Relative Treatment Effects of Two Prelinguistic Communication Interventions on Language Development in Toddlers With Developmental Delays Vary by Maternal Characteristics

Paul J. Yoder
Vanderbilt University
Nashville, TN

Steven F. Warren
The University of Kansas
Lawrence

This paper tests whether two prelinguistic communication interventions have a differential effect on productive and receptive language development 6 and 12 months after the end of treatment. We predicted that treatment effects on language development would vary as a function of pretreatment maternal responsivity or amount of mothers' formal education. Fifty-eight prelinguistic children with developmental delays and their mothers participated in the study. Children were randomly assigned to one of two staff-implemented treatments that were designed to increase intentional communication ability. Results confirmed the prediction that treatment effects on children's receptive and expressive language 6 and 12 months after the end of interventions vary as a function of pretreatment maternal responsivity and education level.

KEY WORDS: prelinguistic communication intervention, language development, developmental disorder, toddlers, parental characteristics

One possible treatment goal for children who are not yet speaking is to increase their prelinguistic intentional communication. Intentional communication is defined here as the use of (a) coordinated attention to adult and object combined with either unconventional gestures or vocalizations or (b) conventional gestures or symbols directed to an adult. When deemed appropriate for a particular child, intentional communication may be targeted because many have posited that frequent intentional communication indirectly or directly contributes to the language development of many children.

There is replicated evidence that the frequency of prelinguistic intentional communication predicts later language levels in children with disabilities (Mundy, Kasari, Sigman, & Ruskin, 1995; Smith & von Tetzchner, 1986; Yoder & Warren, 1999a). Intentional communication may directly or indirectly influence later receptive and/or expressive language for at least four reasons.

First, gestures and vocalizations serve the same pragmatic functions (e.g., requests and comments) as early words. Therefore, fluent

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prelinguistic communicators may be one step ahead in the task of learning the words for the meanings they have already been expressing nonverbally (Bates, O'Connell, & Shore, 1987; Bruner, 1978; Snow, Perlmann, & Nathan, 1987).

Second, prelinguistic and linguistic communication may rely on the same cognitive achievements (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Golinkoff, 1981). For example, linguistic and prelinguistic forms of requesting appear to rely on understanding that desired objects can be acquired via indirect means (i.e., means-end) and that this "means to an end" is often a person (i.e., social agency). The child who has mastered means-end and social agency concepts may be better able to attend to and learn the words for what he or she is requesting than is the child who is still struggling with these cognitive achievements (Yoder & Warren, 1993). Empirical evidence concerning whether one needs to master these cognitive achievements before one learns to talk is equivocal (Rice & Kemper, 1984). However, it should be noted that Kahn (1984) demonstrated that children with mental retardation who received direct training on means-end relations acquired more language in subsequent language intervention than children who received only language intervention.

Third, children who produce relatively complex and frequent vocalizations may have more advanced development of the parts of the brain associated with speech planning and speech functioning than do children who use simple or infrequent vocalizations (Locke, 1989). One line of evidence supporting this hypothesis is the similarity in structure of early vocalizations and early spoken words (Locke, 1983).

Finally, intentional communication may elicit maternal responses, which in turn facilitate later language development (McLean, 1990; McLean & Snyder-McLean, 1978; Yoder & Warren, 1993). Although mothers respond to preintentional communication acts (Harding, 1984), it is hypothesized that they respond to intentional communication more frequently because the latter is more social and more interpretable (Goldberg, 1977; Yoder & Warren, 1993). We will refer to this notion as the "transactional hypothesis."

Three types of parental responses to children's communication are particularly likely to facilitate later language development: compliance, imitative responses, and linguistic mapping (Snow, 1984; Yoder, Warren, McCathren, & Leew, 1998). By compliance, we mean complying with the presumed meaning of the child's communication act. Imitative responses involve the mother's vocally or physically imitating her child's communication behavior. Linguistic mapping is when the adult says what the child's nonverbal communication appears to convey. It should be noted that linguistic mapping differs from attentional mapping (i.e., talking about the child's focus of attention) because the former occurs as a specific response to child communication. All three types of responses have been found to be associated with later receptive and expressive language in children with and without developmental disabilities (Yoder et al., 1998; Yoder & Warren, 1999a).

An intervention study that targets prelinguistic communication in the context of a well-conducted experiment would strengthen our ability to examine whether increasing intentional communication influences later language development. Using the current study's sample, we previously demonstrated that two prelinguistic communication treatments had generalized (Yoder & Warren, 1998) and sustained (Yoder & Warren, 1999b) effects on intentional communication. However, the specific treatment that facilitated increases in intentional communication varied according to two pretreatment maternal characteristics (Yoder & Warren, 1998). These interactions accounted for about 10% of the variance in the outcome variable (i.e., a moderate effect size). These pretreatment characteristics were the proportion of children's communication acts to which mothers responded (i.e., maternal responsivity) and amount of maternal formal education.

Specifically, Yoder and Warren (1998) found that children of highly responsive or highly educated (i.e., above one year of college) mothers learned to use generalized intentional communication more often after experiencing 6 months of staff-implemented Prelinguistic Milieu Teaching (PMT). With the group design used, we were not able to detect a PMT treatment effect on other children in the sample. For the children of mothers with relatively low responsivity, there was also evidence that the contrast treatment, modified Responsive Small Group (RSG), facilitated generalized intentional communication.

PMT uses a child-centered play context, communication prompts for more advanced forms of communication, and social consequences (i.e., specific acknowledgment and compliance) to facilitate prelinguistic targets. Modified RSG also emphasizes following the child's lead and responding to child communication acts. We refer to it as "modified" because, unlike many responsive approaches, we prohibited the use of communication prompts and imitation to differentiate it from PMT.

Historically, and in this sample, amount of maternal formal education has been associated with several aspects of maternal interaction style that is consonant with supporting mother-child conversations (Hoff-Ginsberg & Tardiff, 1995). Responsivity is one of these correlates. Presumably, the extent to which children experienced responsive and communication-eliciting interactions at home influenced what they expected from and how they reacted to interactions with adults at early intervention centers (Yoder & Warren, 1998).

This paper presents our investigation of the relative treatment effects of two prelinguistic communication interventions on receptive and expressive language development 6 and 12 months after the end of treatment. The two treatments were Prelinguistic Milieu Teaching (PMT) and modified Responsive Small Group (modified RSG). We did not expect one treatment to be superior for all children. Instead, we expected the relative treatment effects on receptive and expressive language to vary by pretreatment levels of maternal responsivity and maternal formal education. This is a "moderated" treatment effect (Baron & Kenny, 1986). Given the results of our previous analysis on intentional communication (Yoder & Warren, 1998), we predicted that children with mothers who were highly responsive and had high levels of formal education would benefit most from PMT. In contrast, we predicted that children with mothers who were less responsive and had lower levels of formal education would benefit more from modified RSG. The outcomes in these analyses were measures of productive and receptive language collected 6 and 12 months after treatment ended.

Method

Participants

Fifty-eight children between the ages of 17 and 32 months (mean: 23, *SD*: 4) with developmental delays and their primary parent (the one who reported spending the most time with the child) participated in the study. Thirty-seven of the children were boys, and 21 were girls. There was no association between gender and group (chi square = 2.4; p = .12). These children were recruited from three early intervention centers in a large city in the southeastern United States.

At the pretreatment period, none of the children used more than 5 words according to their classroom teachers. Two children used 2 words in at least one of three communication samples (these samples are described in the Procedures section); another four children used 1 word in one of the three communication samples. The remaining 52 children used no words in the communication samples. Therefore, this sample of children was considered "prelinguistic."

All children scored below the 10^{th} percentile on the expressive scale of the Communication Development Inventory, a frequently used vocabulary checklist (Fenson et al., 1991). Additionally, all of the children fit the Tennessee definition for developmental delay (i.e., at least a 40% delay in at least one developmental domain, or at least a 25% delay in at least two developmental domains). The etiology for these developmental delays varied. Four children had Down syndrome, four were premature with medical complications (e.g., chronic lung disease), and three had "failure to thrive" diagnoses. Two were diagnosed as having pervasive developmental disorder—not otherwise specified, one had macrocephaly, and one had microcephaly. One had Duane's syndrome, one had neonatal meningitis, one had Fetal Alcohol Syndrome, and one had tuberous sclerosis. The remaining 39 children had no identifiable etiology or diagnosis other than developmental delay. The treatment groups were equivalent with regard to diagnosis.

A certified audiologist screened children for hearing losses using sound field screening at 500, 1000, and 2000 Hz. No child scored poorer than 50 dB at any frequency. Six children (three in each treatment group) scored between 26 dB and 50 dB at one or more frequencies. Hearing level did not covary with the proposed predictors of treatment response (i.e., pretreatment maternal responsivity or amount of maternal formal education) nor by treatment group.

Ninety percent (i.e., 52) of the caretakers were the children's mothers. Therefore, we refer to the primary caregivers as "mothers," even though the processes investigated may generalize to other caregivers. In the modified RSG group, one nonmaternal caregiver was a grandmother and two more were fathers. In the PMT group, two nonmaternal caregivers were grandmothers and another was a father.

At the beginning of the study, parents were given a demographic questionnaire containing questions about the parents' employment and level of schooling completed. From the parents' responses, staff members identified the parents' occupational title (Stevens & Cho, 1985; International Standard Classification of Occupations [ISCO], 1986). Using the ISCO metric, the average occupational status of the U.S. population is 34.5 (*SD* = 18; Stevens & Cho, 1985). The median occupational status of our sample was 23 (*SD* = 22). The distribution for the occupational status was positively skewed in our sample (i.e., more low-status participants than would be expected in a normal distribution). Therefore, our sample's occupational status was lower than that of the general population.

The amount of formal education of the primary caregivers averaged high school graduation and ranged from one year of elementary school to postgraduate training. The number of years of schooling completed was scaled on an adapted metric used by Hollingshead and Redlich (1985): 1 = 0 years, 2 = 1–6 years, 3 = 7–9 years, 4 = 10–11 years, 5 = graduation from high school or GED of school completed, 6 = 1–2 years of college or technical school, 7 = 3–4 years of college or technical school, 8 = 1–2 years of graduate or professional school, 9 = over

Table 1. Means (and standard deviations) on selected pretreatment variables within the treatment groups.

Variables	PMT ($n = 28$) *M* (*SD*)	RSG ($n = 30$) *M* (*SD*)
	Treatment groups	
Children		
Chronological age	22 mos (4 mos)	23 mos (4 mos)
Mental age (MA)[a]	15 mos (2 mos)	15 mos (2 mos)
Mental Development Index (MDI)[a]	55 (13)	53 (12)
Number of communication acts[b]	27 (14)	27 (14)
Proportion of acts that are intentional[b]	.80 (.11)	.79 (.16)
Maternal report of words understood[c]	127 (101)	113 (90)
Family		
Amount of mothers' formal education[d]	5.5 (1.5)	4.7 (1.4)
Proportion of acts mothers responded to[e]	.48 (.17)	.53 (.15)

[a] Bayley Infant Scales of Development, 1969, 1993. [b] CSBS (prorated for 15 minutes). [c] McArthur Communication Development Inventory. [d] Demographic questionnaire. [e] Mother-child interaction session.

three years of graduate school or other postgraduate training. The amount of mothers' formal education was equally distributed across the two treatment groups ($p >$ .25). Table 1 presents descriptive statistics on several other child and maternal variables.

Design

Treatment effects were evaluated through a randomized group experiment. Children were randomly assigned to one of two treatment groups and tested for language skills at four intervals spaced 6 months apart (i.e., pretreatment, posttreatment, 6-month follow-up after the end of treatment, 12-month follow-up after the end of treatment). Maternal responsivity and amount of maternal formal education were measured at the pretreatment period. The parents were naive to the treatment methods, hypotheses, and measures to avoid directly influencing their behavior with the child. This was necessary to determine whether it was the increase in child intentional communication, not direct influence on maternal behavior, that caused the effects on language development. Parents agreed to refrain from observing treatment sessions because we were interested in how the parents' behavior might change in response to their children's development.

Procedures

Table 2 presents an overview of the constructs, variables, procedures, and corresponding time periods on which the analyses were based. The following is a description of the procedures. All procedures except the mother-child interaction sessions took place at the child's early-intervention center. The mother-child session took place in a university-based playroom with a one-way observation window.

Communication and Symbolic Behavior Scales (CSBS)

The Communication Temptations and Book Sharing sections of the CSBS (Wetherby & Prizant, 1993) were administered. The CSBS is a series of activities designed to elicit the child's communication and language use. This session lasted between 15 and 25 minutes, depending on the child's engagement with the materials

Table 2. Construct, variable, procedures, and time periods for variables used in the analyses on language outcomes.

Construct	Variable	Procedure	Test period
Comprehension of semantic relations	Number of semantic relations in which familiar and unfamiliar directives were followed	Semantic Relations Test	12-month follow-up
Global measure of receptive language	Age-equivalency score	Reynell Developmental Language Scales	12-month follow-up
Global measure of expressive language	Age-equivalency score	Reynell Developmental Language Scales	12-month follow-up
Maternal responsivity	Proportion of child communication to which mother responds	Mother-child interaction session	Pretreatment
Lexical density	Average of the rate of nonimitative vocabulary words used	Experimenter-child play session & Communication & Symbolic Behavior Scales	Pretreatment through 12-month follow-up

and activities and their persistence in repairing communication breakdowns. The adult conducting the session was never the child's primary clinician, nor were intervention toys used during the session.

Experimenter-Child Interaction Session (ECX)

The children engaged in a session with an experimenter to elicit the children's communication and language in a less-structured interaction than was used in the CSBS. The adult conducting the session was not the child's clinician. Additionally, these sessions did not use toys that were used during the training sessions. The ECX sessions lasted 15 minutes. The toys in this session were a baby doll, 2 baby bottles, a baby spoon, doll hairbrush, rattle, blanket, teapot, 2 cups and saucers, 4 colored cylindrical sticks, a large car, and a toy telephone. The adult was instructed to play at the child's level with the toy of the child's choosing, imitate what the child was doing, and comment on the play. She was instructed to avoid directives for action or communication and to avoid modeling levels of play higher than she had seen the child use during the session.

Mother-Child Interaction Session (MCX)

Mothers were asked to play with their children for a total of 15 minutes, divided into three 5-min segments. During these sessions, the child was seated in a chair that was attached to a table to discourage the child from getting up. In the first segment, developmentally appropriate toys were placed in clear containers that could not be opened without assistance. This segment was designed to elicit mostly requests. In the second segment, the mother was given juice, cereal, and cookies and told to give small portions to the child in response to the child's requests. While the child was eating a snack, brief animal noises and the lowering of a suspended slinky occurred. The mother was told to ignore these events until the child drew the mother's attention to either the sound or the slinky. This second segment is similar to that used by McLean, McLean, Brady, and Etter (1991). The last segment of the mother-child session was free play. A Fischer-Price garage, a spinning top, and a Fischer-Price farmyard were available for play. These toys were not available earlier in the MCX procedure.

Semantic Relations Test

This experimental procedure was adapted from similar procedures described in Bates, Bretherton, and Snyder (1988) and was similar to those described in Miller and Paul (1995). This procedure consists of 12 pairs of directives. Two pairs of directives exemplify one of 6 semantic relations (i.e., Action + Object, Agent + Action, Action + Location, Modifier + Entity, Possessor + Entity, Entity + Location). Within each pair, there was an "easy" and a "hard" directive. The "easy" directive could be correctly responded to largely by relying on nonlinguistic comprehension strategies (Chapman, 1978). For example, a doll, a cup, a stuffed rabbit, and a ball were laid out in front of the child. The examiner said, "Kiss the doll." This directive could be correctly followed by identifying the noun referent and doing what one usually does with a doll in the absence of a bottle or a blanket. The "hard" directive for this pair was "Kiss the ball." To correctly answer this latter directive the child had to understand both the action verb and the direct object noun. A semantic relation was scored as "comprehended" if the child correctly responded to at least one easy and at least one hard directive for that semantic relation. The number of semantic relations comprehended was the variable score used in the analyses and could thus vary from 0 to 6.

Reynell Developmental Language Scales (Reynell & Gruber, 1990)

The receptive and expressive scales of the Reynell were administered to the children to assess global language level in a standardized context. It was included as a complement to the experimental Semantic Relations test and the less controlled language samples. Data from standardized tests may be less prone to measurement error than language samples because of differences in the way the examiner gives the test (Owens, 1991). Additionally, the Reynell produces an age-equivalency score that aids interpretation of possible treatment effects. The split-half reliability for the scales range from .60 to .97 depending on the age of the children (Reynell & Gruber, 1990).

Coding and Transcription

All interaction sessions were coded using repeated observations of videotaped sessions. Observers were trained to at least 85% summary-level reliability before coding or transcribing the data to be analyzed.

Maternal responsivity was coded from the pretreatment mother-child sessions. We used the proportion of child communication acts to which the mother responded as our measure of maternal responsivity. The proportion metric allowed us to control for the number of communication acts while measuring individual differences in mothers' responding. This was desirable because we wanted to measure the extent to which mothers responded to their children's communication. A child communication act was defined as a gesture, vocalization, or symbol directed toward the adult. We defined "gesture" using the list of gestures in the CSBS (Wetherby & Prizant, 1993). A maternal response was an adult behavior that occurred immediately after the child's communication act and that either (a) complied with, (b) linguistically mapped, or (c) asked clarification of the presumed meaning of the child's communication. Additionally a maternal response was scored if it imitated some component of the child's communication act.

To derive our measure of lexical density, we transcribed the experimenter-child and CSBS sessions at all four time periods. To be transcribed as a word the string of phonemes in question had to pass two criteria. First, the string of child phonemes had to be identical to or approximations of words that are included in the *American Heritage Dictionary of the English Language* (1992) or in MacArthur Communication Development Inventory/Infants (Fenson et al., 1991). An "approximation" to a word was a phoneme sequence that had (a) the same number of syllables and (b) at least one morpheme in common with the adult word. Exceptions to the first criteria were common diminutive forms for adult words (e.g., *doggy* or *horsie*) and words that are commonly shortened by young children (e.g., *sketti* for spaghetti and *nana* for banana). When children said both the adult word (e.g., *horse*) and the diminutive form (i.e., *horsie*), they were credited with only one new word. Second, the proposed "word" had to have nonlinguistic support for concluding the child was intending to represent a referent, event, thought, or feeling. For example, if the child said *baba* while pointing to the baby, the transcriber recorded "baby."

Rationale for and Explanation of the Lexical Density Measure

Lexical density is the number of nonimitative word roots used per minute. "Word root" was used to refer to the unbound morpheme of a word (e.g., "ball" and "ball/s" were counted as one word root). This is not a measure of vocabulary size, per se. Instead, lexical density reflects the diversity of meanings that the child uses for frequent communicative purposes. One reason we wanted a measure of diversity of vocabulary use in conversational contexts is that early in development, many children with developmental disabilities have unintelligible speech (Miller, Leddy, Miolo, & Sedey, 1995). Intelligible use of words is important for obvious communicative reasons and because intelligible words are more likely to elicit language-facilitating input from adults than are words that are not intelligible (Yoder, Klee, Hooshyar, & Schaffer, 1997). Additionally, lexical density may index the degree of automatization of talk (Chapman, Streim, Crais, Salmon, Strand, & Negri, 1991). In Chapman's Child Talk model of language acquisition, such automaticity is necessary for children to acquire new forms and functions (Chapman et al., 1991). We used an average score across the experimenter-child session and the CSBS to index lexical density because multiple samples across contexts tend to increase the stability and validity of language sampling (Leadholm & Miller, 1992; Owens, 1991).

The Treatments

The assigned treatment sessions were scheduled four times a week for 6 months. A project staff member conducted the intervention sessions in a room in the child's early intervention center. Each session lasted 20 minutes. If a child missed a session, it was not made up. Attendance at the sessions was not significantly different across treatment groups [$t(56) < 1.0$, $p > .05$; PMT $M = 75$, $SD = 13$; RSG $M = 71$, $SD = 11$].

Prelinguistic Milieu Teaching (PMT)

A primary clinician worked with the child three days a week, and a secondary clinician worked with the child one day a week. A 1:1 teaching format was used in PMT sessions. During PMT sessions, the clinician first attempted to increase the probability of establishing one or more play routines (i.e., turn-taking sequences around an object or activity). When the child was highly motivated to communicate, the least intrusive, but effective, communication prompts were used to elicit requests for objects or actions. PMT teachers attempted to stimulate proto-declaratives (i.e., drawing attention to or sharing positive affect about an object or event) through modeling. More description on PMT can be found in Warren and Yoder (1998) and Yoder and Warren (1998).

Modified Responsive Small Group (RSG)

We employed a responsive small group approach for the contrast treatment because there is evidence that responsivity may facilitate development of prelinguistic communication skills (Wilcox, 1992). One clinician and three children engaged in parallel play during the modified sessions. The clinician was instructed to respond to the children's communication but not to make any demands on them (i.e., either communicative or otherwise). The clinicians were also instructed not to imitate the children's motor or nonword vocal behavior, as this was a primary method of building routines used in the PMT method. We cannot claim to be comparing a complete version of a responsivity treatment with PMT because imitations are encouraged and some types of questions (e.g., those to which the adult does not know the answer) are allowed in many responsivity treatments (e.g., Wilcox, 1992).

Fidelity of Treatment and Coding for Treatment Description

A supervisor observed one of the clinicians per week on a rotating schedule. Supervisors were the principal investigator or female staff members with at least 3 years experience with the treatments. During months 3, 4, and 5, supervisors also videotaped one training session for each clinician-child pair. These sessions were coded in detail. Because the definitions and results of this coding system have been presented previously in this journal, the reader is referred to Yoder and Warren (1998) for more information on the fidelity of the treatment coding system and results. Briefly, the results indicated that teachers of the modified RSG method used proportionally more linguistic mapping and more frequent use of utterances directed to the child's focus of attention than did PMT teachers. PMT teachers used more instances of prompts and consequences for gestures, gaze, and nonword vocalizations.

Reliability

Interobserver reliability for the maternal responsivity and lexical density data was assessed for every fifth data session by independently recoding the videotaped sessions. Test-retest reliability for the Semantic Relations Test was assessed by readministering the test for every fifth subject. This gave us a reliability estimate on at least 20% of the data. Reliability was estimated by generalizability (G) coefficients (Cronbach, Gleser, Norda, & Rajaratnam, 1972). Summary-level reliability was selected because the analyses were conducted at the summary level. The G coefficient for pretreatment maternal responsivity was .93. The G coefficients for lexical density ranged from .83 to .96. The G coefficient for the comprehension of semantic relations was .90.

Results

Analysis Methods

It should be noted from Table 1 that receptive and productive vocabulary were equivalent between groups before treatment. This is important because we used endpoint analyses (regressions using follow-up measures as outcomes) to infer differential growth in language when significant pretreatment by group interactions occurred (Aiken & West, 1991; Cronbach & Furby, 1970). These interactions were tested after controlling for treatment group and the pretreatment predictor. We used the Johnson-Neyman technique to identify the particular level of the pretreatment variable at which the groups differ on the dependent variable (Aiken & West, 1991). An alpha of .05 was used for all significance tests.

For the language variable with measures at all four assessment periods (i.e., lexical density), we used an analysis method that allows a direct test of treatment effects on growth. Significant growth (i.e., time-fixed effect) and a significant interaction between pretreatment predictor and treatment group (i.e., time × group × pretreatment predictor) were tested using hierarchical linear modeling (Byrk & Raudenbush, 1992). If the relevant interaction term was statistically significant, we visually displayed the average growth curve of lexical density for each treatment group within the relevant subgroups to help interpret the interaction (Figure 1).

We used continuous forms of the pretreatment variables to test the predicted interactions because arbitrarily dichotomizing a naturally continuous variable results in loss of information (Pedhazur, 1982). We interpreted only those interactions in which the data met the assumptions of the statistical techniques used (e.g., homoscedasticity, normally distributed residuals, and linearity). We also interpreted only those aspects of the interaction that involved at least 2 subjects per treatment group in the subgroup for which differential treatment effects occurred (Aiken & West, 1991).

Preliminary Analyses

The distributions of all variables involved in the primary analyses were examined before testing the hypotheses (Tabachnick & Fidell, 1989). The distribution of lexical density that is relevant to the growth curve analysis included the data from all time periods. As is the case in most growth models for early child development, the distribution was positively skewed. Because skewed variables can result in violations to the assumption of multivariate normality, an assumption of hierarchical linear modeling, we used a logarithmic transformation for lexical density at all time periods. Logarithmic transformation is a traditional method of normalizing distributions that are severely skewed (Tabachnick & Fidell, 1989). Other variables involved in the primary analyses were approximately normally distributed.

Pretreatment Group Equivalence

To determine whether the random assignment to treatments was successful in creating equivalent groups at the pretreatment period, we tested between-group differences on 24 pretreatment variables. The groups were not statistically different on all but two pretreatment variables (tendency to attribute communication to nonverbal behaviors, proportion of communication acts that were proto-declaratives; see Yoder & Warren, 1998; Yoder & Warren, 1999b). However, neither of the two variables interacted with treatment assignment to predict any language outcome. Neither was associated with any language outcome. Therefore, these pretreatment group differences cannot account for any moderated treatment effects that were detected.

Moderated Effects of the Treatments on Lexical Density

The results of the growth curve analyses confirmed the predictions (Table 3). There is a significant fixed effect for time (i.e., slope of the growth curve), indicating that lexical density increased significantly over time. The children did not talk or use signs at the beginning of the study in either the experimenter-child or CSBS sessions. The average lexical density at the 12-month follow-up was 1.6 word roots per minute (SD = 1.5, Range = 0–6.5). The number of word roots per minute is reported in the text. The transformed lexical density scores are used in Figure 1.

Table 3 also indicates a significant three-way interaction among time, treatment, and the pretreatment predictor (i.e., maternal responsivity or amount of maternal formal education). In both of the interactions, children with mothers who scored high on the pretreatment predictor variable had faster growth in lexical density if they experienced PMT than if they experienced modified RSG. In contrast, children with mothers who scored relatively low on the predictor variable had faster growth in lexical density if they experienced modified RSG than if they experienced PMT. As an example, Figure 1 illustrates the interaction between maternal responsivity and treatment predicting growth in lexical density. A similar pattern is seen for the interaction between amount of maternal formal education and treatment.

As is indicated in Figure 1, the treatment effects became increasingly large with time. To determine the time period at which the average growth curves differed between treatments, we also conducted multiple regressions for the three posttreatment measurement periods. The interaction between pretreatment amount of maternal formal education and treatment was not significant until the 6- and 12-month follow-up periods (R squared change for the interaction term = .07, p = .03; .09, p = .02, respectively). Additionally, the pretreatment maternal responsivity by treatment interaction was not significant until the 12-month follow-up period (R squared change for the interaction term = .08, p = .02).

Table 3. Parameter estimates for the growth curve analyses on lexical density.

	Pretreatment predictor	
Type of effect	Maternal responsivity	Amount of maternal formal education
Random		
Intercept	.04***	.04***
Residual	.07***	.07***
Fixed		
Intercept	.44***	.22***
Time	.05***	.04***
Treatment	–.11	–.03
Pretreatment predictors	–.59	–.07*
Time × Treatment	–.01**	–.008
Time × Predictor	–.08**	–.01***
Treatment Predictor	.83*	.07
Time × Predictor × Tx	.12***	.01**

* p < .05, ** p < .01, *** p < .001

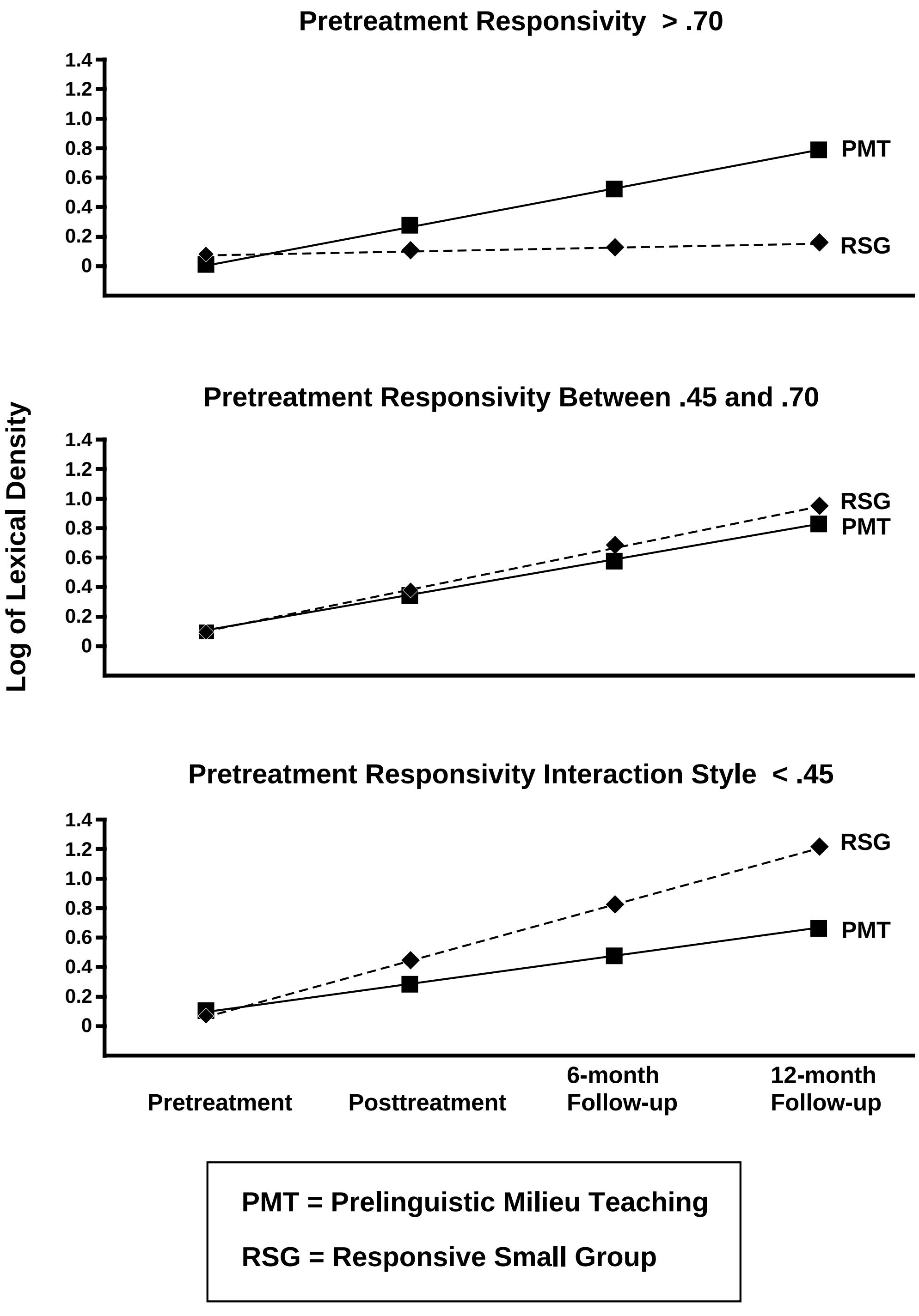
Moderated Treatment Effects on Comprehension of Semantic Relations and Global Language Scores

Table 4 presents the results of the multiple regressions. The treatment effects on comprehension of semantic relations varied as a function of pretreatment maternal responsivity and as a function of pretreatment amount of maternal formal education. The treatment effects on the receptive and expressive scales of the Reynell varied only as a function of pretreatment amount of maternal formal education. Table 5 indicates the threshold scores for the upper and lower regions of significance and the predicted outcome scores for each treatment group within these regions of significance. PMT benefited children of highly responsive parents and children of parents with much formal education. In contrast, modified RSG benefited children of relatively less responsive parents and children of parents with relatively little formal education.

Exploring Alternative Explanations

To explore alternative explanations for the significant statistical interactions, we examined whether other pretreatment variables covaried with pretreatment responsivity and amount of formal education. If so, we tested whether these other pretreatment variables interacted with group to predict the language outcomes. The pretreatment child variables tested were (a) number of child communication acts, (b) number of child intentional communication acts, (c) number of proto-imperatives, (d) number of proto-declaratives, (e) number of vocal communication acts with consonants, (f) mental age, (g) mental development index, (h) highest level of play, (i) comprehension level, (j) ratio of words said to words understood, and (k) means-end stage. The

Figure 1. Average growth curves for lexical density in PMT and RSG for three subgroups based on pretreatment maternal responsivity.



pretreatment maternal variables tested were (a) occupational status, (b) perception of adequacy of family resources, and (c) race. None of these variables met the criteria for explaining the statistical interactions between treatment and pretreatment maternal responsivity or amount of maternal formal education.

Discussion

The results of this report are potentially important for four reasons. First, this constitutes one of the only randomized group experiments investigating an effect of *prelinguistic* communication intervention on later

Table 4. The effect size, *t* test score, and probability of the moderated treatment effects on language development.

Outcome	Pretreatment predictor	*R* for complete model	*R* squared change for the interaction term	*t* test value	*p* value
Number of semantic relations understood	Maternal responsivity	.08	.08	2.17	.04
Number of semantic relations understood	Amount of maternal formal education	.11	.10	2.5	.02
Receptive Reynell	Amount of maternal formal education	.11	.07	2.03	.05
Expressive Reynell	Amount of maternal formal education	.17	.12	2.78	.007

language development. Second, this study attempts to determine whether the effects on language are maintained as much as one year after the end of treatment. Third, this study constitutes one of the few studies examining an effect on language comprehension in toddlers with disabilities. Productive language is a more common outcome measure of early treatment studies. Fourth, this study constitutes one of the only studies examining the hypothesis that relative treatment effects on language vary as a function of maternal characteristics. With the current emphasis on family-centered treatments, evidence of specific parental characteristics that may moderate treatment effects is important to developing optimally effective approaches.

The results of the current study showed that children whose mothers scored relatively high on responsivity and amount of formal education at the pretreatment period benefited most from the PMT treatment. In contrast, children whose mothers scored relatively low on responsivity and amount of formal education at the pretreatment period benefited most from the modified RSG treatment. The interaction between mothers' amount of formal education and treatment group predicted all four language outcomes (i.e., lexical density, Reynell receptive age-equivalency, Reynell expressive age-equivalency, and comprehension of semantic relations). The interaction between mothers' responsivity and treatment group predicted lexical density and comprehension of semantic relations.

Of particular interest is the moderated treatment effect on the comprehension of language. Some have argued that treatment effects on language production, particularly as measured in language samples, only represents helping children use existing language knowledge (e.g., Connell, 1987). There are three reasons why documenting the treatment effect on the Semantic Relations Test and the Reynell receptive scale at the 12-month follow-up adds to our confidence that the treatments facilitated new language knowledge. First, both comprehension tests were constructed to minimize the probability that children can use nonlinguistic strategies to answer the questions correctly. For example, for children to be credited with understanding a semantic relation they had to comply with directives that did not afford the use of the nonlinguistic strategy: "Do what you usually do with the mentioned object" (Chapman, 1978). Second, given the random assignment to groups and the equivalence of the groups before treatment on the number of words mothers said their children comprehended, it is unlikely that group differences in comprehension

Table 5. Predicted outcome scores and threshold values for the regions of significance.

Outcome variable	Pretreatment predictor interacting with treatment	Threshold score defining the region of significance		Predicted outcome score			
				Lower		Upper	
		Lower	Upper	RSG	PMT	RSG	PMT
Semantic relations understood[a]	Maternal responsivity	.37	.68	3.9	2.7	2.7	4.0
Semantic relations understood	Amount of maternal formal education[b]	4.18	6.5	3.6	2.4	2.5	3.8
Reynell receptive age-equivalent[c]	Amount of maternal formal education	4.0	7	2.3	1.9	1.6	2.0
Reynell expressive age-equivalent	Amount of maternal formal education	4.5	6.6	2.1	1.7	1.5	1.8

[a] Range in semantic relations test is 0–6. [b] Amount of maternal formal education 4 = 10th or 11th grade, 5 = high school graduation or GED, 6 = 1–2 years of college, 7 = 3–4 years of college. [c] Age equivalents are in years.

existed before the treatments began. Third, the precise nature of the Semantic Relations Test allows us to document differences in an ability that is not likely to be present during the prelinguistic period (i.e., understanding relational meaning). Therefore, it is likely that the children acquired new understanding of language, not just greater application of existing language knowledge. Future research is needed to fully understand how the treatments affected language comprehension.

Another primary finding was the growing moderated treatment effect on lexical density with each passing measurement period. The lexical density measure was obtained from language samples. It has been argued that language samples provide some of the most socially important evidence of change because they represent what occurs in conversations (e.g., Owens, 1991). Additionally, this growing effect with time is in contrast to many early interventions that have produced effects that "wash out" after about 1 year posttreatment (e.g., Brooks-Gunn, Klebanov, Liaw, Spiker, 1993).

The current study's growing moderated treatment effects on language might have occurred in part because increasing intentional communication may have elicited immediate and continued maternal use of language-facilitating responses. The treatments used have previously been shown to have a sustained effect on intentional communication (Yoder & Warren, 1999b). And mothers and teachers have been shown to respond to intentional communication more than to pre-intentional communication (Yoder & Munson, 1995; Yoder, Warren, Kim, & Gazdag, 1994). Finally, the number of maternal responses has been found to be partly responsible for the relationship between prelinguistic and linguistic communication in children with developmental disabilities (Yoder & Warren, 1999a). Whether this effect continues to be detectable several years after treatment is an empirical question that our data do not address.

When added to the findings of two other reports, the present study's findings contribute an important part of the evidence supporting a transactional effects model (Yoder & Warren, 1993). Many of the children for whom the treatments affected language also experienced treatment effects on intentional communication (Yoder & Warren, 1998). Other reports on this sample have shown that increasing intentional communication affected the frequency with which the children experienced their mothers' linguistic mapping and compliance (Yoder & Warren, in press). It is important to note that the mothers in the present study did not observe the treatment sessions, nor were they informed of their children's progress until after the last follow-up assessment. Therefore, it is unlikely that we had any direct effect on maternal behavior. Instead, any effect on maternal behavior must have been indirect (e.g., through increasing children's intentional communication).

For the subgroup in which PMT was most beneficial, we can rule out the possible explanation that PMT directly affected language development. PMT uses techniques that directly facilitate language far less often than the contrast treatment (i.e., modified RSG) (Yoder & Warren, 1998). Instead, PMT directly elicits and rewards prelinguistic communication (i.e., gestures, eye gaze, and nonword vocalizations). Therefore, it is the results pertaining to this subgroup that most strongly support the hypothesis that prelinguistic communication influences later development in children with developmental disabilities.

In contrast, modified RSG may have had a *direct* effect on language development. Modified RSG clinicians frequently used two techniques that have been posited to directly facilitate language (i.e., talking about the child's focus of attention and linguistic mapping; Girolametto, Pearce, & Weitzman, 1996). The results of this study indicated that a staff-implemented responsive interaction treatment (even in a restricted form) had an effect on the later language development of *prelinguistic* children with developmental delays. But it is also important to note that this effect was demonstrated only at the 6- and 12-month follow-up periods and only in children of mothers with relatively low responsivity and low formal education. The absence of follow-up assessments and the use of only main effect analysis methods may partly explain why an earlier study found no effect of a responsive interaction approach on the language development of young children with developmental disabilities (Girolametto, 1988).

It is likely that maternal responsivity and amount of maternal formal education covary with child characteristics that affect how different children respond to the treatments. Others have found that amount of formal education is the aspect of socioeconomic status (SES) that is most highly correlated with parenting variables (Alwin, 1984; Richman, Miller, & LeVine, 1992; Wright & Wright, 1976). There is replicated evidence that parents with less formal education tend to be more controlling and disapproving of their children than parents with relatively high amounts of formal education (Hoff-Ginsberg & Tardiff, 1995). In contrast, parents with relatively more formal education tend to talk more, provide more object labels, sustain conversational topics longer, and respond contingently to children's speech more often than parents with less formal education (Hoff-Ginsberg & Tardiff, 1995).

Responsivity and other maternal interaction style variables may influence children's behavior and role expectations when interacting with adults, including therapists. Consequently, their behavior during therapeutic interactions may influence the outcome of therapy.

For example, persistent communicators may benefit more from PMT prompts than less persistent communicators. Children of responsive parents may learn to persist in the face of communication breakdowns because their history indicates that their communication attempts usually result in successful acquisition of a communication goal. Future research is needed to better understand the details of how mothers influence their children's use of treatment methods.

For children of parents with unresponsive interaction styles, the results of this study suggest two possible intervention approaches. First, combining parent responsivity education and PMT may be more effective than PMT or modified RSG alone. The authors are currently testing this hypothesis. Second, undemanding responsive interaction treatment methods that involve much talking about the children's focus of attention and reward the children's initiations (Girolametto et al., 1996; Wilcox, 1992) may be preferable to PMT alone. This latter option may be particularly useful when parents are not able to or do not choose to use parent-implemented treatments.

In an effort to control for many possible threats to internal validity, we did not test the extent to which either treatment *can* be effective under optimal conditions. For example, we administered the treatments only 20 minutes four days a week. Teachers and parents were kept naïve to the treatment methods. To differentiate it from PMT, we instructed modified RSG teachers to refrain from imitating the children's behavior and prompting their communication acts. These techniques are permissible in typical responsivity models (e.g., Wilcox, 1992).

Because we used two treatments that may both be effective in facilitating development, the differences between treatment groups may have been reduced. Even so, the effect sizes reported in this study have moderate to strong clinical value, depending on the level of the pretreatment variable. The R square changes for the interaction term ranged between .07 and .12. Cohen (1977) called this level of effect size "moderate." The standardized between-treatment difference on the predicted outcome scores provides another way to quantify effect size. At the level of the pretreatment variable at which the treatments produce different results, this type of effect size ranged between .51 and .56. Cohen called these effect sizes "moderate." At the maximum or minimum level of the pretreatment variable, this latter type of effect size ranged between .75 and 1.3. Cohen called these effect sizes moderately strong to strong effect sizes.

The reader is asked to interpret with caution the exact scores on the pretreatment variables at which the treatments produced significantly different results. For example, we cannot confidently claim that future studies will find that PMT benefits the comprehension of semantic relations only in children of parents with 68% responsivity. The exact pretreatment maternal responsivity scores at which significance was reached were not predicted before the analyses were conducted, nor were they predictable by theory. Therefore, clinical decisions should not be made on the basis of these "threshold" scores.

This study has several strengths that should increase the reader's confidence in the results. First, random assignment of children to treatments increased the probability of achieving equivalent groups before treatment. Analyses confirmed the equivalence of the groups on a host of pretreatment variables. The two variables on which there were pretreatment differences could not account for the findings because they did not covary with any dependent variable nor did any interact with the treatment groups to predict any dependent variable. For example, by randomly assigning children to groups, we reduced the probability that maturation could account for the interactions between pretreatment predictors and treatment groups. By using two treatments, we could control for the familiarity that the children had with the testing center, with examiners, and with test protocols. By using staff members who did not conduct the child's treatment and materials not used in intervention sessions, we could test generalization of skills across materials and people. Finally, the moderated treatment effects were detected on two independent measures of expressive language and two measures of receptive language. Therefore, we were able to demonstrate that the effects were not restricted to a particular procedure nor a particular modality of language development.

In summary, the results of this study support the effect of prelinguistic communication interventions on later language development in children with developmental disabilities. These treatment effects occurred 6 and 12 months after the end of treatment, on a variety of language measures, and in both expressive and receptive modalities. Additionally, the magnitude of the treatment effects became stronger with time. The treatment effects varied by maternal variables that may affect how children respond to clinic-based treatments. Future work needs to focus on why these effects occurred and on devising more specific ways we can match treatments to children's family systems.

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Contact author: Paul Yoder, PhD, GPC Box 328, Vanderbilt University, Nashville, TN, 37203.
Email: paul.yoder@vanderbilt.edu