Word learning in children with Autism Spectrum Disorder

by

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Chapter I

Introduction

Over the past several decades, the United States has seen a significant increase in research focusing on children with Autism Spectrum Disorders (ASD). These disorders are characterized by impairments in communication and social interaction, as well as by the presence of restricted and repetitive behaviors. ASD is an umbrella term for developmental disorders that are qualitatively similar; it includes autism, Pervasive Developmental Disorder – Not Otherwise Specified (PDD-NOS) and Asperger syndrome. ASDs are lifelong disorders (Billstedt, Gillberg, & Gillberg, 2005; Seltzer *et al.*, 2003) and are believed to have a genetic basis (Lord & Bailey, 2002; Volkmar, Chawarska, & Klin, 2005). There are no unique biological markers for ASD available yet; consequently, the disorders are defined behaviorally.

Language delay is a common feature of individuals with ASD (the exception is Asperger syndrome), and language delay is often the first recognized symptom (DeGiacomo & Fombonne, 1998). However, recent reports have suggested that (given current definitions and provision of services) only approximately 15 percent of individuals with ASD will remain nonverbal into late childhood (Lord, Risi, & Pickles, 2004). In the majority of individuals who develop some language, a considerable proportion of them are noted to have abnormalities in their language usage (i.e., echolalia, stereotyped phrases, pronoun reversal, neologisms, unusual intonation, etc.), although syntax, vocabulary and articulation are generally believed to follow typical patterns of development (Jarrold, Boucher, & Russell, 1997; Kjelgaard & Tager-Flusberg, 2001; Tager-Flusberg, 1994). Other individuals have fully fluent language (although they may have difficulties with the social aspects of communication). Many of these difficulties are understood to be the consequence of a lack of pragmatic understanding, rather than deficits in the structural aspects of language (Tager-Flusberg, 1994). Because of the range of delays and impairments of language – pragmatics in particular – researchers have recently begun to consider the usefulness of invoking "word learning" theories in explaining this observed variability of language mastery in individuals with ASD. These theories – which address the process of how children are able to learn a new word – could potentially be useful for operationalizing linguistic development in children with ASD. However, it is first necessary to understand (1) the basic structure of two prominent word learning theories; (2) certain features of early development in children with ASD having to do especially with social awareness and language; and (3) how children with ASD fare in the empirical tasks that form the foundations of word learning theories.

Current Perspectives on Word Learning: An overview

A child hears countless new words each day. However, in order to learn any given new word, a child must not only quickly and accurately determine the referent that goes with the particular sounds they have just heard, but he/she must then decide what other referents warrant the same label. For instance, upon hearing the new word, "*spatula*," the child must address two questions: what is the meaning of the word; that is, to what does the word refer?; and what else can be called "*spatula'*"?

These are complicated questions for an infant or toddler to answer. Yet young children are able to solve this puzzle and, in fact, can do so with minimal exposure to new words. This ability, called "fast-mapping" (Carey, 1978), has been demonstrated in children who have heard a new word only once (Carey & Bartlett, 1978; Dickinson, 1984; Dollaghan, 1985; Heibeck & Markman, 1987) and in children just over a year old (Houston-Price, Plunkett, & Harris, 2005; Woodward, Markman, & Fitzsimmons, 1994). Even children with language impairments (Dollaghan, 1987; Rice, Buhr, & Nemeth, 1990; Rice, Oetting, Marquis, & Bode, 1994) and Williams syndrome (Stevens & Karmiloff-Smith, 1997) are able to map new labels.

Researchers and theorists have tried to explain how it is that children are able to do this so proficiently. One explanation invokes the concept of cognitive biases, also called "lexical principles" or "constraints" (Golinkoff, Mervis, & Hirsh-Pasek, 1994; Macnamara, 1972; Markman, 1989; Merriman, Bowman, & MacWhinney, 1989; Mervis & Bertrand, 1994; Waxman & Kosowski, 1990). Constraints are cognitive strategies that provide "first guesses" to young children as to what is most likely to be the referent of a novel term. A number of constraints have been proposed by different theorists, but generally speaking, these constraints aid the child in the two word learning goals described above: (1) determining the referent of a label, or "mapping" and (2) deciding whether and how to extend the new label, or "generalization".

A useful study by Woodward, Markman and Fitzsimmons (1994) explored the downward age limits of mapping and generalization (to objects that differed from the targets only in color) in children 13- and 18-months-old. In the most successful experiment, a single novel object was labeled *nine* times. Results indicated that, by using these very simple and repetitive methods, even the 13-month-olds were successful in making word-object mappings, but (unlike the 18-month-olds) they had difficulty generalizing the word to a second object which differed in color from the target.

The question of how children extend newly-learned words has been addressed by a number of researchers, in order to reveal what object relations are prioritized. Markman and Hutchinson (1984) found that when children (2 to 5 years old) were asked to find an object similar to the target (i.e., "Can you find *another one*?"), they selected items related to the target thematically (that occur in the same context or event). However, when the question was introduced using a novel word (i.e., "Can you find *another toma*?"), children chose an item associated taxonomically (same kind or category). Imai, Genter and Uchida (1994) included an item that was perceptually similar (i.e., shape) to the target, as well as the thematic and taxonomic associates. Children aged 3 to 5 years made different selections across conditions according to whether the child was asked to "find *another one*" or "find *another toma*". For novel words (i.e., "*toma*"), Imai and colleagues described a developmental shift, moving from appearance- or shape-based choices (rooted in the "shape bias"; Landau, Smith, & Jones, 1998) to taxonomic (or like-kind) responses. This shift has been noted by other researchers (Baldwin, 1992; Golinkoff *et al.*, 1994; but see Genter & Namy, 1999) and occurs between age 2 (Mervis & Neisser, 1987; Waxman & Kosowski, 1990) and age 4 (Golinkoff, Shuff-Bailey, Olguin, & Ruan, 1995).

A second explanation for children's ability to learn new words emphasizes the social pragmatic cues inherent in the interpersonal context of language. It has been postulated that a child's growing awareness of interpersonal and social cues – e.g., gaze direction, head direction, body posture, voice direction, gestures, intonation, facial expression, hand position (Baldwin & Moses, 2001; Bloom, 2000; Tomasello, 2001) – permits him or her to extrapolate the relevant mapping.

Several classic word learning studies from the social pragmatic approach were conducted by Baldwin (1991, 1993). The purpose of the investigations was to determine whether infants (14-15 months, 16-17 months and 18-19 months) were able to consult the speaker's gaze in order to determine the referent of a novel label when in the presence of two novel objects. In one condition – "follow-in labeling" – the investigator followed the child's attention to label the object in the child's possession. In a second condition – "discrepant labeling" – the investigator labeled the object that was in her own hand and thus *not* the focus of the child's attention. In both conditions, the child only heard the novel label *four times* and then was asked to select the target object. Unlike children in the study by Woodward *et al.* (1994), children in the youngest age group were not able to establish word-object mappings (although, notably, the children did *not* make mapping errors in the Discrepant condition. This was interpreted as evidence that the children in this group were monitoring referential intent but did not yet know how to apply that information to a word learning context). The 16- and 17-month-olds were able to successfully map labels in the Follow-in condition but not in the Discrepant condition, and the 18- and 19-month-olds were successful across conditions.

The idea that constraints and social pragmatics might, in fact, be developmentally intertwined has been suggested (Baldwin & Tomasello, 1998; Mervis & Bertrand, 1994), and a recent model fused cognitive constraints and social-pragmatic perspectives (Hollich, Hirsh-Pasek, & Golinkoff, 2000). The understanding of joint attention, eye gaze and pointing – all of which have been shown to be deficient in children with ASD (Dawson *et al.*, 2004; Mundy & Sigman, 1989; Wilkinson, 1998), as will be discussed below – have been argued to be implicated in children's use of constraints (Hollich *et al.*, 2000; Markman, 1992). Rather than pitting these two approaches against each other, then, our current understanding of the word learning process has shifted to consider a complex interplay between social and cognitive factors in the early aspects of language development.

(Note: a third word learning theory that prioritizes the role of associationist learning will not be addressed here due to space limitations; for a discussion, particularly as it is relevant for children with ASD, see Parish, Hennon, Hirsh-Pasek, Golinkoff, & Tager-Flusberg, in press).

Autism Spectrum Disorders (ASD): An overview of early development

Research has indicated that behavioral features associated with ASD often begin to appear within infancy and toddlerhood, and a number of these features appear to be early precursors to pragmatic awareness. For instance, deficits in skills such as looking at other people, social affective response and responding to name (Osterling, Dawson, & Munson, 2002; Werner, Dawson, Osterling, & Dinno, 2000; Zwaigenbaum *et al*., 2005) have all been noted within the first year of life. By age 2, there are even clearer difficulties in social communication for children later diagnosed with ASD. Impairments in sharing enjoyment and/or interest, directing attention, attending to the voices of other people, response to name, initiating social interactions and communicative integration (i.e., coordinating gaze, facial expression, gesture and sound) have all been associated with diagnosis of ASD in children by approximately 24 months of age (Charman *et al*., 1997; Dawson *et al*., 2004; Lord, 1995; Sigman & McGovern, 2005; Wetherby *et al*., 2004).

The appearance of these social communication impairments early in life has suggested to some theorists that the core impairment of ASD is a difficulty orienting and attending to social stimuli (Rogers & Pennington, 1991), referred to by some as the "*social motivation hypothesis*" (Dawson *et al*., 2004; Dawson *et al*., 2005). According to this hypothesis, children with ASD have early impairments in their ability to orient and attend to social stimuli (such as speech, gestures, gaze and facial expression); these impairments in turn disturb children's ability to extrapolate information from these cues and experience normal social development. One particularly important aspect of social attention is joint attention. Joint attention is a triadic interaction involving shared attention between two individuals which is directed towards a third party, object or event. It is believed to be one of the earliest indications of a child's acknowledgement that another individual may be attending to or thinking about something different than the focus of his or her own attention. As such, it is believed to form the foundation for a number of later achievements, including word learning (Baldwin, 1995; Tomasello & Farrar, 1986; Woodward & Markman, 1998) and theory of mind (Baron-Cohen, 1990; Wellman, 1990).

Very young children with ASD have been found to have impaired joint attention skills (Charman *et al.*, 1998; Dawson *et al.*, 2004; Landry & Loveland, 1988; Leekam, Lopez, & Moore, 2000; Mundy & Sigman, 1989). They are most often not capable of consistently responding to or initiating joint attention (Mundy & Sigman, 1989; Mundy, Sigman, & Kasari, 1994; Sigman & Ruskin, 1999), and if children with ASD do develop these skills, the achievement of them is typically delayed by years (Leekam, Hunnisett, & Moore, 1998). This is particularly significant because joint attention appears to play an important role in the development of a number of different skills in ASD, as it does in typical children, and is one of the best predictors of language for children with ASD, concurrently (Dawson *et al.*, 2004; Landry & Loveland, 1988) and prospectively (Charman *et al.*, 2003a; Sigman & Ruskin, 1999; Thurm, Lord, Lee, & Newschaffer, in press).

However, having recognized the general impairments of the ASD population, it is worth also noting the considerable variability within this group. Although, *in general,* children with ASD are impaired in joint attention, some children with ASD do become proficient in joint attention during the preschool years, particularly in the ability to respond to joint attention (Mundy *et al.*, 1990; Sigman & Ruskin, 1999). Children with ASD and stronger nonverbal problem-solving skills (e.g., higher mental ages) may eventually become more successful in negotiating joint attention (particularly responding to joint attention) than their more impaired peers (Leekam *et al.*, 1998).

The significance of the joint attention heterogeneity in the ASD population is accentuated by the numerous findings that (1) as stated above, joint attention skills predict a variety of outcomes (Charman *et al.*, 2003a; Sigman & Ruskin, 1999; Thurm *et al.*, in press), which it could not do if *all* children lacked the ability; and (2) it adds unique prediction over and above that accounted for by nonverbal and verbal mental age (Mundy *et al.*, 1990; Charman *et al.*, 2003a). Related skills show a similar profile: for instance, the ability to understand social intention. Understanding social intention – or what the speaker has in mind – is an area which is typically impaired in individuals with ASD (Baron-Cohen, 1995). However, recent research has indicated that (like joint attention), the ability to read intention is not *universally* absent in children with ASD (Aldridge, Stone, Sweeney, & Bower, 2000; Carpenter, Pennington, & Rogers, 2001). Overall, then, it appears that as our understanding of the features of ASD has become more nuanced, new evidence for considerable heterogeneity of skill (even within areas which have historically been assumed to be profoundly impaired) is increasingly emerging.

Similarly, language delay and impairment has traditionally been acknowledged to be a core feature of ASD, and some theorists formerly even speculated that autism was primarily a language disorder (Rutter & Bartak, 1971). While previous observations of language development suggested that approximately half of individuals with ASD remained non-verbal into adulthood (Bailey, Phillips, & Rutter, 1996), recent longitudinal studies of children who were quite impaired early in life indicate that by late childhood, 40 percent of children were verbally fluent, and another 45 percent had functional (though not completely intact) language (Lord *et al.*, 2004). More recently, both epidemiological investigations and studies of preschool children with ASD indicate that children who are currently receiving diagnoses may be even less profoundly language impaired than these earlier samples (Chakrabarti & Fombonne, 2001; Charman, Drew, Baird, & Baird, 2003b). Indeed, many children with a history of early language delay but consistently strong nonverbal skills are, by late childhood, indistinguishable from their peers who did not have a history of delay (Eisenmajer *et al.*, 1998). There are certainly children with ASD who indisputably have severe language impairment. However, such a marked impairment no longer appears to be a *defining* feature of ASD. As such, it is important to consider the processes by which a number of these more able children with ASD master considerable language skills they attain.

This point is particularly relevant for the question of word learning in children with ASD, as will become clear below, and leads to the central research question of the present investigation. In order to provide a thorough developmental framework for the observed characteristics of language development in children with ASD, it is necessary to further explore the underlying processes of word learning (which, as already reviewed, are believed to be intimately linked to skills like joint attention and understanding of social information) in this population. Two competing but plausible conclusions of such an endeavor emerge: (1) some children with ASD *can*, at least in certain contexts, use the same fundamental mechanisms to acquire words as do typically developing children; or (2) all children with ASD use different (or perhaps immature) processes to learn new words than do typically developing children. The current investigation aims to address which of these conclusions is most appropriate; first, however, the relevant extant literature focusing on word learning in children with ASD will be reviewed.

ASD and Word Learning: An integration

A number of researchers have explored the word learning process in children with ASD, in terms of their ability to determine the referents of new labels. McDuffie and colleagues (2006b) reported that the introduction of labels increases attention to novel objects for young children with ASD but that these children appear to be less proficient at maintaining and following attention, indicating that they may only successfully map words if an adult follows the child's attention. Recently, Swensen and colleagues (2007), using an intermodal preferential looking paradigm with children with ASD (mean age of 33 months), reported that children with ASD demonstrate the *noun bias*, in that – like typically developing children – they interpret a new word as referring to an object rather than an action.

Some researchers have employed the "Baldwinian" methods described above – using "discrepant" and "follow-in" conditions, which differ on the direction of examiner gaze – with samples of children with ASD. Baron-Cohen, Baldwin and Crowson (1997) found that, as a group, profoundly language-impaired children with autism (mean chronological age of 9 years, 2 months with a verbal mental age of slightly over 2 years) were generally unsuccessful in using speaker gaze to determine the referent of a novel label. They could, however, map the words onto the object that was the focus of their own attention. These results were somewhat compromised by the fact that the children included in the study were severely language impaired and much older than typical children included in previous developmental studies. There were methodological concerns as well, in that the label was only introduced twice, children were not encouraged to engage with the objects used (thus perhaps decreasing the children's interest in the activity), and they were asked to select the target object out of six possible alternatives. For children with cognitive impairments, all of these factors might have impeded performance and need to be addressed in a replication study.

Nonetheless, Preissler and Carey (2005) recently replicated this finding. Their sample of children with ASD (mean age of 7 years, 8 months, with an overall average language comprehension age equivalent of 23 months; half of the sample was non-verbal) were significantly more successful in correctly mapping labels when the investigator followed the child's focus of attention than when the investigator's focus of attention (i.e., gaze) was different than their own. This study, like the original, also had a much older, severely language impaired sample of children with ASD. Furthermore (as in the Baron-Cohen *et al.* study), there were methodological issues, such that the target objects used were minimally interesting (a door stop, for instance), and the novel label was introduced only twice. Another concern was that the child was asked to select an object from four objects, two of which had just been used in the labeling activity and two for which the child already had labels (i.e. there were no novel distracters). Thus, if the child picked the wrong target for a label, it was not known whether to interpret this as an incorrect mapping, or simply a guess from the objects for which the child did not have a label.

Two additional studies have looked at word learning ability and have attempted to explore developmental correlates of this skill in children with ASD. McDuffie, Yoder and Stone (2006a) explored relations between attention-following ability, fast-mapping and vocabulary size in 29 children with ASD (at entry to the study, mean participant age: 32.4 months; mean mental age: 18.9 months). These authors hypothesized that fast-mapping ability would mediate the relationship between attention-following and vocabulary size: this hypothesis was confirmed using correlational and regression analyses. However, because latency of gaze (rather than object identification or selection) was used to measure fast-mapping, it is difficult to differentiate between true mapping and what may have been visual exploration of the objects in the direct field of sight. Nonetheless, these were very promising results; they suggested that, not only are children with ASD able to associate labels with objects, but that their ability to do so has important ramifications for their vocabulary development.

Most recently, Parish and colleagues (in press) worked with a sample of children with autism (i.e., *not* ASD more broadly; mean age: 5.08 years; with a mean verbal age equivalent of approximately 21 months and a mean nonverbal age equivalent of approximately 48 months) and two groups of typically developing controls (one matched on language age and the other matched on mental age). In situations where the examiner explicitly labeled a highly interesting object, the children with autism were able to learn the new word (even with a second, less interesting object present). However, in word learning situations where the label was directed towards a "boring" object, or when children were required to deduce the referent of a label based on their partner's social intent (a somewhat complicated process, which involved the examiner "looking" for the object – the 'parlu' – in a bag and making statements such as, "No, that's not a parlu"), children with autism were not consistently successful. Interestingly, children's composite performance in the activities which required an understanding of social intent (but *not* their performance in activities which were unrelated to intent; note that only some of the activities used were word learning activities, while others addressed imitation) significantly predicted concurrent language scores on the Peabody Picture Vocabulary Test.

The findings from McDuffie *et al.* (2006a) and Parish *et al.* (in press) are the first indications that children's performance in word learning tasks may be related to other measures of language ability. Certainly, these are enticing results, but it is important to note some caveats which call into question the clarity of this observed relationship between word learning skill and measures of language. First, it is necessary to replicate McDuffie *et al.*'s results using alternative measures of "fast-mapping" (rather than gaze latency), since this measure could be tapping other skills such as attention or responsiveness. Second, although Parish *et al.*'s "intent" score included performance in some word learning tasks, it also included scores from imitation activities. Thus, before concluding that word learning performance (at least in laboratory based settings) is related to concurrent measures of language, it is essential to address the association between use of social intent and language ability using *only* performance in word learning tasks, rather than a composite score from a set of activities.

The above studies explored the ability of children with ASD to map new words. Proficiency at generalizing or extending words has not been directly addressed in the literature, although some studies have explored categorization in children with ASD. Tager-Flusberg (1985a, 1985b) found evidence for intact categorization skills in school-age children (mean age 10 years, 5 months and a verbal mental age of 5 years, 2 months) with autism. Results generally indicated that children's ability to form linguistic concepts and extend word meanings to different exemplars may not be impaired. Similar findings of intact categorical knowledge, based on sorting tasks, have been reported elsewhere (Shulman, Yirmiya, & Greenbaum, 1995; Ungerer & Sigman, 1987). However, these studies focused on an older sample, as did most of the word-learning studies in ASD, and did not investigate children's selection based on shape or kind, two dimensions particularly relevant for young children.

In a new study, Kelley and colleagues (2006) conducted a categorical induction task with school-age children with ASD (mean age of just over seven years), during which they labeled a picture with both a name and a property (i.e., "rabbit" and "eats grass", based on Gelman & Markman, 1986). They then asked the child whether this property was possessed by four other images: (1) one identical to the original with a slightly altered perceptual appearance ("same"); (2) one of the same kind but a different color or shape ("target"); (3) a perceptually similar object which was a different kind ("perceptual"); and (4) a distracter item which was dissimilar to the original ("distracter"). Two different sets of images were used, one with animate objects and one with inanimate. The ASD group did not perform as well as the typically developing comparison group in either set, but results reached significance only for the animate set. Furthermore, because this study asked children to generalize based on properties rather than labels, it may not necessarily be indicative of how children would perform when simply extending object terms.

The collective findings reported above are informative in addressing a provisional conclusion to the current central research question: do children with ASD use the same or different (or at least, immature) word learning strategies as typically developing children? If conclusions were drawn based only on the studies described above, one might infer that the latter explanation is the most appropriate: all children with ASD use an immature, imitative approach to word learning and never become able to employ detailed social information in their interpretation of language. Indeed, this very supposition has been made by a number of researchers (Baron-Cohen *et al.*, 1997; Carpenter, Pennington, & Rogers, 2002; Golinkoff & Hirsh-Pasek, 2006; McDuffie *et al.*, 2006b; Tager-Flusberg, 2001). Based on what is supposed to be the consequences of general joint attention impairments in ASD, this conclusion is not surprising, particularly because it has been noted that children not only need to understand the procedural aspects of joint attention but also that joint attention is relevant for learning new words (Baldwin, 1995).

On the other hand, a more complex picture of skills in ASD has been emerging of late which is *not* consistent with this conclusion. That is, as reviewed above, it is clear that some children with ASD are relatively more skilled in interpreting and employing nonverbal social cues. Moreover, these skills are meaningfully associated both concurrently and longitudinally with language ability (Dawson *et al.*, 2004; Sigman & Ruskin, 1999), which (for a substantial proportion of individuals with ASD) is no longer delayed by late childhood (Eisenmajer *et al.*, 1998; Szatmari, Archer, Fisman, & Streiner, 1995) We are left, then, wondering why (if some children with ASD are indeed able to understand joint engagement and social information) have our studies on word learning not reflected these abilities in a subset of children with ASD?

There seem to be two primary explanations for the inconsistency between these two bodies of findings. First, these studies have all been complicated by sample composition. The fact that some word learning tasks can be performed successfully by young, less impaired children with ASD (Parish *et al.*, in press) is quite important, because most of these investigations have primarily been done with children who are at least school-aged and profoundly language impaired. Selecting an older, language impaired sample (particularly in light of the core research question, which focuses on children's ability to learn words) may not be the most valid approach; it could be argued that *if* these children *could* negotiate word learning situations, they would perhaps not be profoundly language impaired by late childhood. Thus, addressing this research question in children who are far past the early stages of these developmental processes may not be the most useful strategy. In addition, the inclusion of older, markedly impaired children *without* also including more high-functioning children does not accurately represent the range of skills observed in the ASD population.

On the other hand, investigating younger children can not only yield meaningful results (as evidenced by Parish *et al.*'s work), but it may more provide a more accurate picture of who can and can not complete these word learning activities. In addition, it is important in any word learning investigation to capture a wide range of skill levels, since that is what characterizes ASD more broadly. By starting out with a large sample of children who show considerable diversity of ability, the participants will "filter" themselves into groups of children who can complete these activities and those who can not. It would then be possible to explore what characterizes the groups that emerge based on their performance in word learning tasks.

The other important sample characteristic of a number of these studies – in particular those by Baron-Cohen *et al.* (1997) and Preissler and Carey (2005) – is the selection of comparison samples. Baron-Cohen *et al.* included a chronological- and mental-age matched group of children with mental retardation, but Preissler and Carey did not. Both studies included a comparison sample of typically developing children who were loosely matched on the basis of having the same *chronological age* as the ASD sample's *language age*. It is certainly arguable whether this is an appropriate matching approach, and it is perhaps minimally informative that children with ASD, who are in late childhood and have profound language impairment, don't do as well on language learning task as do typically developing children. On the other hand, including children with ASD to TD children who are more similar in age and matching them in some kind of more meaningful and theoretically-driven way can yield valuable insights about the process of learning new words. Because the question at hand focuses on vocabulary acquisition, it seems most appropriate to focus on young children and match children on vocabulary level – a close proxy for word learning experience – and then see what sort of strategies these children are using to gain the words that they have.

Second, there have been a number of methodological choices that likely influenced the results of previous word learning studies. These earlier studies have used minimally motivating materials (an important detail, per the findings of Parish *et al.*, in press) and have involved complicated approaches to measure constructs like "intent" and "fast-mapping". Perhaps most importantly, they provided limited contextual support, in that they typically provided novel labels a maximum of two times (the one exception is the McDuffie *et al.*, 2006a paper, in which it is unclear how many times the object is labeled). This methodological aspect, while true to the concept of "*fast*-mapping," may particularly disadvantage children with ASD, who often have a number of concurrent developmental impairments (general developmental delay, difficulty with visual disengagement, challenges in regulating attention, etc.). This is exacerbated by the fact that the tasks introduced by Baldwin (1991; 1993) and used by Baron-Cohen *et al.* (1997) and Preissler and Carey (2005) incorporated only the single social cue of eye-gaze; altogether, the ASD child, who is already disadvantaged by his impairments in a number of other cognitive abilities, may not be able to process this quick and nuanced instructional situation before it is over. As a result, rather than being inherently unable to complete these tasks, children on the spectrum may simply require additional learning supports in order to succeed.

Certainly, it is not a novel concept that children with ASD require considerable structure and repetition to learn and are most successful when supported by multiple cues; research has substantiated this observation both in general intervention strategies (Schreibman, Koegel, Hibbs, & Jensen, 2005) and specifically in joint attention situations (Leekam *et al.*, 1998). Indeed, research has shown that there are clear task effects resulting from the structure of an activity: the performance of children with ASD is directly related to the amount of support provided in the task (Clark & Rutter, 1981). In addition, the findings reported by Parish *et al.* (in press) highlight the importance of making an activity highly interesting and engaging for children with ASD. Therefore, any valid test of word learning (that is, whether children with ASD can do these tasks *at all*, not necessarily whether they can do them as efficiently as typically developing children) should include a consideration of these other confounding factors. The importance of scaffolding is compounded when working with a sample of young children, who – even if typically developing – are particularly prone to marked task effects and thus require similar contextual supports (e.g., Woodward *et al.*, 1994).

In order to best support the performance of very young children (with and without ASD) a number of methodological details were planned, with the overall goal of making the activities very clear and very interesting (see Parish *et al.*, in press). Because previous literature (Woodward *et al.*, 1994) indicated that providing a label nine times appeared to maximize performance for young children; in the present investigation, it was considered important to provide the label with equivalent frequency. Moreover, based on suggestions that multiple cues may greatly increase success when working with children with ASD, particularly in joint attention contexts (Leekam *et al.*, 1998), it was deemed important to incorporate additional cues when providing social information.

Thus, there remain gaps in our understanding of word learning in children with ASD. It is useful to administer these tasks – with a consideration of the task effects previously reported in both the developmental literature (Woodward *et al.*, 1994) and ASD literature (Parish *et al.*, in press) – to a much younger, much less impaired sample of children with ASD. It is feasible that, given a broader and younger sample of children who are offered an appropriate level of cues, some of these children with ASD should be able to complete a full range of word learning tasks, even those which require the use of social information. To return again to the central research question, if the children with ASD fail to perform above chance (or if they make consistent patterns of errors, as in previous studies by Baron-Cohen *et al.* and Preissler and Carey) across the full set of word learning activities, it would be further evidence for the conclusion (already supported by previous literature) that ASD is characterized by the use of different or immature word learning mechanisms. On the other hand, if some children with ASD are indeed able to succeed across all of the word learning conditions, it would be the first empirical evidence that some children with ASD can use the same fundamental processes – including those which require the use of social information – to learn words as do typically developing children. Such a finding would make available new possibilities for the kinds of language and social contexts that are accessible to children with ASD, as well clarify what kinds of situational supports are needed to encourage success.

Current Investigation

The current investigation uses a variety of tasks to explore word learning performance in children with ASD, with a particular emphasis on whether children use social information to learn new words. Relative to previous literature, the current investigation included a younger ASD sample with a wider range of skill; it also included additional instructional supports, as will be discussed below. A sample of young children with ASD, children with developmental delay/language delay (DD/LD) and children with typical development (TD) were recruited to explore their ability to learn new words across different situations.

Recruitment was done in two ways. Due to the considerable heterogeneity of skill in young children with ASD, it was anticipated that it would be difficult to find sufficient numbers of children who could succeed throughout these tasks if recruitment was done only cross-sectionally. Therefore, some of these children were consecutively recruited through ongoing longitudinal projects (which included children at risk for developing ASD, as well as comparison samples), and others were recruited from the community as cross-sectional participants. For both groups of children, it was considered essential that there be some indication that the general paradigm was meaningful for the child before proceeding with the word learning tasks. As a result, a pre-test activity (the "Familiar Object trial," described below) served as a sort of "entry task" and was used for all participants. Only those children who passed the pre-test activity were administered the word learning tasks.

Because this "entry task" (which determined whether or not a child received the word learning tasks) was used, preliminary analyses will compare the children who did and did not pass this task. There were three preliminary hypotheses about the results from the Familiar Object trial:

Preliminary Hypothesis #1: The TD children who pass the Familiar Object trial will be older than those who do not pass; there will be no chronological age difference between the children who do and do not pass the trial for the ASD and DD/LD samples.

Preliminary Hypothesis #2: Within the ASD and DD/LD samples, the children who pass the Familiar Object trial will have higher verbal and nonverbal IQs than the children who do not pass; there will be no IQ difference between the TD children who do and do not pass the trial.

Preliminary Hypothesis #3: Within the children who pass the Familiar Object trial, the mental age of the ASD sample will be higher than that of the TD and DD/LD samples. Furthermore, the children in the ASD sample who pass the trial will be older than their successful counterparts in the TD (but not DD/LD) sample.

The children who passed the Familiar Object trial were given the word learning tasks. In order to make the diagnostic groups equivalent on vocabulary levels (thus controlling for word learning experience and permitting an examination of underlying *mechanisms* of word learning), the children with ASD will be individually matched to children without ASD based on expressive vocabulary score on the MacArthur-Bates Communicative Development Inventory (Fenson, 1993). Within these matched samples, analyses will address word learning performance. Four central sets of analyses will be used to address two guiding hypotheses, as well as two exploratory research questions:

Central Hypothesis #1: In tasks that do not require using social information (i.e., Novel Labeling Task and Follow-in condition of the Pragmatics Task), there will not be significant diagnostic group (i.e., ASD, DD/LD and TD) differences in the accuracy of performance, when children are matched for expressive vocabulary size.

Exploratory Analyses #1: Due to the complexities of previous research and the considerable methodological changes made in the present investigation, there is no planned hypothesis regarding performance in the task that *does* require social information. Therefore, diagnostic group differences (when matched for expressive vocabulary size) will be explored in the accuracy of performance for the task that requires using social information (i.e., the Discrepant condition of the Pragmatics Task).

Central Hypothesis #2: For the ASD sample, performance in the word learning tasks will be associated with measures of language and joint attention.

Exploratory Analyses #2: Because of the lack of clear research findings about the ability to generalize words in children with ASD, there is no planned hypothesis regarding group differences in performance. Instead, diagnostic group differences will be explored in the pattern of responses for the task that probes children's extension of a familiar word (Word Extension Task).

Chapter II

Methods

Participants

Participants were consecutively recruited through ongoing longitudinal studies (focusing on young children at risk for ASD, as well as comparison samples) at the University of Michigan Autism and Communication Disorders Center (UMACC). The consecutive recruitment strategy (as opposed to targeted recruitment) ensured that all children – regardless of skill level – were given the entry task, thus permitting a wide range of children to enter into the study. Recruitment was also conducted by: (1) contacting local clinics that serve target populations (i.e., children with Down syndrome) and posting informational flyers in order to recruit additional children for the developmental delay/language delay (DD/LD) and typically developing (TD) groups; (2) screening the client database of UMACC's clinic for children who were appropriate for participation.

The overall sample included three groups of children: 59 TD children between 13 and 29 months of age; 29 children with a diagnosis of ASD, which included 15 children with a diagnosis of autism and 14 with a diagnosis of pervasive developmental disorder – not otherwise specified (or PDD-NOS), all between 13 and 61 months of age; and 12 children with DD/LD between 15- and 36-months-old (see Table 1 for sample demographics). Children in the DD/LD group had a heterogeneous mix of primary diagnoses: Down syndrome (2), expressive language disorder (3), non-specific mental retardation (5), seizure disorder (1), and mixed receptive-expressive language disorder (1). For the ASD sample, a distinction was not made between autism and PDD-NOS because of the considerable instability of these diagnoses for very young children (Lord *et al.*, 2006). Children for whom English was not the primary language used at home and children with disabilities that precluded standard administration of the assessments (i.e., severe visual impairment and moderate to severe motor impairments) were excluded. All participants had a minimum of 10 object-names reported as comprehended on the MacArthur Bates Communicative Development Inventory (normally reached by 8 months of age; see Fenson *et al.*, 1993).

Measures

All measures administered by the present investigation have been shown to have adequate test-retest and internal consistency and included the following:

(1) The *Mullen Scales of Early Learning* (MSEL; Mullen, 1995) evaluate cognitive functioning for children from birth to 5 years, 8 months of age. The MSEL yields an overall IQ score, as well as subtest scores for gross and fine motor skills, visual reception, and receptive and expressive language. These subtests permit the derivation of both ratio and standard nonverbal and verbal scores. For children who failed to reach the floor required to obtain a deviation IQ score, ratio IQ scores were used for full-scale scores.

(2) The *Autism Diagnostic Observational Schedule* (ADOS; Lord *et al.*, 2000) is a semi-structured, standardized assessment of communication, social interaction and play for children who have been referred for possible autism. A module is selected based on the child's language level. Children in this study were administered either Module 1 (preverbal or single words) or an experimental version intended for children under approximately 30 months of age (the "ADOS – Toddler Module"). The ADOS involves a variety of social "presses" designed to elicit behaviors relevant to a diagnosis of autism. A standardized

diagnostic algorithm can be calculated, consistent with autism criteria in DSM-IV/ ICD-10, and yields sub-scores for communication and social domains. Established cut-off scores based on algorithm totals are used to differentiate autism, autism spectrum, and non-autism spectrum participants. As such, higher algorithm totals indicate more abnormality.

(3) The *Autism Diagnostic Interview – Revised* (ADI-R; LeCouteur, Lord, & Rutter, 2003) is a standardized 90-minute caregiver interview that generates separate scores for socialization, communication and restricted and repetitive behaviors in children referred for possible autism. The accompanying algorithm adequately discriminates individuals with autism or ASD from other comparison groups (Risi *et al.*, 2006).

(4) The *MacArthur-Bates Communicative Development Inventory – Words and Gestures* or *Words and Sentences* (CDI; Fenson, 1989) is a parent checklist of early receptive and expressive vocabulary, as well as nonverbal communicative skills; it has been shown to have excellent validity and reliability for both normal and autistic populations (Charman *et al.*, 2003b; Fenson *et al.*, 1993; Luyster, Lopez, & Lord, in press). There are two forms (Words and Sentences, and Words and Gestures). The appropriate one is selected based on the child's age and developmental level.

(5) A *Consensus Best Estimate Diagnosis.* Criteria presented for Autistic Disorder or PDD-NOS by the DSM-IV (American Psychiatric Association, 1994) and scores on the ADI-R and ADOS (according to whether or not children's scores in each area reach the cutoff for autism or ASD) were used to make a best estimate diagnosis by R.L. and C.L.. Children who were not judged to meet DSM-IV criteria (even if they did meet cutoffs on the ADI-R and ADOS) were ruled out of the ASD group.

Materials

Pilot studies indicated that children with ASD did not consistently demonstrate high motivation to complete tasks when the endpoint of the activity was ambiguous. As a result, all word learning tasks involved using a small wastebasket with a swinging top (painted to look like a ladybug), into which the child deposited the object. This procedure not only allowed for clear closure (placing the object in the "bucket"), thus increasing attention and motivation, but it also allowed for procedural uniformity. Materials for specific tasks are described below. All materials for all tasks were actual objects (as opposed to pictures or cut-outs).

A full set of "familiar objects" was established for the pre-test activity, or the "Familiar Object trial"; this set included the following objects: dog, spoon, fork, brush, comb, bucket, cup, shoe, cat, ball, airplane, car, duck, flower, keys, baby and bottle. The target word learning tasks required separate sets of materials; two full "kits" were established, both of which contained a complete set of word learning materials. All the materials used in the Novel Labeling Task and Pragmatics Task were selected to be interesting (i.e., they generally made a small noise or movement) but not extremely exciting.

The Novel Labeling Task materials were comprised of a set of four "target" novel objects and a corresponding set of identical objects that differed only in color from the "target" objects; this second set was used as the generalization set. The Pragmatics Task included six novel objects, three of which were used in each condition (one as the "investigator's toy," one as the "child's toy," and one as the distracter). In both tasks, objects were randomly assigned to different roles in the activity (i.e., if they were the labeled object or the distracter) prior to administration.

There were seven arrays of materials for the Word Extension Task. All were based on words which commonly occur in children's early vocabulary: bathtub, book, bottle, cup, crayon, shoe, and spoon. Each array consisted of four objects, none of which were an actual exemplar of the label. That is, for instance, the spoon array included the following objects: (a) fork; (b) bowl; (c) small dental mirror; and (d) rubber grip (but *not* a bottle). The exemplars for each array were selected to differ in particular ways from the target object (see Figure 1).

The validity of the Word Extension Task materials was established by obtaining adult ratings of how well each target item matched pictures of the target word according to three sets of judgments: shape similarity ("how similar in shape are items A and B?"), taxonomic similarity ("how much are items A and B the same kind of thing?"), and thematic relatedness ("how related are items A and B?"). Twelve undergraduates rated 10 initial sets of items (see Appendix 1 for details). The ratings were on a scale of 1-7. Any set in which an intended match was not consistently rated higher than the non-matches was discarded, resulting in the seven remaining sets of items listed above.

Procedures

This project received approval from the University of Michigan Medical School Institutional Review Board. Recruitment of families was contingent upon either (1) parental contact of research staff at UMACC or (2) prior parental indication of interest in future research participation (for those participants who were recruited through UMACC's client database). When parents expressed interest in participation, details of the study were provided and consent was obtained. Two appointments were completed for each family. The first appointment required the attendance of either one or both parents and allowed for the completion of the ADI-R. The second appointment required the attendance of either one or both parents, as well as the child participant. During the child's evaluation, cognitive testing was completed first, followed by the target word learning tasks (described below). The ADOS was administered last. At least one parent was in the testing room and in close proximity to the child during the administration of all measures. The tests were all administered in a quiet room, with the parent(s) and one experimenter present. The entire session was videotaped.

Procedures in the word learning tasks were based on methods presented in Woodward, Markman and Fitzsimmons (1994): multiple objects were placed in front of the child and then playfully placed in a bucket. Novel labels were randomly assigned to be used in each word learning task prior to administration from a list of 20 simple, nonsense words, most of which had been previously used in word learning studies (e.g., *dipu, blicket, fep, toma, peri,* etc.). For all tasks described below, the placement of objects in front of the child (from left to right) was randomly assigned prior to administration.

Preference Observation

A preference observation was conducted. Prior to administering the word learning tasks, the investigator initiated a brief play session, during which each experimental item was briefly introduced to the child, and the child was encouraged to "put it in the bucket". If the child appeared to be excessively interested in an item, or afraid of it, that toy was removed from the novel item set and replaced by another pre-determined object.

Familiar Object Trial

In order to select items which were familiar to a particular child and for which he/she knew labels, parents were asked during a pre-appointment phone-call which of the familiar labels their child best understood. If the child had only words outside of these labels, an item set was developed based on parent report. The Familiar Object trial took approximately 1 minute. Children were presented with three objects (one familiar and two distracters) and asked a test question (e.g., "Can you put the dog in the bucket?"). Contingent upon successful completion of the pre-test, the three word learning tasks were administered. The justification for this was that if the child was unable to complete the paradigm with a *known* label and object, they would not be able to meaningfully complete the activity with a *novel* label and object. Assuming, then, that the child passed the Familiar Object Trial, the Novel Labeling Task was administered first, followed by the Pragmatics Task and the Word Extension Task.

There were important practical and theoretical justifications for the use of the Familiar Object trial as an "entry task". In terms of logistics, this task permitted us to monitor the children in the longitudinal projects in order to determine when it was appropriate to give the word learning tasks. From a theoretical perspective, this task permitted us to "filter" out the children who did not have the requisite skills to attend to the situation and follow a specific command. It was essential that the word learning tasks *not* be administered unless the child could do this activity; if they were, and the child failed the word learning tasks, there would be no way to ascertain whether the child failed because they did not understand the activity or because they did not learn the new word. In general, then, this activity allowed the possibility that an observed deficit in the word learning tasks was, indeed, an *ASD*-specific deficit, rather than one due to other confounding factors.

Novel Labeling Task

This task was based on the work of Woodward, Markman and Fitzsimmons (1994). It addressed whether children were able to map new labels onto novel objects. The task was divided into a training phase and a testing phase. Two novel objects were used: one was introduced as the "labeled" object (i.e., the *toma*) and the second served as the "commented" object.

Training Phase: The investigator addressed the child while moving the object in the child's front visual field and said, "That's a *toma*. See, it's a *toma*. Look, it's a *toma*." This "phrase-triplet" was repeated two more times, resulting in nine consecutive repetitions of *toma*. To make the non-labeled object equally salient as the *toma*, the investigator next drew attention to the non-labeled object using similar phrase-triplets: "Ooh, look at that. Yeah, see it? Wow, look at that," for an overall total of nine comments.

Testing Phase: After the training phase, the investigator presented all three objects (target, commented and a distracter), asking "Can you put the *toma* in the bucket?" If (and only if) the child correctly selected the *toma*, the investigator introduced the generalization set and repeated the test question. The items used in the generalization set differed from those used in the training and testing phases only in color, and no additional training was provided. The justification for administering this task *only* to those children who passed the Novel Labeling Task was that if the child was unable to correctly identify the object labeled in the training phase, they would not be able to meaningfully generalize that label to another exemplar.

Pragmatics Task

This task was based on previous research by Baldwin (1991; 1993) and assessed children's ability to use social understanding to determine the referent of a new label. There were two conditions (Follow-in and Discrepant). In each condition, a different set of three unusual objects was used. Videotapes of all Pragmatics Task administrations were reviewed via videotape by R.L. in order to ensure accurate administration; any administration which did not comply with the following procedures was not included in the analyses.

Discrepant training: The investigator placed two novel items on the table and demonstrated an interesting action with each toy. While sitting opposite the child, she placed the toy previously designated as the "child's toy" in the child's hand and picked up the "investigator's toy," resting it in the palm of her hand. The investigator held her object at approximately 60 degrees from her midline, with her face turned towards her own toy (i.e., and *away* from the child's toy, which was visible only in her peripheral vision). While the child was holding and looking at the "child's toy" and the investigator was holding the "investigator's toy," she then said "That's a peri. See, it's a peri. Look, it's a peri" while maintaining her gaze towards the toy in her palm. The phrase-triplet was uttered two more times (resulting in nine presentations of the label); at no point was a phrase-triplet introduced when the child was already looking at the investigator's toy. After the ninth label, the child was allowed to play with the objects for up to one minute.

Discrepant testing: The investigator placed three objects (two novel objects from the training phase and one distracter) in front of the child and asked, "Can you put the *peri* in the bucket?"

Follow-in training: Follow-in training was similar to Discrepant (i.e., investigator sat opposite the child and placed "child's toy" in the hand of child and placed the "investigator's toy" in her own palm), except that a second set of novel toys was used. Furthermore, rather than shifting her object and face to the side, the examiner faced forward, gazing directly towards the child and the child's toy at the time that she vocalized the novel label (e.g., *dax).* The investigator began each phrase-triplet only when the child was looking at his own toy.

Follow-in testing: Follow-in testing was identical to that of the Discrepant condition, but a different distracter was used.

Word Extension Task

The investigator then began the Word Extension Task, which took 2 to 4 minutes to administer. This task was loosely based on work done by Markman & Hutchinson (1984) and Imai *et al.* (1994) and focused on children's ability to apply familiar labels to a set of objects based on taxonomy versus perceptual or thematic similarity. One array of objects was selected based on parent report of labels known by the child. During test administration, the referent of the target label was never shown. The investigator presented the child with a set of three of the four objects from the array and then asked the child to select the object that has the target label, i.e., "Can you put the bottle in the bucket?" The question was asked up to three times to elicit a response before the next set was presented. After the item was selected, the next set of items was arranged and placed on the tray. Altogether, four sets were presented (in order to present every possible combination of three out of four objects, i.e., objects A, B and C together, objects A, C and D together, etc.). After completion of the word learning tasks, the child was offered a snack in order to finish the assessment on a positive note and allow the parents to ask any questions that they had.

Design

For the preliminary analyses, data were interpreted using two different approaches: one for children who were recruited as cross sectional participants and the other for those who were recruited through ongoing longitudinal projects (see Table 2). Cross-sectional participants (which included 57 TD children, 12 children with ASD and 10 children with DD/LD) were seen only once and all data were taken from this one visit. This meant that if the child did *not* pass the Familiar Object trial (which was the case for 17 TD children, 7 children with ASD and 2 DD/LD children), they were *not* administered the word learning tasks (as described above in Procedures) and thus did not have any other word learning data. Longitudinal participants were consecutively recruited from ongoing projects of children at high risk for ASD (as well as appropriate comparison samples; this included 2 TD children, 17 children with ASD and 2 children with DD/LD), and each child received the Familiar Object trial during each of their research appointments at our center. Data included below in the word learning analyses are from the first time that they passed the Familiar Object trial, and thus the first time that they were administered the word learning tasks. All children –except for one child with ASD – who participated longitudinally eventually passed the Familiar Object trial and received the word learning tasks.

There are many years of evidence indicating differences between ASD and TD children who attain the same skill, such that children with ASD are often considerably delayed in mastering new skills, both chronologically and developmentally (Chakrabarti & Fombonne, 2001; Charman *et al.*, 2003b; Happe, 1995). Therefore, differences were expected between the ASD and TD children who passed the Familiar Object trial in measures like chronological age, developmental age, cognitive ability and expressive vocabulary size. Given these expected differences (which would disadvantage the children with ASD in the word learning tasks), it was considered a more interesting question to consider whether children with ASD who are (in some way) equivalent to their TD peers are still performing less well in the target word learning tasks. Therefore, a matching strategy was planned.

Matching children with ASD to comparison groups on language ability is a complicated issue and one that does not have a clear solution; rather, it has been suggested that matching should be done in a manner most appropriate to the research question at hand (Charman, 2004). One option is to use mental ages from standardized measures. However, researchers have suggested that this is not necessarily the best approach (Tager-Flusberg, 2004), because of considerable variability within the ASD population; moreover, research has indicated that children with ASD may need to reach higher developmental ages in order to attain the same cognitive achievements as their typically developing peers (Happe, 1995). Therefore, matching children on mental age would again disadvantage the children with ASD, since they may need to progress further developmentally than their non-ASD peers in order to master a skill – in this case, the ability to learn a new word.

On the other hand, using vocabulary size is a better proxy for word learning experience; employing this strategy would make the ASD and TD samples equivalent on the key behavior – vocabulary – thus allowing their performance on the word learning tasks to provide clues as to the strategies that the children used in order to reach that level of mastery. Measuring vocabulary using some standardized measures with very young children (with or without ASD) often poses the risk of floor effects (Charman *et al.*, 2003a) . Conversely, some measures (the MSEL in particular) may *over*estimate some early vocabulary for children with ASD (Lord *et al.*, 2004) because it does not clearly distinguish between functional and non-functional use of words. However, recently there has been a considerable amount of work evaluating the use of parent report – especially the CDI – in very young samples of children with ASD and TD (Charman, 2004; Charman *et al.*, 2003b; Luyster *et al.*, in press). The CDI has been shown to have high agreement, particularly for expressive language, with other standardized measures (Charman, 2004; Fenson *et al.*, 1993;

Luyster *et al.*, submitted; Stone & Yoder, 2001). In addition, it poses less of a risk of attaining floor effects and may be a more representative measure of children's meaningful use of words than some standardized measures.

Therefore, because the central question of the current investigation was one of vocabulary acquisition, and because our samples were quite young both chronologically and developmentally, this option seemed to be the most appropriate. We individually matched children based on expressive vocabulary as reported on the CDI; 16 of the pairs were matched within 30 words (out of a possible total of 396) on the CDI, the remaining 5 pairs were matched within 50 words. It is important to note that, despite matching, the groups were not anticipated to be generally equivalent in other areas like developmental and chronological age or IQ scores, precisely because of the inherent developmental differences between children with ASD and those without. However, the goal for the matching process was to make the groups equivalent on the measure (i.e., vocabulary) which was most relevant for the central research question of the current investigation, that is, the mechanisms of how children learn new words. [Note: Appendix 2 includes the entire *unmatched* sample; results do not differ significantly from those reported from the matched samples.]

Chapter III

Results

Preliminary results from the Familiar Object trial will be provided first, followed by several separate results sections. Because of the multiple sections of results, flow charts (Figures 2 and 3) provide an outline of how the samples were used. Part I will address the results of the Novel Labeling Task and Pragmatics Task using the data from 21 children with ASD and 21 individually matched TD children. Part II will address performance in the Labeling and Pragmatics task as it relates to other measures of cognitive ability and joint attention; this will include only the data from the 21 ASD participants. Part III will address the results of the Word Extension Task using the data from 17 children with ASD and 17 individually matched TD children. Part IV will provide a comparison of the performance of the typically developing sample to the extant literature, using the full TD sample of children who passed the Familiar Object trial (n=42). Because of the small sample sizes, non-parametric tests were used throughout the following analyses except where noted.

Preliminary Findings

Familiar Object Trial

The following section will elaborate on the characteristics of the children who did and did not pass the Familiar Object trial, as mentioned above in "Design". Only those children who successfully passed this trial received the target word learning tasks.

This was done in two ways, according to whether the children were recruited into the present investigation through other, ongoing longitudinal projects or whether they were recruited as a cross-sectional participant. A general description of the overall sample composition is presented for each diagnostic group (see Table 2). For the children in the cross-sectional group, two groups of children are compared: those who passed the Familiar Object trial and those who failed it. As such, each child is represented only once. For the children in the former category, the descriptions below – when possible – present the characteristics of children across two appointments: the *last* appointment in which they failed the Familiar Object trial, and the *first* appointment in which they passed this trial. That is, all children have the potential to be represented twice, in a "before" and "after" fashion. This was not the case for all longitudinal participants, because some children passed the task on the first administration; specific details of the children who went from not passing to passing the Familiar Object trial during longitudinal projects are provided in Table 3, which provides scores at the last visit which the children did not pass and the first visit which they did pass.

As anticipated, a minority of children in all groups were unable to complete the Familiar Object trial. Forty-two of the 59 TD children (71.19%) passed the Familiar Object trial; 21 of the 29 children with ASD (72.41%) passed the trial, and 10 of 12 children with DD/LD (83.33%) passed. As illustrated in Table 2, for the TD group, the group of children who passed was significantly older ($t = 2.55$, $df = 57$, $p < .05$) and had a higher nonverbal IQ (NVIQ; $t = 2.44$, $df = 57$, $p < .05$), verbal IQ (VIQ; $t = 2.22$, $df = 57$, $p < .05$), nonverbal MA (NVMA, $t = 3.58$, $df = 57$, $p < .05$), verbal MA (VMA, $t = 3.01$, $df = 57$, $p < .05$), and vocabulary score ($t = 2.36$, $df = 41.80$, $p < .01$) than the children who did not pass. Within the ASD group, the children who passed the trial had higher VIQ ($t = 3.25$, $df = 28$, $p < .01$), higher VMA ($t = 3.19$, $df = 27.45$, $p < .01$) and higher NVIQ ($t = 2.31$, $df = 28$, $p < .05$) than those who did not, but there was no difference in chronological age, NVMA or expressive vocabulary between children who did and did not pass the trial. There were insufficient data to compare the subgroups within the DD/LD sample. Based on the results from the TD and ASD samples, then, the children who passed the Familiar Object trial generally had higher cognitive skills than those who did not.

ANOVAs including only those children who passed the Familiar Object trial and comparing across diagnostic groups indicated diagnostic group differences in NVIQ [$F(2, 69) = 25.38$, $p < .01$], VIQ [$F(2, 69) = 30.39$, $p < .01$] and chronological age [$F(2, 70) = 18.67$, $p < .01$]. Planned contrasts indicated that the TD group had significantly higher NVIQ than the ASD group ($t = 4.69$, $df = 69$, $p < .01$), who in turn had a higher NVIQ than the DD group ($t = 2.70$, $df = 69$, $p < .01$). The same pattern was observed in VIQ. The TD group was also younger than the ASD group ($t = 4.48$, $df = 70$, $p < .01$) and the DD group ($t = 5.07$, $df = 70$, $p < .01$), but the ASD and DD groups were not different from each other. There were no significant group differences in NVMA, VMA or expressive vocabulary. Because of the small number of children with DD/LD who successfully passed the Familiar Object trial, this group was excluded from all remaining analyses.

As presented in the "Procedures" section, only those children who passed the Familiar Object trial were given the word learning tasks (since those who failed were not able to complete the basic paradigm of the tasks). As previously outlined, each of the children with ASD who passed the Familiar Object trial was individually matched (based on CDI expressive vocabulary totals) to one child in the TD sample who passed the Familiar Object trial. Due to incomplete data for some children, the matching process was done twice, once for the Labeling and Pragmatics Tasks (Part I matched sample, see Table 4, which included the 21 children with ASD who passed the Familiar Object trial and 21 matched TD children) and once for the Word Extension Task (Part III matched sample, see Table 11, which included the 17 children with ASD who had Word Extension Task data and 17 matched TD children).

Part I. Novel Labeling and Pragmatics Tasks

Novel Labeling Task

These analyses used the Part I matched sample (Novel Labeling and Pragmatics Tasks, see Table 4), which included the 21 ASD children who had passed the Familiar Object trial and 21 matched TD children. (Note: although groups were matched on expressive vocabulary, the matched samples were also equivalent on VMA.) Of this Part I sample, 14 of the 21 (66.67%) TD children and 16 of the 21 (76.19%) children with ASD passed the Novel Labeling Task. Using a binomial distribution, results indicated that the rate of passing the Novel Labeling Task was significantly greater than what would be expected by chance in TD group ($p < .01$) and in the ASD group ($p < .01$) . A McNemar test indicated no group difference in the rate of passing the Novel Labeling Task ($p = .75$).

To our surprise, Mann-Whitney tests indicated that there were not significant differences in chronological age (CA), vocabulary size, NVIQ, NVMA, VIQ or VMA between those children who successfully passed the Novel Labeling Task and those who did not (see Table 5). However, using the data from only those children who passed the task, Mann-Whitney tests indicated a significant diagnostic group difference in chronological age (such that the ASD group was older than the TD group; $U = 51.00$, $p < .05$), and in NVIQ and VIQ (with the TD group higher in both, $U = 43.50$, $p < .01$ and $U = 22.00$, $p < .01$, respectively). There were no group differences in mental age or expressive vocabulary size within children who passed the Novel Labeling Task, suggesting that group differences –

such as evidence that only the children with ASD and exceptionally large vocabularies or particularly high mental ages were successful at this task – do not emerge when looking only at the children who succeed.

Novel Labeling Task: Generalization

As described in the Methods section, only those children who passed the Novel Labeling Task were administered the generalization trial (in which they were asked to select a new exemplar of the target, differing in color from the original one). This was because if they could not correctly select the labeled object, we did not consider it meaningful to ask them to generalize the label. Consequently, these data were collected only for the Part I children who passed the Novel Labeling Task (ASD: n = 16; TD: n = 14). Data were missing for one ASD child due to examiner error, but of the 15 with generalization data, 14 (93.33%) children passed the generalization task. In the TD group, 9 of the 14 children (64.29%) passed the generalization task (see Table 6). Binomial distributions indicated that the rate of passing the generalization task was significantly greater than chance for both diagnostic groups ($p < .05$ for TD group, and $p < .01$ for ASD group). A McNemar test indicated that there was not a group difference in the rate of passing the generalization task ($p = .50$).

Mann-Whitney tests indicated that there were not significant group differences in CA, NVIQ, VIQ, or vocabulary size between children who passed the task versus those who did not. However, analyses using the data only from children who passed the task revealed that, relative to the TD group, the ASD group was older ($U = 22.50$, $p < .01$) and had a lower NVIQ ($U = 28.00$, $p < .05$), and lower VIQ ($U = 11.50$, $p < .01$). There was also a trend for the ASD group to have a higher NVMA ($U = 33.00$, $p = .06$).

Pragmatics Task

These analyses used the same Part I matched sample as above, which included the 21 children with ASD who had passed the Familiar Object trial and 21 matched TD children. As outlined in the Baldwin (1993) paper, the assumption behind the analyses for the Pragmatics Task is that if children do not use social information in mapping a new label, they should simply select the object that was the focus of their own attention, regardless of the focus of the examiner during labeling. On the other hand, if they are able to understand the significance of the speaker's focus, they should select their own toy less often when the label was presented in the Discrepant condition than when it was introduced in the Follow-in condition. Also in keeping with the findings of the Baldwin paper (in which differences across conditions emerged at 18 months), the Part I TD and ASD samples were split according to mental age into "younger" (i.e., VMA of younger than 18 months, which included only four TD children and five children with ASD) and "older" (VMA 18 months and above, including 17 TD children and 16 children with ASD) groups (Note: mental age was used rather than chronological age due to lack of younger children with ASD. It is acknowledged that this is an imperfect split in terms of the resulting sample sizes, but it is the only one which is rooted in theoretical and empirical observations and thus has reasonable predictions). See Figures 4 and 5 for the results (chance levels indicated with the solid horizontal line).

Performance within each of the two VMA groups was similar across diagnostic groups. The rate of selecting the child's own toy did not differ across the TD children and children with ASD for either the Follow-in (two-sided Fisher's exact tests; younger MA: p = .79; older MA: p = .25) and Discrepant (two-sided Fisher's exact tests; younger MA: p = .50; older MA: p = .50) conditions. Analyses looking within diagnostic group and across MA levels indicated that, for the TD sample, the rate of selecting the child's own toy was not different across conditions for the younger MA group (one child, or 25%, in both conditions; two-tailed McNemar test, $p = 1.00$) or the older MA group (47% in the Follow-in condition and 18% in Discrepant; two-tailed McNemar test, $p = .13$). A clearer pattern was found in the ASD group: there was no effect of condition on selecting the child's own toy for the younger MA group (20% in Follow-in, 0% in Discrepant; two-tailed McNemar, $p = 1.00$), but there was an effect for the older MA group (two-tailed McNemar test, $p < .05$), such that the child's toy was selected more often in the Follow-in condition (68.75%) than in the Discrepant condition (12.50%). That is, for both diagnostic groups with older MA, children were more likely to pick their own toy when the examiner *had* been labeling that toy (i.e., in the Follow-in condition) than when the examiner *had not* been labeling that toy (i.e., in the Discrepant condition), but this difference only reached significance in the ASD group.

In order to determine if children selected the correct toy more often than what would be expected by chance, binomial tests were used for each diagnostic group. In the TD group, the children in the younger MA group selected the child's toy at levels which were not significantly different than chance in the Follow-in (25%, $p = .11$) and Discrepant (25%, $p = .60$) conditions. The older MA children, surprisingly, also selected their own toy at a rate which was not significantly greater than chance (47%, $p = .16$) in the Follow-in condition but was significantly less than chance (18%, $p < .01$) in the Discrepant condition. For the ASD sample, the younger MA group selected the child's toy at chance levels (20%) in the Follow-in condition. However, unlike their TD counter-parts, *none* of the five children with younger MA in the Discrepant condition selected the child's toy (a level below chance, $p < .01$). The older MA children in the ASD group selected the child's toy at a rate significantly above chance in the Follow-in condition (69%, $p < .01$) and (like their TD peers) significantly below chance in the Discrepant condition (13%, $p < .001$).

Alternative analyses of the Pragmatics Task data: ASD sample only

The analyses conducted above are based on those reported in the original Baldwin (1993) paper. However, subsequent publications have used an alternative strategy, focusing on "direction of gaze" (Baron-Cohen *et al.*, 1997; Preissler & Carey, 2005). A "Listener Direction of Gaze" (LDG) strategy was characterized by children's selection of the toy to which they were attending (that is, their own toy), whereas a "Speaker Direction of Gaze" strategy (SDG) was characterized by children's selection of the toy to which the examiner was attending.

Previous studies have differed on whether they base this strategy on just the Discrepant condition or on both the Follow-in and Discrepant condition. Baron-Cohen *et al.* (1997) based their strategy analyses only on the Discrepant condition and reported that 71 percent used the LDG strategy and only approximately 29 percent of children with autism used the SDG strategy (a rate which did not differ from chance). Preissler and Carey (2005) used more stringent criteria, requiring that children consistently selected toys across *both* conditions in order to be categorized as using a strategy. Their results indicated that observed that 39 percent of children with ASD demonstrated the LDG strategy, and 28 percent used the SDG strategy, as 70 percent of their typically developing sample did. Using the less stringent criteria – that is, just performance in the Discrepant condition – that Baron-Cohen *et al.* (1997) used, yields somewhat similar results in the Preissler and Carey (2005) sample: 61 percent used an LDG strategy, and 39 percent used the SDG strategy (not tested against chance).

In order to provide an interpretation that is in keeping with these previous studies, similar analyses of the ASD sample were conducted using the present data. The typical sample was excluded from this set of analyses, since the intent was to compare the performance of the current ASD sample to that reported by previous investigations. In order to be consistent with previous approaches, both the more and less stringent criteria will be used to describe strategy use.

The characteristics of the current Part I ASD sample, according to whether they passed or failed each Pragmatics Task condition, are shown in Tables 7 and 8. Using the *less* stringent criteria – basing strategy use solely on performance in the Discrepant condition – indicates that the present sample had only two children select their own toy (the LDG strategy, 9.52%), whereas 10 (47.62%) children used the SDG strategy, a proportion which marginally different from chance, $p = .05$. This is greater than the proportions reported by Preissler and Carey (39%) and Baron-Cohen and colleagues (29%). It seems of note that *all* of the children in the present ASD sample who passed the Discrepant condition had *also* passed the Follow-in condition, so there was considerable consistency of performance. See Figure 6 for a visual representation of the performance of the present and previous samples in the Discrepant condition.

Using the more stringent criteria – performance in both the Follow-in and Discrepant conditions – permits comparison only to the Preissler and Carey (2005) results. As in previous studies, errors were examined for the children who did not pass the conditions of the Pragmatics Task. In order to do this, each child was coded based on the observed "strategy" of selecting objects. Three strategy characterizations were used: (1) Speaker direction of gaze (SDG, selecting toys which were focus of speaker across both conditions); and (2) listener direction of gaze (LDG, selecting toys which were focus of listener across both conditions); and (3) all other strategies. A visual representation of the strategy results from the current sample, as well as Preissler and Carey's (2005) sample is presented in Figure 7. Unlike results in the extant literature, the present study did not reveal that a substantial proportion of the ASD group was using the LDG strategy, which would lead the child to select the focus of their *own* attention in both conditions. Rather, nearly half (or about 20% more than what has been previously reported) of the current ASD sample successfully used the SDG strategy to map words in both the Follow-in and Discrepant conditions.

Finally, because the samples from Baron-Cohen *et al.* (1997) and Preissler and Carey (2005) were children with profound language impairment, it was speculated that there might be more overlap in results if the analyses of the current investigation were limited only to children with significant language impairments. Criteria to define substantial language impairment were generated based on scores on the MSEL. In general, scores which were greater than two standard deviations below the mean were considered to be indicative of significant impairment. Thus, there were two possible cut-offs, and a child had to meet only one: either (1) VIQ equal to or less than 70; or (2) expressive language T-score equal to or less than 30. There were only five children in the current ASD sample who met one or both of these criteria. Qualitative analyses indicated one of these children passed both the Discrepant and Follow-in conditions. The other four children did not pass either task. They did not select the child's own toy in the Follow-in condition, and perhaps more notably, they also did not select the child's own toy in the Discrepant condition (both of which, if observed, would have been consistent with an LDG strategy, as reported in previous studies).

Part II. Associations between performance in the Novel Labeling and Pragmatics Tasks and language and joint attention measures: ASD sample only

Analyses in this section included the data from the 21 children with ASD used in Part I. Previous research has indicated a relationship between performance in word learning tasks and scores on language measures (McDuffie *et al.*, 2006a; Parish *et al.*, in press), and there is some suggestion that this relationship may be specific to tasks which require an understanding of social intent (although this not been clearly established). In order to explore this question in the current investigation, the word learning tasks were divided in a manner consistent with the hypotheses, according to whether they required an understanding of social information. Children's scores ('0' for failing, '1' for passing) were summed for the Novel Labeling Task and the Follow-In condition of the Pragmatics Task to create a "no social information" (or NSI) score, ranging from 0 to 2. Children's scores on the Discrepant condition of the Pragmatics Task were used as the "social information" or (SI) score, which (since it was based only on one task) was binary. These scores were intended to (as closely as possible) approximate the "non-intent" and "intent" scores used by Parish *et al.* (in press), and the "no social information" total is somewhat similar to the "fast-mapping" score used by McDuffie *et al.* (2006). Score on the CDI were used as measures of expressive vocabulary, and language age equivalents (both receptive and expressive) were taken from the MSEL.

See Tables 9 and 10 for mean scores on the dependent language variables according to NSI and SI scores (scores from the ASD Familiar Object "no pass" visits are included in the tables as a reference group, although they weren't included in the analyses). A Kruskal Wallis test indicated no differences according to NSI scores in any of the dependent variables. Similarly, Mann-Whitney tests indicated no differences according to SI scores in the dependent language measures.

Because the above results reported in Part I – which indicated that a considerable proportion of the children with ASD *could* successfully interpret social information in the Discrepant condition – were inconsistent with previous findings, additional confirmation of these joint attention skills was sought using the data from the ADOS. Children were given a score according to their performance in the Pragmatics Task: '0' for passing neither condition, '1' for passing the Follow-in condition only, and '2' for passing both conditions. The central question was whether children with these different scores would differ on ADOS items having to do with joint attention. ADOS items were selected for these analyses based on a previously published factor analysis, which indicated that six ADOS items formed a "joint attention" factor in a large scale study of children with ASD diagnoses (Gotham, Risi, Pickles, & Lord, 2007). These items were 'Pointing', 'Gestures', 'Response to joint attention', 'Initiation of joint attention', 'Showing' and 'Unusual eye contact'.

In general, codes on the ADOS are scored from '0' to '3', with a higher score being more indicative of abnormality. This does not necessarily indicate that a child who scores '0' on an item is performing in the manner that a typically developing child would, it simply means that there was no abnormality evident during the structured observation. The summaries and scoring guidelines for two codes ('Response to joint attention' and 'Pointing', each with codes of 0 to 3; Lord *et al.*, 2000) are presented below, as general examples of ADOS scoring conventions and (as will be shown below) they appear to be most relevant for the present investigation.

1. **Response to joint attention.** This rating codes the child's response to the examiner's use of gaze and/or pointing in order to direct his/her attention to a distant object. The

rating should not be affected by the child's understanding of language (i.e. he/she must follow the direction of the examiner's gaze or pointing, but does not have to understand what was said).

0 = Uses the orientation of the examiner's eyes and face alone as a cue to look toward the target, without the need for pointing. The child must follow the examiner's gaze and turn his/her face or eyes in the direction of the target after watching the examiner do so; he/she does not actually have to catch sight of the target.

1 = Responds to the examiner's pointing by looking at or toward the target.

2 = Looks at the target when it is activated or placed directly in front of him/her, but does not make use of the examiner's gaze or pointing in order to locate the target from a distance.

3 = No interest or awareness of the target. If it is not possible to get the child's attention in order to direct it in five attempts, assign this rating.

2. **Pointing.** This item describes socially-directed pointing, which includes pointing for the purpose of requesting and/or for shared attention. The term *distal* here denotes pointing that is not close to touching (e.g., more than about 2 inches/5cm away).

0 = Points with index finger to show visually-directed referencing (coordinated gaze to object and person) of distal objects in at least two contexts.

1 = Uses pointing to reference objects, but without sufficient flexibility or frequency to meet criteria for a rating of 0 (e.g., only one instance of pointing that fits the preceding description for a 0 rating, or absence of coordinated gaze with distal pointing though the child may vocalize); OR produces an approximation of pointing rather than an index finger point; OR coordinates only pointing that includes touching a picture or other nearby objects with gaze or vocalization; OR points only to a person or to himself/herself.

2 = Points only when close to or actually touching an object, without coordinated gaze or vocalization.

3 = Does not point to objects in any way.

Associations between Pragmatics Task scores and individual scores on the six specific ADOS items pertaining to joint engagement (to reiterate: 'Pointing', 'Gestures', 'Response to joint attention', 'Initiation of joint attention', 'Showing' and 'Unusual eye contact') were explored. Results of chi-squares were not significant. In order to determine a possible explanation for these findings, children's individual scores were examined. Based on this inspection, it appeared that the lack of significant results may have been due to limited variability; that is, most of the children received scores of 0 or 1 on the target ADOS items, indicating that they were showing less abnormality in each area than some of their peers.

Re-running these tests and including the children who did *not* pass the Familiar Object trial (thus increasing the range of scores) yielded significant results for the 'Response to Joint Attention' item, such that the children who failed to respond to joint attention in the ADOS (i.e. received scores of 2 or 3, indicating that they could not follow a point or would not attend to the task at all) were also the ones who were unable to pass the Familiar Object trial (Chi-square: $\chi^2 = 23.46$, df = 9, $p < .01$). In contrast, the children who passed the Familiar Object trial were all were able to follow either the examiner's gaze (codes of 0) or the examiner's point (codes of 1) to an interesting object.

Similar results were found for 'Pointing' ($\chi^2 = 18.03$, df = 9, $p < .05$), indicating that the children who did not pass the Familiar Object trial were more likely to be markedly impaired in spontaneously pointing to share their interest in or desire for an object or event. On the other hand, the children who passed the Familiar Object trial all showed the ability to use pointing to reference objects.

Part III. Word Extension Task

Of the 21 children with ASD in the Part I sample (as described above), four children with ASD were missing Word Extension Task data. Consequently, only 17 children with ASD were included in these analyses along with 17 individually matched (on expressive vocabulary, although the groups did not differ on VMA once matched) TD children; these children comprise the Part II sample. Proportions of each type of response were created for each participant: one for taxonomic responses, one for thematic responses and one for appearance responses. Table 11 provides these proportions as well as sample characteristics. Preliminary analyses revealed no effect of which specific array was used on proportions of item selection.

Wilcoxon Signed Ranks tests indicated no diagnostic group differences in the proportion of taxonomic, thematic or appearance selections. Tests within each diagnostic group indicated that, for both the TD and ASD samples, the rate of taxonomic and appearance selections were significantly greater than the rate of thematic selections (Wilcoxin Signed Ranks tests, $p < .01$) but were not different from each other. For the TD sample, taxonomic and appearance selections occurred at a rate greater than chance (Wilcoxin Signed Ranks tests, $p <.05$), while the proportion of thematic selections was less than would be expected by chance ($p <.01$). In the ASD sample, the proportion of taxonomic choices was greater than chance ($p < .01$), and the proportion of thematic selections was less than chance

($p < .01$). However, the rate of appearance selections did not differ from chance levels ($p = .10$)

As mentioned in the introduction, previously published literature has indicated that there is a shift in how children generalize words sometime after age 2 years. Therefore, in order to approximate this comparison as closely as possible (given the limited age range of the current sample), the sample was split according to whether VMA was (1) equal to or less than 24 months, which included 8 TD children and 6 ASD children; or (2) greater than 24 months, which included 9 TD children and 11 ASD children. As above, diagnostic group comparisons (Mann-Whitney tests) were not significant for any of the three proportions. In addition, the younger and older children did not show significant differences in their pattern of item selection.

Part IV. Comparison with Previous Literature: TD sample only

In order to evaluate the typicality of the performance of the TD sample relative to previously published literature, a brief review and comparison will be provided, using the findings reported by Woodward and colleagues (1994), as well as those reported by Baldwin (1993). Each task will be reviewed in turn. It is important to note two important methodological discrepancies between the present investigation and the previously published works: the current study used a one-trial pass/fail design, whereas the Woodward *et al.* (1994) and Baldwin (1993) investigations employed multiple trials and explored the number of trials successfully passed by each participant. In addition, chance levels were 50% in previous investigations and 33% in the present investigation.

The Familiar Object trial is similar to tasks completed by both Woodward *et al.* (1994) and Baldwin (1993). Both the Woodward *et al.* and Baldwin studies compared children of different age groups: Woodward and colleagues compared children 13 months of age to children 18 months of age, and Baldwin compared children 14-15-months-old, 16-17-months old, and 18-19-months old. Both studies found important age-related differences in performance. Therefore, in order to most closely approximate these age categories, the entire current sample of TD children (n=59) was split into 2 groups based on chronological age: children younger than 18 months of age and those 18 months and older.

In the present study, approximately 71% of the entire TD sample passed the Familiar Object trial. In the younger group (n=22), 54.55% of children passed the Familiar Object trial; in the older group (n=37), 81.08% of children passed. Both groups performed significantly better than what would be expected by chance, or 33%, $p < .01$. This is consistent with what was observed in the Woodward *et al.* study ("Study 1" is used as the comparison study for the present purposes), in which 13-month-olds were successful in 68% of familiar label trials and 18-month-olds were successful in 76% of trials; both groups performed above chance levels. Similarly, Baldwin reported that her sample of children younger than 18 months were successful (on average) on familiar labels 72% of the time, and children 18 months and older were successful (on average) 76% of the time; both groups performed above chance levels. Overall, the children in the present samples perform at similar levels to what has been reported by others.

Results for the Novel Labeling Task were compared to findings reported by Woodward *et al.* (1994). The same age categories as above (i.e., under and over 18 months of age) were used because of the previously established age-related differences in similar tasks. All 42 children who passed the Familiar Object trial were included. Of the 12 children under 18 months of age, 7 (58.337%) passed the Novel Labeling Task, a rate which was marginally different from chance ($p = .06$). Of the 30 children in the older group, 53.33% (n=16) passed the activity, which was greater than would be expected by chance (p < .05). Comparison to the results of Woodward *et al.* varies according to which study (out of four reported in the paper) is used. The range of successful performance in new label trials reported for 13-month-olds was 50% (in the least optimal condition, not significantly different from chance level) to 70% (in optimal conditions, significantly above chance levels). Likewise, the range of success rates for 18-month-olds was 56% (in the least optimal condition, not significantly different from chance) to 88% (in the optimal condition, significantly greater than chance). Overall, then, it appears that the older children in the present investigation – like in the previous studies – consistently passed this task at a rate greater than chance, whereas the younger children did not.

In terms of performance on the generalization trials, a direct comparison with Woodward *et al.* (1994) is not feasible. The present investigation administered the generalization trial only if the child successfully passed the labeling trial, whereas Woodward and colleagues administered this condition to all children. However, a summary of the findings from Woodward *et al.* is offered for a general comparison. Woodward's 13-month-olds did not perform significantly above chance levels in any condition, although in the optimal condition, their performance with the generalization trials approached significance (66%). The 18-month-olds' best performance was 81% (significantly above chance) and their worst was 63% (not statistically different from chance).

In the present sample, 7 children under 18 months of age received this task and 6 of them passed (85.71%); this was significantly greater than what would be expected by chance (p < .01). For the children 18 months and older, 9 of 16 (56.25%) children successfully completed the task, a rate which was marginally greater than chance (p = .05). These results are somewhat consistent with those reported by Woodward and colleagues: the older group performed slightly below expectations, whereas the younger group did better than anticipated, perhaps because we administered this trial only to those children who succeeded in the Novel Labeling Task.

The results for the Pragmatics Task will be compared to the findings reported by Baldwin (1993). It is important to note, again, that the Baldwin paper used percent of selections over several trials, whereas the current investigation used a single session pass/fail design. The original paper by Baldwin includes three groups of young children: one group of 14- to 15-month-olds, one of 16- to 17-month-olds, and one of 18- to 19-month-olds. Baldwin (1993) reported that only the oldest age group was more likely to select the child's toy in the Follow-in condition than in the Discrepant condition. More specifically, in the Follow-in condition, the youngest group selected their toy 52% of the time (not significantly different from chance), while the older two groups selected their own toys 68% and 77% of the time (respectively, both significantly greater than chance). In the Discrepant condition, the younger two groups selected their own toy at chance levels (41% and 51%), whereas the oldest group selected their own toy only 26% of the time (significantly less than chance).

The present TD sample (using the same two age-based groups as above: under and over 18 months of age) was somewhat inconsistent with the pattern reported by Baldwin. Surprisingly, in the Follow-in condition the younger group and the older group both selected their own toy levels marginally greater than chance (41.67% and 48.29%, respectively, both $p = .06$). The results were also unclear for the Discrepant condition, in which the younger group and the older group (as expected) selected their own toy at a level less than chance (25% and 13.33%, respectively).

It is unclear why the typically developing children – particularly the older children – in the current investigation did not perform as clearly as those in Baldwin's original study.

However, one possible interpretation was introduced by Woodward and colleagues when faced by a similar conundrum in their own project. They reported that in their Study 3, in contrast to their Studies 1 and 2, the older children suddenly performed only at chance levels (similar to the current sample) while the younger children did much better overall. They interpreted this as a possible indication that some of the details of Study 3 (using nine label repetitions instead of two, which was adopted by the present investigation in order to increase the likelihood of success for developmentally younger children) might have made the procedure "boring" for the older children (Woodward *et al.*, 1994, p. 562). It is feasible that this confound was present also in the current investigation.

The Word Extension Task is sufficiently different from previous studies to make direct comparisons difficult. However, a brief comparison will be made between the two studies which provided a rough framework for the Word Extension Task and the results from the current investigation. Markman and Hutchinson (1984) had a sample of 4- and 5-year-olds. They reported that, in generalizing a basic-level word – a known object label – to either taxonomically or thematically related pictures (note that there was no appearance related alternative), the children chose the taxonomically related image 57% of the time. In the paper by Imai and colleagues (1994), the first experiment indicated that the percentage of taxonomic, appearance (i.e., shape), and thematic related selections differed across 3-year-olds (10%, 68% and 21%, respectively) and 5-year-olds (28%, 56% and 16%, respectively). That is, selections were primarily driven by appearance but taxonomic selections increased with age. However, these experiments used *novel* words, not familiar ones. The authors also reported that if they provided additional categorical information (making it more similar to the activities used by Markman and Hutchinson and the current investigation), children were less likely to select the shape-related picture and more likely to make a taxonomic based selection.

These findings are generally consistent with the results of the present investigation, which found that selections were based largely on taxonomy and appearance, rather than on thematic relations. The indication that, with additional familiarity with the objects, the proportion of taxonomic and appearance selections become more equivalent is also consistent with the present investigation (which used familiar, not novel, labels). Unfortunately, a more extensive evaluation of the comparison with these previous studies is not possible, because the children in the present sample are younger than those in the previous investigations and do not bridge the same developmental period. That is, although the present investigation did not detect age-related differences, it is likely that our sample did not include the necessary age range in order fully address this question of developmental change.

Chapter IV

Discussion

The results will be discussed in order of the hypotheses presented in the Introduction; first, the preliminary hypotheses will be addressed, followed by the central hypotheses. The first preliminary hypothesis stated that the TD children who passed the Familiar Object trial would be older than those who didn't, and that this age difference would not be found in the ASD and DD/LD samples. Analyses confirmed this, but only for the ASD sample (the DD/LD sample was too small to permit comparisons). These results suggest chronological age is associated with important developmental attainments, but that this relationship was unique to the TD sample; such findings have been reported in similar previous studies (Parish *et al.*, in press). The second preliminary hypothesis stated that, for the ASD and DD/LD samples, IQs would be higher in the children who passed than in those who didn't, and that this difference would not be observed in the TD sample. Although analyses supported this difference for the ASD sample, they also confirmed this IQ difference for the TD sample (which was not predicted); overall, then, general cognitive ability appeared to be an important factor of performance for children with and without ASD. Finally, the third preliminary hypothesis stated that, within the children who passed the Familiar Object trial, the mental age of the ASD sample would be higher than that of the comparison samples, and the chronological age of the ASD sample would be higher than that of the TD (but not DD/LD) sample. These predictions were only partly confirmed:

there were no mental age differences between the groups of children who passed the task. However, as anticipated, the ASD and DD/LD groups were not different in chronological age, and both were older than the TD group. The lack of mental age differences, although not predicted, may have been partly the results of the limited chronological age range and considerable mental age variability within that group. On the other hand, the observed age difference is consistent with the anticipated general developmental delay of children with ASD and DD/LD. Taken together, these findings may be a marker that this young group of children with ASD who passed the Familiar Object trial is not as impaired as previous samples; that is, they experience a chronological delay in skills, but not a clear delay in terms of mental age when compared to non-ASD peers.

The first central hypothesis stated that the ASD sample and TD sample would not differ in tasks that did not require social referencing – that is, in the Novel Labeling Task and the Follow-in condition of the Pragmatics Task. The results were consistent with this, and will be addressed for each activity in turn.

Accuracy of performance in the Novel Labeling Task did not differ across groups, and both groups performed above chance levels. Not surprisingly, the Novel Labeling Task appeared to be the task which was easiest for the children in the current investigation. This ability – mapping a new word in the presence of a novel object – appeared to be unique (at least within this relatively high-functioning sample), in that it was not accounted for in a simple way by related factors. In a sample of this size, such group differences (if present) are likely to be clouded by considerable individual variability. Nonetheless, it appeared that the children with ASD who passed this task did so at a different point in their development than their TD peers; the children with ASD were nearly a year older chronologically (as one would expect in a group of children characterized by developmental delay) and had lower IQ scores, although again, there were no differences in mental age associated with passing the activity.

One particularly interesting aspect of the performance of the ASD sample is that, *if* they pass the Novel Labeling Task, their mapping of the word appears to be much more robust than that observed in the TD group. This is evidenced by their stronger performance in the generalization trial. These findings – of the facility of children with ASD in some word learning situations – are consistent with recent reports of the ability of children to *map* words (Baron-Cohen *et al.*, 1997; McDuffie *et al.*, 2006a; Parish *et al.*, in press; Preissler & Carey, 2005; Swensen *et al.*, 2007). However, this somewhat contradicts previous observations of the difficulty that children with ASD have in *generalizing* words. Researchers (Baron-Cohen *et al.*, 1997) have noted the tendency of children with ASD to use words in rigid, specific ways; instead, the current findings suggest that children with ASD not only can learn a word relatively quickly, but they can then flexibly generalize that word to a new exemplar differing in color. It will be important for future research to test the limits of this skill across different kinds of words, objects and situations. It may also be informative to explore this ability across different children on the autism spectrum with varying levels of verbal and nonverbal skill.

The apparent integrity of word learning skill in children with ASD was also observed in the results for the Follow-in condition. Results for the children with ASD were generally similar to those for the TD group, a finding which was consistent with Central Hypothesis #1. In fact, the ASD sample did somewhat *better* than the TD group, in that although both groups selected their toy at chance with younger VMA, only the ASD group selected their toy above chance levels in the older VMA group. Overall, nearly 60% of the children with ASD successfully passed this task. This is in agreement with previous reports that have found no impairment when the examiner is labeling the object which is already the focus of the child's attention (Baron-Cohen *et al.*, 1997; McDuffie *et al.*, 2006a; Preissler & Carey, 2005).

The first set of exploratory analyses was used to address group differences in the Discrepant condition of the Pragmatics task, an activity which required social referencing. The results indicated that there was no effect of diagnostic group in the Discrepant condition. In addition, once the groups had been divided based on their VMA, neither the younger nor older MA groups revealed diagnostic group differences. Indeed, as above, the ASD group did as well (or perhaps better) than the TD group. While the younger VMA TD group selected their toy at chance (as expected) in the Discrepant condition, the younger VMA ASD group selected their toy at *less* than chance, a behavior typically associated with older children. Certainly, these results for the younger MA groups are limited by very small sample sizes; results for the older TD and ASD VMA groups were similar, in that both selected their toy less than chance, as anticipated.

Overall, the performance of the ASD sample is in line with the findings of Baldwin (1991, 1993) and suggests that the children with ASD (at least, those in the older MA group) were successfully using social information to guide their word-object mapping. In addition, the present investigation found not only that the typically developing children and those with ASD did not show differences in rates of successful mapping, but they also appeared to have the same pattern of mastery, in that their response to the two different conditions became more differentiated with developmental age. In this, too, the ASD group had a clearer pattern of response than the TD sample (at least, when considering only the 21 TD children in the matched sample).

These results are inconsistent with those reported by previous studies using a similar methodology in older, more language-impaired children with ASD (Baron-Cohen *et al.*, 1997; Preissler & Carey, 2005), both of which reported that children with ASD were not successful at using social information to map new words. Because this discrepancy could be due to differences in analytic strategy, an extra set of analyses were added to the present investigation in order to make the analyses more parallel. The results of these additional analyses were again in contradiction to previously published results. They indicated that, within the children with ASD, more children used a "speaker direction of gaze" strategy (mapping the word to the object that is the focus of the *speaker)* than used a "listener direction of gaze" strategy (mapping the word to the focus of their own attention). Even in an analysis which included only those children with substantial language impairment, the current study failed to find evidence for a consistent LDG strategy in the ASD sample.

The second central hypothesis predicted that performance in the word learning tasks would be associated with measures of language and joint attention. Results did not clearly substantiate these claims and are somewhat inconsistent with previous literature (McDuffie *et al.*, 2006a; Parish *et al.*, in press). The current analyses did not indicate any relationship with language as measured by the MSEL or CDI. In addition, performance in the Pragmatics Task was not related with joint attention as measured by the ADOS (although, as will be discussed below, there were important differences in ADOS scores between children who did and did not pass the Familiar Object trial). The lack of significant findings in the present investigation may have been due to limited variability in the "scores" from the word learning tasks, particularly as there were clear measurement differences between the present and previous investigations (both of which used scores with much greater ranges than the current study).

Results from the Word Extension Task addressed the second exploratory research question. The TD and ASD groups generalized words in a similar fashion, in that neither group seemed to select items primarily based on "kind;" both used taxonomy and appearance to guide their object choices (although for the children with ASD, the rate of appearance selections did not differ from chance). These findings are among the first to address word extension in children with ASD. They are consistent with other findings about linguistic categories in children with ASD (Shulman *et al.*, 1995; Tager-Flusberg, 1985a, 1985b; Ungerer & Sigman, 1987), but unlike previous investigations of typically developing children, there did not appear to be a developmental shift in children's object choices. However, the study included a limited range of both chronological and mental age. It will be important to replicate these findings with a broader sample and consider them in the context of other preliminary reports which have called into question the presence of a "shape bias" in children with ASD (Tek, Jaffery, Swensen, Fein, & Naigles, 2007).

All of the above conclusions provide valuable empirical evidence. However, interpreting these results requires attention to the characteristics of the children who passed the tasks. It is first worth noting that all the children who were administered these activities were ones who could complete a socially-driven task of complying with an expectation or instruction (Familiar Object trial, see Table 2); completing this task was associated with IQs in the average range. This was also the case for all three target word learning activities (see Tables 5, 7 and 8). In addition, the children with ASD who were able to complete these tasks were older than their TD counterparts.

There are important implications to these observed characteristics. Children with ASD are delayed in their ability to complete word learning tasks; this should not be surprising, based on what is known about the general development of children with ASD and the development of joint attention skills in particular. Based on the present sample, it appears that general cognitive skill (even for the TD group) has a bearing on a child's ability to attend and meaningfully complete a task with relatively complex demands, whether in terms of simply sitting at a table and following instructions or in terms of monitoring their activity partner and reading social cues. This is consistent with findings that low-ability children with ASD have a particularly difficult time responding to all kinds of attention bids, whether vocal, visual, or physical contact (Leekam & Ramsden, 2006), and suggests that the task demands of these activities may be overwhelming for a number of children on the spectrum.

On the other hand, for children with less pronounced cognitive deficits, these situations may be meaningful and developmentally significant. Indeed, the relatively high cognitive ability of the current ASD sample (at least, those who successfully passed the Familiar Object trial) is a marked difference from the children included in the samples of Baron-Cohen *et al.* (1997) and Preissler and Carey (2005). It is possible that the present sample – a younger, less impaired group of children with ASD – represents a different group of children within the autism spectrum. Certainly, a number of these children had minor language delay, but few of them had profound language impairment. Research has indicated that, by mid- to late-childhood, children with ASD and a history of language delay are not consistently distinguishable on measures of language from their peers who did not have a language delay (Eisenmajer *et al.*, 1998); overall, it appears that children without a language delay, or even ones with a minor delay, may be on a very different developmental trajectory than those with profound early impairment.

Clearly, a certain level of cognitive and joint attention ability is required in order for a child to negotiate word learning tasks (usually attained by 18 months of age, as reported in

Baldwin, 1991, 1993). Not only were the children with ASD who successfully completed the word learning tasks generally of average intelligence, they were also – like their typically developing counterparts – the ones who have some mastery of joint attention. It is important perhaps to note that this does not indicate that joint attention is intact in autism, because of larger considerations (beyond the scope of the current investigation) having to do with timing, flexibility, consistency and integration of joint engagement abilities.

The finding that a substantial proportion of the ASD sample succeeded both in the joint attention and word learning situations may perhaps be counter-intuitive to our general understanding of ASD, which is largely characterized by the assumption that these kinds of situations are not negotiable for children with ASD. Nonetheless, it is consistent with the growing body of evidence suggesting that there is considerable heterogeneity in social engagement skills within the ASD population (Carpenter *et al.*, 2001; Sigman & McGovern, 2005). It may be helpful to again invoke broader theories of developmental pathways in autism spectrum disorders. The *social motivation hypothesis* (Dawson *et al.*, 2002; Mundy & Neal, 2001) posits that a number of observed impairments in autism – particularly those having to do with joint attention – are "down-river" disturbances of an early disruption of a child's motivation to attend to social stimuli. One possible mechanism of this motivational disturbance is that, unlike a typically developing child, a child who later develops ASD may not neurologically experience positive emotional feedback from social information. As such, individual differences in a child's social attention (even within the ASD population) will have important implications for the acquisition of joint engagement skills – and in fact, Dawson and colleagues (2004) have shown that the relationship between social orienting and language is mediated by a child's joint attention skills. Research has also indicated that, although joint attention ability discriminates children with ASD from those without ASD

(Charman *et al.*, 1998; Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998), the groups are better defined by including information about children's skills in social orienting (Dawson *et al.*, 2004).

Indeed, there were children in the present sample who were able to score well on the joint attention items on the ADOS but who did not succeed in the Pragmatics Task, a finding which may indicate some limitations or more subtle impairments of joint attention skill. These children (relative to their peers who succeeded in the tasks) had lower VIQ on average, and four of them had language scores in the impaired range. Notably, these children did not make consistent errors in the pragmatics task (unlike those in previously reported samples), which may have been a consequence of the additional scaffolding provided in the current investigation. Overall, this may indicate a consequential interplay between cognitive ability and joint engagement. In order to address this question, it will be important to explore developmental relations and mechanisms which lead up to word learning skills: does joint attention need to be accompanied by other abilities, such as relative mastery of more general social orienting skill or a certain level of cognitive development? Do all children who develop joint attention eventually proceed to master word learning situations? In addressing these questions, it will be valuable to have a more fine-grained measure of joint engagement skills than the ADOS, which is based on fairly discrete activities.

The lack of a relationship between performance in the word learning tasks and concurrent measures of language is inconsistent with previous literature (McDuffie *et al.*, 2006a; Parish *et al.*, in press); however, (as described in the Introduction), these previous findings are not firmly established, and there are considerable methodological differences between past and present investigations. The difference in language scores between children who did and did not pass the Familiar Object trial is more marked than between different word learning scores (although differences do appear in the expected direction, they are not significant). It may be the case that, if there were a more nuanced measure of word learning performance, or if there had been a wider chronological and developmental age range within the children who passed the Familiar Object trial, significant differences might have emerged. Future research should continue to investigate this issue using different samples and measurement approaches; it also is valuable to consider this question both concurrently and longitudinally.

In light of the above conclusions, it is important to revisit the central question presented earlier: does it appear to be the case that (1) children with autism use the same mechanisms to acquire words as do typically developing children; or is it that (2) children with autism use different (or perhaps immature) processes to learn new words? The present findings suggest that the former explanation may be more appropriate, although there remain unanswered questions. That is, *if* a child with ASD successfully masters the necessary cognitive and social communication skills, a considerable proportion of them – like their typically developing peers – are able to recruit social information in word learning situations. Conversely, for the children with ASD who are more impaired in social communication and cognition, these kinds of word learning situations are not accessible.

Overall, then, it does not appear to be the case that children with ASD are universally unable to learn words through the "pragmatics" approach, a finding which strongly refutes the idea that there is something inherently different about the process of learning new words in all children with ASD. Nonetheless, there are some very central issues which must be addressed. First, within the sub-group of children with ASD who have some joint engagement skills, why are some able to succeed in these word learning situations and some not? It is possible that there may be meaningful degrees of skill pertaining to joint engagement (e.g., ability to follow single vs. multiple cues, gestural cues but not gaze, broad social orienting ability), or that there are developmental or cognitive differences (e.g., mental age, visual disengagement skills), or that the child requires more or less scaffolding within a learning situation. Perhaps more realistically, it may also be a combination of the above factors and many others. More broadly, within all children on the spectrum, what is the range of word learning skill? It is evident that, at least by early childhood, not all children master the most complex word learning situations. It may be possible to locate a child within a developmental pathway of word learning which may help to explain observed impairments within some segments of the population (e.g., idiosyncratic and highly specific use of words).

There are important points to be noted about the "real world" significance of these findings. First, it is clear that it is a relatively small subset of children with ASD who can succeed across these word learning tasks. Moreover, it is questionable whether the current word learning situations in any way approximate the kinds of situations that are naturally encountered by young children on the spectrum, because the general design of the study was modified in order to "scaffold" the children to be successful. This was done in a number of ways, including repeating the label nine times, rather than two, as had been done by Baron-Cohen and colleagues (1997) and Preissler and Carey (2005); by providing highly interesting toys (as in Parish *et al.*, in press); by including fewer distracter objects than Baron-Cohen *et al.* (1997) and employing an additional social cue (facial orientation). The overall completion of the activity, which was structured by a motivated and attentive examiner, is also likely more optimal than the average "everyday" activity. As intended, all of our modifications may have increased the likelihood that children were able to succeed in these tasks. However, in situations where a child is required to use social information to learn a word heard only once or twice, a child with ASD may not be so proficient. This could be a very meaningful distinction, because the word learning situations which are typical of a child's daily interactions may *not* be ones from which a child with ASD can learn. Future research should work to operationalize the ways in which the actual word learning situations which occur in the lives of children with ASD differ from these laboratory-based settings, as well as any resultant differences in child learning.

Gaining a better understanding of the robustness of word learning skill will be important to understand how this ability may be related to other cognitive and social skills. That is, if (1) delays in joint attention are already slowing the language development process; and (2) children with ASD require more explicit labels than are usually provided, then the combination of these factors could certainly result in a delay in vocabulary development. However, both of these components could easily be addressed through intervention efforts. Interventions have been developed which support children in learning joint attention skills (Kasari, Freeman, & Paparella, 2006; Whalen, Schreibman, & Ingersoll, 2006). Teaching these skills is an important first step – indeed, response to intervention and rate of improvement over time appears to be mediated by a child's joint attention skills (Bono, Daley, & Sigman, 2004; Sigman & McGovern, 2005; Yoder & Stone, 2006).

After joint attention skills have been established, caregivers and educators could be encouraged to teach single words within very structured and highly repetitive situations. While children are mastering these skills, it may be helpful to make the target object particularly salient, by holding it, moving it and selecting very interesting objects. It is useful to note that this strategy – using lots of repetition and very motivating objects – is not new to ASD intervention, nor does it need to be employed in an explicit teaching session

(Koegel, 2000). Rather, it specifies a way of speaking to children with ASD and structuring play in a way that may have beneficial effects for their acquisition of new words. Whereas previous investigations have suggested that following (rather than directing) a child's attention may be key for supporting language development (McDuffie *et al.*, 2006a; Siller & Sigman, 2002); the current results suggest that although this may be the case for children who are not yet able to follow joint attention, a wider range of "shared interest" situations are appropriate for children who can interpret a partner's gaze.

There are limitations of the present investigation which should be acknowledged and addressed by future research. Despite our efforts to identify a DD/LD comparison group, we were unable to recruit a sufficient number of participants. This is partly an artifact of the target group, because (unlike children with ASD, who evidence symptoms of abnormality within the first year or two of life) a number of children with DD/LD may not have identifiable cognitive or language delays early in life. In addition, they may have other handicaps (i.e., profound cognitive impairment, difficulties with attention) that make these kinds of activities particularly difficult to administer meaningfully. Fortunately, because the current ASD group was not significantly impaired, the lack of a DD/LD comparison sample does not substantially limit the present findings. Nonetheless, future research should refine these methods using a comparison sample which is closely matched to the ASD children on cognitive ability.

Furthermore, the overall sample of the present investigation was small; this has important implications for the power of the analyses. We also noted that although the typically developing sample generally performed as anticipated, results (particularly for the Pragmatics Task) were not as clear as in previous studies. Finally, the approach of the present investigation (which included both longitudinal and cross-sectional participants) may have clouded some aspects of the study, particularly having to do with "entry" to the project. However, one of our central questions was whether some children with ASD can negotiate a range of word learning situations, and the answer is clearly "yes."

Historically, our understanding of ASD has been largely based on identifying clear group deficits which provide diagnostic boundaries. However, it is becoming increasingly evident that there are degrees of skill across individuals – particularly in areas such as joint engagement and language – which do not necessarily conform to such well-defined group distinctions. Although complex, these nuances of individual differences contain much of the developmental richness which we must explore in order to accurately present of the features of ASD. These findings add to our theoretical models of development and can contribute to our plans to effectively intervene and improve the lives of individuals who experience ASD.

Table 1. Overall sample demographics

	TD N=59	ASD N=29	DD/LD N=12
Male*	38 (63.64%)	27 (93.10%)	9 (75.00%)
Female	21 (36.36%)	2 (6.90%)	3 (25.00%)
Race*			
Caucasian	55 (93.22%)	24 (82.76%)	7 (58.33%)
African-American	--	1 (3.45%)	2 (16.67%)
Asian/Pacific Islander	1 (1.69%)	--	--
Bi-racial/Other	3 (5.09%)	4 (13.79%)	3 (25.00%)
Maternal Education* †			
At least a 4 year college degree	49 (83.05%)	22 (75.86%)	9 (75.00%)
Some college/associate's degree	5 (8.47%)	4 (13.79%)	1 (8.33%)
Highschool diploma/G.E.D. or less	3 (5.08%)	3 (10.35%)	--
Mean Chronological Age (in months)**	19.05 (*SD* = 3.76)	29.59 (*SD* = 10.54)	34.50 (*SD* = 12.51)
Mean Nonverbal IQ (NVIQ)**	112.58 (*SD* = 15.92)	86.41 (*SD* = 21.46)	70.50 (*SD* = 24.54)
Mean Nonverbal MA (NVMA)*	21.62 (*SD* = 4.67)	25.12 (*SD* = 8.11)	24.41 (*SD* = 5.45)
Mean Verbal IQ (VIQ)**	104.93 (*SD* = 15.75)	72.39 (*SD* = 25.80)	62.59 (*SD* =16.20)
Mean Verbal MA (NVMA)	20.58 (*SD* = 5.38)	20.29 (*SD* = 9.03)	20.95 (*SD* = 6.46)
Mean Number of Words Said on CDI	101.81 (*SD* = 97.97)	104.48 (*SD* = 98.22)	91.78 (*SD* = 80.82)

† Maternal education data missing for 2 TD children and 2 DD/LD children
* groups significantly different $p < .05$; ** groups significantly different $p < .01$

Table 2. Characteristics of children according to performance on the Familiar Object trial: Means and standard deviations (in parentheses)

Group	Sample	Performance	Chronological Age (in months)	Nonverbal IQ	Nonverbal MA	Verbal IQ	Verbal MA	Expressive Vocabulary (CDI)
TD (n=59)	Longitudinal (n=2)	No Pass (n=1)	14.00 --	104.00 --	14.50 --	111.09 --	16.00 --	28.00 --
	Cross-sectional (57)	No Pass (n=17)	17.18 (3.94)	104.94 (15.91)	18.50 (3.41)	98.00 (14.73)	17.47 (4.26)	56.35 (71.84)
	Longitudinal (n=2)	Pass (n=2)	14.00 [a] (1.41)	109.00 [a] (7.07)	15.19 [a] (0.51)	112.50 [a] (2.12)	15.79 [a] (1.92)	22.50 [aa] (20.51)
	Cross-sectional (57)	Pass (n=40)	20.25 (3.53)	116.48 (15.55)	23.38 (4.30)	107.00 (15.27)	22.14 (5.25)	125.10 (101.82)
ASD (n=29)	Longitudinal (n=17)	No Pass (n=7)	23.67 (5.57)	88.51 (9.17)	21.89 (4.23)	77.03 (18.37)	17.05 (7.00)	73.80 (114.46)
	Cross-sectional (n=12)	No Pass (n=7)	34.43 (6.97)	66.73 (12.87)	23.78 (4.14)	42.47 (16.60)	13.66 (2.75)	49.17 (35.24)
	Longitudinal (n=17)	Pass (n=16)	23.06 (8.05)	96.88 [b] (15.12)	23.32 (7.91)	84.93 [bb] (18.01)	20.02 [bb] (8.40)	85.20 (103.70)
	Cross-sectional (n=12)	Pass (n=5)	40.60 (11.84)	85.81 (35.67)	32.81 (11.34)	84.98 (27.45)	32.61 (6.98)	202.40 (59.07)
DD/LD (n=12)	Longitudinal (n=2†)	No Pass (n=1)	24.00 --	85.00 --	20.28 --	72.75 --	17.46 --	N/A --
	Cross-sectional (n=10)	No Pass (2)	44.50 (30.41)	59.00 (14.14)	18.50 (0.71)	49.50 (0.71)	14.25 (3.89)	105.50 (88.39)
	Longitudinal (n=2†)	Pass (n=2)	27.50 (0.71)	74.00 (12.73)	20.96 (2.06)	52.75 (16.62)	15.45 (2.77)	1.00 --
	Cross-sectional (n=10)	Pass (n=8)	32.38 (8.31)	72.79 (29.81)	26.00 (5.74)	69.14 (15.87)	23.68 (6.06)	98.17 (88.88)

[a] Significantly higher than TD 'No Pass' group, $p < .05$, [aa] Significantly higher than TD 'No Pass' group, $p < .01$

[b] Significantly higher than the ASD 'No Pass' group, $p < .05$; [bb] Significantly higher than the ASD 'No Pass' group, $p < .01$

† CDI data missing for one participant

Table 3. Characteristics of longitudinal participants across two visits (based on not passing/passing Familiar Object trial)

		Chronological Age (in months)	Nonverbal IQ	Nonverbal MA	Verbal IQ	Verbal MA	Expressive Vocabulary (CDI)
TD (n=1)	No Pass	14.00	104.00	14.50	111.09	16.00	28.00
		--	--	--	--	--	--
	Pass	15.00	104.00	15.54	114.00	17.14	104.00
		--	--	--	--	--	--
ASD (n=6)	No Pass	24.00	88.02	21.89	78.44	17.06	73.80
		(6.16)	(10.16)	(4.23)	(16.62)	(7.00)	(114.46)
	Pass	29.20	86.02	26.69	75.05	23.78	182.50
		(10.23)	(10.54)	(8.37)	(13.30)	(9.09)	(86.87)
DD/LD (n=1)*	No Pass	24.00	85.00	20.28	72.75	17.46	N/A
		--	--	--	--	--	--
	Pass	27.00	83.00	22.41	64.50	17.42	N/A
		--	--	--	--	--	--

* Missing CDI data

Table 4. Part I: Matched sample characteristics

	ASD N=21	TD N=21
Male*	20 (95.24%)	15 (71.43%)
Female	1 (4.76%)	6 (28.57%)
Race		
Caucasian	18 (85.70%)	20 (95.24%)
African-American	1 (4.76%)	--
Asian/Pacific Islander	--	--
Bi-racial/Other	2 (9.54%)	1 (4.76%)
Maternal Education		
At least a 4 year college degree	18 (85.72%)	19 (90.48%)
Some college/associate's degree	2 (9.52%)	2 (9.52%)
Highschool diploma/G.E.D. or less	1 (4.76%)	--
Mean Chronological Age (in months)***	30.86 (*SD* = 10.49)	20.19 (*SD* = 3.02)
Mean Nonverbal IQ (NVIQ)***	95.17 (*SD* = 23.04)	115.14 (*SD* = 14.61)
Mean Nonverbal MA (NVMA)**	28.55 (*SD* = 9.04)	23.00 (*SD* = 4.23)
Mean Verbal IQ (VIQ)***	82.33 (*SD* = 19.81)	112.24 (*SD* = 15.43)
Mean Verbal MA (VMA)	25.29 (*SD* = 8.87)	23.02 (*SD* = 5.10)
Mean Number of Words Said on CDI	158.15 (*SD* = 102.01)	156.48 (*SD* = 110.18)

* groups marginally different, $p = .05$
** groups significantly different, $p < .05$
*** groups significantly different, $p < .01$

Table 5. Part I: Performance in the Novel Labeling Task, means and standard deviations (in parentheses)

	ASD		TD	
	Fail (n=5)	**Pass (n=16)**	**Fail (n=7)**	**Pass (n=14)**
Chronological Age (in months)	37.00 (14.19)	28.94[a] (8.75)	20.43 (3.69)	20.07 (2.79)
Mean Nonverbal IQ (NVIQ)	85.61 (37.74)	98.16 (16.97)	112.57 (16.60)	116.43[b] (14.00)
Mean Nonverbal MA (NVMA)	29.40 (8.09)	28.29 (9.55)	23.07 (4.79)	22.97 (4.12)
Mean Verbal IQ (VIQ)	75.78 (33.47)	84.39 (14.34)	114.29 (14.59)	111.21[b] (16.26)
Mean Verbal MA (VMA)	26.70 (10.21)	24.85 (8.73)	23.93 (5.74)	22.56 (4.92)
Number of Words Said on CDI	161.85 (126.55)	157.00 (97.98)	153.57 (119.54)	157.93 (109.88)

[a] Significantly higher than TD 'Pass' group, $p < .05$

[b] Significantly higher than the ASD 'Pass' group, $p < .01$

Table 6. Part I: Performance in the Novel Labeling Task, Generalization, means and standard deviations (in parentheses)

	ASD		TD	
	Fail (n=1)	**Pass (n=14)**	**Fail (n=5)**	**Pass (n=9)**
Chronological Age (in months)	36.00	29.29[a] (8.57)	21.60 (3.21)	19.50 (2.32)
Mean Nonverbal IQ (NVIQ)	75.00	99.33 (16.91)	118.20 (15.51)	115.44[b] (13.97)
Mean Nonverbal MA (NVMA)	29.00	28.99 (9.81)	25.10 (5.26)	21.79 (3.05)
Mean Verbal IQ (VIQ)	99.00	83.51 (14.82)	116.60 (22.14)	108.22[bb] (12.51)
Mean Verbal MA (VMA)	35.00	24.90 (8.42)	25.70 (7.19)	20.82 (1.98)
Number of Words Said on CDI	224.00	163.36 (93.89)	235.00 (134.31)	115.11 (69.46)

[a] Significantly higher than TD 'Pass' group, $p < .01$

[b] Significantly higher than the ASD 'Pass' group, $p < .05$

[bb] Significantly higher than the ASD 'Pass' group, $p < .01$

Table 7. Part I: ASD performance in the Pragmatics Task - Follow-in condition, means and standard deviations (in parentheses)

	Fail (n=9)	Pass (n=12)
Chronological Age (in months)	32.33 (14.34)	29.75 (6.89)
Mean Nonverbal IQ (NVIQ)	91.34 (24.46)	98.05 (22.56)
Mean Nonverbal MA (NVMA)	27.36 (8.91)	29.45 (9.42)
Mean Verbal IQ (VIQ)*	70.21 (17.61)	91.43 (16.65)
Mean Verbal MA (VMA)	21.44 (7.68)	28.17 (8.88)
Number of Words Said on CDI	139.56 (106.10)	172.10 (101.19)

* groups significantly different $p < .05$

Table 8. Part I: ASD performance in the Pragmatics Task - Discrepant condition, means and standard deviations (in parentheses)

	Fail (n=11)	Pass (n=10)
Chronological Age (in months)	31.91 (13.24)	29.70 (6.87)
Mean Nonverbal IQ (NVIQ)	89.37 (23.37)	101.55 (22.06)
Mean Nonverbal MA (NVMA)	27.06 (8.22)	30.19 (10.04)
Mean Verbal IQ (VIQ)*	73.72 (17.82)	91.82 (18.13)
Mean Verbal MA (VMA)	22.59 (7.63)	28.26 (9.55)
Number of Words Said on CDI	143.93 (112.33)	173.80 (92.66)

* groups significantly different $p < .05$

Table 9. Part II: Language scores (means and standard deviations) by "no social information" (NSI) scores, ASD sample only

	No pass Familiar Object trial (n=14)	Score = 0 (n=1)	Score = 1 (n=12)	Score = 2 (n=8)
Words said (on CDI)	61.49 (76.04)	103.00 (--)	154.94 (117.20)	169.88 (86.83)
Receptive language age equivalent (on MSEL)	14.90 (4.95)	23.00 (--)	23.06 (10.87)	28.95 (9.26)
Expressive language age equivalent (on MSEL)	15.10 (6.10)	22.00 (--)	23.86 (8.28)	27.73 (7.56)

Table 10. Part II: Language scores (means and standard deviations) by "social information" (SI) scores, ASD sample only

	No pass Familiar Object trial (n=14)	Score = 0 (n=11)	Score = 1 (n=10)
Words said (on CDI)	61.49 (76.04)	143.93 (112.33)	173.80 (92.66)
Receptive language age equivalent (on MSEL)	14.90 (4.95)	22.06 (8.32)	28.86 (11.24)
Expressive language age equivalent (on MSEL)	15.10 (6.10)	23.12 (7.31)	27.59 (8.16)

Table 11. Part III: Sample characteristics for children completing the Word Extension Task

	ASD N=17	**TD N=17**
Chronological Age (in months)**	30.00 (6.26)	20.82 (3.54)
Mean Nonverbal IQ (NVIQ)*	99.80 (21.21)	116.24 (16.32)
Mean Nonverbal MA (NVMA)**	30.41 (8.22)	24.07 (5.44)
Mean Verbal IQ (VIQ)**	85.46 (19.66)	112.53 (11.84)
Mean Verbal MA (VMA)	27.59 (8.13)	23.73 (4.77)
Number of Words Said on CDI	183.01 (93.99)	170.71 (93.85)
Proportion of taxonomic selections	50.00 (24.12)	46.08 (19.12)
Proportion of thematic selections	5.88 (14.06)	11.27 (16.65)
Proportion of appearance selections	36.27 (28.85)	40.69 (26.17)

* groups marginally different $p = .05$
** groups significantly different $p < .01$

Table 12. Appendix 1: Adult ratings of Word Extension Task arrays

	Items in each array			
	Distracter	Taxonomically related	Thematically related	Appearance/Shape related
Taxonomic Ratings				
Apple	*1.00*	***6.92***	*1.67*	*2.58*
Bathtub	1.25	**6.08**	4.00	2.67
Bed	*1.67*	***4.08***	*3.67*	*2.42*
Book	1.50	**5.50**	3.42	2.75
Bottle	1.67	**6.83**	3.83	2.17
Car	*1.83*	***6.83***	*5.00*	*4.83*
Crayon	1.00	**6.75**	3.83	1.83
Cup	1.50	**6.50**	4.33	2.08
Shoe	1.41	**6.66**	3.58	3.92
Spoon	1.75	**6.83**	3.83	1.91
Thematic Ratings				
Apple	*1.58*	*6.58*	***3.42***	*1.83*
Bathtub	1.64	3.91	**6.64**	1.91
Bed	*1.58*	*4.25*	***3.83***	*1.67*
Book	2.20	1.90	**5.10**	2.60
Bottle	1.09	3.72	**6.27**	1.73
Car	*2.17*	*5.33*	***6.75***	*4.33*
Crayon	1.17	3.92	**6.67**	2.75
Cup	1.42	3.83	**6.42**	1.83
Shoe	1.16	3.92	**6.83**	3.50
Spoon	2.36	4.09	**6.27**	2.27
Appearance/Shape Ratings				
Apple	*1.50*	*6.17*	*3.17*	***5.83***
Bathtub	2.08	1.42	2.58	**5.50**
Bed	*2.00*	*4.33*	*4.58*	***6.25***
Book	1.00	3.92	3.92	**6.00**
Bottle	2.42	4.08	1.08	**6.17**
Car	*1.27*	*6.50*	*1.00*	***4.12***
Crayon	1.27	3.91	1.64	**6.09**
Cup	2.17	3.25	3.50	**5.08**
Shoe	1.17	3.75	3.92	**6.08**
Spoon	1.00	4.27	2.00	**6.45**

Note: Items in bold are target item for each set of ratings, and arrays in italics were excluded based on the criteria described in Appendix I

Table 13. Appendix 2: Unmatched sample characteristics

	ASD N=21	TD N=42
Male**	20 (95.24%)	25 (59.52%)
Female	1 (4.76%)	17 (40.48%)
Race		
Caucasian	18 (85.70%)	39 (92.86%)
African-American	1 (4.76%)	--
Asian/Pacific Islander	--	1 (2.38%)
Bi-racial/Other	2 (9.54%)	2 (4.76%)
Maternal Education†		
At least a 4 year college degree	18 (85.72%)	36 (85.72%)
Some college/associate's degree	2 (9.52%)	4 (9.52%)
Highschool diploma/G.E.D. or less	1 (4.76%)	1 (2.38%)
Mean Chronological Age (in months)**	30.86 (*SD* = 10.49)	19.86 (*SD* = 3.38)
Mean Nonverbal IQ (NVIQ)**	95.17 (*SD* = 23.04)	115.76 (*SD* = 14.97)
Mean Nonverbal MA*	28.55 (*SD* = 9.04)	22.94 (*SD* = 4.46)
Mean Verbal IQ (VIQ)**	82.34 (*SD* = 19.81)	107.83 (*SD* = 15.49)
Mean Verbal MA	25.29 (*SD* = 8.87)	21.90 (*SD* = 5.25)
Mean Number of Words Said on CDI	158.15 (*SD* = 102.01)	121.17 (*SD* = 101.11)

†Maternal education data missing for one TD child
* groups signicantly different, $p < .05$; ** groups significantly different $p < .01$

Table 14. Appendix 2: Performance in the Novel Labeling Task, means and standard deviations (in parentheses)

	ASD		TD	
	Fail (n=5)	Pass (n=16)	Fail (n=19)	Pass (n=23)
Chronological Age (in months)	37.00 (14.19)	28.94[a] (8.75)	19.53 (3.12)	20.13 (3.62)
Mean Nonverbal IQ (NVIQ)	85.61 (37.74)	98.16 (16.97)	112.79 (15.96)	118.22[b] (13.97)
Mean Nonverbal MA (NVMA)	29.40 (8.09)	28.29 (9.55)	22.26 (3.83)	23.50 (4.92)
Mean Verbal IQ (VIQ)	75.78 (33.47)	84.39 (14.34)	106.95 (16.78)	108.57[b] (14.67)
Mean Verbal MA (VMA)	26.70 (10.21)	24.85 (8.73)	21.60 (5.33)	22.14 (5.28)
Number of Words Said on CDI	161.85 (126.55)	157.00 (97.98)	104.47 (87.96)	134.96 (110.83)

[a] Significantly higher than TD 'Pass' group, $p < .01$

[b] Significantly higher than the ASD 'Pass' group, $p < .01$

Table 15. Appendix 2: Performance in the Novel Labeling Task, Generalization, means and standard deviations (in parentheses)

	ASD		TD	
	Fail (n=1)	Pass (n=14)	Fail (n=8)	Pass (n=15)
Chronological Age (in months)	36.00	29.29[aa] (8.57)	21.50 (2.88)	19.40 (3.85)
Mean Nonverbal IQ (NVIQ)	75.00	99.33 (16.91)	121.00 (12.36)	116.73[bb] (14.95)
Mean Nonverbal MA (NVMA)	29.00	28.99[a] (9.81)	25.31 (4.36)	22.54 (5.06)
Mean Verbal IQ (VIQ)	99.00	83.51 (14.82)	114.63 (17.27)	105.33[bb] (12.53)
Mean Verbal MA (VMA)	35.00	24.90 (8.42)	24.94 (5.94)	20.65 (4.39)
Number of Words Said on CDI	224.00	163.36 (93.89)	181.50 (126.63)	110.13 (96.89)

[a] Marginally higher than TD 'Pass' group, $p = .05$

[aa] Significantly higher than TD 'Pass' group, $p < .01$

[bb] Significantly higher than the ASD 'Pass' group, $p < .01$

Table 16. Appendix 2: Unmatched sample characteristics for children completing the Word Extension Task

	ASD N=17	**TD N=34**
Chronological Age (in months)*	30.00 (6.26)	19.44 (3.42)
Mean Nonverbal IQ (NVIQ)*	99.80 (21.21)	116.74 (15.09)
Mean Nonverbal MA (NVMA)*	30.41 (8.22)	22.69 (4.48)
Mean Verbal IQ (VIQ)*	85.46 (19.66)	106.59 (13.53)
Mean Verbal MA (VMA)*	27.59 (8.13)	21.20 (4.71)
Number of Words Said on CDI*	183.01 (93.99)	108.56 (88.75)
Proportion of taxonomic selections	50.00 (24.12)	40.44 (26.52)
Proportion of thematic selections	5.88 (14.06)	7.84 (13.91)
Proportion of appearance selections	36.27 (28.85)	39.95 (30.55)

* groups marginally different $p < .01$

Figure 1. Design of Word Extension Task arrays

Object	**How Similar To Target?**
A	Taxonomically (i.e., same category)
B	Thematically (i.e., same context)
C	Similar in appearance but dissimilar in function
D	Distracter (dissimilar)

Figure 2. Flow chart for TD participants

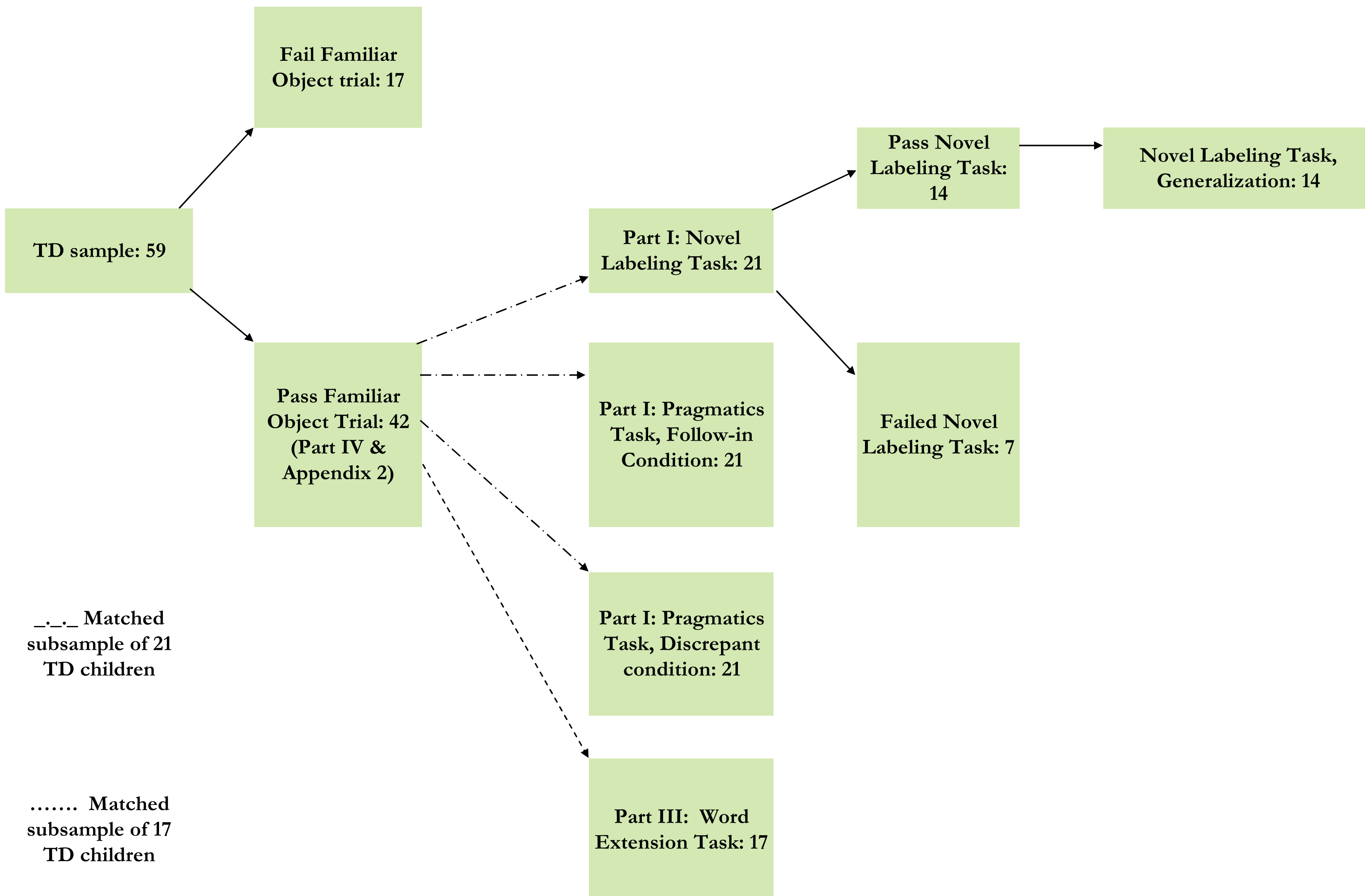


Figure 3. Flow chart for ASD participants

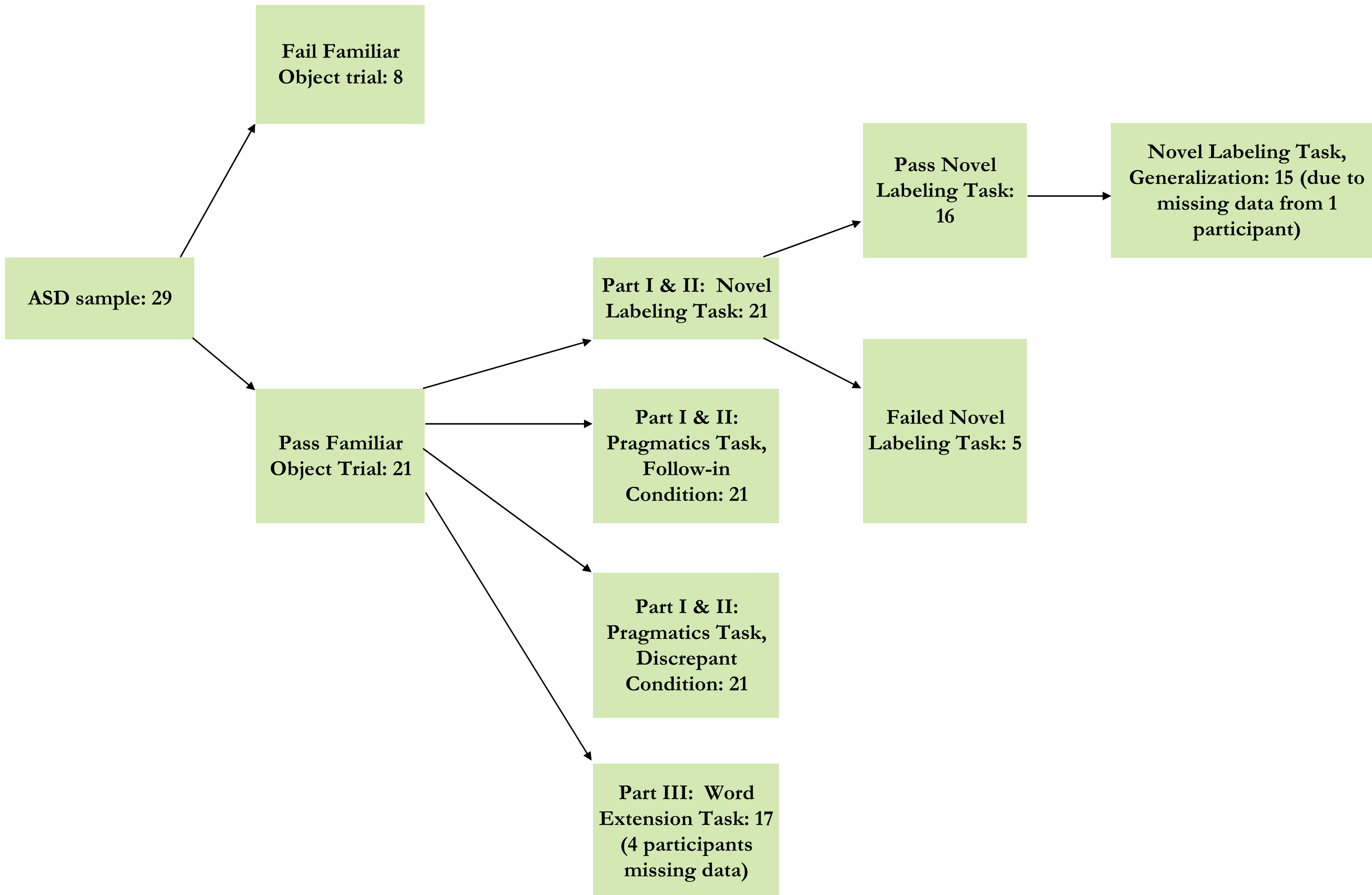


Figure 4. Part I: Performance of the matched TD sample in the Pragmatics Task

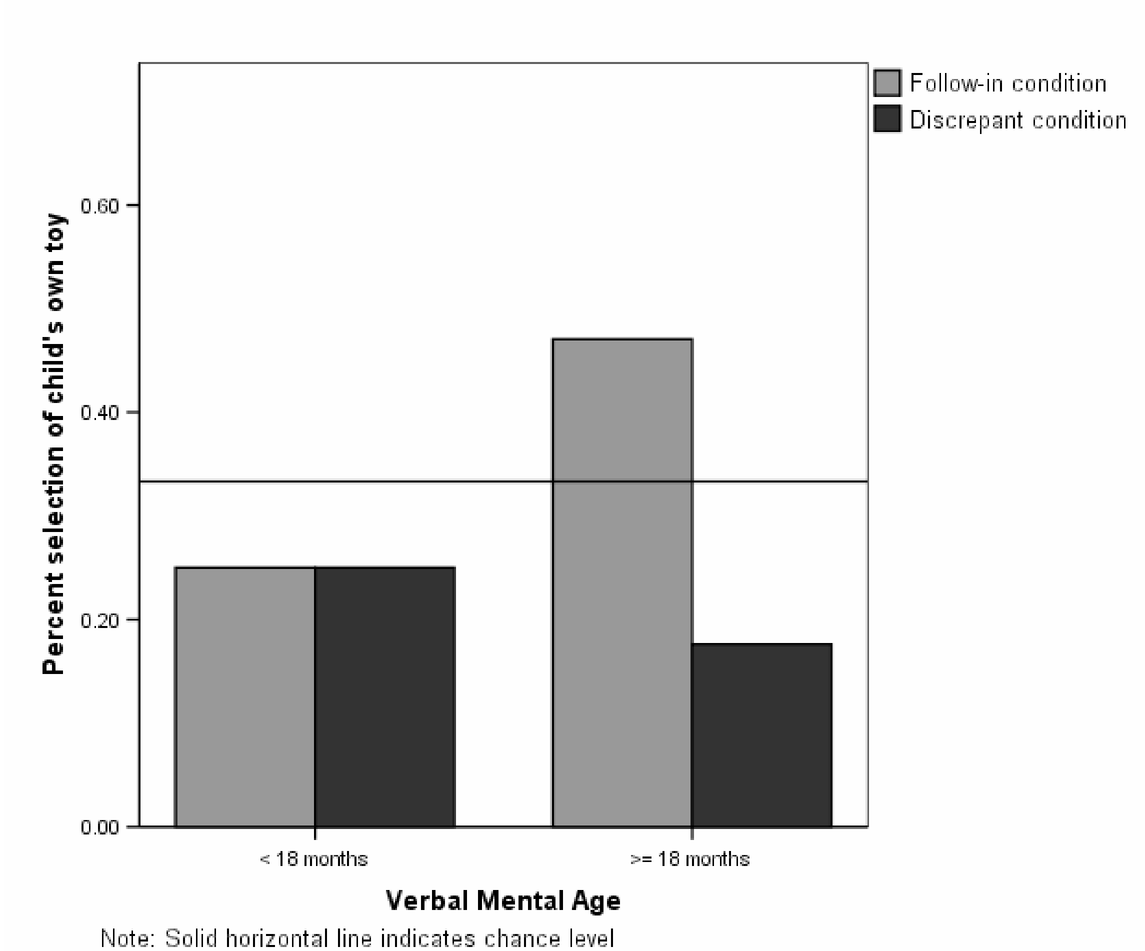
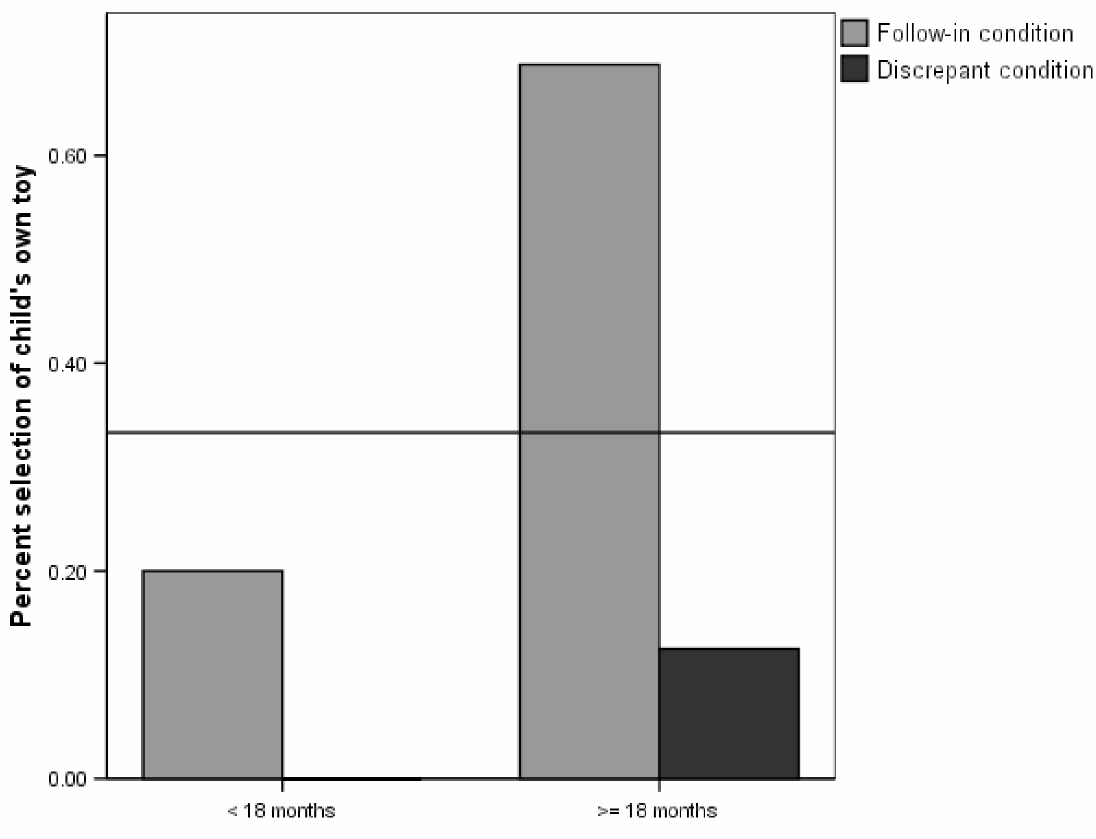


Figure 5. Part I: Performance of the matched ASD sample in the Pragmatics Task



Note: Solid horizontal line indicates chance level

Figure 6. Part I: Strategy use in previously reported and present samples (Discrepant condition only)

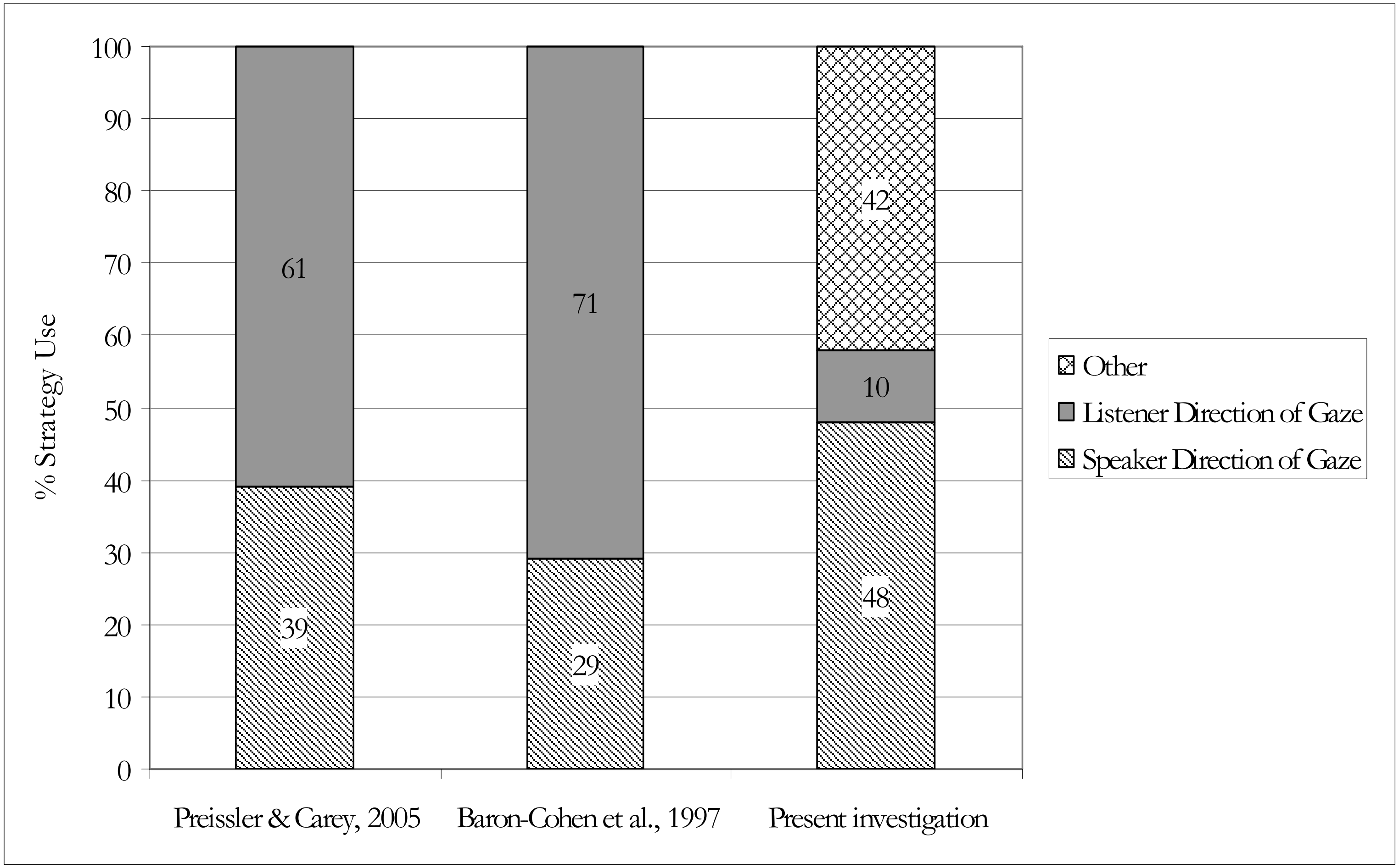


Figure 7. Part I: Strategy use in previously reported and present samples (Follow-in and Discrepant conditions)

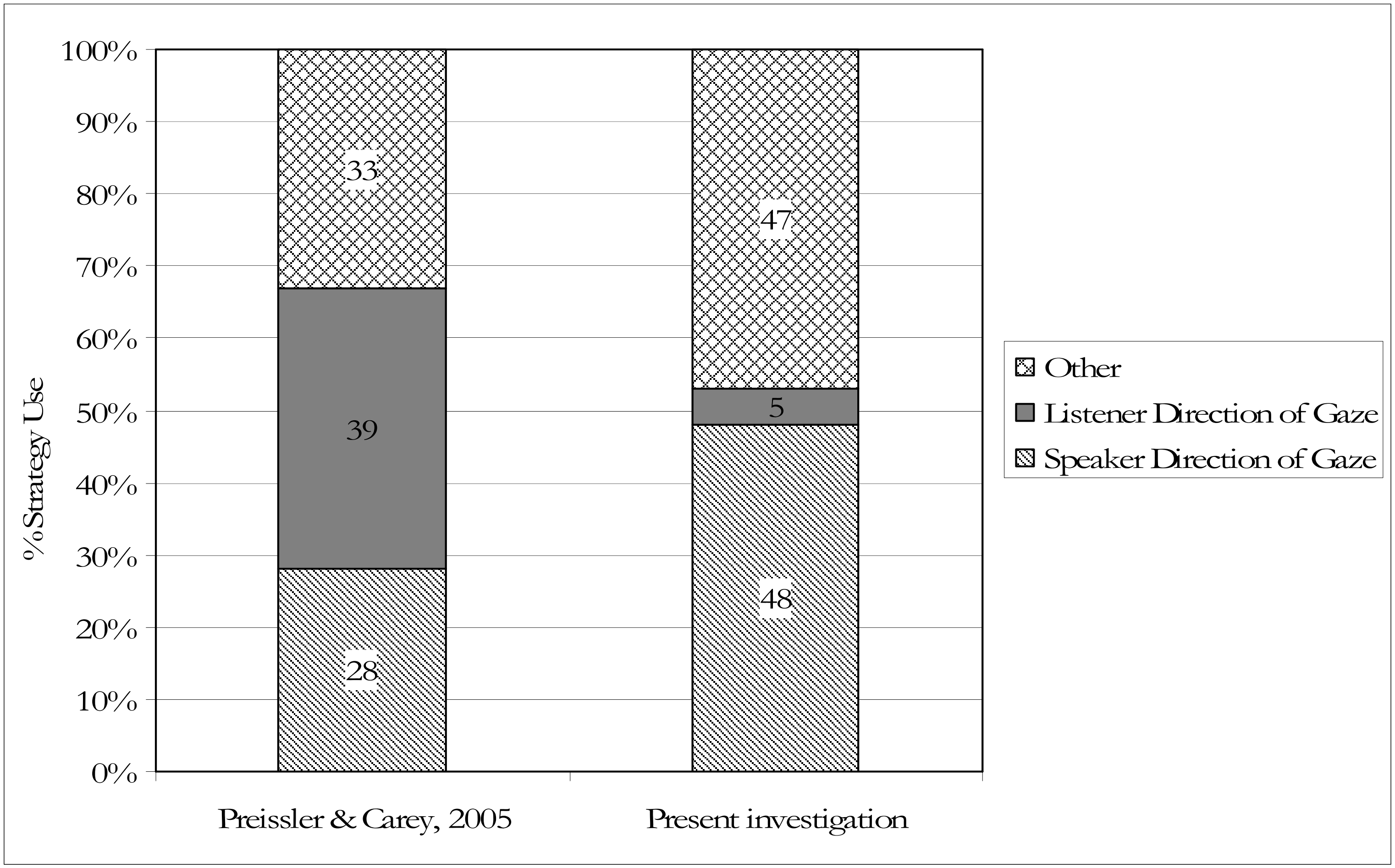
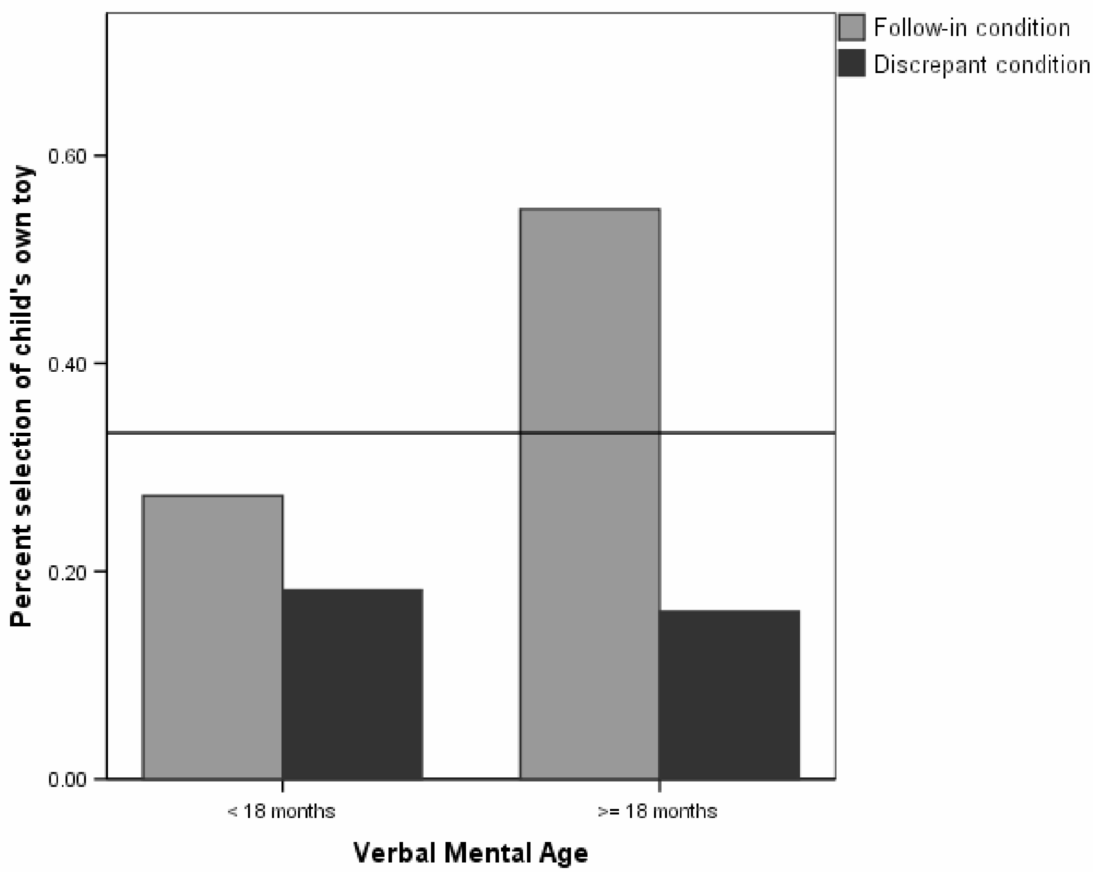


Figure 8. Appendix 2: Performance of the unmatched TD sample in the Pragmatics Task



Note: Solid horizontal line indicates chance level

Appendix 1

Adult Ratings of Word Extension Task Arrays

The validity of stimuli used for the Word Extension Task was ascertained through adult ratings. The materials used in the Word Extension Task were all objects. However, it was not possible to have a sufficient number of these 10 proposed object sets to use for the adult ratings. Therefore, photographs were taken of each object. These photographs were presented to the undergraduates for ratings. Three sets of ratings were collected based on how well each target item matched each picture choice according to shape similarity ("how similar in shape are items A and B?"), taxonomic similarity ("how much are items A and B the same kind of thing?"), and thematic relatedness ("how related are items A and B?"). Twelve undergraduate students rated 10 initial sets of items and provided ratings on a scale of 1-7. We included sets in the study for which either (1) the intended match was rated above 5.0 and the three unintended matches were rated below 4.0; or (2) the difference scores between the intended match and the three non-matches were all above 2.0. Ratings information and stimulus sets can be seen in Table 12.

There were seven sets that met these criteria. Each is listed below according of the target label, and each item included in the array will be also listed in the following order: taxonomically related, thematically related, appearance/shape related, and distracter.

1. Crayon: marker, paper pad, chip clip, funnel
2. Book: check register, paper, CD case, coaster

3. Bathtub: sink, washcloth, rectangular box, magnet
4. Cup: water bottle, plate, candle holder, soap drainer
5. Shoe: boot, sock, squeak toy, spice bottle
6. Spoon: fork, bowl, dental mirror, rubber grip
7. Bottle: cup, bib, mousse container, tea ball

Appendix 2

Results Using Unmatched Sample

In order to determine if important differences would emerge in the results should the *entire* TD sample be included (i.e., not just the ones who are matched to the ASD sample), this section will report on the results with all 42 TD children who passed the Familiar Object trial and, thus, received the word learning tasks. Again, the 21 children with ASD who also passed the Familiar Object trial (these are the same children who were used in the primary results section) were also included. See Table 13 for sample characteristics.

Novel Labeling Task

Using the complete sample described above, 23 of the 42 (54.76%) TD children and 16 of the 21 (76.19%) children with ASD passed the Novel Labeling Task (see Table 14). Results indicated that the rate of passing the Novel Labeling Task was significantly greater than what would be expected by chance in TD group (one-sample t-test, $t = 2.80$, $df = 41$, $p < .01$) and in the ASD group (binomial distribution, $p < .01$) . A Fisher's exact test indicated no group difference in the rate of passing the Novel Labeling Task ($p = .12$, two-sided Fisher's exact test).

There were not significant differences in chronological age (CA), vocabulary size, nonverbal IQ (NVIQ), or verbal IQ (VIQ) between those children who successfully passed the Novel Labeling Task and those who did not (see Table 14).

However, using the data from only those children who passed the task, independent samples *t*-tests indicated significant diagnostic group differences in chronological age (such that the ASD group was older than the TD group ($t = 4.34$, $df = 37$, $p < .01$), and in NVIQ ($t = 4.04$, $df = 37$, $p < .01$) and VIQ ($t = 5.12$, $df = 37$, $p < .01$), with the TD group higher in both. There were no group differences in NVMA, VMA or expressive vocabulary size within children who passed the Novel Labeling Task.

Novel Labeling Task: Generalization

As described in the Methods section, only those children who passed the Novel Labeling Task were administered the generalization trial. Consequently, these data were collected only for the Part I children who passed the Novel Labeling Task (ASD: n = 16; TD: n = 23). Data were missing for one ASD child due to examiner error, but of the 15 with generalization data, 14 (93.33%) children passed the generalization task. In the TD group, 15 of the 23 children (65.22%) passed the generalization task (see Table 15). Binomial distributions indicated that the rate of passing the generalization task was significantly greater than chance for both diagnostic groups ($p < .01$). A Fisher's exact test indicated that there was not a group difference in the rate of passing the generalization task ($p = .12$, two-sided Fisher's exact test).

Mann-Whitney tests indicated that there were not significant group differences in CA, NVIQ, VIQ, or vocabulary size between children who passed the task versus those who did not. However, analyses using the data only from children who passed the task revealed that, relative to the TD group, the ASD group was older ($U = 36.50$, $p < .01$) and had a lower NVIQ ($U = 46.00$, $p < .01$) and lower VIQ ($U = 26.00$, $p < .01$). There was also a trend for the ASD sample to have a higher NVMA ($U = 59.00$, $p = .05$)

Pragmatics Task

The TD and ASD samples were split according to mental age into "younger" (i.e., VMA of younger than 18 months, which included 11 TD children and five children with ASD) and "older" (VMA 18 months and above, including 31 TD children and 16 children with ASD) groups. See Figure 8 for the TD results (refer to Figure 5 for the original ASD results; chance levels indicated with the solid horizontal line).

Performance within each of the two VMA groups was similar across diagnostic groups. The rate of selecting the child's own toy did not differ across the TD children and children with ASD for either the Follow-in (two-sided Fisher's exact tests; younger MA: $p = .64$; older MA: $p = .24$) and Discrepant (two-sided Fisher's exact tests; younger MA: $p = .46$; older MA: $p = .54$) conditions. Analyses looking within diagnostic group and across MA levels indicated that, for the TD sample, the rate of selecting the child's own toy was not different across conditions for the younger MA group (27.27% in Follow-in and 18.18% in Discrepant,; two-tailed McNemar test, $p = 1.00$). However, it did differ for the older MA group (54.84% in the Follow-in condition and 16.12% in Discrepant; two-tailed McNemar test, $p < .01$). A similar pattern was found in the ASD group: there was no effect of condition on selecting the child's own toy for the younger MA group (20% in Follow-in, 0% in Discrepant; two-tailed McNemar, $p = 1.00$), but there was an effect for the older MA group (two-tailed McNemar test, $p < .05$), such that the child's toy was selected more often in the Follow-in condition (68.75%) than in the Discrepant condition (12.50%). That is, for both diagnostic groups with older MA, children were significantly more likely to pick their own toy when the examiner *had* been labeling that toy (i.e., in the Follow-in condition) than when the examiner *had not* been labeling that toy (i.e., in the Discrepant condition).

Analyses also addressed whether children selected the correct toy more often than what would be expected by chance. In the TD group, the children in the younger MA group selected the child's toy at levels which were not significantly different than chance in the Follow-in (27%) and Discrepant (18%) conditions. The older MA children selected their own toy at a rate which significantly greater than chance ($p < .05$) in the Follow-in condition (55%) and significantly less than chance (16%, $p < .01$) in the Discrepant condition. For the ASD sample, the younger MA group selected the child's toy at chance levels (20%) in the Follow-in condition. However, unlike their TD counter-parts, *none* of the five children with younger MA in the Discrepant condition selected the child's toy (a level below chance, $p < .01$). The older MA children in the ASD group selected the child's toy at a rate significantly above chance in the Follow-in condition (69%, $p < .01$) and (like their TD peers) significantly below chance in the Discrepant condition (13%, $p < .001$).

Word Extension Task

The 17 children with ASD who had Word Extension Task data were included in these analyses along with all 34 TD children who had Word Extension Task data (data were missing for 8 participants due to child fussiness or examiner error). Proportions of each type of response were created for each participant: one for taxonomic responses, one for thematic responses and one for appearance responses. Table 16 provides these proportions as well as sample characteristics. Preliminary analyses revealed no effect of which specific array was used on proportions of item selection.

Independent sample *t*-tests indicated no diagnostic group differences in the proportion of taxonomic, thematic or appearance selections. Tests within each diagnostic group indicated that, for both the TD and ASD samples, the rate of taxonomic and appearance selections were significantly greater than the rate of thematic selections (paired samples *t*-tests, $p < .01$) but were not different from each other. For the TD sample, taxonomic and appearance selections occurred at a rate greater than chance (one-sample *t*-tests; taxonomic, $t = 3.40$, $df = 33$, $p < .01$; appearance, $t = 2.85$, $df = 33$, $p < .01$), while the proportion of thematic selections was less than would be expected by chance (one-sample *t*-test, $t = 7.19$, $df = 33$, $p < .01$). In the ASD sample, the proportion of taxonomic choices was greater than chance (binomial distributions, $p < .01$), and the proportion of thematic selections was less than chance ($p < .01$). However, the rate of appearance did not differ from chance levels ($p = .10$)

As mentioned in the introduction, previously published literature has indicated that there is a shift in how children generalize words sometime after age 2 years. Therefore, in order to approximate this comparison as closely as possible (given the limited age range of the current sample), the sample was split according to whether VMA was (1) equal to or less than 24 months, which included 25 TD children and 6 ASD children; or (2) greater than 24 months, which included 9 TD children and 11 ASD children. As above, diagnostic group comparisons (Mann-Whitney tests) were not significant for any of the three proportions. In addition, the younger and older children did not show significant differences in their pattern of item selection.

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