was tested three times over the course of these 3 sessions (for each permutation within the set).

Generalization Assessments

Three generalization assessments were given after the completion of the training program to assess whether the children could generalize the word learning skill (Object-Object test) or words (Photo-Object and Photo-New Photo tests) to different stimuli.

Photo-New Photo Generalization Test

A set of 20 photo cards was compiled to match 10 photo cards used in fast-mapping and 10 cards used in gaze-following training sessions. Some of the cards were drawn from different photo sets, some from the same photo set and some were printed from a photo library. All cards were standardized in color and size to the original training photo cards.

The Photo – New Photo Generalization test assessed whether the words learned in fast-mapping and gaze-following training sessions could be generalized from the training photo to a different photo. A memory test was given using the photo generalization stimuli. Over the course of 2 days, each of the 10 fast-mapping and 10 gaze-following cards was tested.

***Figure 15***. Examples of Photo-New Photo Stimuli :


Golfer


Violin


Record

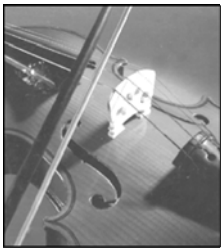


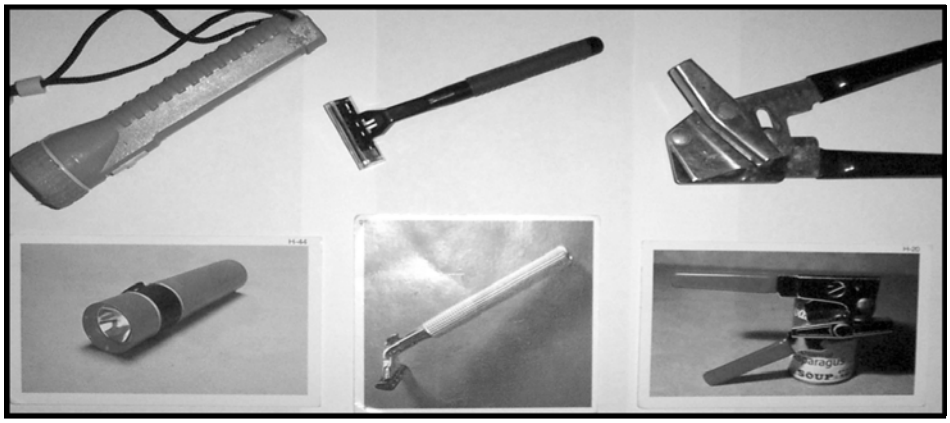
Photo-Object Generalization Test

Object stimuli were chosen using the same procedure as photo stimuli (Figure 16) . Children had to indicate an object in all 3 trials for it to be considered *known* and in none of the 3 trials for it to be considered *novel.* A set of novel target objects (20) was gathered and divided equally into separate boxes corresponding to the 2 conditions (fast-mapping, gaze-following). The photo to object stimuli included 20 photos corresponding to these 20 objects. Novel distractor objects (20) and known objects (10) were also placed in separate boxes. Edible objects used as known stimuli were kept in ziploc bags and never used as rewards. Stimuli were small 2”-10”, whole objects that were easy to place on a table and pick up. Familiar objects were used in control trials to ensure the children were able to point to named objects. The novel distracter objects were used as context stimuli in the memory test stimulus array.

The Photo-Object Generalization test assessed whether words introduced as photos in either fast-mapping or gaze-following conditions could be generalized to objects. The Photo to Object (P-O) test used photos to introduce 10 words in the fast-mapping condition and 10 words

in the gaze-following condition (on different days). These same words were reintroduced in a memory test using objects corresponding to the original photos (appendix B ).

***Figure 16***. Example of Photo-Object Stimuli :



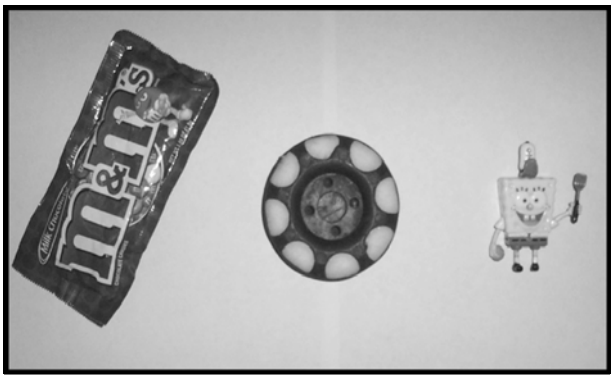
Object-Object Generalization test

Another set of 20 novel target objects was divided equally into separate boxes corresponding to the fast-mapping and gaze-following conditions. The same familiar object and novel (distracter) object set used in the photo-object generalization test was used in the object-object generalization test (Figure 17).

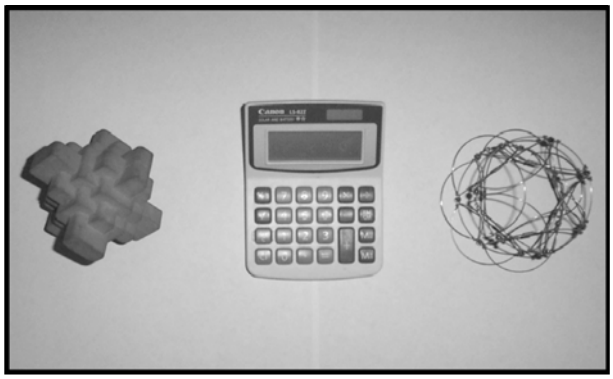
The Object-Object Generalization test assessed whether children could apply the fast-mapping and gaze-following word-learning skills they had learned on photos (in the intervention) to objects. The Object-Object Generalization test used objects to introduce 10 new words in both the fast-mapping and gaze-following conditions (on different days). These same objects were reintroduced in a memory test the day after the reference test (appendix B).

***Figure 17.*** Example of Object-object Stimuli :

Fast-mapping Trial




Gaze-following Trial



Some stimuli (tape measure) were intrinsically more entertaining than others (cup lid). To prevent confounds related to object function, objects were placed in the set with similar characteristics (lid with ruler, tape measure with spool of thread) and a stimulus adjustment period was added to each trial. At the beginning of each trial (reference and memory), the experimenter handed each of the items to the child. The experimenter let the child explore each item for 10 seconds before placing it in the set. The purpose of this was to counteract the children's tendency to immediately grab whichever object interests them or to become distracted by the possibilities of the objects, instead of attending to the task and the new words.

Generalization Test Scoring

Scores were the number correct out of 10 trials. The Object – Object Generalization test included both a reference and a memory test score because it assessed the generalization of the fast-mapping and gaze-following skills from a photo condition to an object condition. The Photo-Object and Photo – New Photo Generalization tests only required a memory test score because they assessed the generalization of a word from one exemplar to another.

Reliability of Scoring

Six children from the CAD group in the assessment were videotaped during the intervention to ensure the reliability of the assessment scores (using the same Sony digital Mini DV recorder). All of their training sessions were recorded. A random selection of 3 taped sessions for each child was viewed and compared to the transcribed data. The prompts recorded in the data sheets were 98% consistent with the performances recorded on the videotapes (4 errors found out of the 180 trial sample). The session scores (number of independent correct responses) were 100% consistent with the performances recorded on the videotapes

Intervention Timeline

The intervention took 59 days in addition to the 10 days in the assessment program (Table 14).

**Table 14.**

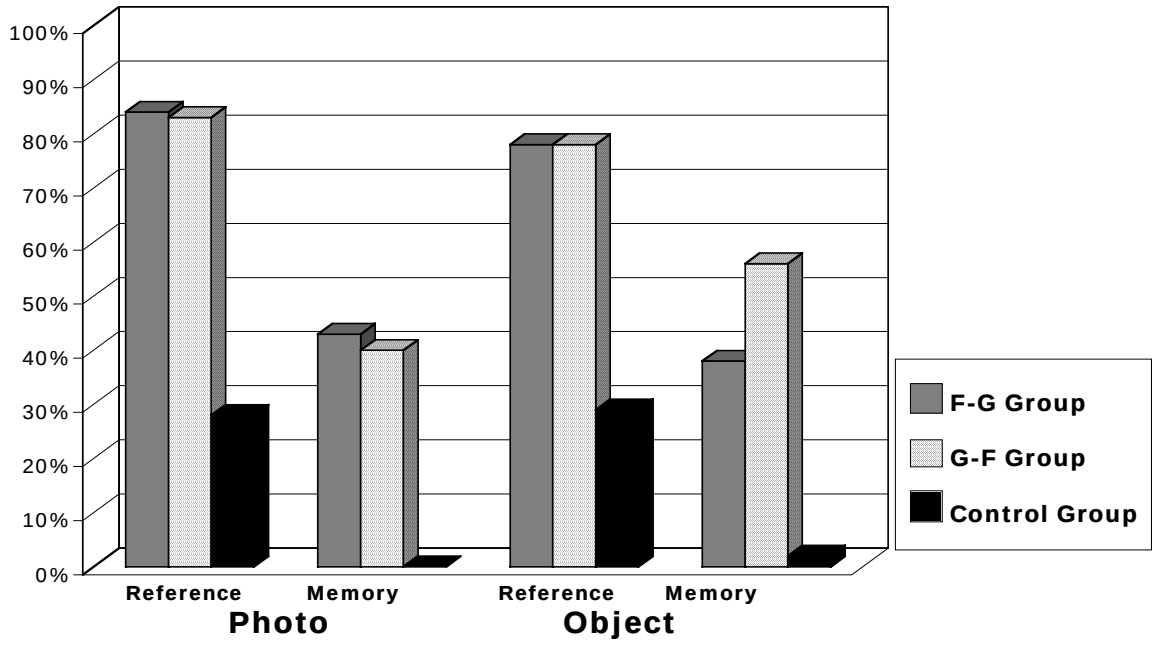
| **Day #** | **Assessment/Intervention type** |
|---|---|
| 1-10 | Assessment tests (*served as baseline*) |
| 11-31 | 20 sessions of fast-mapping (or gaze-following) training; including daily memory tests |
| 32 | Overall fast-mapping (or gaze-following) memory test for all words learned during the intervention |
| 33 | Fast-mapping (or gaze following) Photo-new photo generalization test |
| 34 | Fast-mapping (or gaze following) reference test |
| 35 | Fast-mapping (or gaze-following) memory test |
| 36-56 | 20 sessions of Gaze-following (or fast-mapping) training; including daily memory tests |
| 57 | Overall gaze-following (or fast-mapping) memory test for all words learned during the intervention |
| 58 | Gaze-following (or fast-mapping) Photo-new photo generalization test |
| 59 | Gaze-following (or fast-mapping) reference test |
| 60 | Gaze-following (or fast-mapping) memory test |
| 61 | Gaze-following reference test: Object-object generalization |
| 62 | Gaze-following memory test: Object-object generalization |
| 63 | Fast-mapping reference test: Object-object generalization |
| 64 | Fast-mapping memory test: Object-object generalization |
| 65 | Gaze-following reference test: Photo-object generalization |
| 66 | Gaze-following memory test: Photo-object generalization |
| 67 | Fast-mapping reference test: Photo-object generalization |
| 68 | Fast-mapping memory test: Photo-object generalization |
| 69 | Follow-up interview with parent |

# Results

## Fast-mapping Reference Trials

A one-way analysis of variance was used to analyze the difference between the post-test scores for group. Group did significantly predict the variance, F (2, 11) = 6.59, p= 0.013. A pair-wise comparison between the individual groups determined that there was no significant difference in fast-mapping post-test scores between the counter-balanced training groups but there was a highly significant difference between the Control group post test raw score and both of the training groups : F-G group (mean difference=4.6, p = 0.008), G-F group (mean difference=4.8, p=0.008). The F-G and G-F groups were pooled into a larger *Training* group and compared to the Control group. A one-way analysis of variance confirmed that group (Training vs Control) significantly predicted the difference between pre- and post-test scores on fast-mapping reference tests, *F (1,12) =14.38, p=0.003*. This suggests that training was related to significant improvements in fast-mapping scores but the order of training was not (Figure 18).

***Figure 18.*** Fast-mapping Post-test Scores (Reference & Memory)

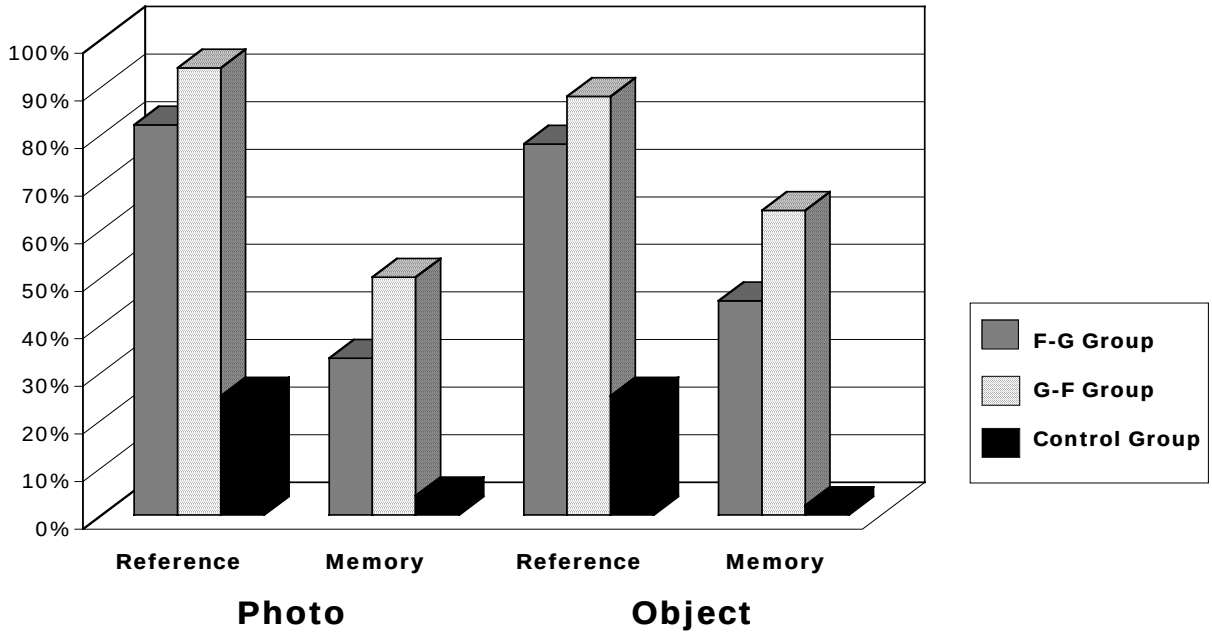



Gaze-following Reference Trials

The Gaze-following training program results were consistent with the fast-mapping training program results. A one-way analysis of variance was used to analyze the difference between the post-test scores for each training group. A pair-wise comparison between the individual groups determined that there was no significant difference in gaze-following post-test scores between the counter-balanced training groups, but there was a highly significant difference between the post test raw scores for the Control group and the F-G and G-F training groups : F-G group (mean difference= 5.8, $p < 0.001$) and G-F group (mean difference = 5.0, $p < 0.001$). The F-G and G-F groups were pooled into a larger *Training* group and compared to the Control group. A one-way analysis of variance confirmed that group (Training vs Control) significantly predicted the difference between pre- and post-test scores on fast-mapping

reference tests $\underline{F}\ (1,12) = 43.9,\ p < 0.001$. Gaze-following training was related to significant improvements in gaze-following scores but the order of training was not (see Figure 19).

***Figure 19.*** Gaze-following Post-test scores (Reference & Memory)




Gaze-following & Fast-mapping

Gaze-following and fast-mapping performance improved over the course of the training program for both the F-G and G-F groups. The prompts used to correctly identify the target word faded gradually from sessions 1-20. Fast-mapping session scores (number of unprompted correct responses per session) increased from the first to the last session (Figure 20) for the F-G and G-F groups. Gaze following session scores also demonstrated a similar pattern of improvement from the first to last session (Figure 21) for the F-G and G-F groups.

***Figure 20.*** Fast-mapping Reference Test & Session Scores:

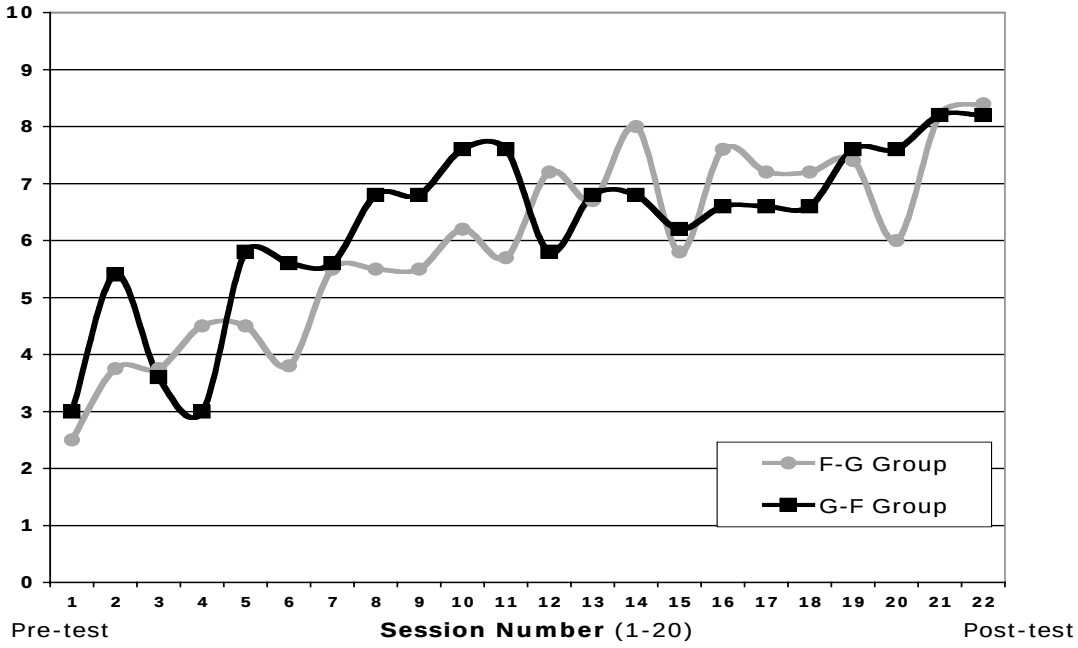
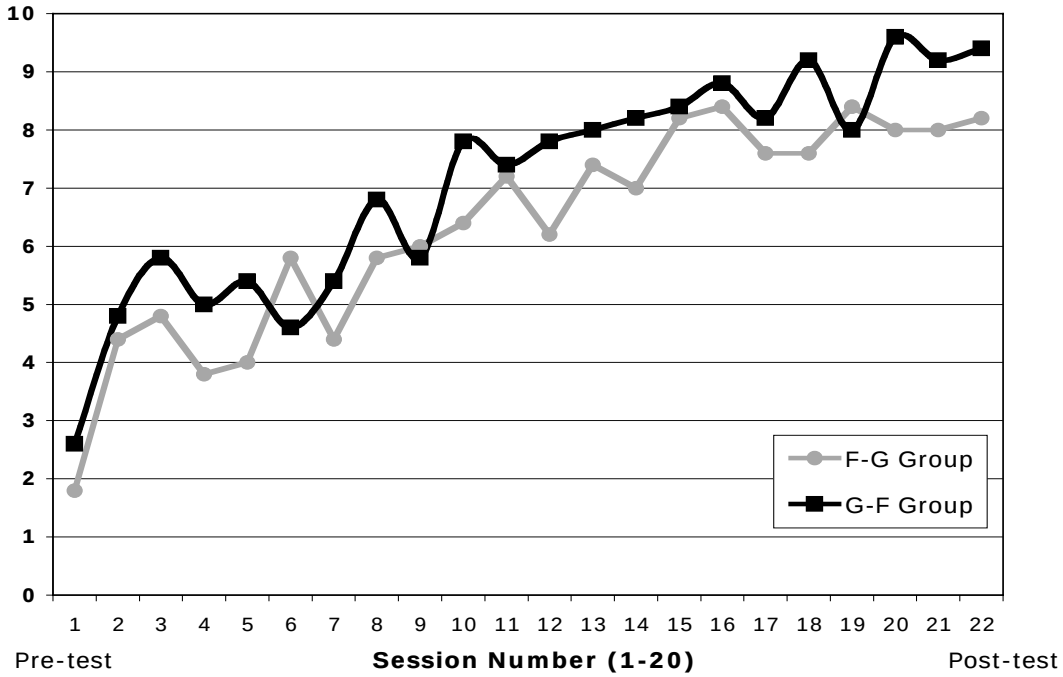
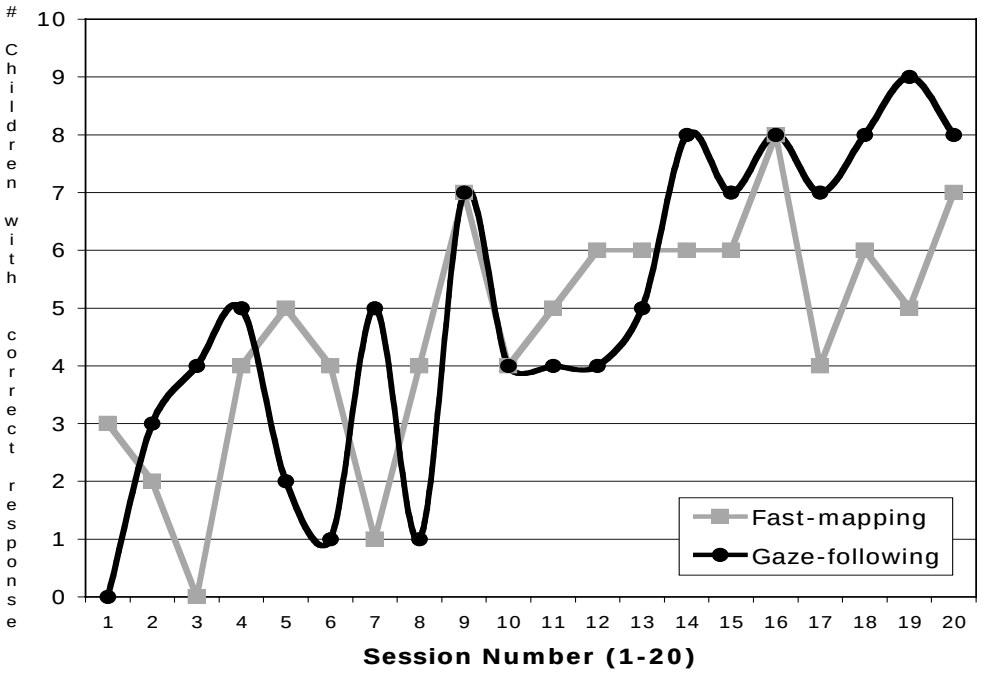



**Figure 21.** Gaze-following Reference test and Session scores:



The number of independent correct responses may not represent the ability to use linguistic and social cues to establish immediate reference to a new word because the word could only be introduced once before it is no longer completely novel. Each session included 10 chances for the child to establish reference for the word. Hence, it is only the first trial that could be considered a pure estimate of rapid word learning ability in either the fast-mapping or gaze-following conditions. The number of CAD who were able to establish reference (locate the target object) on the first trial gradually increased over the course of the training program. The increase in first (trial 1) correct responses showed more variability between sessions, but showed a gradual increase similar to the percentage of overall (trials 1-10) correct responses (Figure 22).

***Figure 22.*** Number of children with first-trial correct responses :



Group Effects:

The fast-mapping and joint-attention interventions were counter-balanced to control for order effects. The order that the intervention was received did not have a significant effect on post-test reference scores. Pair-wise comparisons found no significant difference in fast-mapping scores (mean difference= 0.007, p=0.959) or gaze-following scores (mean difference= -0.151, p=0.229) between the F-G group and the G-F group.

Fast-mapping Memory Tests

A one-way analysis of variance was used to analyze the difference between the pre-test memory scores and the post-test scores for each group. Similar to the Reference test scores, when the memory test scores of the three groups were analyzed separately, group did not significantly predict the variance, $F(2,11) = 3.74$, $p = .058$. When the F-G and the G-F groups were pooled into a larger *Training* group and compared to the Control group, training did significantly predict the variance , $F(2,11) = 8.12$, $p = 0.015$). Pair-wise comparisons between post-test memory raw scores for individual groups showed an insignificant difference between the F-G and G-F groups (mean difference=0.95, p= 0.883) but a highly significant difference between the Control group and the F-G (mean difference =2.25, p = 0.033) and G-F (mean difference= 3.20, p=0.038) groups. Training was related to significant improvements in fast-mapping memory scores. The order of training was not. This implies that training effected the ability to both establish initial reference and to remember the word for future reference.

Object-Object Generalization test

The Object-Object Generalization test was administered to all groups to determine whether CAD were able to establish reference using real objects instead of photos in both the fast-mapping and gaze-following conditions. Object-Object Generalization test scores for the *Training* group (F-G and G-F combined) were compared to the scores for the Control group using an analysis of variance. There was a significant difference between the training and control groups in the Object-Object Generalization scores on both the fast-mapping [$F$ (1,12) =21.93, $p< 0.001$] and gaze-following [$F$ (1,12) =43.64, $p<0.001$] reference tests. There was a signficant difference in the Object-Object Generalization scores on both the fast-mapping [$F$ (1,12)=13.12, $p=0.003$] and gaze-following [$F$ (1,12)=35.22, $p<0.001$] memory tests.

The CAD who were trained were better able to establish reference with real objects than CAD who were not. This suggests that both fast-mapping and gaze-following skills initially learned on photos were generalized to objects without a generalization training protocol.

Photo – Object Generalization test

The second generalization test was administered to both of the the training groups (F-G and G-F) after their completion of the interventions to determine whether they were able to generalize the words they learned from photos to objects. The CAD were given two 10-trial sessions to introduce 10 words in the fast-mapping condition and 10 words in the gaze-following condition (on different days) using photos as stimuli in the same method used for the pre and post reference tests. The memory tests that followed were also methodologically identical except that the photos were replaced with representative object stimuli. A t-test for independent variables found a significant difference (mean difference= 4.35, $p< 0.001$) between Photo-Object

Generalization test scores and chance (3.3), suggesting that children could generalize words learned from photos to subsequent exposures with their corresponding objects.

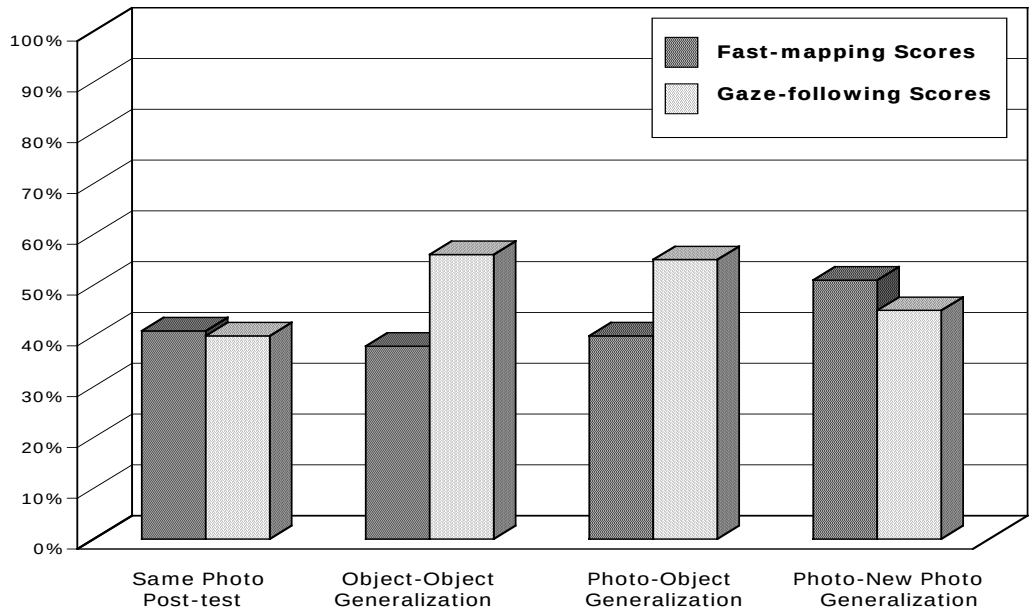
Photo – New Photo Generalization test

The third generalization test was administered to both of the training groups (F-G and G-F) the day after their post-training memory test. This generalization test presented different exemplars of photos they had been introduced to during the training program they had just completed. A t-test for independent variables found a significant difference (mean difference= 4.42, $p< 0.001$) between the Photo-New Photo Generalization test scores and chance, suggesting that children generalized words learned from one photo to a different photo.

Post-test v. Generalization Tests

Post-test memory scores were consistent with Generalization memory scores for all groups (Figure 23). Post test scores (using photo stimuli) were similar to the generalization test scores (using object stimuli) in both fast-mapping and gaze-following conditions. Gaze-following memory scores were slightly higher on the Object–Object and Photo–Object Generalization tests while fast-mapping scores were higher on the Photo-New Photo Generalization test.

***Figure 23.*** Generalization Memory Scores (Fast-mapping & Gaze-following) :




The Generalization test scores suggest that there was something about using objects in a gaze-following condition that may improve the ability to remember words upon subsequent exposures. For example, it may be easier or more natural for children to follow eye gaze to a 3D object than to a 2D photo. It may be necessary to look more closely at photos to recognize identifying features during the fast-mapping process than it is during the gaze-following process. Hence, children may have been more apt to notice distinguishing characteristics that would help them generalize to photos with similar features. Whereas, a child who follows gaze to identify a photo may choose the photo without actually looking at it.

Table 15 combines all of the assessment scores (pre-training reference and memory tests, post-training reference and memory tests, photo-different photo generalization test, photo-object generalization test, object-object generalization reference and memory test) for each child. [11] Although all children in the training group improved in at least one of the interventions, not all

[11] The control group did not participate in the photo-different photo or photo-object generalization tests.

improved in both. The individual data shows that the fast-mapping intervention did not improve the post-test scores for Children 8 and 9 while the gaze-following intervention did not improve the post-test scores for Child 7. The individual data shows that there may have been a test-retest effect for the photo-different photo generalization test because some children performed better on the photo-different photo test than the initial memory test.

**Table 15.** Individual Pre-Test and Post-Test Raw Scores :

| | Fast-mapping | | | | | | | | Gaze-following | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Child # | Pre Train | | Post Train | | Dif-pic Gen | Pic-obj Gen | Obj-obj Gen | | Pre Train | | Post Train | | Dif-pic Gen | Pic-obj Gen | Obj-obj Gen | |
| Total # words | 15 | | 10 | | 10 | 10 | 10 | | 15 | | 10 | | 10 | 10 | 10 | |
| FG Group | R | M | R | M | M | M | R | M | R | M | R | M | M | M | R | M |
| 1 | 2 | 0 | 9 | 2 | 6 | 9 | 9 | 2 | 0 | 0 | 10 | 3 | 5 | 9 | 10 | 3 |
| 2 | 2 | 0 | 10 | 3 | 4 | 0 | 7 | 4 | 2 | 1 | 9 | 2 | 3 | 6 | 5 | 2 |
| 3 | 10 | 7 | 10 | 7 | 8 | 10 | 10 | 6 | 4 | 4 | 10 | 7 | 9 | 10 | 10 | 7 |
| 7 | 5 | 0 | 9 | 4 | 5 | 8 | 8 | 7 | 5 | 0 | 5 | 4 | 3 | 7 | 6 | 5 |
| 8 | 4 | 0 | 4 | 0 | 1 | 6 | 5 | 0 | 3 | 0 | 7 | 0 | 5 | 2 | 8 | 5 |
| GF Group | | | | | | | | | | | | | | | | |
| 4 | 3 | 1 | 9 | 7 | 8 | 10 | 10 | 7 | 5 | 2 | 10 | 8 | 6 | 8 | 9 | 8 |
| 5 | 6 | 1 | 10 | 7 | 5 | 3 | 6 | 4 | 2 | 2 | 9 | 8 | 4 | 2 | 7 | 4 |
| 6 | 4 | 0 | 9 | 6 | 3 | 11 | 10 | 8 | 5 | 1 | 10 | 9 | 3 | 8 | 9 | 7 |
| 9 | 3 | 0 | 3 | 0 | 3 | 7 | 4 | 2 | 5 | 0 | 8 | 0 | 3 | 2 | 9 | 6 |
| 10 | 6 | 3 | 10 | 0 | 4 | 7 | 9 | 7 | 5 | 0 | 10 | 0 | 2 | 6 | 1 | 7 |
| Control | | | | | | | | | | | | | | | | |
| 11 | 3 | 0 | 3 | 0 | -- | -- | 3 | 0 | 4 | 0 | 4 | 1 | -- | -- | 4 | 1 |
| 12 | 2 | 0 | 2 | 0 | -- | -- | 3 | 0 | 4 | 0 | 3 | 1 | -- | -- | 2 | 0 |
| 13 | 3 | 0 | 3 | 0 | -- | -- | 2 | 0 | 5 | 0 | 3 | 0 | -- | -- | 3 | 0 |
| 14 | 3 | 0 | 3 | 0 | -- | -- | 4 | 1 | 3 | 0 | 0 | 0 | -- | -- | 1 | 0 |
| 15 | 3 | 0 | 5 | 0 | -- | -- | 2 | 0 | 2 | 0 | 2 | 0 | -- | -- | 2 | 0 |

R= reference test M= memory test

Word Diary & Follow-up Interview

At the beginning of the training program, all parents were given a word diary to document parental observations of changes in their children's language functioning over the course of the 3 months of the program (training, interval, post-test). Parents were blind to whether their child was in the experimental or control group. When the training program was completed, parents participated in a short follow-up interview (Appendix E) where they returned the word diaries and answered questions about changes in language functioning. Parents were not told about the training procedures or the results until after this interview was completed. All parents reported improvement in language functioning at some level. Parents of children in control groups reported general improvements in behavior (i.e. increased eye contact in response to hearing their name, decreased tantrums and an increase in spontaneous gestures and following 1-step directions). None of these behaviors were targeted by the training program. In addition to the general improvements in behavior reported by the parents of children in the control group, parents of children in the experimental group reported behaviors that may be related to skills targeted in the interventions (i.e increase in receptive language, increased identifying of objects, and increased following of gestures or eye contact when hearing new words). In the word diary, three parents (of children in the experimental group) reported their child spontaneously speaking new words that had not been taught to them. Two of these children actually produced words (tractor, violin) introduced during the interventions. This suggests that the effects of the intervention may be generalized to word learning in the home.

Individual Differences

The words chosen as known stimuli were based on parent/teacher reports and initial picture-pointing assessments. Additionally, the unknown stimuli were chosen from a pool of

low frequency words (from the Photo Cue Cards set). Some of the words may have been more available to them (envelope, mayonnaise) than others (loom, riveter, pharmacist) depending on their experience. Some objects may have confused children because they were similar to objects they already knew (record is like CD, typewriter is like keyboard, tractor is like car). Some children may have focused on specific aspects of a picture that were familiar to them (cars in the parking lot, floor on the pharmacy, numbers on the calculator). Children may also have experience with some objects that interfere with their ability to learn some words (i.e. one child referred to the carpenter as "the Bob-the-builder"). Individual experience with different words may be able to account for some of the variance found in the first trials. Words were selected in different orders for all of the children. A line-item analysis for each of the words did not show a significant effect for any single word on the total first-trial success rate. Though individual differences likely play an important role in initial word mapping, this experimental procedure was not sensitive enough to statistically analyze their effects.

A regression analysis was used to compare Vineland sub-domain scores to both pre- and post-test scores to determine if any developmental domain was more related to fast-mapping and gaze-following. Multi-colinearity between sub-domain scores compromised the analysis because language and social domains cancelled each other out leaving activities of daily living (i.e. toileting skills) as the only significant variable predicting outcome. ADI scores could not be regressed on outcome variables because the scores represent a threshold (not a scale). The ADI could only predict whether outcome measures were related to CAD compared to CMR.

Three individual items (eye contact, self-stimulatory behavior, echolalia) were chosen from the ADI to determine if they predicted outcome measures. The presence of echolalia was correlated with outcome measures ($r=0.55$, $p<0.05$) but the other variables were not. The ADI,

however, was not sensitive enough to capture the variance in severity of these symptoms. In the ADI, parents are asked to assign a number to the frequency/severity of each specific symptom of AD. For example, « does your child repeat words or phrases immediately after hearing them ? » (0=never or rarely, 1= sometimes, 2= often, 3=speech almost exclusively echoes what was said, 8= no speech). Children with very heterogenous symptoms of AD may all still qualify for similar scores (i.e. 2-3 on the echolalia measure). Future research should use more sensitive measures to evaluate how individual symptoms affect word learning in both conditions.

# Discussion

The Intervention focused on whether children who did not pass fast-mapping and gaze-following tests would benefit from an ABA program designed to train these skills individually. The CAD were the only ones who qualified to participate in the intervention because they did not pass the fast-mapping and gaze-following assessments.

| Intervention Questions : |
| --- |
| 1) Will word learning improve if children are taught gaze-following/fast-mapping?<br>2) Which training program will have the best outcome (is there an order effect)?<br>3) Will children be able to generalize the words or the word-learning skills? |

***1) Will word learning improve if children are taught gaze-following/fast-mapping?***

The impetus for designing a training program to target fast-mapping and gaze-following skills came from similar training programs already established in standard ABA preschool curricula. When CAD start an ABA preschool, many of their programs involve "pre-academic" skills that emerge automatically in TDC and CMR. Many of these skills are pre-requisites for learning words. For example, CAD must first be taught how to make eye contact. These eye contact programs involve highly controlled discrete trials, requiring physical prompts and intricate generalization programs before CAD will engage in gaze-following long enough to proceed to standard academic goals. CAD must also be taught how to visually scan pictures and how to look at multiple objects in a set. CAD first have to master pointing to a photo from a set of two with a blank distracter (blank card) before they can point with a similar distracter (different photo) before they can proceed to pointing to objects out of a set of three. Trials for any pointing activity require that the child's attention is oriented to all stimuli on the table, to

prevent them from only looking at one item or choosing based on a position bias. Both gaze-following and scanning programs have been successful components to ABA preschools. If these skills can be trained using the principles of ABA, it is a logical next step to train them within social and non-social word-learning conditions.

The 15 children in the CAD group from the assessment were divided into three groups for the intervention. The first group received a month of fast-mapping training followed by a month of gaze-following training. The second group received gaze-following first then fast-mapping training. The third group served as a control, receiving no training. All CAD performed similarly (at or below chance) on fast-mapping and gaze-following pre-tests. Upon completion of the training program, both training groups performed significantly better on post-tests than the control group. There was no significant improvement in post-test scores (compared to their pre-test scores) for the CAD who did not participate in the training program. Most of the CAD who did participate, however, improved so much that their post-test scores were equivalent to their typically developing peers in the assessment.

The results suggest that participation in the training program improved the ability to establish reference in both fast-mapping and gaze-following conditions.

As they progressed in the training program, the CAD seemed to be getting more confident in their word-object mappings as evidenced by their decreased tendency to choose more than one card and their increased tendencies to point directly or quickly. Their improved memory scores suggest they were more certain of their ability to establish reference; eye gaze and object context cues were more salient to them.

The emergent coalition model (refer to pages 11-15) evaluates the role that confidence plays in word learning by representing it as a differential weight assigned to each source of input

in the coalition. When children have successfully established reference via fast-mapping long enough, they become confident in using nonsocial strategies like familiar context cues. When children have established reference via gaze-following long enough, they shift to relying on social strategies like gaze-following. The issue of confidence changes when skills are isolated and worked on within a predictable structured ABA framework. A child may become more confident in their reference ability because they were given the opportunity to establish reference in the same exact situation ten times in a row. Contingent reinforcement would only strengthen this confidence.

***2) Which training program will have the best outcome (is there an order effect)?***

The developmental onset of fast-mapping precedes the onset of gaze-following as a primary means of word learning in TDC (Hollich et al, 2000). To control for the possibility that fast-mapping may be a pre-requisite for gaze-following, the training programs were counter-balanced. The fact that there was no order effect (the order the interventions were received did not effect the post-test scores) does not mean that fast-mapping is not a pre-requisite for gaze-following word learning. The training program could not replicate the complexity of the emergent model of word learning because each session was controlled for instructions and activities. Real word learning takes place in a dynamic environment with additional pragmatic cues from activities and shared experiences. Further, each training program lasted a month with 2 weeks between them. The actual emergence of each skill takes much longer and the onset of fast-mapping precedes gaze-following word learning by approximately 6 months. A lack of order effect should not be interpreted as a lack of relationship between the two skills.

AD is a disability defined by a constellation of symptoms. There were some individual differences in the fast-mapping and gaze-following training programs. Most children performed

similarly in both training conditions. Two children had difficulty in the fast-mapping training condition. Child 8 (in the F-G group) and Child 9 (in the G-F group) demonstrated a tremendous variability in performance between sessions. Their fast-mapping post-test scores were at chance levels (33-40%). They seemed to have not benefited from the fast-mapping program. However they both showed significant progress during the gaze-following program. Upon completion of gaze-following training, their gaze-following post-test scores showed the same level of progress as the other children in the training groups (70-80%). These two children shared a lot of similar behavioral symptoms. Both children were never able to look at the entire set of photos. They would look at each card individually one at a time, or they would only stare at one card, ignoring the rest of the set. They had significantly more physical stimulatory behaviors than other children (e.g. hand flapping, jumping). They would visually inspect parts of object or card stimuli for long periods of time. Both were mostly mute, producing fewer than 3 words. They had no self-stimulatory verbalizations or babbling. They made some spontaneous eye contact coordinated towards requested objects. They enjoyed being sung to and participated in circle time. If left alone, they would run around or jump in place but they rarely played with objects.

In comparison, two children had difficulty in the gaze-following condition. Child 3 and child 7 (both in the F-G Group) performed better on fast-mapping than gaze-following tasks. Child 3 was the only child able to pass the fast-mapping pre-test. She was unable, however, to pass the gaze-following pre-test. Child 3 was able to improve over the course of training. After the gaze-following training program, child 3 scored as high on gaze-following post-tests as her typically developing peers (100%). Child 7, however, did not show significant improvement upon completion of the gaze-following training program. His post-test gaze-following scores (50%) were slightly better than his pre-test gaze-following scores (33%). These two children

also shared similar symptoms with each other. Children 3 and 7 had delayed echolalia and regularly exhibited self-stimulatory verbalizations. Both memorized songs or long phrases and repeated them in order, showing signs of distress if interrupted. Both had extremely poor eye contact, requiring physical prompts to look. If left alone, both would engage in parallel play with objects (i.e. rolling toy cars, doing puzzles) showing no interest in peers. During group activities, both regularly walked away inappropriately. Children 3 and 7 had more impairments in the "socialization" domain and fewer impairments in the "stereotypic behaviors" domain of the ADI than Children 8 and 9.

The small child sample prevents an appropriate analysis of the relationship between autistic symptoms in different ADI domains as they contribute to word learning. Future research should focus on how different domains of symptoms relate to fast-mapping and gaze-following.

***3) Will children be able to generalize the words or the word-learning skills?***

A skill is not considered "mastered" until it can be generalized to different situations. The real world of word-learning usually involves objects as referents. Objects were not used in the training program because their characteristics confounded the children's ability to pay attention without having to inhibit a grabbing response (as was reported in the first pilot). Once photos had been used to train the skill, children were re-introduced to objects as stimuli. Children who had participated in the training program were equally able to establish reference with photos as with objects. In the gaze-following condition, they were better able to establish reference with objects. Because objects had never been used in the pre-tests or training program as stimuli, the children had no prior experience with objects in either condition. Children in the

Control group performed worse with object than with photos, suggesting that training may be related to a decrease in the grabbing response. The Object-Object generalization test verified that the CAD in the training groups generalized word-learning skills from one context to another.

Both word-learning skills were generalized from photos to objects, but what about the words themselves? Were the words really "learned" or was a specific photo recognized in response to a specified word in a similar situation ? A true test of generalization would include many different exemplars for each word given in many different situations with different speakers and different task demands. Future research can pursue the extension period of word-learning. This research focused on the necessary first step to word learning: establishing reference and recognizing a mapped referent. For these purposes, the Photo-Object and Photo-New Photo Generalization tests were used. The results of these generalization tests suggest that the CAD in the training group were able to generalize a word they learned from a photo to a similar-looking object or photo they saw the next day. In order to accomplish this, the children must have looked closely enough at the photo to identify certain defining features. The children would have to recall some features and compare them to features of matching objects or photos in order to recognize the referent. This can be a very difficult task even for TDC because there are so many possible features of a photo that may be the defining feature. For example, one photo depicted a weightlifter on a bench-press and the other a weightlifter using a barbell. A child would have had to notice the weights as a salient feature in initial exposure and recognized them in the subsequent encounter. One of the characteristics of AD is stimulus over-selectivity (tendency to focus on parts of features instead of the entire form/context). The fact that children were able to recognize features at all in a different referent let alone from a single encounter is strong evidence that children were capable of generalizing the word.

Photo-object and Object-object generalization tests each introduced 10 words in the gaze following and 10 words in the fast-mapping condition. These generalization tests were given after both the gaze-following and fast-mapping training programs were completed. Because the training interventions were counter-balanced for order, the FG group took the generalization tests 5 weeks after completing the fast-mapping intervention and 1 week after completing the gaze-following intervention ; the GF group took the generalization tests 5 weeks after completing the gaze-following intervention and 1 week after completing the fast-mapping intervention. The fact that both the GF and FG groups were able to pass these generalization tests suggest that the training program had a lasting effect on their fast-mapping and gaze-following abilities. Participants in the interventions retained their ability to pass fast-mapping and gaze-following tests 5 weeks after completing the program.

Whether children generalize a skill they have learned within a structured A.B.A. program depends on their motivation to continue to use the skill. The A.B.A. framework used in the training intervention included reinforcement contingent on correct responses. However, CAD who fast-map outside of the classroom will quickly learn that there are no M&Ms or Doritoes that appear when a new word is mapped. In typically developing children, learning new words is intrinsically rewarding because it helps them communicate more effectively. CAD do not seem to be as motivated to communicate as their typically developing or mentally retarded peers. Unlike their preverbal peers, CAD do not compensate for their lack of speech with gestures or exhibit nonverbal behaviors to express interest or initiate social interactions. The failure of the CAD in this study to pass the reference tests does not conclusively indicate a fast-mapping or gaze following impairment. It is possible that they were not motivated by the experimental task to answer correctly. However, the fact that they were able to point to words that they knew and

they actively guessed the words they did not know suggests that they were sufficiently motivated. The issue of motivation must be addressed in the generalization program so that the skills learned in the intervention can be applied to the real world of word learning. This may be accomplished by setting up naturalistic (i.e. off the table top) opportunities for fast-mapping and gaze following where contingent reinforcement is provided. Contingent reinforcement can be gradually faded for praise until the child is motivated to learn words independently. This motivation is partially dependent on the child's ability to use the words they learn to communicate. Therefore, it is imperative that receptive word-learning interventions be incorporated into a program that teaches productive language (i.e. through speech or a picture exchange system) so that recently mapped words can be used in meaningful communication.

# CHAPTER IV. GENERAL DISCUSSION

## IV.1 How Symptoms of AD may Effect Word Learning

Are there symptoms of AD that explain the fast-mapping and gaze-following impairments? There are 2 dominant models proposed to explain the underlying cognitive impairments in AD. One model emphasizes impairments in social processing (theory of mind) while the other emphasizes impairments in nonsocial attention mechanisms (central coherence). There are also 2 dominant models of rapid word learning. One model of word learning emphasizes the role of social processing (gaze-following) while the other model focuses on nonsocial attention mechanisms (fast-mapping).

This dissertation will conclude with a theory to account for the word-learning impairments found in the dissertation assessments. By interpreting the 2 models of word learning into the framework of the 2 models of AD, this dissertation posits that the receptive language delay found in AD is the result of both an impaired theory of mind and a central coherence deficit. Specifically, the impaired theory of mind in AD interferes with social word learning skills (gaze-following) while the central coherence deficit interferes with linguistic word learning skills (fast-mapping).

## IV.2 Theory of Mind Model of AD

The *Theory of Mind* model claims that the complex capacity for human communication originates from a person's ability to form theories about what other people are thinking (Wellman, 1990). Humans form theories about the perspectives (intentions, feelings, motivations and beliefs) of others by assessing nonverbal behaviors within the social activity context. TDC are capable of using these theories to infer the intention of speakers when interpreting language (Tomasello,1992 ;1995). CAD have difficulties with the nonverbal social aspects of interaction (e.g. deficient gaze-following, turn-taking, pretend play,emotional reciprocity) that are an integral part in early communication. It was therefore proposed that AD involves an impaired theory of mind (see Baron-Cohen, 1996, for review).

The Impaired Theory of Mind model of AD posits that the core symptoms of the disorder are attributable to a *social* information processing impairment which prevents CAD from being able to take the mental perspective of others. CAD perform more poorly on theory of mind tests than CMR. In one study, Only 20% of CAD (ages 6.1 – 17years) were able to pass a theory of mind test which was signficantly less than the (90%) of TDC (ages 4.5-5.9) and children with Mental Retardation (ages 6.3-17) who passed the same test (Baron-Cohen, Leslie, & Frith, 1985). Several studies offer similar data to support an impaired theory of mind in AD (Baron-Cohen, 1991 ; Dahlgren & Trillingsgaard, 1996 ; Sparrevohn, & Howie, 1995). These theory of mind deficits have been reported in the Autistic population across various ages and IQs (Baron-Cohen, 1989 ;1991 ; Frith & Happe, 1995 ; Perner et al, 1989 ; Tager Flusberg, 1992). Higher functioning CAD perform better but not on par with (MR and typically developing) controls on theory of mind tasks. Advanced theory of mind tasks require the attribution of mental states to

photos of people's eyes and recordings of people's voices (Baron Cohen, Wheelwright and Joliffe, 1997). The few (20%) CAD who were able to pass first-order theory of mind tasks showed significant impairments in higher-order theory of mind tasks (Kleinman, Marciano, & Ault, 2001).

## Theory Of Mind Impairment & Word Learning

Impaired Theory of Mind can account for many of the language impairments characteristic of AD (Baron-Cohen, et al 1995 ; Baron-Cohen, Leslie & Frith, 1985 ; Baron-Cohen, Tager-Flusberg, & Cohen, 1993 ; Frith 1989). Many of the pragmatic impairments reported in later language development could be explained by an impaired theory of mind. For example, adults with AD show significant deficits (offering too much or too little information) in their ability to *maintain* topics of conversation or form coherent narratives (Hurtig et al, 1982). This is indicative of a Theory of Mind impairment in understanding to what information the speaker has access. Further, the fact that adults with AD consistently misinterpret indirect requests, metaphors and figurative speech (Sabbagh, 1999) suggests that they have a difficult time differentiating between what people say and what they mean.

Referring back to the social model of word learning, the first social skill that emerged was the ability to have protoconversations through face-to-face interactions. TDC show a preference for attending to faces over any other pattern from birth. Preschool CAD do not show the same preference. CAD attend to features of faces differently/inconsistently as compared to TDC (Joseph & Tanaka, 2003 ; Dervelle et al, 2004) or CMR (Gepner, de Gelden & de Schonen, 1996). There is neurological evidence showing significantly less EEG activity in the fusiform gyrus (area responsible for facial processing) in older CAD (Hubl et al, 2003). According to the

typical model of social development, a deficit in face processing or eye contact would logically effect the later development of gaze-following abilities.

CAD have significant deficits in their ability to jointly attend to objects with others ( Loveland & Landry, 1986 ; Mundy, Sigman & Kasari, 1990). This impaired gaze-following apparently has cascading effects in early communicative behaviors. A lack of showing and protodeclarative gestures is a major diagnostic marker for AD (Baron-Cohen, 1989). Further, CAD show a marked impairment in symbolic behaviors, even in play. Symbolic behaviors indicative of symbolic thought may play a vital role in language. CAD who have increased language have increased symbolic play (Jarrold, Boucher, & Smith, 1993). Imitative behavior is also impaired in CAD. Whereas typical toddlers will perform a relatively complex behavior to achieve a goal if it is modeled for them (Meltzoff, 1988), CAD show little interest in the way other people do things. In a goal-directed activity, CAD may achieve a goal similar to nonautistic peers, but the process of achievement may be through trial an error of their own repetoire of behaviors (more socially similar to newborn infants). For example, while teaching two children to play a basketball game with a computerized scoreboard, the CMR repeatedly threw the ball toward the basket to get points. The CAD dropped the ball, pushed away the therapist and proceeded to re-program the computer score until it was at the highest value. In his mind, the child with AD had "won the game" because he had achieved the goal.

One theory proposes that CAD's social understanding is acquired through a painstaking reasoning process whereas the same understanding is achieved *intuitively* by TDC (Bowler, 1992). A closer examination of performance on Theory of Mind tests reveals that the CAD who do pass take a longer time and arrive at the answers via a different logical process than typically developing children (Leslie & Roth, 1993 ; Travis, Sigman & Rushkin, 2001). The non-intuitive

social information processing strategies may fail to support word learning because they are too slow and cumbersome.

Without the ability to quickly process social information, CAD will miss social cues such as eye gaze necessary to establish reference. Further, if some CAD do not understand the difference between personal point of view and the public perspective, they will fail to develop a mature sense of "conventionality". These CAD would therefore be more likely to make semantic errors and use language inappropriately.

The impaired theory of mind manifests itself early in development. Infants with AD do not automatically engage in gaze-following. Research on CAD suggests that their gaze-following deficit in infancy predicts the extent of their theory of mind impairment in later childhood (Baron-Cohen, 1991). Gaze-following is one of several social processes facilitating vocabulary growth (as discussed by Bruner, 1983; Dunham et al, 1993). Those CAD who have the least severe gaze-following deficits have the best prognosis for later language development (Bono, Daley & Sigman, 2004; Wilkinson, 1998). Baron-Cohen's "Theory of Mind" account of AD suggests that a social-information processing impairment (i.e. gaze-following) underlies the impairments in language acquisition (Baron-Cohen, 1996).

## VI.3 Central Coherence Model of AD

Typically developing children have a “central coherence” attention mechanism that allows them to automatically organize pieces of information into a holistic coherent pattern (i.e. a gestalt). Frith (1989) has suggested that autistic individuals have a weak central coherence that causes difficulties in deriving coherent meaning from multiple stimuli and understanding the conceptual links that join pieces of information in a sensible way. This weak drive for central coherence biases children towards processing information at an analytic (wheel + handlebars) rather than global (bicycle) level. The “Central Coherence Deficit” account of AD posits that the core symptoms of the disorder are attributable to a general complex information processing impairment which prevents CAD from being able to consider the overall context when deciding what contextual feature is the relevant focal point. For example, CAD shown a photo of a bicycle on a road may identify it as a picture of a " road" or a "wheel" instead of a "bicycle " because they are viewing only one portion of the overall photo. Further, CAD may generalize the term " bicycle" to all objects with wheels (cars, trucks, wagons) because that is the only part of the referent they are focusing on.

Experimental evidence supports the theory that individuals with AD process information in a more piecemeal and bottom-up fashion (Frith & Happe, 1995). CAD show superior performance to controls on Embedded Figures Tests where an analytic approach is advantageous because the test requires attention to the more local information (Shah & Frith, 1983). CAD also show peak performance on the Block Design subtest of the Wechsler Intelligence Scales (Happe, 1994). This test requires the child to focus on the separate, constituent parts of a design rather than on the whole (Wechsler,1991). CAD also experience stimulus overselectivity (tendency to

select a small or irrelevant feature of a stimulus as the focus) much more so than children with other developmental disabilities (Lovaas, 1977, Kanner, 1943). Stimulus overselectivity interferes with establishing reference because a child may think the word " bike" refers to just the wheel. Stimulus overselectivity interferes with generalizing a word because a child may think the word "dog" only applies to brown dogs or labradors. Further, CAD may learn a word in one context (table in school) and not generalize it to a new context (at home).

The Central Coherence Deficit is consistent with the problems shifting attention and selectively inhibiting responses that children with AD exhibit (Ciesielski, Courchesne, & Elmasian, 1990; Ciesielski, et al, 1995). Psychological research supporting the central coherence deficit (executive function tests) demonstrates specific behavioral impairments in attention shifting (monitoring multiple cues on line) and selective inhibition (evaluating relevance based on the overall context). Visual attention studies have also supported the Central Coherence Deficit account of AD. Adults with AD did not show any impairment in their ability to automatically respond to a visual stimulus. They did demonstrate impairments in skills requiring spatial working memory and executive control over reflexive behavior. This suggests CAD have difficulties volitionally suppressing responses to compelling stimuli that are irrelevant to the overall activity context (Minshew, Goldstein & Siegel, 1997). Subsequent oculomotor tests indicate that adults with AD also have problems sustaining location information for brief periods of time to guide their response behavior. They appear to have difficulty holding information online over time to integrate it from multiple sources (Minshew, Luna & Sweeney, 1999). According to the Emergent Coalition Model, this is exactly the type of attention mechanism necessary to accomplish word learning.

## Central Coherence Deficit & Word Learning

The Central Coherence Deficit model of AD can be used to explain many of the symptoms of language impairment. Performance on pragmatic measures of language would appear to be affected by a central coherence deficit, as the conveyance and comprehension of the overall context is critical in interpreting individual pieces of information (Ozonoff, & Miller, 1996). For example, CAD are less likely to make the correct interpretation of a homograph when it requires comprehension of the overall sentence. Further, CAD have difficulties understanding the main point of a narrative. The Central Coherence Deficit account can also explain the social-communicative impairment in AD. The inability to take an entire context into consideration to selectively inhibit irrelevant social events could prevent individuals with AD from responding selectively to subtle social cues. Even simple social engagement of gaze-following requires considering the speaker's eye gaze within the overall context (changing features of the environment/activity).

Paul Bloom (2000) proposed that fast-mapping operates on relevance cues. He demonstrated that children do not memorize information that they perceive as being "stored in the world" (outside color or location of an object). They conserve their memory for information that is transient and inaccessible (names, linguistic information, inside color) (Bloom, 2000). Adults demonstrate "change blindness". They are frequently unaware of changes in their environment that are irrelevant to their ongoing activity/focus. Apparently they are "usefully unaware". Being economical with attention/memory could expedite learning and retrieval of information. Individuals with AD demonstrate a hyper-sensitivity to change (opposite of "change blindness"). For example, a child was upset by the slight change in position of a lamp

in a room (Hobson, 1993). Stimulus over-selectivity is a well-documented symptom of AD (Lovaas et al, 1979; Kolko et al, 1980). Problems with over-selectivity may be related to perceptual impairments

(hyper- and hypo-sensitivity), which have been reported in AD across all sensory (e.g. auditory, tactile, visual, vestibular) domains (Talay-Ongan & Wood, 2000). CAD consistently focus on irrelevant features of objects (smell, texture) when sorting items into categories. When exploring objects, they have a tendency to focus on irrelevant parts of objects or features of a situation (APA, 1994; Filipek et al, 1999). These symptoms are indicative of organizational (ie. executive) impairments in inhibiting attention to what is irrelevant.

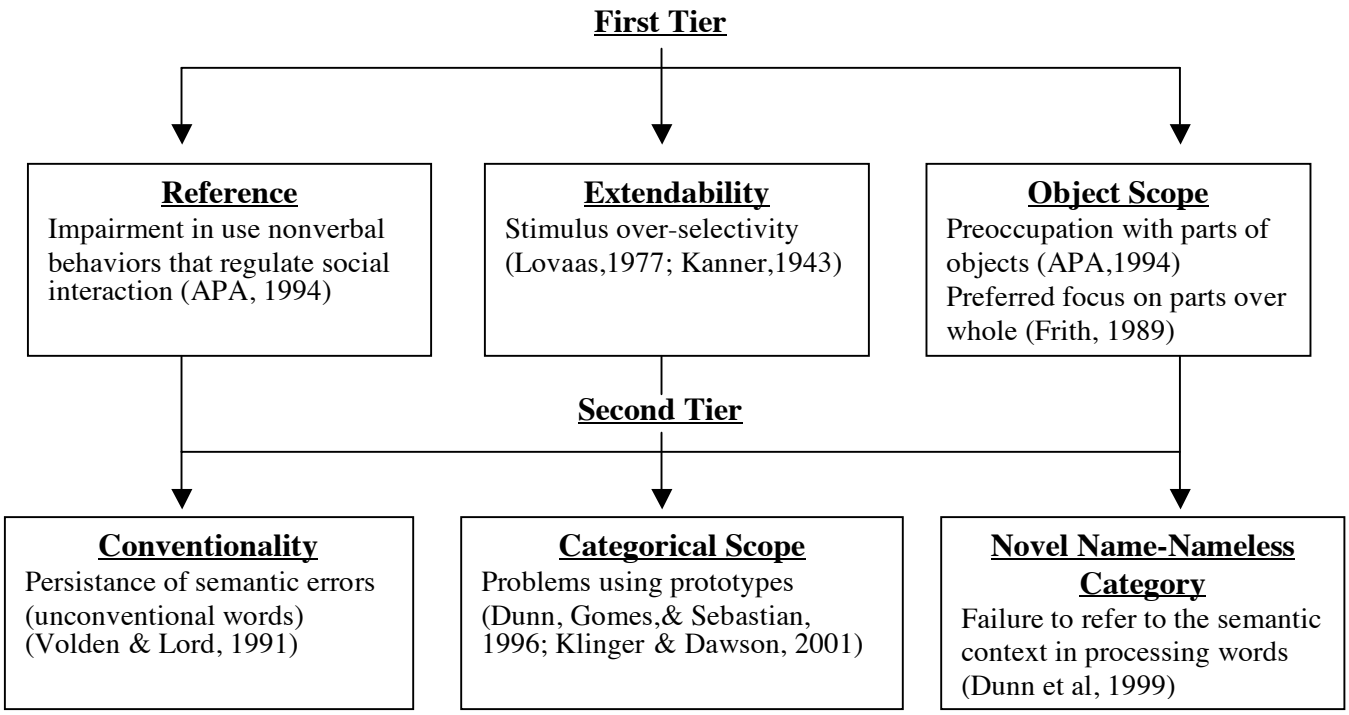
Organizing the symptoms of AD using Golinkoff's Lexical Principles Framework (pg 29) illustrates how many of the primary symptoms of AD may interfere with word learning (Figure 24). Symptoms within the social domain of AD may effect emerging lexical principles. CAD show impairments in the pre-linguistic communicative exchanges (turn taking, eye gaze, gestures) that are the basis for establishing gaze-following (McArthur & Adamson, 1996; Baron-Cohen, 1996), the pre-requisite for the principle of reference. Symptoms within the stereotypic behaviors domain may also effect lexical principles. CAD have a tendency to be rigid, inflexible and over-selective in their attention to details (Prizant, 1983), which could cause problems in generalizing new words outside of their original context (principle of extendability). CAD appear to have impairments in comprehending the conventional function of objects. They do not differentiate their exploratory actions on objects based on function (i.e. try to wave/ bang/ mouth/stack all new toys) (Williams, Costell & Reddy, 1999). The perceptual attention symptoms of AD (Adrien et al, 1987; Freeman, 1979; Freeman, Ritvo, & Schroth, 1985; Hermelin & O'Connor, 1970; Schopler, 1966) involve focusing on irrelevant features of objects.

CAD use this focus to create and organize unconventional categories (e.g. forming categories based on smell instead of shape). They also show a tendency to focus on specific parts of objects as opposed to the whole object (APA, 1994), which is in direct violation of the principle of object scope. If symptoms undermine the foundation, the principles within the second tier may not emerge to provide sufficient structure to support the word learning skills that are essential in the typical construction of vocabulary.

There is evidence of impairments in the second tier of the lexical principles framework (Figure 19). TDC spontaneously repair their own word choices to agree with conventional adult forms (Clark & Hecht, 1983). CAD not only make semantic mapping errors based on a personal (as opposed to the adult's) frame of reference, but they demonstrate little evidence of attempts to repair these errors in the face of miscommunication (Volden & Lord, 1991). TDC define the categorical scope by creating a summary representation (prototype) of items within that category. CAD show significant impairments in their ability to form and use prototypes (Dunn, Gomes, Sebastian, 1996, Klinger & Dawson, 2001). TDC use the context of familiar objects to locate the novel object when they apply the Novel name-nameless category (N3C) principle. CAD have problems referring to the overall semantic context when processing words (Courchesne, 1986).

The symptoms of AD could possibly lead to significant impairments in all three of the second tier lexical principles discussed. This study focused on fast-mapping (the N3C principle) because of its special relationship with the onset of rapid word learning. Future research should address other principles within the framework that may also be impaired in AD.

***Figure 24*** Potential Sources of Lexical Impairment in AD :




A Central Coherence Deficit could account for a general rapid word learning impairment in AD. Such a deficit could impair the ability to establish reference (knowing what the speaker is referring to in the immediate context). The deficit would obviate the cues that provide relevant reference information. Problems assessing relevance could make it difficult to determine when it is relevant to memorize information (leading to a delayed vocabulary) as well as what contextual information is necessary to map to a word (leading to semantic errors).

## IV. 4 A Unified Model of Autistic Word Learning

Previous research has suggested that the theory of mind impairment underlies the delayed and atypical word learning in AD. This interpretation does not take into consideration the role that nonsocial symptoms play in word learning. The social and linguistic word learning impairments found in the dissertation assessment can be interpreted within the framework of the social and nonsocial theories of AD. The Impaired Theory of Mind model can be used to explain the gaze-following impairment, while the Weak Central Coherence model can be used to explain the fast-mapping impairment. The social-nonsocial distinctions (between the two theories of word learning and the two accounts of AD) are methodological ones. In actual language development, social and nonsocial factors are impossible to disentangle.

Lexical development in CAD is both delayed and deviant compared to mental age-matched peers with other developmental disabilities. The most convincing evidence of deviant word learning comes from the analysis of semantic errors (Volden & Lord, 1991). Semantic errors have been interpreted as being evidence that CAD may be learning words incorrectly based on a single exposure. The argument was made that CAD were making semantic errors because an impaired theory of mind compromised their ability to engage in gaze-following with a speaker (Baldwin, Baron-Cohen, Crowson, 1997). Though this is certainly one method of making a semantic error, it is also possible that CAD are making semantic errors because a weak central coherence compromises their ability to attention shift, to form relational categories and to focus on multiple aspects of a context simultaneously. Therefore, both Theory of Mind and Central Coherence accounts of AD would predict the word learning deficits found in the pilot and dissertation assessment results.

Neurological research offers insight to how weak central coherence possibly relates to impaired theory of mind. CAD appear to focus on parts of a face before they see the whole whereas TDC perceive the face before they focus on its component parts (Muller, Ambrose, Allen, Courchesne, 2001). In this manner, weak central coherence might mediate basic levels of social information processing (i.e. perceiving speaker's direction of eye gaze) involved in word learning. There is also neurological evidence of abnormalities in the attention-shifting region of the brain in individuals with AD (Chugani et al, 1997). A general attention-shifting impairment could lead to weak central coherence (by compromising executive control of attention) while also causing impaired theory of mind (by compromising gaze-following).

Weak central coherence may also affect word learning by compromising the speaker's theory of mind. As discussed in the introduction (pages 19-24), the social environment fosters the lexical principle of conventionality. Adults scaffold children's abilities in early word learning by naming objects relevant to the child's attention/interest. If a child with AD perceives the word in a way that is foreign to the adult speaker, the adult will have a difficult time taking the child's perspective (i.e. developing an autistic theory of mind). Parents, teachers and therapists who work closely with CAD play a routine guessing game to figure out the referent of the child's attention. This notion that the children are "in their own world" or are "somewhere else" illustrates how establishing joint reference can be a laborious task.

The core of AD may involve two separate but interacting impairments in Theory of Mind and Central Coherence. Although the nature of their developmental interaction is still unknown, there is a significant correlation between performance on Theory of Mind and Central Coherence tests in the general population as well as in CAD (Jarrold,et al, 2000). The impaired "theory of mind" account has not successfully explained the weak central coherence found in AD.

However, weak central coherence (broadly defined) has been used to explain the impairment in theory of mind. If central coherence is related to theory of mind, and a theory of mind impairment compromises word learning, then a weak central coherence would also compromise word learning. Weak central coherence could account for the failure of the CAD in the pilot and dissertation assessments to pass the fast-mapping tests.

Both Impaired Theory of Mind and Weak Central Coherence models of AD can be incorporated into a unified developmental theory that explains the word-learning impairment in AD. The ongoing experience of sensory aberrations (as a result of perceptual-attention executive impairment) may inhibit the processes through which social interactivity, attachment and communication skills develop leading to the domain-specific theory of mind impairment (refer to discussion in Talay-Ongan & Wood, 2000).

Evidence for attention-mediated social functioning comes from studies that factor in the complexity of stimuli when measuring receptivity to social input. CAD perform best at tasks designed to investigate the ability to interpret social situations based on social cues when only one cue was available (e.g. tone, content, nonverbal or object) than when multiple cues are available (Pierce, Glad & Schreibman, 1997). Research involving non-social tasks confirms the finding that domain general attention symptoms (i.e. executive functions) play a key role in performance (Hughes et al, 1994; Ozonoff, Pennington & Rogers, 1990; Prior & Hoffman, 1990; Rumsey & Hamburger, 1988). CAD perform best in multi-component tasks when only one component is present, and worst when all are present (Burke & Cerniglia, 1990).

Recall that the emergent coalition model (pages 11-15) proposed that language develops from a set of domain general skills that gradually become more domain specific as they develop within a specialized lexical network. Several skill sets are available to solve the same lexical

problem (establishing reference), but they develop at different rates depending on age and experience. These skill sets enable the child to process complex and subtle information from a variety of sources (e.g. prosody, object substance, eye gaze, novelty) simultaneously in order to establish immediate reference. It has been suggested that a general complex information processing impairment underlies both the impaired theory of mind and weak central coherence symptoms of autism (Minshew & Goldstein, 1998).

The three key points to the emergent coalition model are the concept of emergence, the inclusion of a coalition of cues and the process of differentially weighing lexical information. The concept of emergence suggests that language develops from a set of domain general skills (novelty detection, eye contact) that gradually become more domain specific (N3C principle, joint attention) until they are readily used for language acquisition (fast-mapping, gaze-following). Conceptualizing sources of lexical information as a "coalition" of cues captures the richness and complexity of the communicative environment. Words are introduced in so many different contexts, children must learn to adapt to subtle and complex sources of information if they are to become expert word-learners. Some sources of information are less salient because of the variance in the environment (e.g. speaker, activity, object context). Additionally, some sources are less salient because of the variance in the child (e.g. age, attention, experience, ability). As they glean more experience from communicative contexts, children learn which cues are reliable and which cues should only be used as defaults. This gets to the concept of differential weighting. The coalition alone is not enough to explain language development because linguistic and social skills in the coalition develop ("emerge") at different times and at different rates. Domain general skills may be present at the same time early on (i.e. novelty detection & eye contact) but develop at different rates. The domain specific skill of fast-

mapping emerges from the domain general skill of novelty detection and is then applied to word learning by 18 months. Meanwhile, the gaze-following skill has emerged from the domain general skill of joint attention, but it won't be used to learn words until later in the second year.

The Emergent Coalition Model explains that the rapid word learning is contingent upon the child's ability to perceive multiple cues from a variety of sources and weigh the information based on its salience and relevance. If the core symptoms of AD involve an impaired ability to process complex information (Weak Central Coherence) which underlies the Theory of Mind impairment, then the ability to perceive cues (via fast-mapping and gaze following processes) necessary for establishing reference would be impaired in CAD. This theory is supported by the finding that the CAD who participated in this dissertation assessment were unable to establish reference in either the fast-mapping or gaze-following conditions.

## IV.5 Conclusion

Previous research on TDC identified two primary methods of establishing reference that played a critical role in word learning. Previous research on CAD identified two primary symptoms that played a key role in the autistic developmental delays. This dissertation compared the two dominant theories of word learning (fast-mapping and gaze-following) to the two dominant models of AD (Weak Central Coherence and Impaired Theory of Mind).

The results of the assessment support the theory that the word learning impairment in AD is the result of impairments in processing social ( gaze-following) and linguistic (fast-mapping) information. These impairments obscure the ability of CAD to establish reference when they hear a new word. Without the ability to establish reference immediately, language development is fixated at an infant stage where words must be learned through direct indications and repeated exposures.

The results of the intervention suggest that the reference impairments identified in the assessment can be isolated and treated through ABA training programs. CAD who participated in these training interventions were able to master these pre-requisite word-learning skills and generalize them to new stimuli. After completion of the training interventions, CAD were not only able to establish reference between a new word and object but they were better able to remember the word the next day.

Previous research has suggested that CAD had difficulties learning words because they had a gaze-following impairment which could be accounted for by an underlying theory of mind impairment. The results of the assessment support the previous finding of gaze-following impairments, however, they also indicated that gaze-following is not the only word learning skill impaired in CAD. The Theory of Mind model can be used to explain the gaze-following deficit

because gaze-following involves social information processing. However, the Theory of Mind model cannot be used to explain the fast-mapping deficit because fast-mapping does not rely on social information processing. The Weak Central Coherence model of AD can be used to explain the fast-mapping deficit because it involves contextual information processing. If deficits in gaze-following can be accounted for by impaired theory of mind and deficits in fast-mapping can be accounted for by weak central coherence, there should be a relationship between scores on word-learning tests and scores on central coherence/theory of mind tests. This dissertation, however, did not include any tests of theory of mind or central coherence abilities. Future research should compare *gaze-following* and *fast-mapping* to *theory of mind* (i.e. Sally-Anne test) and *central coherence* (i.e. Embedded Figures) test performance .

The Emergentist Coalition Model suggests that earlier lexical principles can compensate for later emerging principles in typical lexical development (Hollich et al, 2000). If social principles (i.e. gaze-following) are the only source of impairment, CAD may be able to recover vocabulary development by placing more emphasis on non-social principles (i.e. fast-mapping). This would result in an initial delay with minimal long-term consequences. The results of the assessments, however, suggest that the word learning impairment in AD is more pervasive. Because both gaze-following and fast-mapping skills were found to be impaired, the *entire* foundation of vocabulary is vulnerable to incomplete/incorrect mappings. Without a strong fast-mapping ability to compensate for weak gaze-following, word learning may not be recoverable. The results of this dissertation suggest that symptoms of AD interfere with the ability to establish reference (via gaze-following or fast-mapping) to learn words.

# APPENDIX A. REFERENCE TEST STIMULI

## TARGET PHOTOS

| Fast-mapping Words | | | Gaze-following Words | | |
|---|---|---|---|---|---|
| Pre-test | Training | Post-test | Pre-test | Training | Post-test |
| astronomer | astronomer | apron | arcade | arcade | architect |
| construction | construction | bakery | barber | barber | DJ |
| electrician | dentist | bride | canopener | butcher | Files |
| envelope | electrician | calculation | chef | canopener | furniture |
| laundromat | envelope | florist | desert | carpenter | Gas |
| lawyer | golpher | helmet | hardware | chef | handkercheif |
| loom | laundromat | mechanic | hotel | desert | highway |
| mayonaise | lawyer | skrewdriver | mill | floutist | Razor |
| photographer | loom | skyscraper | pharmacy | hardware | receptionist |
| record | mayonaise | veteranarian | record | hotel | spools |
| surveyor | parking-lot | | scarf | landscaper | |
| tailor | photographer | | .secretary | mill | |
| typewriter | record | | taxi-cab | pharmacy | |
| violin | riveter | | tennis-court | record | |
| weightlifter | stadium | | trailer | riveter | |
| | surveyor | | | scarf | |
| | tailor | | | secretary | |
| | typewriter | | | taxi-cab | |
| | violin | | | tennis-court | |
| | weightlifter | | | trailer | |

## CONTEXT PHOTOS

| Known | | Novel (distracter) | | | |
|---|---|---|---|---|---|
| **Known (A-G)** | **Known (H-Z)** | **Novel (A-D)** | **Novel (E-L)** | **Novel (M-R)** | **Novel (S-Z)** |
| apple | hamburger | airport | faucet | mailman | salad |
| bannanas | house | bank | fireman | mall | Scissors |
| ball | ice cream | binoculars | flower-pot | mime | see-saw |
| bathroom | juice | blender | gas attendant | mushroom | shoe-store |
| bird | M&Ms | bookstore | globe | neon sign | Snail |
| bread | pizza | bowling-alley | grocery store | nutmeg | store |
| blocks | popcorn | bridge | groomer | olives | Sugar |
| bubbles | plate | bus stop | hair-curlers | onions | sunbather |
| candy | pretzels | calendar | hospital | painter | Swiss-army knife |
| cheerios/cereal | pool | celery | ice skate | parasail | theatre (movie) |
| cheese | puzzle | church | iron | park | tire iron |
| Cheezballs | raisins | chicken | jogger | payphone | toaster oven |
| cookies | slide | clothespin | jukebox | pilot | tractor |
| crayon | shoes/sneakers | clothes store | lake | p.o.box | trumpet |
| cup | soap | clown | lamp | pot | uniform |
| dress | soda | cowboy | lantern | radio | umbrella |
| eyes | spoon | drive-in | lawnmower | record store | vacuum |
| flower | T-shirt | dock | library | restaurant | waitress |
| fries | teddy bear | doctor | luggage | row-machine | window-washer |

# APPENDIX B. GENERALIZATION TEST STIMULI

## TARGET PHOTOS & OBJECTS

| FAST-MAPPING WORDS | | | GAZE-FOLLOWING WORDS | | |
|---|---|---|---|---|---|
| Photo-Dif Photo | Photo-Object | Object-Object | Photo-Dif Photo | Photo-Object | Object-Object |
| astronomer | CD | baster | barber | bowtie | Barrette |
| construction | corkskrew | battery | butcher | hammer | Calculator |
| lawyer | map | chopsticks | hotel | jelly | Candle |
| loom | mirror | disk | mill | keys | Gourd |
| photographer | nails | foil | pharmacy | lock | holepunch |
| record | necklace | frame | record | newspaper | rawhide |
| tailor | purse | lid | secretary | paint-brush | Ruler |
| typewriter | ring | puck | taxi-cab | pasta | scrunchee |
| violin | string | stamp | tennis-court | razor | teabag |
| weightlifter | sunglasses | troll | trailer | watch | thermometer |

## CONTEXT PHOTOS & OBJECTS

| **Known Stimuli** | | **Novel (Distracter) Stimuli** | | |
|---|---|---|---|---|
| **Known (A-C)** | **Known (D-Z)** | **Novel (A-G)** | **Novel (H-Po)** | **Novel (Pu-Z)** |
| ball | flower | alien (toy) | highlighter (triangle 3-tip) | pudding mix |
| book | Juice(box) | CD-opener | ice-pop-maker | rubber fractal-shape toy |
| bird (toy) | M&Ms | cassette-tape | keychain | rubix-pyramid |
| bowl | pretzels | chalk-board eraser | matchbook | scotch-tape-dispenser |
| candy | sock | chapstick | melon-baller | tape-measure |
| car (toy) | Soda (can) | Bottle stopper | mustard | tea-ball |
| chips | Spongebob Squarepants | drawer-handle | nail-polish | tic-tacs |
| cookies | spoon | dumpling press | nutmeg-shaker | tire guage |
| crayon | Spiderman | earrings (6 sets) | plastic push-button | transformer-toy |
| cup | toothbrush | glue stick | pom-pom stick | wire celestial-ball toy |

# APPENDIX C. REINFORCMENT LIST

| **Edible** | **Non-edible** | **Activity** |
|---|---|---|
| cheerios | Action figures | Pull/roll silly putty |
| Cheese (1/2 "pieces) | Blocks | Roll car down ramp |
| Cheeseballs/cheesenips | Books | Blow bubbles |
| Chips | Chalk board | Color |
| Choc. Chip cookies | Dolls (velcro dress-up puzzle) | Make noises with animal toys |
| Corn chips (fritos) | Little people farmhouse | |
| Doritoes | Little people bus | Sing Songs : |
| Fruit roll-ups | Magazines/catalogues | Down by the bay |
| Gelt (chocolate candy) | Magna-doodle | Head, shoulders, knees & toes |
| Gummy bears | Musical toys | Itsy-bitsy spider |
| Juice (sip for 5 seconds) | Musical books | Row your boat |
| Licorice | Pez dispensers | Spongebob themesong |
| Lollypop (for 5 seconds) | Play dough/silly putty | Twinkle Twinkle |
| M&Ms | Pop-up toy | Wheels on the Bus |
| Marshmellows | Puzzle | |
| Nerds (tiny candy) | Speak-n-say | Tokens for : |
| Oreos | Toy dinosaurs | Break |
| Pez candy | Toy food | Computer time |
| Pretzels | Toy horses | Ice-pop |
| Popcorn | Costume jewelry | Ride on tricycle |
| Potato straws | | TV time |
| raisins | | Trampoline time |
| Ritz crackers | | Trip to token store |
| Soda (sips) | | |
| Sugar-free wafers | | |

## APPENDIX D. SEMANTIC ERRORS LIST

| CHILD WITH PDD-NOS | | | CHILD WITH MENTAL RETARDATION | | |
|---|---|---|---|---|---|
| **Real word** | **Semantic Error** | **Error Type** | **Real word** | **Semantic Error** | **Error Type** |
| Pharmacy | Tek | Neologism | Carpenter | Boom (+ pound) | Limited feature + gesture |
| Welder | Treh | Neologism | Ice cream | Yum (+ stir) | Limited feature + gesture |
| Jukebox | Clock | No relation | Fireman | Wee-ooo wee-oo | Related Sound |
| Teacher | Trucks | No relation | Book | ASL sign | nonverbal correct alternative |
| Bridge | water | Limited feature | Dancer (wore ballet slippers) | Shoes | Limited feature |
| See-saw | Floor | Limited feature | Milk | Water | Function & Form related |
| Highway | car | Limited feature | Highway | Road | Correct alternative |
| Mechanic | Dirty | Limited feature | Mechanic | Dirty | Limited feature |
| Puzzle | Dominoes | Functionally related | Kettle | Hot | Limited feature |
| Ice cream | Cake | Functionally related | Hamburger | eat | Action related |
| Chips | Cereal | Functionally Related | Scisssors | cut | Action related |
| Crayon | Draw | Action related | Arcade | play | Action related |
| Scissors | Simba | Phonologically Related | Cheese-doodles | Cheese-burger | Phonologically Related |
| Mail | Book | Similar form | Record | CD | Similar form |
| Knife | Brush | Similar form | Files | Books | Similar form |
| Table | food | Event Related | Camera | Smile | Event Related |
| Mill | Boat | Overgen-eralization | Bucket | Beach | Event Related |
| Mime | Monster | Misinterpreted photo? | Welder (w/mask) | monster | Misinterpreted photo? |
| Electrician (with beard) | pirate | Misinterpreted photo ? | Sandwhich | Bun | Functionally related |
| Kettle | Teapot (song) | correct alternative | Skyscraper | House | correct alternative (in NYC) |
| Barber | Haircut | Correct alternative | Barber | Haircut | Semantic function |

*Participants speech was limited to 1-word (usually non-spontaneous) utterances. They did not speak in full sentences. Participants labeled photos in response to "What is this ?" question.*

## APPENDIX E. PARENT QUESTIONNAIRE :

*The parent questionairre was conducted after both training interventions were completed. Before the interventions, parents were given a "word diary" to keep track of any new words their child learned over the course of the 2 months ; to help them better answer the questionnaire. Parents were blind to whether their child was in the training or control groups.*

1) Has your child demonstrated any understanding of new words that you have not taught him/her ? (name the words and explain)

2) Have you noticed a change in your child's ability to follow 1 or 2-step instructions ?

3) Have you noticed a change in your child's spontaneous communication ? (i.e. gesturing or speaking unprompted, not in response to a question)

4) Have you noticed a change in your child's overall eye contact ? What about eye contact when you are talking to him/her ?

5) Has your child learned or forgotten any words in the past 2 months ? What were they ? How do you know ?

6) Have you noticed a change in your child's ability to identify objects during shared activities (i.e. at dinner you ask "give me the ketchup" and he/she does).

7) Have you noticed any change in your child's ability to sort objects by function/shape (i.e. putting clothes and toys in separate locations when picking up)

8) Have you noticed any difference in your child's speech ?

9) Have you noticed any difference in your child's use of gestures or sign language ?

10) Has there been any change in your child's negative behaviors (i.e. tantrums). If so, Please explain how they have changed, particularly if the cause has changed.

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