Predicting Lexical Density Growth Rate in Young Children With Autism Spectrum Disorders

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Purpose: The purpose of this longitudinal correlational study was to test whether an environmental variable and 4 child variables predicted growth rate of number of different nonimitative words used (i.e., lexical density).
Method: Thirty-five young (age range = 21–54 months) children with autism spectrum disorders (ASD) who were initially nonverbal or low verbal participated in the study. Lexical density was measured at 3 times: at entry into the study as well as 6 months and 12 months after entry into the study. Growth curve analysis was used to test the associations. The predictive value of the putative predictors in the model was tested after controlling for initial expressive language impairment.
Results: Initial frequency of intentional communication and diversity of object play were predictors of lexical density growth above and beyond initial expressive language impairment (both pseudo R^2s = .14).
Conclusions: Intentional communication and diversity of object play may represent important prelinguistic goals for young children with ASD. These skills not only have been shown to be malleable through treatment, but they also provide a context for linguistic input from others that may facilitate language development.

Key Words: autism, spoken language, predictors

Several retrospective reports identify "useful speech by age 5 years" as a consistently strong predictor of later adaptive functioning in individuals with autism spectrum disorders (ASD; DeMyer et al., 1973; Gillberg & Steffenburg, 1987; Kobayashi, Murata, & Yoshinaga, 1992; Rutter & Lockyer, 1967). "Useful speech" has come to mean referential spoken word use that is frequent, communicative, and nonimitative (DeMyer et al., 1973; Kobayashi et al., 1992; Venter, Lord, & Schopler, 1992).

Lexical Density as a Measure of "Useful Speech"

For speech to be communicative, it must be produced for the purpose of conveying a message to a social partner. The spoken words must also be linked to specific referents (e.g., objects, actions, ideas) and be pronounced in a sufficiently accurate manner to be generally understood. For communicative speech to be functional, it must also be frequent and flexible. That is, using the same word repeatedly, or speaking only in imitation of others, is not as useful as the ability to use many different nonimitative words.

Yoder and Stone (2006a) posited that the number of different nonimitative words produced is a particularly face-valid metric of useful speech in children with ASD. This measure has been called "lexical density" because it reflects both talkativeness and productive vocabulary size (Yoder, Warren, & McCathren, 1998). One theory of early language development considers it a measure of fluency in early productive language use (Chapman et al., 1991).

Lexical density is typically derived from a conversational language sample. Conversational language samples have become the method of choice for many speech-language pathologists because they resemble more common, and possibly less inhibiting, language use contexts than those used in standardized tests for many preschoolers (Miller, 1981). Words reported on parent questionnaires may be infrequently used or even no longer used. Therefore, conversational contexts and lexical density scores from such contexts may represent a particularly valuable metric for the construct of useful speech in young children with ASD.

Although there are no published reports that use lexical density as an outcome in children with ASD, much past research has been conducted to identify single variables that predict the broader and related constructs of vocabulary size (e.g., McDuffie, Yoder, & Stone, 2005) or global expressive language (e.g., Sigman & Ruskin, 1999; Stone & Yoder, 2001) in this population. Additionally, no work has been done to predict growth in lexical density in children with ASD who *begin the study with almost no language*. The present study seeks to identify variables that are malleable that also predict growth of lexical density with the ultimate goal of informing treatment practices and goals.

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Putative Predictors of Lexical Density Growth in Children With ASD

Expressive language impairment and initial lexical density. With this goal in mind, it is useful to identify predictive child and environmental variables after controlling for the influence of initial degree of expressive language impairment as quantified by standard scores. Expressive language impairment may be severe due to a multitude of issues, many of which are relatively difficult to change through educational treatments (e.g., oral motor ability, general intelligence level). Therefore, I use expressive impairment as a proxy variable for a host of relatively stable influences on growth of lexical density. Additionally, controlling initial language developmental level (i.e., initial lexical density) is critical if one is to eliminate a relatively trivial explanation for the associations of interest. For example, controlling for initial language level prevents the association between diversity of play and rate of lexical density growth being explained by the notion that children with initially high lexical density have both relatively good play skills and relatively fast growth in lexical density (Yoder & Kaiser, 1989).

I have identified four putative child predictors: attention following, intentional communication, motor imitation, and diversity of object play. Three of these (attention following, intentional communication, and motor imitation) are justified through social-pragmatic theory and empirical work. Social-pragmatic theory states that children are able to learn the meanings of words because they have access to social information from communicative partners within episodes of triadic joint attention (Baldwin & Moses, 1996; Hollich, Hirsh-Pasek, & Golinkoff, 2000; Tomasello, 2001, 2003). Triadic attention occurs when the child uses eye gaze, vocalization, and gesture (Mundy & Markus, 1997) to respond to, initiate, and maintain episodes of shared reference to objects or events with another person (Bakeman & Adamson, 1984; Bretherton, 1992). Learning new words presents a special problem for children diagnosed with ASD, in part, because these children have core deficits in using triadic attention behaviors (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, three behaviors were identified based on theoretical and empirical support for the relation of these specific behaviors to vocabulary outcomes for children with autism: attention following (i.e., point and gaze following), intentional communication (a subset of which is initiating joint attention), and motor imitation (a subset of which is imitation of actions with objects).

Attention following. Attention following is the child's compliance with adult attentional directives. Hollich et al. (2000) claimed that infant attentional focus is the cornerstone of the early ability to associate label and object. Implicitly, they were referring to the link between attention following and vocabulary comprehension. Conceptually, attention following is related to vocabulary comprehension. Attention following is thought to help children accurately map the words other people use onto the objects and events that others are talking about by releasing the child from a dependency on people talking about things already within the child's attentional focus. Thus, I would expect attention following to enhance children's understanding of and eventual meaningful use of words. Several studies have documented that attention following is related to later expressive language (McDuffie et al., 2005; Sigman & Ungerer, 1984), even when controlling for initial language level (Sigman & Ruskin, 1999) and initial mental age (Mundy et al., 1986) in young children with ASD.

Intentional communication. Intentional communication is another putative predictor of lexical density. Without the intent to communicate, even children with a large productive vocabulary will only use their words to label the environment or self-regulate, not to communicate with others. Preverbal intentional communication is the use of gestures, gaze, and nonword vocalizations that co-occur with or are used in sequence with attention to object and person to communicate (Yoder & Warren, 1993). The presence of coordinated attention to object and person is relevant to the development of linguistic communication, in part, because most early word learning probably occurs within exchanges in which the child shows explicit attention to both an object or event referent and the person with whom he is communicating (i.e., coordinated attention to object and person; Bates, 1979). Coordinated attention to object and person may also be an early indicator of "understanding others' intentions," a theoretically important precursor to linguistic communication (Tomasello, 1995). Bruner (1974) suggested that nonverbal intentional communication provides the basis for later linguistic communication in that children only need to learn the words for meanings they are already communicating. Additionally, intentional communication recruits linguistic input from parents, which might in turn facilitate vocabulary acquisition (Yoder & Warren, 2001). There is replicated evidence that frequency of the two major pragmatic functions—commenting (sharing positive affect or interest about an object or event with another person) and requesting (asking for an object or action using nonverbal means)—predicts later production in children with ASD (McDuffie et al., 2005; Sigman & Ruskin, 1999).

In the present study, I do not distinguish between pragmatic functions of intentional communication. No published study has demonstrated that intentional communication without respect to pragmatic function predicts productive language in children with autism. To date, most researchers have focused on commenting because there has been more consistent replication of commenting predicting later language in children with ASD than studies on requests. The finding that one function is related to later language and the other is not does not mean that one predictor is a significantly stronger predictor of language than the other. It is quite likely that the confidence intervals around each predictor's correlation coefficient overlap. In fact, both functions use coordinated attention to object and person, and both functions elicit linguistic input from others. In one of the only empirical tests of the relative strength of comments versus requests as predictors of later language in children with ASD, McDuffie et al. (2005) found that both commenting and requesting explained unique variance in later production in children with ASD. McDuffie et al.'s results suggest that considering both comments and requests, instead of just comments, accounts for more variance in later language.

Motor imitation. Another putative child predictor of lexical density is motor imitation. Varied explanations have been proposed for the ways in which motor imitation might contribute to language development. Motor imitation has been proposed as a cognitive mechanism for learning socially constructed behaviors (Bates, Thal, Whitesell, Fenson, & Oakes, 1989), as an index of the child's understanding of other's intentional action (Meltzoff, 1995), or as a system for communicating shared understanding between social partners (Nadel, Guerini, Peze, & Rivet, 1999). Regardless of the precise role played by motor imitation, its potential importance to the acquisition of referential communication was acknowledged long ago (Bates, 1979).

In this study, I do not distinguish between types of motor imitation. However, elsewhere in the literature, two basic dimensions of motor imitation are frequently acknowledged: motor imitation of actions without objects and motor imitation of actions with object support. For children with ASD, there is replicated evidence that motor imitation without objects (McDuffie et al., 2005; Stone, Ousley, & Littleford, 1997) and with objects (Charman et al., 2003; McDuffie et al., 2005) predicts later production. Finally, there is replicated evidence that a composite measure including motor imitation tasks both with and without objects predicts later language production (Stone et al., 1997), even when controlling for initial language status (Stone & Yoder, 2001). There is no evidence that one type (i.e., with vs. without objects) of motor imitation is significantly more related to later language than the other.

Diversity of object play. The last putative child predictor of lexical density growth is diversity of object play. Its selection is not justified through social-pragmatic theory of language development. However, diversity of object play is a predictor of later language in children with autism (Sigman & Ruskin, 1999). Diversity of object play may predict meaningful language in children with ASD because children with many action schema demonstrate greater object knowledge, thereby providing a greater number of nonverbal concepts onto which the children can potentially map language. Apart from its contribution to object knowledge, diversity of object play is theoretically predictive of communicative word use because it provides opportunities for joint attentional episodes, which are the most frequent context for early linguistic communication (Tomasello, 1995). Considering diversity of object play as a predictor of language growth may be particularly relevant in children with ASD who display restricted interests in their play. Clinically, children with ASD with very restricted object play repertoires have more difficulty engaging in turn-taking. Empirically, Sigman and Ruskin (1999) found diversity of object play to be positively related to gains in expressive language over 12 months time in children with autism.

Amount of treatment. In addition to within-child influences, environmental factors are important in understanding why some children with ASD develop useful speech and others do not. One such factor is early intervention. Most, if not all, American children after the age of 3 years who have a diagnosis of ASD are in some sort of instructional program designed to facilitate language development. Current ways to measure intervention in the community is through estimating the sheer amount of therapeutic experience (e.g., Bono, Daley, & Sigman, 2004; Stone & Yoder, 2001).

There are two studies that raise the question of whether amount of therapy has an additive effect (i.e., it adds to the predictive power of the model after controlling for other significant predictors) or multiplicative effect (i.e., it statistically interacts with another predictor) on expressive language. Stone and Yoder (2001) found that the number of hours in speech-language therapy predicted later global expressive language after controlling for initial global expressive language and initial motor imitation. Bono et al. (2004) found that amount of therapy predicted growth in age equivalency scores on a standardized language test only in children with relatively high attention-following ability. Although neither study focused on lexical density, they are germane to the rationale for the present study because lexical density is an overlapping construct with expressive language.

Research Questions

The overall purpose of the study was to shed light on why some initially nonverbal or low verbal children with autism acquire linguistic communication skills relatively rapidly while others do so more slowly. Identifying child and treatment characteristics that predict growth rate in lexical density may help us identify characteristics that enable the better outcomes. Results from correlational studies, such as the current one, provide the groundwork for later experimental studies that are better suited to testing whether detected predictors are causally related to growth in lexical density. The research questions for this study are twofold:

1. Which of the putative child and environmental predictors are associated with growth of lexical density in young children with ASD?
2. Does amount of therapy statistically interact with attention following to predict growth in lexical density such that amount of therapy predicts growth in lexical density only in children with relatively high attention-following ability?

Method

Participants

Thirty-five children participated in the study. They met the following inclusion criteria: (a) a diagnosis of autistic disorder (AD) or pervasive developmental disorder-not otherwise specified (PDD-NOS), (b) chronological age between 18 and 60 months, and (c) use of fewer than 10 words during the two communication samples employed. Children were excluded if they demonstrated severe sensory or motor deficits, or if English was not the primary language spoken in the home. Children obtained hearing screenings outside of the project prior to entering the study. All children who could be tested passed the hearing screening.

Research diagnoses were based on results from the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000). The ADOS was administered by examiners who had been trained and certified to use Module One (i.e., the subsection for predominantly nonverbal children) of the ADOS. AD and PDD-NOS are two subcategories on the autism spectrum (American Psychiatric Association, 2000). All of the children had received clinical diagnoses of either AD (32) or PDD/NOS (3). All 35 children received ADOS scores consistent with a classification of autism. The median formal educational level of the primary parent was 3–4 years of college (range: 10th grade to more than 2 years of graduate school). Sixty-nine percent (24) of the sample members were Caucasian, 23% (8) were African American, and 8% (3) reported "Other." Eighty-nine percent (31) of the children were male. Table 1 presents descriptive information for the sample. Lexical density and attention following have greater standard deviations than means. These two variables were skewed to the right (i.e., there were more children than would be expected from a normal distribution that scored lower than the mean on these two variables).

Design and Overview

This study used a longitudinal correlational design to identify the predictors of growth in lexical density. Lexical density was measured at three measurement times spaced approximately 6 months apart. Growth rate was quantified as the slope for each individual's linear growth curve (Raudenbush, Bryk, Cheong, & Congdon, 2001). The child putative predictors were measured at entry into the study (i.e., Time 1). Times 2 and 3 occurred 6 and 12 months after entry into the study, respectively. The amount of therapy was measured monthly during the first 6 months of the study and at the end of the study.

All children were enrolled in one of two treatments that were administered (i.e., within-project treatments). The results of the treatment efficacy analyses are reported elsewhere (Yoder & Stone, 2006b). However, it is important to note that within-project treatment assignment did not alter any of the putative associations. The test of the effect of within-project treatments on the associations of interest is the statistical interaction between treatment group and the putative correlate predicting growth of lexical density. These interactions were all nonsignificant. In general, almost all children with ASD obtain treatments. I have controlled some of that variance by conducting these correlational analyses in children for whom at least some of their treatment experience is standardized. Unlike correlational studies that are not embedded within treatment studies, I could test whether at least the treatments administered affected the associations of interest. They did not.

TABLE 1. Means and standard deviations for descriptive variables at Time 1.

Variable	*M*	*SD*	Range
Chronological age (months)	33.6	8.4	21–54
Nonverbal mental age (months)[a]	18.6	3.7	11.5–26.5
Verbal mental age (months)[a]	11.9	2.8	7–19
Cognitive standard score[a,b]	51	5.3	48–67
Number of words child understands[c]	86	74	1–277
Lexical density[d,e]	0.5	1.0	0–5
Attention following[e]	1.6	2.2	0–8
Intentional communication[d,e]	25	17	4–83
Motor imitation score on MIS[f]	7.8	6.4	0–32
Diversity of object play[g]	39	22.5	7–123

[a]Based on the Mullen Scales of Early Learning (Mullen, 1992). Nonverbal age equivalency is the average age equivalency from the fine motor and the visual spatial subscales. The verbal age equivalency is the average age equivalency from the receptive and expressive subscales. The standard score is given for the Learning Composite.
[b]Standard scores under the possible minimum (i.e., 49) were assigned 48.
[c]MacArthur Communicative Development Inventories (Fenson et al., 1991).
[d]Number of intentional communication and different nonimitative words from the unstructured free-play with examiner.
[e]Number of attention following, intentional communication, and different nonimitative words from the Early Social Communication Scales (Mundy et al., 1996).
[f]Motor Imitation Scale total raw score (Stone et al., 1997).
[g]The number of unique anticipated actions with objects from the Developmental Play Assessment (Lifter, 2000).

Procedures

Mullen Scales of Early Learning (MSEL). The MSEL (Mullen, 1992) procedure was given at Time 1. The MSEL, a standardized developmental test for children age 3 to 68 months, consists of five subscales: gross motor, fine motor, visual reception, and language reception and expression. The gross motor subscale was not administered for the current study. The *T* score for the language expression subscale was used as the index of expressive language impairment. The internal consistency of this subscale for the current sample was .75.

Motor Imitation Scale (MIS). The MIS (Stone et al., 1997) procedure was administered at Time 1. The MIS is a 16-item assessment of motor imitation designed for use in young children with autism. The items are presented in a structured, but playful, context. The experimenter demonstrates the item for imitation saying, "Do this" or "Do what I do." The child's response is then scored on a 0–2 scale where 0 = *failure to imitate,* 1 = *an emerging response,* and 2 = *a passing response*. Motor imitation is operationally defined as the sum of the child's best performance score from each of the 16 items on the MIS. The authors of the MIS report acceptable internal consistency ($n = 54$, $\alpha = .87$) and an acceptable 2-week test–retest reliability coefficient of .80 ($n = 30$) in young children with ASD (Stone et al., 1997). The total score from this procedure was used as the variable.

Developmental Play Assessment (DPA). The DPA (Lifter, 2000) procedure was administered at Time 1. An adapted version of the DPA was used. In this procedure, the examiner presents three sets of toys and allows the child to explore each set for approximately 5 min. During our adaptation of the DPA, the examiner is instructed not to model any play behaviors for the child but is allowed to imitate the child's behaviors. The same procedure and toys are used with all participants. This procedure was coded for presence of predetermined action schema with objects.

Adapted version of the Early Social Communication Scales-Abridged (ESCS-A). The ESCS-A (Mundy, Hogan, & Doehring, 1996) instrument was given at Times 1, 2, and 3. This version is shorter than the more familiar ESCS (Seibert, Hogan, & Mundy, 1982) and consists of a series of activities designed to elicit communication. Activities include (a) activating two windup and two handheld mechanical toys designed to elicit requests and initiating joint attention, (b) engaging in a tickle game ("Baby Bumble Bee" song), (c) conducting eight attention-following trials (e.g., saying, "NAME," with short-arm point and gaze), and (d) presenting one transparent, closed jar containing a windup toy. The examiner attempted to get the child's attention prior to introducing each trial. Trials were repeated up to three times if necessary. Verbal prompts and upturned palms were used to prompt requests, when needed. This procedure was coded for attention following and intentional communication at Time 1 and lexical density at all measurement times.

Unstructured free-play with examiner (UFPE). This procedure was administered at all three measurement times. During this 15-min session, developmentally appropriate objects (i.e., toy baby bottle, baby spoon, doll's hairbrush, two teacups, two saucers, teapot, female baby doll, four colored drumsticks, two cubes of foam rubber, baby rattle, toy car, baby's blanket, Fisher-Price Chatter telephone pull-toy) were accessible to the child. The examiner played with the same or similar toy as the child by imitating the child's play. If the child did not attend to any toy for 10 s, the examiner selected an interesting object and used the object in a play schema that was at or below the cognitive level observed for the child. Examiners verbally commented on the child's or their own actions and vocally imitated the child's discrete vocalizations. Examiners were instructed not to use any type of communication prompt (e.g., no time delays, questions, or gestural prompts were allowed). This procedure was coded for intentional communication at Time 1 and lexical density at all measurement times.

Nonproject treatment questionnaire. This questionnaire was administered monthly for the first 6 months and then again at 12 months after study entry. Parents were asked to estimate the number of hours that their children obtained a variety of different therapy types and methods during the past month. Two variables were derived: (a) the average number of hours in communication/speech/language therapy per month and (b) the average number of hours in all therapies per month. The parental estimates were added to the observed within-project treatment attendance (M = 3.3 hr/month, SD = 0.3). The variables analyzed were the sum across nonproject and within-project treatment attendance.

Coding, Data Entry, and Reliability

All primary and reliability coding was conducted by paid research staff who were not aware of the hypotheses of the current correlational study. Attention following was coded from videotapes of the Time 1 ESCS-A. Attention following was coded if the child looked at the referent immediately (i.e., within 3 s) after the examiner called the child's name, said, "Look!" and pointed with the elbow pulled close to the torso and looked at the referent.

Intentional communication was coded from videotapes of the ESCS-A and UFPE sessions with the aid of a custom-made software program (Transcript Builder; Tapp & Yoder, 2001b). Intentional communication was operationally defined as conveying a message to another person by either (a) the use of gestures, vocalizations, and eye gaze combined with coordinated attention to an object and a person, or (b) the use of conventional gestures (e.g., distal points) or symbols (e.g., spoken words or sign language; Yoder & Warren, 1993). The number of intentional communication acts was summed across the ESCS-A and UFPE at Time 1 for this putative predictor variable.

Lexical density was transcribed from videotapes of the ESCS-A and UFPE sessions with the aid of Transcript Builder at all three measurement times. A word approximation had to meet all of the following criteria: (a) contain at least one accurate consonant and vowel combination occurring in the correct position, (b) have either the correct number of syllables or a developmentally appropriate syllabic reduction or derivation, (c) be in the unabridged English dictionary, (d) not be immediately imitated from an adult model or a repetition of the child's immediately preceding utterance, and (e) refer to an object or event that the child was attending to when he or she said the word. If a word was used both in the ESCS-A and UFPE, it was counted once. The number of different nonimitative words (i.e., lexical density) summed across procedures was derived for each measurement time and used as the raw data for the individual growth curves. This was the primary dependent variable: growth rate of lexical density.

The diversity of object play was coded from videotapes of the DPA at Time 1. I designed and a computer programmer wrote a software application called Playcoder to be used with the DPA (Tapp & Yoder, 2001a). Playcoder has a list of anticipated actions for each of the toys in the DPA. When the observer sees a play action the observer thinks may be an anticipated action with one of the experimental materials, the observer selects the toy set that the child was using, selects the particular toy the child touched from the toy set, and indicates the action from a list of anticipated actions. The list of anticipated actions includes only those that children with ASD and typically developing children customarily perform with a particular toy in the assessment. The list was constructed from Lifter's (2000) list and our own experience with children with ASD. Mouthing, banging, and shaking were considered "undifferentiated play." Other actions are types of functional play and symbolic play schema. The software outputs the number of unique actions observed. The diversity of object play variables was the number of unique anticipated actions observed.

All data in analysis spreadsheets were independently checked by reentering the data and using an Excel macro that "flagged" cells without exact matches. All flagged cells were checked a third time to determine the correct entry. Interobserver reliability was estimated from independently coded, randomly selected sessions that made up at least 20% of the sessions from which coded variables were derived. The intraclass correlation coefficients (ICCs) were .80, .98, and .96 for Time 1 attention following, intentional communication, and diversity of object play, respectively. The ICC for lexical density at Time 3 was .98. There was little variance at Times 1 and 2 for lexical density. Therefore, ICC was not an appropriate reliability estimate for this variable at those times. Small over large agreement proportion for lexical density (i.e., lexical density identified by one observer divided by that of the other observer) was estimated for this variable at Time 1 and Time 2. The average agreement proportion for lexical density was 1.0 and 0.95 for Times 1 and 2, respectively.

Analysis Approach

To test the effect of putative predictors on growth rate of lexical density, I used mixed-level modeling (i.e., hierarchical linear modeling; Raudenbush et al., 2001). This application of mixed-level models is designed to identify the values of the individual growth curve parameters (Level 1 analysis) and identify the predictors of them (Level 2 analysis). With three measurement times, it is best to fit a simple linear function (i.e., a straight line) to individual growth data because using a more complex fit (i.e., a quadratic function) would not allow statistical tests on the growth curves. A simple linear function is described mathematically as an intercept and slope (i.e., growth rate). Our primary interest was in identifying predictors of growth rate (i.e., slope) for lexical density. I set the initial value for "time" at zero and subsequent values at months from entry into the study to two decimal places. This practice allows one to interpret the intercept as initial lexical density ability and to treat variance in when Time 2 and Time 3 occurred relative to Time 1 as a continuous, analyzed variable instead of as a source of error (Singer, 1998). The average time from entry for Times 2 and 3 was 6.5 (SD = 0.47) and 12.5 (SD = 0.29) months, respectively. I centered the putative predictors by subtracting the grand mean from the values to reduce the intercorrelation among putative predictors of growth in lexical density (Bryk & Raudenbush, 1992). The full maximum-likelihood estimation method was used to estimate the parameters. Only analyses that met the statistical assumptions of mixed-level modeling were reported.

Results

Preliminary Analyses

Table 2 supplements the information provided in Table 1 to complete the descriptive information about the variables that were analyzed to test the research questions. It includes the descriptive information about the predictors and lexical density at Times 2 and 3.

Level 1 analyses indicated that the growth curves fit the raw lexical density data well, that there was positive average growth in lexical density, and that there was significant variance in the rate of growth in lexical density. Level 1 analysis involves determining (a) the extent to which a straight line as estimated by the Level 1 analysis fit individuals' raw data for the lexical density variable (i.e., the reliability of the slope parameter), (b) whether there was an average nonzero initial lexical density score and an average nonzero growth rate in lexical density (i.e., significance of the fixed effect for intercept and slope, respectively), and (c) whether there was significant variance in the initial value and growth of lexical density (i.e., significance of the random effects for intercept and slope, respectively). The most important of these were reliability for, nonzero value for, and significant variance in slope. The reliability of the slope parameter was .94. The fixed effects were nonsignificant for intercept, $t(33) = 1.6$, $p = .12$, and significant for slope, $t(33) = 3.29$, $p = .003$. The random effects were nonsignificant for intercept, Wald $\chi^2(33) = 20.19$, $p > .5$, and significant for slope, Wald $\chi^2(33) = 560$, $p < .001$. The average growth curve for lexical density without knowledge of the predictors was approximately one word every 2 months (i.e., slope = .5).

TABLE 2. Means and standard deviations for balance of analyzed variables.

Variable	*M*	*SD*	Range
Expressive language impairment at Time 1[a,b]	21	3	19–30
Amount of total treatment per month (in hours)[c]	16	9	11–145
Amount of communication treatment per month (in hours)[d]	10	5	11–29
Lexical density at Time 2[e]	3	5	0–17
Lexical density at Time 3[e]	7	11	0–50

[a]Based on the Mullen Scales of Early Learning (Mullen, 1992).
[b]*t* scores (population $M = 50$, $SD = 10$).
[c]Average of attendance per month to nonproject and project treatments across the first 6 months of the study and the Time 3 measurement period.
[d]Average of attendance per month to nonproject communication/language/speech therapy plus average attendance per month to project treatment across the first 6 months of the study and the Time 3 measurement period.
[e]Number of different nonimitative words from the Early Social Communication Scales (Mundy et al., 1996) and examiner–child free-play.

Table 3 presents the intercorrelations of the Time 1 child putative predictors of growth of lexical density. It is noteworthy that frequency of intentional communication and motor imitation were unrelated and that frequency of intentional communication and diversity of play were moderately related. Attention following was related strongly to both motor imitation and frequency of intentional communication. Similarly, motor imitation and diversity of play were strongly related. In contrast, Time 1 expressive language impairment was unrelated to all other Time 1 predictors of lexical density growth.

As predicted, Time 1 expressive language impairment accounted for significant variance in growth in lexical density, $t(32) = 3.11$, $p = .004$. Table 4 provides the relevant summary information. It is important to note that adding the Time 1 expressive language impairment variable improved the fit of the model compared with the unconditional

TABLE 3. Intercorrelation of putative child predictors of lexical density growth.

Predictor	Motor imitation	Frequency of intentional communication	Attention following	Diversity of object play
Expressive language impairment	−.16	.26	−.24	−.02
Motor imitation	—	.17	.63*	.49*
Frequency of intentional comm.		—	.52*	.36*
Attention following			—	.68*

*$p < .05$.

Level 1 model, $\chi^2(2) = 20.4$, $p < .001$. The relevant information for identifying whether a putative predictor accounts for significant variance in growth of lexical density is the significance of the fixed effect for the predictor on the slope of the dependent variable. All such predictors are identified after controlling for initial lexical density. The pseudo R^2, .04, indicates a small but statistically significant effect size. Children with better expressive standard scores had faster growth in lexical density.

Research Question 1: What Are the Variables That Predict Growth in Lexical Density After Controlling for Expressive Language Impairment?

Only intentional communication, $t(28) = 2.85$, $p = .009$, and diversity of object play, $t(28) = 3.5$, $p = .002$, continued to be significant predictors of growth in lexical density after controlling for expressive language impairment and initial lexical density (see Table 4). These findings were identified in separate analyses in which one predictor was added after controlling for expressive language impairment. It is noteworthy that adding either intentional communication, $\chi^2(2) = 52.0$, $p < .0001$, or object play diversity, $\chi^2(2) = 52.27$, $p < .0001$, significantly improved the model fit over using only Time 1 expressive impairment. The effect size of either object play diversity or intentional communication with expressive impairment accounted for a moderate amount of variance in growth in lexical diversity. However, neither Time 1 intentional communication nor Time 1 diversity of object play continued to be a predictor of lexical diversity growth after controlling for each other. Finally, the amount of communication/speech/language therapy children received was not related to the growth rate of lexical density after controlling for Time 1 expressive language impairment, $t(32) = 0.69$, $p = .5$. It should be noted that pseudo R^2 values should be interpreted with caution because they can, under certain circumstances, be negative (Kreft & deLeeuw, 1998). A negative pseudo R^2 is not meaningful. The circumstances under which this can occur did not apply in the present study.

Research Question 2: Does Amount of Language Therapy Statistically Interact With Time 1 Attention Following to Predict Growth in Lexical Density?

Neither the amount of communication/speech/language therapy, $t(30) = 0.61$, $p = .55$, nor total therapy, $t(30) = 1$, $p = .32$, that children received statistically interacted with their Time 1 attention following to predict growth in lexical density.

Secondary Analyses: Demonstration That the Treatments Did Not Affect the Detected Associations

Some readers may be concerned that the different treatments administered to the children affected the associations of interest. This concern may be particularly salient for some readers because the treatments provided focused explicitly on and had an effect on intentional communication and ultimately lexical density (Yoder & Stone, 2006a, 2006b). As mentioned above, the test of whether the treatments affected the associations of interest is the significance test on the statistical interaction between the predictor variable and treatment group assignment predicting lexical density growth. The detail on the results of these tests is provided here for the predictors intentional communication and diversity of object play to provide the reader with further information regarding this important issue.

The statistical interaction between diversity of object play and treatment group predicting the rate of lexical density growth was nonsignificant, $t(30) = -1.86$, $p = .07$. This

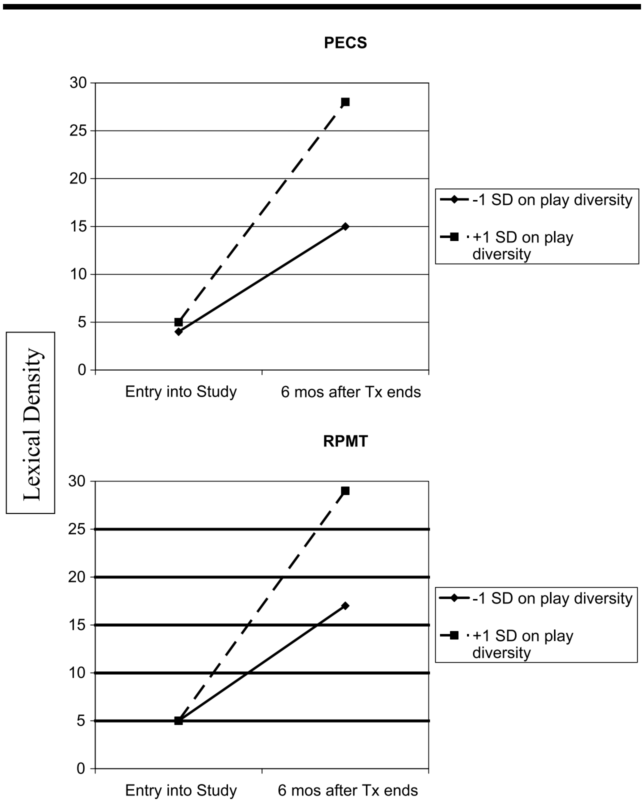
TABLE 4. Unstandardized coefficients for fixed effects of predictors and random effects of residuals for individual growth curves.

Variable	Intercept fixed coefficient on slope	Expressive language fixed coefficient on slope	Other predictors fixed coefficient on slope	Pseudo R^2 residual
Level 2 with expressive language impairment	.50	.12	NA	.04
Level 2 with expressive language impairment and intentional communication	.50	.08	.02	.14
Level 2 with expressive language impairment and diversity of object play	.52	.13	.19	.14

interaction had the largest effect size (albeit nonsignificant) of those that are relevant to testing whether the treatments differentially affected the associations discussed in this article. Therefore, more detail will be given about it to illustrate why interpreting the simpler model without group and the Predictor × Group term is justified. The deviance statistic is a chi-square that compares the chi-square statistic for the model with group, predictor, and product term as the predictors with that for the nested, simpler model with only group and diversity of play as predictors. Nonsignificant deviance statistics indicate that the more complex model does not add explanatory power. The deviance statistic with two degrees of freedom was 2.2 ($p = .33$). The pseudo R^2 for the more complex model with the product term was .02 (i.e., a very small effect size). Additionally, treatment group does not add anything above play by itself (deviance statistic = .2, $p > .5$). This nonsignificant interaction is displayed in Figure 1. These results mean that the treatment group, whether considered by itself or in interaction with diversity of play, does not add to our understanding of why some children have steeper growth curves than others on lexical density.

Similarly, the statistical interaction between intentional communication and treatment group predicting the rate of lexical density growth was nonsignificant, $t(30) = -.01$, $p = .99$. The deviance statistic (two degrees of freedom) for adding the product term was .21 ($p > .5$).

FIGURE 1. Illustration of the nonsignificant interaction between treatments and play diversity predicting growth in lexical density.



Discussion

This longitudinal correlational study was designed to identify predictors of growth of lexical density, arguably a particularly face-valid measure of useful speech, in initially nonverbal children with ASD. I controlled for initial degree of expressive language impairment because it represented a predictor that was relatively stable but that influences growth in useful speech. Initial lexical density was also controlled to eliminate a common alternative explanation for longitudinal correlations. The results showed that intentional communication and diversity of object play were predictors of lexical density growth after controlling for Time 1 expressive language impairment and initial lexical density. However, which predictor is responsible for the association is unclear because the two predictors were moderately intercorrelated (i.e., $R^2 = .13$). I also tested whether there was a statistical interaction between the amount of therapy children received and their attention following predicting growth in lexical density. No such interaction was detected in the present study. This did not replicate a statistical interaction that Bono et al. (2004) had found predicting a global expressive language variable.

There are several possible explanations for why I did not replicate the interaction between attention following and language therapy predicting growth in expressive language reported by Bono et al. (2004). The participants in that study had higher chronological, mental, and language ages than the participants in the current study. The dependent variable in the Bono et al. study was different from that used in the current study. Bono et al. used a standardized global language test; I used lexical density from conversational samples. Bono et al.'s measure of treatment experience included all types of therapies (including speech-language therapy). I examined two types of therapy attendance variables: amount of all types of therapies and amount of communication/speech/language therapy. Neither variable statistically interacted with attention following to predict lexical density growth. However, the types or quality of treatments represented in the current study may have been different from those in the Bono et al. study.

The findings of this study offer further support for the hypothesis that intentional communication or diversity of object play are potential explanatory variables for why some children with ASD develop useful speech while others do not. Aspects of intentional communication (McDuffie et al., 2005; Sigman & Ruskin, 1999) and diversity of object play (Sigman & Ruskin, 1999) have already been found to predict the broader construct of expressive language in young children with ASD. However, the present study adds to this support in a number of ways. First, our dependent measure is arguably a particularly face-valid index of useful speech for a number of reasons. Growth curve modeling escapes several of the problems with endpoint and gain score approaches to identifying predictors of language development (Singer, 1998). Communication or language samples may be considered a socially important measurement context because such contexts mimic conversations that may be common in the natural environment of young children. Communication or language samples allow direct observation of language, rather than relying on parent report of potentially low-frequency, imitative, or lost language use. Logically, lexical density is influenced by both productive vocabulary size and by talkativeness, both functional productive language measures for the initial language acquisition stage. Second, I controlled for expressive language impairment, which may covary with a host of relatively stable factors. Doing so might allow us to identify potential influences on children's useful speech that do not covary with the relatively stable factors represented by initial expressive language impairment.

Although correlational studies do not allow strong confidence in inferring that intentional communication or diversity of object play cause individual differences in useful speech, they do identify potentially causal variables. Only treatment studies that increase intentional communication and/or diversity of object play in the context of internally valid research designs will allow confidence that these variables have causal influence on useful speech. Interestingly, both intentional communication and diversity of play are amenable to change as a function of educational treatments with children with ASD (Kasari, Freeman, & Paparella, 2000; Lifter, Sulzer-Azaroff, Anderson, & Cowdery, 1993; Whalen & Schreibman, 2003; Yoder & Stone, 2006b). Using such treatments with an eye toward testing whether treatments with these companion goals increase the value of language intervention compared with language intervention alone would be a valuable next step.

If future research confirms the causal influence of intentional communication or diversity of play on language acquisition, one clinical implication of the findings is that intentional communication and diversity of object play are probably important companion goals for children with autism who need to learn to talk to communicate. When children communicate often and play with a variety of objects in a variety of ways, they set the opportunity for two types of adult linguistic input that may affect language development. Linguistic mapping is putting the child's preceding nonverbal communication into words (Yoder & Warren, 1993). Descriptive talking is talking about the child's focus of attention (Siller & Sigman, 2002). If the child plays in a variety of ways, this provides more diverse action referents to talk about.

In terms of methodology, the present article provides an illustration that correlational findings detected within treatment studies can and should be interpreted when it can be shown that the study treatments did not affect the associations of interest. One tests whether there is a treatment group difference in the association between a predictor and a criterion variable by testing the statistical interaction between the predictor and the treatment groups predicting the criterion variable. In the current study, such interactions were nonsignificant and had very small effect sizes. In such cases, it needlessly complicates matters and reduces statistical power to retain the treatment group and its interaction with the predictor in the predictive models. Finally, some readers will question the generalizability of the associations because these participants had particular treatments. This is not a valid concern in the present case because it was shown that the treatments had no discernible effect on the associations of interest. Additionally, most children with ASD have had treatments. If correlational findings were discounted because of the occurrence of treatments, all correlational findings from children with ASD would be discounted.

In summary, intentional communication and diversity of object play were predictors of growth rate of a face-valid measure of useful speech in young children with ASD: growth in lexical density. Given that these two predictors are significant above and beyond initial expressive language impairment and that they are malleable through treatment, intentional communication and diversity of object play are very likely to be useful goals for young children with ASD who are not yet speaking frequently to communicate.

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