# Prelinguistic Predictors of Vocabulary in Young Children With Autism Spectrum Disorders

**Andrea McDuffie**
Waisman Center,
University of Wisconsin—Madison

**Paul Yoder**
Vanderbilt University, Nashville, TN

**Wendy Stone**
Vanderbilt University and
Vanderbilt Children's Hospital,
Nashville, TN

**Purpose:** The goal of the current study was to identify a predictive model of vocabulary comprehension and production in a group of young children with autism spectrum disorders. Four prelinguistic behaviors were selected for consideration as predictors based on theoretical and empirical support for the relationship of these behaviors to language development.
**Method:** The study used a longitudinal correlational design. Participants were twenty-nine 2- and 3-year-olds diagnosed with autism spectrum disorders. The prelinguistic behaviors—attention-following, motor imitation, commenting, and requesting—were measured at the initial visit. Vocabulary comprehension and production were measured 6 months later.
**Results:** Commenting was the only unique predictor of comprehension after the degree of cognitive delay was controlled. Both commenting and motor imitation of actions without objects were unique predictors of production over and above the other skills and when the degree of cognitive delay was controlled.
**Conclusions:** The finding that both commenting and motor imitation simultaneously accounted for unique variance in vocabulary production is new to the literature and requires replication. However, results suggest that increasing behaviors that allow children with autism to make their current focus of attention obvious to social partners may be an effective approach for supporting word learning in young children with autism.

**KEY WORDS: autism spectrum disorders, language comprehension, language expression, preschool children, language disorders**

Most children with autism spectrum disorders (ASD) have delays in language development relative to their nonverbal mental age (Stevens et al., 2000; Tager-Flusberg, 1988; Tager-Flusberg & Sullivan, 1998), and approximately half of young children with autism fail to acquire speech as their primary mode of communication (Prizant, 1996). It is not yet known why some children with autism learn to talk and others do not. However, research has shown that early language ability is related to positive long-term outcomes for children with autism (Gillberg, 1991; Howlin, Mahood, & Rutter, 2000; Liss et al., 2001) and that verbal skills are the strongest longitudinal predictors of social-adaptive functioning (Venter, Lord, & Schopler, 1992). Given the strong predictive relationship between early vocabulary and later use of multiword utterances in typically developing children (Bates, Bretherton, & Snyder, 1988; Bates, Dale, & Thal, 1995; Bates & Goodman, 1999; Fenson et al., 1994), understanding the process of word learning for children with autism represents an


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important first step toward increasing the proportion of these children with functional language skills.

According to a social-cognitive theoretical framework, children are able to establish referential understanding and learn the meanings of words because they have access to many different types of social information from communicative partners within episodes of triadic interaction (Baldwin & Moses, 1996; Hollich, Hirsh-Pasek, & Golinkoff, 2000; Tomasello, 2001, 2003). The term *triadic interaction* describes a situation in which infants have the opportunity to coordinate their attention between a social partner and an object or ongoing event that provides a joint focus of attention (Bakeman & Adamson, 1984). Within episodes of triadic interaction, prelinguistic infants learn to use behaviors such as eye gaze, affect, and gesture (Mundy & Markus, 1997) to respond to, initiate, and maintain episodes of shared reference (Bakeman & Adamson, 1984; Bretherton, 1992). These types of prelinguistic behaviors are often referred to as triadic attention skills.

Learning new words presents a special problem for children diagnosed with ASD because they have core deficits in triadic attention skills (Mundy & Sigman, 1989; Mundy, Sigman, & Kasari, 1990, 1994; Mundy, Sigman, Ungerer, & Sherman, 1986; Sigman & Kasari, 1995; Sigman, Mundy, Sherman, & Ungerer, 1986). A number of prelinguistic behaviors may be included under the broad classification of triadic attention skills. For the current study, four such behaviors were identified, based on theoretical and empirical support for the relationship of these specific behaviors to vocabulary outcomes for children with autism: attention-following, commenting, requesting, and motor imitation.

## Relationship of Attention-Following to Vocabulary Acquisition

Attention-following refers to the child's ability to change the direction of head and eyes in response to a change in the direction of adult focus (Scaife & Bruner, 1975). Children who have the ability to follow adult attentional cues to objects or events in the environment should learn more words and avoid mapping errors during word learning (Baldwin, 1991, 1993a, 1993b). Children with autism who are not able to follow the speaker's referential focus may make inaccurate word–object pairings when the adult's focus of attention is different from their own. According to research by Baron-Cohen, Baldwin, and Crowson (1997), learning inappropriate labels during vocabulary acquisition poses a potential problem for children with autism, who often map a novel word to their own focus of attention rather than to the object that is the adult's intended referent.

For children with autism, there is replicated evidence for the concurrent relationship between attention-following and vocabulary comprehension (Landry & Loveland, 1988; Mundy et al., 1986), even when there are controls for chronological age, initial language level (Sigman & Ruskin, 1999), and initial mental age (Mundy et al., 1986). Currently, there is no empirical evidence for the predictive relationship between attention-following and comprehension outcomes for children with autism. Because researchers often do not report null findings, it is difficult to determine whether this association has been adequately considered. The absence of a reported longitudinal association between attention-following and comprehension in children with autism also may be due to the difficulty of accurately measuring vocabulary comprehension. There is replicated evidence for both the concurrent (Carpenter, Pennington, & Rogers, 2002; Landry & Loveland, 1988; Mundy et al., 1986) and predictive relationship (Sigman & Ungerer, 1984) between attention-following and vocabulary production, even when there are controls for chronological age, initial language level (Sigman & Ruskin, 1999) and initial mental age (Mundy et al., 1986).

For typically developing children, there is replicated evidence that attention-following is positively related to vocabulary comprehension. This relationship is observed both concurrently (Carpenter, Nagell, & Tomasello, 1998; Landry & Loveland, 1988; Mundy & Gomes, 1998; Mundy, Kasari, Sigman, & Ruskin, 1995) and longitudinally (Carpenter, Nagell, & Tomasello, 1998; Morales et al., 2000; Morales, Mundy, & Rojas, 1998; Mundy & Gomes, 1998; Mundy et al., 1995; Ulvand & Smith, 1996). The predictive relationship between attention-following and comprehension is significant even when there are controls for initial chronological age and mental age, as well as initial language status (Mundy & Gomes, 1998; Mundy et al., 1995). For a group of 14- to 17-month-olds, attention-following accounted for unique variance in predicting comprehension over and above other joint attention skills, even when initial chronological age, mental age, and language comprehension status are controlled (Mundy & Gomes, 1998).

Replicated evidence indicates that attention-following is positively related to vocabulary production for children with typical development; this relationship is observed concurrently (Carpenter, Nagell, & Tomasello, 1998; Masur & Ritz, 1984; Mundy & Gomes, 1998; Mundy et al., 1995; Mundy, Sigman, & Kasari, 1994; Slaughter & McConnell, 2003) and longitudinally (Carpenter, Nagell, & Tomasello, 1998; Delgado et al., 2002; Desrochers, Morissette, & Ricard, 1995; Laakso, Poikkeus, Katajamaeki, & Lyytinen; 1999; Markus, Mundy, Morales, Delgado, & Yale, 2000; Masur & Ritz, 1984;

Morales et al., 1998; Mundy & Gomes, 1998; Mundy et al., 1995), as well as after controls for initial age (Mundy et al., 1995) and language status (Morales et al., 2000; Mundy et al., 1995) are in place. There is also unreplicated evidence that attention-following is a concurrent correlate of both vocabulary comprehension and production for toddlers with Williams syndrome (Laing et al., 2002).

## Relationships of Commenting and Requesting to Vocabulary Acquisition

Commenting and requesting are the two pragmatic functions most frequently used for intentional communication by prelinguistic children (Wetherby, Cain, Yonclas, & Walker, 1988). Intentional communication refers to any gesture or vocalization produced by the child that is either conventional or symbolic in form or produced in combination with a behavior that demonstrates simultaneous or sequential coordinated attention to an object and person (Yoder, 2000). The term *conventional* refers to gestures and vocalizations that are used regularly and have a mutually recognized meaning within a social group (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979). Examples of conventional gestures include waving bye-bye, shrugging the shoulders, turning up the palm for "give," pointing distally, nodding the head, or shaking (Yoder, 2000). Although commenting and requesting can take the same overt behavioral form (e.g., pointing), there is an important motivational distinction between the two pragmatic functions (Mundy, 1995; Mundy & Stella, 2000). While requesting (also called initiating behavior regulation) is seen as an instrumental behavior (Bates et al., 1979; Mundy et al., 1986), commenting (also called initiating joint attention) is considered a type of social approach behavior that involves the expression of shared positive affect or interest toward both the referent and the social partner (Kasari, Sigman, Mundy, & Yirmiya, 1990; Mundy, 1995; Mundy & Willoughby, 1998).

Children who are proficient in the use of these prelinguistic behaviors need only superimpose conventional forms onto pragmatic functions that they have already mastered (Bates, O'Connell, & Shore, 1987; Bruner, 1974; Snow, Perlmann, & Nathan, 1987). Additionally or alternatively, commenting and requesting may be important for word learning because they elicit responses that facilitate vocabulary development (Yoder & Munson, 1995; Yoder & Warren, 1993, 1998). For example, a mother can be responsive to her child's intentional communication in several different ways, including imitation of the child's behavior, compliance with the child's request, and linguistic mapping of the child's presumed message (Yoder, Warren, McCathren, & Leew, 1998). Yoder and Warren (1999) demonstrated that, for children with developmental delays, maternal responsivity mediated the relation between prelinguistic intentional communication and later language (Yoder & Warren, 1999).

For children with autism, there is replicated evidence for a concurrent association between commenting and comprehension (Sigman & Ruskin, 1999) when mental age is controlled (Mundy et al., 1986) and unreplicated evidence for the predictive relationship between commenting and comprehension (Charman et al., 2003). There is replicated evidence for a concurrent association between commenting and production (Landry & Loveland, 1988; Sigman & Ruskin, 1999) and for the predictive relationship between commenting and production (Stone & Yoder, 2001), even when nitial language status and chronological age are controlled (Sigman & Ruskin, 1999). There is unreplicated evidence for a concurrent relationship between requesting and both comprehension and production (Mundy, 1987) and for a significant predictive relationship between requesting and production, when chronological age and initial language status are controlled (Sigman & Ruskin, 1999).

For typically developing children, there is replicated evidence that commenting is related to vocabulary comprehension both concurrently (Bates, Thal, Whitesell, Fenson, & Oakes, 1989; Mundy, Sigman, Kasari, & Yirmiya, 1988) and longitudinally (Bates et al., 1979; Blake, 2000; Desrochers et al., 1995; Ulvand & Smith, 1996). There is replicated evidence that commenting is related to vocabulary production both concurrently (Blake, 2000; Mundy et al., 1988; Sigman & Ruskin, 1999) and longitudinally (Camaioni, Castelli, Longobardi, & Volterra, 1991; Desrochers et al., 1995; Mundy et al., 1988; Ulvand & Smith, 1996). For a group of 14- to 17-month-olds, commenting accounted for unique variance in production over and above attention-following, even when initial chronological age, mental age, and language production status are controlled (Mundy & Gomes, 1998).

There is replicated evidence that requesting is predictively related to both comprehension (Mundy et al., 1995; Ulvand & Smith, 1996) and production (Camaioni et al., 1991; Mundy et al., 1995; Ulvand & Smith, 1996) for children with typical development. There is also replicated evidence that requesting predicts later language production for children with Down syndrome (Smith & von Tetzchner, 1986), even after age and initial language status are controlled, although the variance accounted for is small (Mundy et al., 1995). Finally, requesting is a significant predictor of language comprehension (Sigman & Ruskin, 1999) and production in children with mixed etiology intellectual delay, even when chronological age (Sigman & Ruskin, 1999) and initial language level (Yoder, Warren, & McCathren, 1998) are controlled.

## Relationship of Motor Imitation to Vocabulary Acquisition

Varied explanations have been proposed for the ways in which motor imitation may contribute to language development. These include consideration of motor imitation as a cognitive mechanism for learning socially constructed behaviors (Bates et al., 1989; Piaget, 1962; Uzgiris, 1999), as an index of the child's understanding of others' intentional action (Carpenter, Akhtar, & Tomasello, 1998; Carpenter, Nagell, & Tomasello, 1998; Meltzoff, 1995), or as a system for communicating shared understanding between social partners (Nadel, 2002; Nadel, Guerini, Peze, & Rivet, 1999; Ninio & Bruner, 1978; Uzgiris, 1981). Regardless of the precise role played by motor imitation, its potential importance to the acquisition of referential communication was acknowledged quite long ago (Bates, 1979; Bates, Bretherton, Snyder, Shore, & Volterra, 1980). Two basic dimensions of motor imitation are frequently acknowledged in the literature: motor imitation of actions with objects and motor imitation of actions without object support. Although the contribution of vocal or verbal imitation ability to language outcomes in children with autism remains an open question, the goal of the current study was to examine prelinguistic behaviors that could be considered triadic attention skills, that is, behaviors used by prelinguistic children to coordinate attention between social partners and objects within the context of triadic interactions. Thus, although verbal imitation is a potentially important predictor, its role was not considered in the current study.

For children with autism, there is replicated evidence that motor imitation without objects is concurrently related to both comprehension (Abrahamsen & Mitchell, 1990; Sigman & Ungerer, 1981, 1984) and production (Carpenter et al., 2002; Stone, Ousley, & Littleford, 1997). There is also unreplicated evidence that motor imitation without objects is predictively related to production (Stone et al., 1997). In regard to motor imitation with objects, there is unreplicated evidence for a predictive relationship with comprehension (Charman et al., 2003). Finally, there is replicated evidence that a composite measure including motor imitation tasks both with and without objects is concurrently (Stone et al., 1997; Stone & Yoder, 2001) and predictively related to language production (Stone et al., 1997), even when initial language status is controlled (Stone & Yoder, 2001).

For typically developing children, there is unreplicated evidence that motor imitation without objects is concurrently related to language comprehension (Sigman & Ungerer, 1984) and replicated evidence that motor imitation without objects (or with nonfeatured placeholder objects) is concurrently related to language production (Bates et al., 1980). Predictively, there is replicated evidence that motor imitation without objects is related to language production (Bates et al., 1979; Carpenter, Nagell, et al., 1998; Snow, 1989). Finally, for typically developing children, there is replicated predictive evidence (Charman, 2003; Laakso, Poikkeus, Katajamaeki, & Lyytinen, 1999) that motor imitation of actions with objects is related to language production.

In the current literature review, we examined empirical evidence for the association between motor imitation of single actions with language comprehension and production. For both typically developing children and late-talking toddlers, the type of imitation found to be related to language comprehension was imitation of sequences of gestures within the context of familiar, scripted routines, such as eating, drinking, and putting the baby to bed (Bates et al., 1980; Thal & Bates, 1988; Thal & Tobias, 1992, 1994; Thal, Tobias, & Morrison, 1991). When these routines were performed with the objects typically used for such routines, no significant associations with comprehension were observed. Imitation of sequences of actions within a scripted routine was related to language comprehension only when a nonfeatured placeholder object, such as a block, was used in the task. Similarly, the type of imitation found to be related to language production in these same studies was imitation with an inappropriate object; that is, the child had to perform a modeled action typically associated with one object while using a different object. These results allowed Bates and colleagues to conclude that the type of imitative gestures that are most related to either language comprehension or production are "stripped down" gestures with "minimal support from referent objects" (Bates et al., 1980, p. 420).

Most studies considering the relationship of motor imitation to language development have used measures of motor imitation without objects or have used aggregate measures of motor imitation across actions with and without objects. To determine which type of motor imitation is most predictive of language, it is important that both types of imitation be examined within the same study because there may be systematic differences in either the samples or the statistical power of studies that examine the relation of only one type of motor imitation to language outcomes.

Three studies of typically developing children (Bates et al., 1980; Carpenter et al., 1998; Snow, 1989) and two studies of children with autism (Carpenter et al., 2002; Stone et al., 1997) have examined the relationships of both types of motor imitation to later language. For purposes of comparison with other studies, tasks with appropriate or featured objects in the study by Bates and colleagues (1980) are considered in the category of motor imitation with objects, while tasks with inappropriate objects or placeholder objects are considered in the category of motor imitation without objects. In all five studies, the associations with language were stronger for motor imitation of actions without objects (or with placeholder objects), although the five studies did not address the question of whether there is a significant difference in the strength of association between the two types of imitation and later language. The results of these studies are summarized in Table 1.

Studies demonstrating a relationship between motor imitation and comprehension for children with autism have considered either imitation without objects (Abrahamsen & Mitchell, 1990; Sigman & Ungerer, 1981, 1984) or imitation with objects (Charman et al., 2003). The two studies of children with autism that considered both types of imitation provided replicated concurrent evidence that imitation without objects is related to language production and that motor imitation of actions with objects is not (Carpenter et al., 2002; Stone et al., 1997). There is also unreplicated predictive evidence for the latter finding (Stone et al., 1997). However, no previous study for children with autism has directly tested whether one type of motor imitation accounts for greater variance in comprehension and production than does the other.

## Unique Variance Accounted for by Prelinguistic Skills

Very few studies of any group of children have examined the predictive association between a prelinguistic skill and later language while the researchers simultaneously controlled for the variance accounted for by other prelinguistic variables. In one such study of children with autism, Stone and Yoder (2001) used an aggregate measure of motor imitation both with and without objects and demonstrated that motor imitation was a unique predictor of productive language over and above commenting. For children with Down syndrome, Mundy and colleagues (1995) demonstrated that requesting was a unique predictor of language production over and above attention-following or commenting. In a recent study, Yoder and Warren (2004) demonstrated that commenting was a unique predictor of productive language for children with mixed etiology intellectual disabilities. Finally, for typically developing children, Mundy and colleagues (1995), as well as Mundy and Gomes (1998), demonstrated that attention-following was a unique predictor of comprehension over and above either commenting or requesting. Although commenting was a unique predictor of production over and above either attention-following or requesting for a group of 14–17-month-old typically developing children (Mundy & Gomes, 1998), attention-following was a unique predictor of production when the typically developing participants represented a broader age range (8–28 months; Mundy et al., 1995).

## Research Question

The goal of the current study was to identify the most parsimonious predictive model of later vocabulary comprehension and production in a group of very young children diagnosed with ASD. Theory and

**Table 1.** Findings of studies that examined both types of motor imitation.

| | Population | | Comprehension | | Production | |
|---|---|---|---|---|---|---|
| | | | Type of imitation | | Type of imitation | |
| Study | TD | ASD | With objects | Without objects | With objects | Without objects |
| Bates et al. (1980) | XX | | .17 | .46* | .36* | .51* |
| Snow (1989) | XX | | *ns*[a] | *ns*[a] | *ns*[a] | .21* |
| Carpenter et al. (1998) | XX | | | | .21 | .39* |
| Stone et al. (1997) | | XX | | | .21[b] | .49*[b] |
| | | | | | .36[c] | .43*[c] |
| Carpenter et al. (2002) | | XX | | | .09 | .67* |

*Note.* TD = typical development; ASD = autism spectrum disorders.

[a]Not significant, but *r* value not reported. [b]Concurrent association. [c]Predictive association.

*$p < .05$.

research suggest that children with specific etiologies of impairment may demonstrate differing profiles of association between prelinguistic behaviors and later language (Mundy & Gomes, 1998; Yoder & Warren, 2004). For example, attention-following and commenting are unique predictors of comprehension and production, respectively, for typically developing children, while requesting is a unique predictor of production for children with Down syndrome and motor imitation is a unique predictor of production for children with autism. The question of identifying unique predictors of later language can be tested most efficiently by simultaneously evaluating the unique contributions of a group of target variables. For this study, a group of triadic attention skills were selected for consideration. A preliminary research question addressed whether either of the two types of motor imitation uniquely predicted later vocabulary over and above the other type.

# Method

## Participants

Forty children with ASD participated in this study. Data for 11 of these children were not included in the analysis for the following reasons: failure to return for Time 2 (4 children), lack of attention to or engagement with stimulus objects (2 children), child dissent (1 child), and equipment errors (4 children). Data for the remaining 29 participants will be reported in this analysis. These children had a mean age of 32 months at entry into the study (Time 1) and were seen approximately 6 months later for follow-up (Time 2). Two of the participants were females. A summary of participant characteristics is presented in Table 2.

Mothers of all the participants had graduated from high school; 58.6% had college degrees or higher. Socioeconomic status was computed with the Hollingshead Index of Social Status (Hollingshead, 1985), resulting in a mean prestige score of 49.5 (*SD* = 12.2, range = 22–66). This composite score is based on an algorithm combining educational and occupational status. Scores from 32 to 47 represent the middle range, with lower scores representing higher ranking for educational and occupational prestige.

**Table 2.** Descriptive characteristics of participants at initial visit.

| Characteristic | *M* | *SD* | Range |
|---|---|---|---|
| Chronological age (months) | 32.4 | 6.3 | 24–46 |
| Time until follow-up (months) | 6.3 | 0.6 | 5.3–7.9 |
| Mullen standard score | 59.6 | 13.6 | 48–101 |
| CARS severity of autism | 33.5 | 4.3 | 23.5–44 |

*Note.* Mild–moderate range of severity for Childhood Autism Rating Scale (CARS) is 30–36.

All children had received a clinical diagnosis of autism (*n* = 20) or pervasive developmental disorder not otherwise specified (PDD-NOS; *n* = 9) from a licensed psychologist with extensive experience in the assessment of young children. Clinical diagnoses were based on criteria provided in the *Diagnostic and Statistical Manual of Mental Disorders—Fourth Edition—Text Revision* (*DSM–IV–TR*; American Psychiatric Association [APA], 2000). Diagnosis of autism was confirmed for all participants using the Autism Diagnostic Observation Schedule—Generic (ADOS–G; Lord, Rutter, DiLavore, & Risi, 1999). Participants were recruited from several sources (e.g., a university-based diagnostic evaluation center, a state network providing early identification services, parents or other community agencies); they also met the following inclusion criteria: (a) absence of identified genetic, metabolic, or progressive neurological disorders and (b) absence of severe sensory or motor deficits, according to parent report.

## Design

The study used a longitudinal correlational design. Attention-following, commenting, requesting, motor imitation, vocabulary comprehension and production, and degree of cognitive delay were measured at Time 1. Vocabulary comprehension and production were measured at Time 2.

## Procedure

*Proximal attention-following procedure (PAF).* Many studies of attention-following use distal attention-directing cues (e.g., adult turning the head, pointing, calling the child's name; Mundy, 1987; Mundy et al., 1990, 1994; Mundy et al., 1986; Seibert, Hogan, & Mundy, 1987). Had such distal attentional directives been used in the current study, it was judged that many of the children would have scored a zero, thereby reducing the utility of the measure. Given the developmentally young status of the present study sample, it was decided that the examiner should continually redirect the child's attention back to the object during the teaching phase for each trial, using promixal attention-directing cues.

The attention-following procedure consisted of eight trials and usually took less than 6 min to administer. During the procedure, the child was seated or stood behind a curved table that was positioned against a corner of the testing room. The examiner was seated across the table approximately 24 in. from the child. A parent or research assistant helped the child stay in the general area behind the table, and parents were instructed to refrain from interacting with the child during the trials. Each participant was tested with the same objects, and each object was presented to the child for approximately 30 s. Only one object was visible to the child at a time. Side and order of object presentation were randomly assigned across children.

During each trial, the examiner attempted to gain the child's attention and then introduced the object from the designated side by bringing the object up from below the table edge across from the child. Then, the examiner moved the object diagonally across the table until it was centered in front of the child and close enough for the child to reach out and touch it. The examiner used multiple cues designed to increase the probability of the child's attention-following: (a) presenting only a single object at a time, (b) placing the object close to the child and encouraging the child to handle the object, (c) using child-directed speech, (d) using proximal gestures (e.g., pointing), (e) using adult eye gaze and head turns toward the object, and (f) moving the object. These strategies were used continuously throughout each trial to encourage and redirect the child's attention to the stimulus object. After approximately 25 s, the object was removed and the next object presented.

The eight stimulus objects used in this procedure were constructed from a variety of small wooden shapes. The objects were approximately 5 to 7 in. tall and were attached to a 4-in. diameter circular wooden base that made it possible for each object to stand on a table without rolling. Each object, including the base, was painted a glossy, bright color. The objects were constructed so that they did not resemble any objects that would be familiar to young children, as confirmed through pilot testing.

*Motor Imitation Scale (MIS; Stone et al., 1997).* The MIS provides an observational measure of immediate, elicited motor imitation ability. Administered within a structured testing situation, it consists of 16 single-step motor imitation activities, half involving imitation of an action with an object and half involving imitation of an action without an object. Only a single object is available to the child during trials that assess imitation with objects. For each MIS item, the child has three opportunities to imitate the examiner's action, and the examiner scores each item as pass (2), emerging (1), or fail (0) on the basis of the quality and accuracy of the imitation. Emerging responses are those involving partial imitation in that the child attempts the imitative act, but does not complete it correctly (e.g., the child holds up a finger, but does not wiggle it). After the examiner demonstrates the target action, the child is instructed, "You do it." The examiner does not label the modeled action. For the current study, raw scores for the MIS items with and without objects were used as separate variables, and scores could range from 0 to16 for either of the two variables. MIS items measuring motor imitation with objects included tapping spoon on table, shaking noisemaker, walking small dog across table, walking hairbrush across table, putting block on head, putting beads around neck, pushing car across table, pushing cup across table. MIS items measuring motor imitation without objects included clap hands, wave hand, drum hands on table, scratch fingers on table, pat cheek, open and close fist, pull ear, bend index finger. The MIS is not designed to sample verbal imitation behaviors. Stone and colleagues (1997) described the psychometric properties of the MIS in detail. The MIS has excellent interrater reliability; Cohen's kappa collapsed across MIS items and participants was .80. The standardized alpha coefficient for the total MIS was .87, and test–retest reliability across a 2-week period was .80.

*Screening Tool for Autism in Two Year Olds (STAT; Stone, Coonrod, & Ousley, 2000; Stone, Coonrod, Turner, & Pozdol, 2004).* The STAT consists of 12 items presented during a playlike interaction. STAT items are designed to sample play (two items), imitation with objects (four items), and prelinguistic communication behaviors (six items). Within the category of prelinguistic communication behaviors, two of the items are designed to elicit requesting, and four are designed to elicit commenting. Administration of the STAT takes approximately 20 minutes. For the current study, the STAT provided a period of semistructured interaction with the examiner during which all of the children were exposed to or played with the same materials for approximately the same length of time. Administration of the STAT was videotaped and coded to obtain frequencies of commenting and requesting behaviors. STAT imitation items were typically administered at the end of the STAT session, and these imitation items were *not* included in the sample of behavior that was coded to derive the intentional communication variables.

*MacArthur Communicative Development Inventory (CDI; Fenson et al., 1994).* The CDI, a widely used parent report instrument that has high utility in characterizing early lexical and grammatical skills, was used to assess vocabulary comprehension and production. The CDI Infant Scale contains a vocabulary checklist of 396 words typically acquired by children exposed to American English from 8 to 16 months of age. The Infant Scale was used instead of the Toddler Scale for the current study, because the latter does not have a comprehension checklist. None of the participants reached the ceiling level in number of words understood or number of words understood and said, indicating that the CDI Infant Scale was developmentally appropriate for this group of children. Parents were asked to independently complete a CDI record sheet that was mailed to their homes prior to each visit. The completed CDI forms were checked during each visit, and assistance was offered to the parent if the form had not been filled in correctly. CDI raw scores were used as the metric for the size of comprehension and production vocabulary. According to parent reports of vocabulary production, 8 of the 29 participants were nonverbal at the initial visit, and 3 of these children continued to be nonverbal at the follow-up.

*Mullen Scales of Early Learning (MSEL; Mullen, 1995)*. The MSEL, a standardized developmental test for children aged 3 to 60 months, consists of five subscales: gross motor, fine motor, visual reception, language comprehension, and language production. The gross motor subscale was not administered for the current study. The standard score for each participant was used to provide an index of overall degree of cognitive delay.

*Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Renner, 1999)*. The *CARS* is a 15-item behavior rating scale that is used to provide a rating of severity for children with autism. After observing the child and examining other relevant information, the examiner rates the child on each item using a 7-point scale that reflects the degree to which the child's behavior deviates from that of a typically developing child of the same age. A total score is computed by summing across the individual item scores. Scores falling in the autism range can be divided into two categories: mild-to-moderate autism and severe autism.

## Coding

Administration of the PAF and the STAT at Time 1 was videotaped, captured into digital format, and coded using ProcoderDV (Tapp, 2003), a software system designed for personal computers. As 30 frames of data are available for each second of video recording, ProcoderDV allows precise frame by frame coding of observational data from digital media. After coding, data files were exported into MOOSES software (Tapp, Wehby, & Ellis, 1995) for calculation of cumulative durations and frequencies for subsequent analysis.

*Attention-following*. Attention-following was coded for each object presented during the PAF. The timing for each trial began when the examiner raised the stimulus object above the edge of the table and into the child's potential field of vision. During a trial, the onset of the child's attention-following was coded each time the child looked at the object and continued as long as the child maintained visual attention. The offset of attention-following occurred whenever the child looked away from the object. During each trial, the total duration of attention-following was recorded in a cumulative manner. That is, over the course of each trial, coding for attention-following resumed each time the child reestablished eye contact with the stimulus object. During a 25-s trial, for example, if the child looked at the object for 4 s, looked away for 7 s, looked at the object again for 5 s, and then looked away for 9 s, at which time the object was removed, the total amount of attention-following for that trial would be coded as 9 s. The stimulus object, as well as the child's direction of eye gaze, had to be clearly visible in each frame during which attention-following was coded. Attention-following was not coded during frames when either the object or the child's face was off-camera, and these frames were not included in calculating the length of the trial.

The variable used to quantify attention-following for each child was the proportion of time spent looking at the objects across all trials. The length of time that an object was presented during each trial sometimes varied because of a child's behavior. The mean length of each PAF trial was 23.2 s ($SD$ = 4.7 s, range 13.9–35.6 s). A proportion metric was used because preliminary analysis confirmed that trial duration was positively correlated with duration of object attention, $r(29) = .39$, $p < .04$, two-tailed. The proportion was computed for each child using the cumulative duration that the child looked at all the objects as the numerator and the total duration of the trials for that child as the denominator. The attention-following variable was calculated from presentation of all eight stimulus objects for 20 children, seven stimulus objects for 1 child, and six stimulus objects for 8 children. Faulty camera angles precluded accurate coding of eye gaze in the trials that were eliminated from the analysis for these 9 children.

*Commenting and requesting*. Videotapes of the administration of the eight STAT items designed to elicit play, requesting, and commenting (exclusive of the four STAT imitation items) were coded to identify frequency of intentional communication acts that served the pragmatic functions of commenting and requesting. Intentional communication was defined as any gesture or vocalization produced by the child that was either conventional or symbolic in form or occurred in combination with behavior that demonstrated simultaneous or sequential coordinated attention to object and person.

Commenting and requesting are the two pragmatic functions most frequently used for intentional communication by prelinguistic children (Wetherby et al., 1988). Commenting behaviors serve an indicating function and may involve the sharing of positive affect (Mundy, 1995; Mundy & Sigman, 1989; Mundy, Sigman, & Kasari, 1990, 1994; Mundy et al., 1986; Seibert et al., 1987). Examples of prelinguistic behaviors coded as commenting could include (a) smile and eye gaze to examiner during an object spectacle, (b) clapping and eye gaze after the child has stacked blocks, and (c) a show of the child's toy to the examiner. Requesting behaviors have an instrumental or behavior-regulating function (Bruner & Sherwood, 1983; Seibert et al., 1987). Examples of prelinguistic behaviors coded as requesting could include (a) use of a reach toward a desired toy accompanied by eye gaze to the examiner, (b) move- ment by the child of the examiner's hand to the lid of a closed container of goldfish crackers, and (c) giving of a deflated balloon to the examiner to repeat routine of blowing up balloon. Only unprompted commenting and requesting behaviors were included in the current analyses.

The portion of the STAT that was coded lasted approximately 10 minutes, but varied slightly across participants. Preliminary analysis confirmed that the duration of time coded was not related to the frequency of commenting, $r(29) = .046$, $p < .814$, two-tailed, or frequency of requesting, $r(29) = .245$, $p < .200$, two-tailed. Thus, frequency rather than rate was used as the metric for both intentional communication variables.

### Reliability

Interobserver reliability was estimated between two observers using generalizability (G) coefficients (Cronbach, Gleser, Norda, & Rajaratnam, 1972) for the summary level variables that were coded (i.e., attention-following, commenting, and requesting). Reliability coding was calculated for a random sample of 20% of the PAF procedures and STAT sessions. The G coefficients were .964, .991, and .996 for attention-following, commenting, and requesting, respectively. G coefficients greater than .6 are considered acceptable (Mitchell, 1979).

## Results

### Preliminary Data Analysis

The bivariate correlations between both types of motor imitation and vocabulary outcomes are presented in Table 3. A preliminary research question asked whether either type of motor imitation accounted for variance above and beyond the other when both skills were considered together in predicting vocabulary. To conduct this analysis, both motor imitation variables were entered together into a linear regression predicting either comprehension or production. This type of analysis demonstrates whether a particular predictor (e.g., motor imitation of actions with objects) and a dependent variable (e.g., production) continue to have a significant association after the variance shared with another predictor (e.g., motor imitation of actions without objects) is statistically controlled.

**Table 3.** Bivariate correlations of both types of motor imitation with Time 2 vocabulary ($N = 29$).

| | Type of motor imitation | |
|---|---|---|
| Time 2 vocabulary | Without objects | With objects |
| Comprehension | .375* | .259 |
| Production | .591** | .486** |

*$p < .05$, one-tailed. **$p < .01$, one-tailed.

For the prediction of comprehension, the analysis yielded nonsignificant changes in the amount of variance accounted for by either motor imitation with objects ($R^2$ change = .002, $t = -.256$, $p < .400$, one-tailed) or motor imitation without objects ($R^2$ change = .08, $t = 1.515$, $p < .07$, one-tailed). Thus, despite significant bivariate associations, neither motor imitation variable accounted for unique variance in predicting comprehension. This null finding can be attributed to the large intercorrelation between the two metrics of motor imitation, $r(29) = .770$, $p < .00$, one-tailed. For the prediction of production, motor imitation of actions without objects remained a significant predictor ($R^2$ change = .12, $t = 2.152$, $p < .02$, one-tailed) when motor imitation with objects is controlled. However, motor imitation of actions with objects had a nonsignificant and negligible association with production after motor imitation without objects is controlled ($R^2$ change = .002, $t = .305$, $p < .381$, one-tailed). Based on these findings, the decision was made to retain only motor imitation of actions without objects as the type of imitation used in all remaining analyses. (Imitation of actions without objects did have a significant bivariate association with comprehension, justifying the inclusion of this variable as a predictor of comprehension.)

The bivariate correlations of degree of cognitive delay with the prelinguistic predictors were .26, .22, .02, and .36 for motor imitation without objects, commenting, requesting, and attention-following, respectively. Only the association between attention-following and the degree of cognitive delay reached significance at the .05 level. The bivariate correlations of the degree of

**Table 4.** Mean values of study variables ($N$ = 29).

| Variable | *Mean* | *SD* | Range |
|---|---|---|---|
| Time 1 CDI comprehension | 125.93 | 96.93 | 6–372 |
| Time 1 CDI production | 61.83 | 95.18 | 0–346 |
| Time 2 CDI comprehension | 225.79 | 102.91 | 0–390 |
| Time 2 CDI production | 137.62 | 122.40 | 0–390 |
| Motor imitation with objects | 6.24 | 4.70 | 0–16 |
| Motor imitation without objects | 4.10 | 5.26 | 0–16 |
| Attention-following | .46 | .19 | .11–78 |
| Requesting | 9.69 | 9.32 | 0–47 |
| Commenting | 10.03 | 9.09 | 1–32 |

*Note.* CDI = MacArthur Communicative Development Inventory

cognitive delay with vocabulary outcomes were .32 and .36 for comprehension and production, respectively. Both associations reached significance at the .05 level.

## Primary Data Analysis

The first step toward identifying a predictive model of vocabulary acquisition was to examine whether any of the four prelinguistic behaviors measured at Time 1 were significantly related to either comprehension or production measured at Time 2. The means, standard deviations, and ranges for all variables examined in this study are presented in Table 4. Bivariate correlations between the prelinguistic behaviors at Time 1 and vocabulary at Time 2 are presented in Table 5. One-tailed $p$ values were used in these and all subsequent analyses, as all associations were predicted to be positive. There also were significant bivariate associations, ranging from .3 to .7, between the four prelinguistic variables and initial vocabulary size. The decision was made not to control for initial language status in the analyses, as doing so left little outcome variance to explain.

Only two of the prelinguistic behaviors, motor imitation without objects and commenting, were significant bivariate predictors of vocabulary comprehension. These two predictors were entered simultaneously into the second step of a multiple regression analysis,

**Table 5.** Bivariate correlations of Time 1 prelinguistic skills with Time 2 vocabulary ($N$ = 29).

| Vocabulary | Motor imitation without objects | Commenting | Requesting | Attention-following |
|---|---|---|---|---|
| Comprehension | .375* | .513** | .293 | .296 |
| Production | .591** | .505** | .337** | .360* |

*$p$ < .05, one-tailed. **$p$ < .01, one-tailed.

**Table 6.** Results of multiple regression analysis predicting comprehension.

| Variable | *B* | *SE B* | $\beta$ | *t* | $R^2$ *change* |
|---|---|---|---|---|---|
| Step 1 | | | | | |
| Cognitive delay | 2.43 | 1.38 | .32 | 1.76** | .10 |
| Step 2 | | | | | |
| Cognitive delay | 1.42 | 1.29 | .19 | 1.10 | .03 |
| Motor imitation w/o objects | 3.41 | 3.51 | .17 | .97 | .03 |
| Commenting | 4.60 | 2.01 | .41 | 2.29* | .14 |

*$p$ < .05, one-tailed. **$p$ < .01, one-tailed.

after degree of cognitive delay was controlled. Only commenting remained a significant predictor of Time 2 comprehension when degree of cognitive delay and motor imitation without objects were controlled. The results of this analysis are presented in Table 6.

All four of the prelinguistic behaviors were significant predictors of vocabulary production. With only 29 participants, the number of predictors exceeded the subject-to-variable ratio rule of 10:1 for linear regression analyses, making it necessary to reduce the number of predictors to three. To guide the selection process, all four predictors were entered into a principal component analysis (PCA). (A PCA attempts to identify a small number of underlying factors that explain variance or patterns of correlation in a larger number of observed variables.) This analysis resulted in the rotated component matrix of two weighted factors presented in Table 7. The weights of the loadings reflect the extent of relation between each of the original variables and each of the factors. The factor loadings indicated that motor imitation without objects and requesting loaded on one factor, representing 39.6% of the variance, while commenting and attention-following loaded on another factor, representing an additional 33.7% of the variance.

The two variables loading together on factor one (i.e., motor imitation without objects and requesting) were entered together into the second step of a

**Table 7.** Results of principal component analysis for the prelinguistic skills.

| | Component | |
|---|---|---|
| | One | Two |
| Motor imitation without objects | .847 | .270 |
| Requesting | .887 | −.058 |
| Commenting | .278 | .753 |
| Attention-following | −.071 | .839 |

Table 8. Results of multiple regression analysis predicting production.

| Variable | B | SE B | β | t | $R^2$ change |
|---|---|---|---|---|---|
| Step 1 | | | | | |
| Cognitive delay | 3.26 | 1.6 | .36 | 2.02* | .13 |
| Step 2 | | | | | |
| Cognitive delay | 1.68 | 1.36 | .19 | 1.24 | .03 |
| Motor imitation w/o objects | 9.99 | 3.71 | .43 | 2.69** | .15 |
| Commenting | 4.08 | 2.13 | .30 | 1.92* | .08 |

*$p < .05$, one-tailed. **$p < .01$, one-tailed.

regression analysis predicting production. Degree of cognitive delay was entered in the first step in these analyses. Only motor imitation without objects was a significant predictor of production ($R^2$ change = .16, $t$ = 2.58, $p$ < .01, one-tailed) over and above both requesting and degree of cognitive delay. Similarly, the two variables loading together on factor two (i.e., commenting and attention-following) were entered together into the second step of an additional regression analysis predicting production. Only commenting was a significant predictor of production ($R^2$ change = .14, $t$ = 2.31, $p$ < .02, one-tailed) over and above both attention-following and cognitive delay. Thus, two separate analyses had indicated that, when cognitive delay was controlled, only one variable within each factor had a significant relation with production over and above the other variable that loaded on the same factor. Therefore, motor imitation without objects and commenting were selected for inclusion in the final regression analysis predicting production. When entered together into the second step of the regression, both motor imitation without objects and commenting were unique predictors of vocabulary production over and above the variance accounted for by cognitive delay. The results of this analysis are presented in Table 8.

## Discussion

The primary goal of this study was to identify a parsimonious set of predictors of vocabulary comprehension and production in a group of very young children with ASD. Social pragmatic theory and previous empirical findings were used to select four prelinguistic skills as putative predictors of vocabulary outcomes. The prelinguistic predictors represented potentially important pragmatic and functional distinctions within the broader category of triadic attention skills. Empirical studies of language acquisition for children with autism have rarely examined the relation of one prelinguistic skill to vocabulary while the contributions of other prelinguistic skills were controlled. Results demonstrated that, after cognitive delay was controlled, commenting was the sole unique predictor of vocabulary comprehension while commenting and motor imitation without objects both were unique predictors of production.

### Commenting as a Unique Predictor of Comprehension

This study replicated the recent demonstration of a significant predictive relationship between commenting and comprehension in children with autism (Charman et al., 2003). There is also replicated evidence that commenting is a correlate of language comprehension for typically developing children (Bates et al., 1979; Desrochers et al., 1995). Thus, there is empirical support for the generalizability of the finding that commenting is a significant predictor of the number of words children with autism can understand. However, studies of typically developing children have demonstrated that attention-following is a unique predictor of comprehension over and above the variance accounted for by either commenting or requesting (Mundy et al., 1995).

Given the deficit in attention-following that is characteristic of developmentally young children with autism, it may be less likely that these children will learn new words by changing their own focus of attention in order to identify the object or event labeled by an adult. A mismatch between the attentional focus of the child and the referential focus of the adult can lead to incorrect word–object pairings for children with autism. For example, when learning novel words during an experimental task, children with autism always assumed that the adult was labeling the object that was the child's own focus of attention (Baron-Cohen et al., 1997). In contrast, by 16 months of age, typically developing children avoid learning an incorrect word when the adult's focus of attention differs from their own (Baldwin, 1991, 1993a). The finding that commenting accounted for unique variance in comprehension over and above the other prelinguistic predictors supports the hypothesis that intentional communication can provide an alternative pathway to word learning for children who have difficulty responding to adult pragmatic cues for establishing joint reference.

Children use commenting behaviors to indicate reference to a particular object or event. Adults are likely to respond to child intentional communication by providing language that facilitates linguistic mapping (Yoder & Munson, 1995; Yoder & Warren, 1999, 2001). That is, after a child indicates that he or she is attending to an interesting object or event by producing a prelinguistic comment, the adult may respond by labeling the object or event that is the focus of the child's attention. This type of adult labeling behavior is called "follow-in" linguistic mapping. During follow-in linguistic mapping, the adult assumes the burden of achieving shared reference and modifies his or her own focus of attention so that it corresponds with that of the child. The construct of follow-in linguistic mapping was introduced by Tomasello and Farrar (1986) in a study demonstrating that maternal references to objects inside of joint attention episodes were positively correlated with child vocabulary at 21 months, while labels that attempted to redirect the child's focus of attention were not. In addition, children were better at learning novel words during an experimental task when the adult labeled an object that was already the focus of the child's attention (i.e., when the adult "followed-in" to the child's attentional focus) than when the adult redirected the child. Baldwin (1991, 1993b) also used the construct of follow-in labeling to describe a situation in which the adult labels an object that is already the focus of the child's interest, as contrasted with "discrepant" labeling which describes a situation in which the adult labels an object other than the one to which the child is attending.

Follow-in linguistic mapping may be important for young children with autism for several reasons. When the adult follows the child's lead and labels the child's focus of attention, the resultant word–object pairings will be appropriate. Because the child has initiated the communicative act by commenting, he or she may be more motivated to attend to the correspondence between label and object (Wetherby, Reichle, & Pierce, 1998b). Finally, frequent commenters may be likely to communicate for social purposes. This is relevant because one of the primary reasons for acquiring symbolic communication may be to share the contents of the mind (Bloom, 1993), essentially a social purpose. Given that, as a group, children with autism tend to be infrequent commenters, children with autism who comment frequently may be among the more socially inclined or more socially proficient.

## *Commenting and Motor Imitation Without Objects as Unique Predictors of Production*

The current finding that commenting and motor imitation of actions without objects both accounted for unique variance in later language production, over and above the other skills, is new to the literature and needs replication prior to generaliziation to the population of young children with autism. For children with autism, however, there is replicated evidence for the predictive relationship between commenting and language production (Sigman & Ruskin, 1999; Stone & Yoder, 2001), as well as replicated evidence for the predictive relation between motor imitation without objects and language production (Stone et al., 1997; Stone & Yoder, 2001).

Stone and Yoder (2001) demonstrated that, when initial language status was controlled, motor imitation was a unique predictor of language production over and above commenting. However, there are several differences between Stone and Yoder and the current study. Stone and Yoder used a composite measure of motor imitation, including items both with and without objects. In the current study, a preliminary analysis demonstrated that a measure of imitation with objects did not add to the variance in production that was predicted by imitation without objects, thus justifying the use of the latter imitation variable as the metric for motor imitation in the analysis.

Although the current study included coding of intentional communication behaviors from a structured interaction that was videotaped, Stone and Yoder (2001) used a parent report measure of commenting behaviors. Direct observation of intentional commenting may be a more sensitive measure of commenting than is a parent report of commenting. Finally, Stone and Yoder controlled for initial language level in their analysis, providing a more conservative test of predictive associations than was provided by the present study. Thus, the finding that commenting and motor imitation without objects both were significant predictors of vocabulary production at Time 2, while expected, requires replication to demonstrate generalizability to the population of children with autism.

The theoretical rationale presented for expecting the relationship between commenting and comprehension can also apply to the relationship between commenting and production. Although comprehension and production may dissociate to some degree, we may assume that comprehension is necessary, if not sufficient, for vocabulary production. Acquiring comprehension of a new object label, at the very least, should make that word available for productive use. Thus, if commenting is a unique predictor of comprehension, it is reasonable to expect that it would also be related to production.

There is also theoretical support for significant variance in word production accounted for by imitation without objects over and above that accounted for by commenting. Well-practiced motor schemes (e.g., bye-bye) that children learn through imitation and first perform within scripted routines become decontextualized over time and can eventually function as representational gestures used for communication (Iverson & Goldin-Meadow, 1998). In addition, the ability to imitate actions without objects outside of a familiar context and the ability to use words referentially may both rely on the development of representational thought (Bates, 1979; Bates et al., 1980). Both imitation (Nadel et al., 1999) and commenting (Mundy, 1995) are known to elicit social attention from conversational partners. Children who find social attention reinforcing may be more likely to use both of these behaviors as ways to interact with adults. Motor imitation and commenting may allow children with autism to participate in the kinds of social interactions that scaffold the acquisition of names for object referents.

## Implications of the Findings for Intervention

There is not yet replicated evidence that targeting a prelinguistic skill is the best way to facilitate language development. However, the current findings suggest that commenting and motor imitation without objects represent important potential intervention targets. Future intervention studies will need to clarify these issues, but results of the current study are consistent with the hypothesis that increasing behaviors that allow children with autism to make their current focus of attention obvious to adult conversational partners, such that adults can comply with the child's message and provide linguistic mapping for child initiations, may be an effective approach for supporting word learning in young children with autism.

## Limitations of the Study

The small sample size of the current study reduced statistical power. In addition, the need to avoid exceeding the subject-to-variable ratio required for multiple regression analysis (i.e., 10 participants for each predictor) made it necessary to limit the number of variables that ultimately were entered into the analysis predicting production. A larger sample would eliminate the need for the multistep process used to arrive at the final predictive models.

A second limitation of the study was the inability to statistically control for initial language status. Two sets of findings influenced this decision. First, comprehension and production at the initial visit accounted for more than 55% and 70% of the variance in follow-up comprehension and production, respectively. Partialing initial vocabulary in the analyses would have left little variance in vocabulary outcomes to explain. In addition to directly influencing vocabulary outcomes, it is possible that the prelinguistic skills also had an indirect influence on Time 2 vocabulary through their previous effect on initial language status. If the prelinguistic variables had already influenced vocabulary size at Time 1, and these associations were stable over time, controlling for initial vocabulary could eliminate the effect of the very relation that was the focus of consideration. However, an alternative explanation is that the direction of effect went from initial language status to the prelinguistic variables. In this case, assuming stable language differences over time, initial language may have influenced vocabulary outcomes indirectly by acting through the prelinguistic behaviors (Yoder & Kaiser, 1989). As with all correlational studies, it is not possible to rule out the possibility that a third variable, such as initial language status, explains the observed associations.

A third limitation is that correlated measurement error may have increased the probability that significant effects were detected in this sample that do not exist in the population of children with autism. This may be the case if an unmeasured variable, such as compliance or self-regulatory ability, influenced which children were able to participate successfully in the experimental tasks in this study. For example, if only children with high levels of compliance were able to complete the attention-following task, then the obtained results would not necessarily generalize to the population of children with autism, many of whom have difficulty complying with task demands and unfamiliar routines. Use of parent reports for measuring vocabulary may have introduced an additional source of correlated measurement error if parental or family characteristics influenced both the prelinguistic behaviors and the way that the vocabulary checklist was completed.

A final limitation of the study addresses the fact that more significant associations were observed for vocabulary production than for vocabulary comprehension. Comprehension in young children is often scaffolded by the context or routine in which a word is used (Coggins, 1998), making it difficult to judge whether a child actually knows a given word. In addition, children with autism often fail to comply with adult directives to look at or retrieve an object referent, adding to the challenge for parents in accurately reporting their child's lexicon. In contrast, parents can be much more definite in reporting the words that their children are able to produce. Therefore, fewer predictive associations with comprehension than with production could have occurred because of greater measurement error associated with parent reports of comprehension. As a group, the weaknesses noted for the current study are intrinsic to almost all correlational investigations of early language in children with autism.

## Directions for Future Research

Results of the current study provide an initial inquiry into identifying unique predictors that contribute simultaneously to the early development of language in children with autism. Future studies may replicate these findings with a larger group of participants, enabling the consideration of a greater number of predictors. In addition, the current study revealed a high level of intercorrelation between language scores at Time 1 and Time 2, preventing the analyses from controlling for initial language levels. A larger or different sample of children may not demonstrate such stability in language development over time. Increasing the amount of time between the initial and follow-up assessments also may allow a more stringent test of the associations under consideration.

The imitation measure used in the current study did not specifically evaluate the use of representational gestures, that is, the kind of gestures that children initially use interchangeably with object labels. Using a modified version of the imitation measures designed by Bates and colleagues (1980) would allow comparison of several different aspects of motor imitation performance (i.e., real vs. placeholder objects, sequences of actions vs. single actions, and imitation within a scripted context vs. an unsupported context). The aspects of motor imitation measured with the tasks developed by Bates and colleagues may yield a different pattern of associations with vocabulary outcomes than the measure used in the current study. It would be especially interesting to determine if the ability to produce a sequence of gestures within a familiar routine were related to comprehension for children with autism.

The current study did not examine the potential contribution of vocal imitation ability to language outcomes for children with autism. Motor imitation of actions without objects was selected for consideration in this study because there is prior replicated evidence for this type of motor imitation as a predictor of language development and because this type of motor imitation can be considered a triadic attention skill. However, exploring the relationship between vocal imitation and later language development, and exploring the relationship between action imitation and the ability to imitate sounds, words, and phrases, provide important areas for future research in children with ASD. Finally, targeting commenting and motor imitation through an intervention study would provide a direct test of the influence of these predictors on vocabulary outcomes.

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Contact author: Andrea McDuffie, Room 533A, Waisman Center, University of Wisconsin, 1500 Highland Avenue, Madison, WI 53705. E-mail: mcduffie@waisman.wisc.edu