A Randomized Trial of Longitudinal Effects of Low-Intensity Responsivity Education/Prelinguistic Milieu Teaching

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Purpose: To evaluate the longitudinal effects of a 6-month course of responsivity education (RE)/prelinguistic milieu teaching (PMT) for young children with developmental delay.
Method: Fifty-one children, age 24–33 months, with fewer than 10 expressive words were randomly assigned to early-treatment/no-treatment groups. All treatment was added as a supplement to services that the children received in the community. Follow-up data were collected 6 and 12 months after the conclusion of the initial 6-month treatment/no-treatment conditions.
Results: No effects of this treatment were detected 6 or 12 months after the conclusion of the initial treatment condition.
Conclusions: M. E. Fey et al. (2006) reported that 6 months of RE/PMT led to a significant treatment effect in the use of intentional communication in 1 of 2 communication sampling contexts. This finding, combined with evidence from other studies, suggests that RE/PMT may be applied clinically at low intensity with the expectation of medium-sized effects on children's rate of intentional communication acts over the short term. The results of the present study, however, provide no evidence for the anticipated longer term benefits of this intervention. Further investigation of the approach at higher intensity levels and for longer periods of time is warranted.

KEY WORDS: early intervention, language intervention, communication intervention, prelinguistic milieu teaching, responsivity education, longitudinal effects, developmental delay, Down syndrome

Responsivity education (RE)/prelinguistic milieu teaching (PMT) is an early communication intervention designed to help children with developmental delay who are limited in their production of nonlinguistic communicative acts and late in their production of words to produce more frequent and more complex nonverbal communication acts. In line with Yoder and Warren's (2001, 2002) results, Fey et al. (2006) reported the results of a study that demonstrated that 6 months of RE/PMT leads to significant gains in children's rates of intentional communication acts. The logic of RE/PMT, however, is that by arming children with a broader and more frequently used repertoire of intentional nonverbal communication behaviors, and by sensitizing parents to these changes, the intervention can prepare children to develop and use early lexical language skills more efficiently than would otherwise be possible. Thus, it is important to examine the effects of this approach at points after the formal prelinguistic intervention has been limited or discontinued. The present study provides such an examination by reevaluating the children studied by Fey et al. 6 and 12 months after a 6-month course of RE/PMT was discontinued.

Theoretical Basis Underlying RE/PMT

The basic premises and hypotheses underlying RE/PMT stem from a transactional model of social communication development (McLean & Snyder-McLean, 1978; Sameroff & Chandler, 1975). This model presumes that early social and communication development are facilitated by bidirectional, reciprocal interactions between children and their environment. For example, a change in the child, such as the onset of intentional communication, may trigger a change in a responsive social environment. Parents and other adults may be more inclined to repeat and expand the child's nonverbal messages using words. This type of response is often termed *linguistic mapping* or *interpreting* of the child's nonverbal acts. These changes then support further development in the child (e.g., increased communication and vocabulary) and should lead to further changes in the caregiver's input (e.g., more complex language interaction with the child). In this way, both the child and the environment change over time and affect each other in reciprocal fashion as early achievements pave the way for subsequent development.

The low-intensity early intervention system supported by services mandated under the Individuals With Disabilities Act Part C (1997) in the United States can only be effective in leveraging the development of communication and language skills if intervention generates transactional effects in which the growth of child communication skills is directly assisted by daily caregiver–child interaction. This reciprocal impact of child on parent language and parent on child language should lead to a multiplier effect in which a small dose of early intervention has significant long-term benefit. This multiplier effect is necessary when we consider that typical early intervention supported by Part C programs represents only 1 or 2 hr per week of a young child's potential learning time (Bailey, Aytch, Odom, Symons, & Wolery, 1999). Thus, except in those cases in which direct intervention accounts for a relatively large portion of a child's waking hours (e.g., some interventions provided to young children with autism), transactional effects that extend beyond a clinician's face-to-face therapeutic interactions with child and family are necessary for early intervention efforts to achieve their potential.

RE/PMT is an approach intended to equip children and parents with the abilities needed to initiate and extend the types of transactions that lead to spontaneous communication development. In RE, parents are taught to recognize their children's nonverbal communication attempts and to respond to them in meaningful ways that reinforce the children's efforts and inform them about more complex and conventional ways to communicate their messages. In PMT, children are taught to communicate more effectively by alternating their gaze from the objects of their attention to an adult and by combining such coordinated attention with gestures and vocalizations to express frequent, clear prelinguistic comments and requests. This teaching is done directly by clinicians in natural play settings and consists of the following key components: (a) following the child's attentional lead, (b) building social play routines (e.g., turn taking interactions, such as rolling a ball back and forth), (c) using prompts, such as time delays (e.g., after rolling the ball back and forth, withholding it until the child initiates a request to roll it), as well as (d) natural consequences to the child's acts (e.g., giving the child the desired ball). Theoretically, this complementary focus on parent sensitivity and responsivity to child communication (i.e., in RE) and on the frequency and complexity of child communications (i.e., in PMT) should set the stage for a transactional cycle that is self-perpetuating.

The Empirical Basis for RE/PMT

The initial explorations of the effects of PMT by Yoder and Warren and their colleagues (Warren, Yoder, Gazdag, Kim, & Jones, 1993; Yoder, Warren, Kim, & Gazdag, 1994) focused on just a few children and used single-subject, multiple-baseline designs. These studies showed that increases in the children's frequency and clarity of prelinguistic requesting following intervention were correlated with increases in linguistic mapping by teachers and parents who were naïve to the specific techniques and goals of the intervention. In other words, the teachers and parents of children who increased their use of nonverbal requests increased their use of contingent responses that repeated, rephrased, or otherwise incorporated the presumed meaning of the child's act. Furthermore, children's intentional requesting targeted in these studies was shown to generalize across people, settings, communication styles, and time.

On the basis of the promising results of these initial small *N* intervention studies, Yoder and Warren (1998, 1999a, 1999b, 2001) conducted a relatively large ($N = 58$) longitudinal experimental study of the effects of PMT on the communication and language development of children with general delays in development. Fifty-eight children between the ages of 17 and 32 months ($M = 23$, $SD = 4$) with developmental delays and their primary parent participated in the study. Of the children, 52 had no productive words at the outset of the study; the remaining 6 children had between one and five productive words.

The children were randomly assigned to one of two treatment groups. Of the children, 28 received PMT; the other 30 children received an intervention termed *responsive small group* (RSG). RSG represented an adaptation of the responsive interaction approach. The adult played with the children in a highly responsive manner

and commented on what they were doing but never attempted to elicit or prompt any communication function or form directly, as is characteristic of PMT. Treatment sessions for both groups were 20 min per day, 3 or 4 days per week, for 6 months.

After 6 months of intervention, there were no significant main effects for either PMT or RSG; however, both interventions had a range of effects on intentional communication development among subgroups of the children. The treatment that was most effective depended on the pretreatment maternal interaction style and the education level of the mother (Yoder & Warren, 1998, 2001). For children with highly responsive and relatively well-educated mothers (i.e., 3–4 years of college), PMT was effective in fostering generalized intentional communication development. However, for children with relatively unresponsive and less well-educated mothers, RSG was relatively more successful in fostering generalized intentional communication development.

The effects of maternal responsivity as a mediator and moderator of intervention effects rippled forward throughout the longitudinal follow-up period in Yoder and Warren's (1998, 2001) studies. Yoder and Warren demonstrated that children in the PMT group with relatively responsive mothers received increased amounts of responsive input from their mothers in direct response to the children's increased intentional communication (Yoder & Warren, 2001). Furthermore, the effects of the intervention within this group were reflected in the number of intentional communication acts (Yoder & Warren, 1998) and in the number of requests and comments (Yoder & Warren, 1999b) produced by the children. These effects became greater with time and significantly affected measures of expressive (i.e., lexical-density and expressive scores on the Reynell Developmental Language Scales; Reynell & Gruber, 1990) and receptive language development (i.e., number of semantic relations understood and receptive scores on the Reynell Developmental Language Scales) 6 and 12 months after intervention ceased (Yoder & Warren, 1999a, 2001). This finding contrasts with the results of several early intervention studies in which the effects were reported to wash out over time (Farran, 2000). This general pattern of outcomes suggested that the most effective application of PMT might be one in which it is complemented by a parent-based approach designed to increase parent responsivity to child communication.

This hypothesis was first examined in a randomized efficacy trial of RE/PMT by Yoder and Warren (2002). This study involved 39 prelinguistic toddlers with developmental delays and their primary parents. As in Yoder and Warren's previous study, all children scored below the 10th percentile on the Expressive Scale of the MacArthur Communicative Development Inventory (MCDI; Fenson et al., 1991) and met the Tennessee definition for developmental delay. However, in this study, 17 of the children (44% of the sample) had Down syndrome (DS), whereas in Yoder and Warren's (1998) study, only 4 of 58 participants had DS (7%). Half of the children were assigned randomly to the treatment condition, RE/PMT, which was offered as a supplement to their community-based intervention, and half received only the community-based services. Results indicated that the parent-training component of the intervention enhanced parent responsivity, as planned. However, the pattern of results in terms of various measures of child communication development varied by pretreatment characteristics, and on some measures, the control group achieved growth superior to that of the intervention group. Specifically, the intervention accelerated growth in comments and vocabulary if children began treatment with low frequencies on these measures but appeared to limit growth along these dimensions for children who began treatment with relatively high rates of comments and canonical vocal communication. Furthermore, whereas children without DS benefitted from RE/PMT, the group of children with DS that had not received RE/PMT exhibited faster growth in their use of requestive communicative acts than did the group that received the intervention.

In the most recent investigation of the effects of RE/PMT, Fey et al. (2006) systematically replicated Yoder and Warren's (2002) study with 51 toddlers (average 26 months of age at the start of the study) with developmental delays. Children were randomly assigned to receive either RE/PMT as a supplement to their community-based services or to receive only those services already provided by the community program. Of the 51 participants, 26 had DS. Two procedural modifications were made for this study in part to accommodate Yoder and Warren's findings. First, clinicians reduced task demands on children's requesting compared with Yoder and Warren's study. For example, for children who were especially limited in their production of requests, rather than requiring the child to combine a gesture or vocalization with a shift in gaze from the desired object to the adult, the gaze shift alone was accepted as a request in the early stages of treatment. Second, one commonly used PMT procedure is to attempt to facilitate vocalizations by imitating the child's nonverbal productions. However, this seems potentially confusing to the child if the child is producing the vocalization as part of an intentional communication act. Therefore, a change was made so that when a child produced a clearly intentional act with a vocalization, clinicians responded by mapping the vocalization with a word. For example, if the child said [di] while pointing to bubbles and looking at the clinician, the clinician mapped this as "bubbles" rather than imitating [di].

On the basis of data collected at the end of 6 months of intervention, Fey et al. (2006) reported the first main

effect yet reported for RE/PMT. Specifically, they observed a statistically significant multivariate effect favoring children who received RE/PMT, on the basis of a structured play interaction with an unfamiliar examiner using the Communications Temptations and Book Sharing components of the Communication and Symbolic Behavior Scales (CSBS; Wetherby & Prizant, 1993). When univariate effects were analyzed, a moderate effect (d = 0.68) was noted in the total number of intentional communication acts relative to the community intervention group. This finding was not replicated, however, in a 15-min sample involving the children and their caregivers. In this alternate context, no significant multivariate or univariate effects were observed for treatment. In each case, however, adjusted means following the 6-month intervention were greater for the treatment group than for the community intervention controls.

It is important to note that there were no Treatment Group × Etiologic Group interactions in Fey et al.'s (2006) study. Children with DS generally followed the trends established for the group as a whole. Although it was not statistically reliable, the size of the effect of RE/PMT on use of intentional communication acts in the structured play interaction was nearly as large for the DS group alone (d = 0.65) as it was with all participants combined (d = 0.68). In addition, all other nonsignificant comparisons within the group of children with DS favored the subgroup of children who received RE/PMT. Thus, the results of Fey et al.'s study indicate that a course of RE/PMT can have significant positive effects on frequency of communication among developmentally delayed 2-year-olds who are communicating infrequently, including children with DS.

The Present Investigation

In the current report, we present the outcomes for the same group of children studied by Fey et al. (2006) at two additional time points: 6 and 12 months following the completion of RE/PMT (i.e., Time 3 and Time 4, respectively). Unfortunately, we discontinued use of the CSBS as a measurement context during Times 3 and 4 because of concerns after Time 2 about its developmental appropriateness for some children in the sample. However, all other measurement contexts were the same as in Times 1 and 2. During the 6 months immediately following completion of RE/PMT (i.e., between Times 2 and 3), no project-based intervention was provided to the children in either group. This allowed us to determine at Time 3 whether the initial effects of 6 months of RE/PMT were either maintained or even strengthened as might be predicted by the transactional model and the results of Yoder and Warren's (2001) study. During the final 6 months of the 18-month study (i.e., between Times 3 and 4), we provided children in both the RE/PMT and no-treatment groups 45 min per week of intervention from clinicians within our project and six sessions of RE. This intervention gave us some control over the linguistic environments of our participants and ensured that they were all getting at least some high-quality language intervention. We hypothesized that if early RE/PMT had the long-term effects we developed it to have, then children in our RE/PMT group would exhibit a greater response to this limited, low-intensity booster language intervention than would children in the control group.

Primary Study Purpose

The two primary study purposes were as follows:

1. To determine the extent to which 6 months of early RE/PMT, as a supplement to community-based services, has long-term effects on children's communication (i.e., rate of intentional communication) and language development (i.e., number of different words per minute during a communication sample and number of words reportedly spoken or signed on the MCDI) measured 6 and 12 months after its conclusion.
2. To determine the extent to which RE/PMT, as a supplement to existing services, has longitudinal affects on parental behaviors (i.e., parental responsivity) 6 and 12 months after the conclusion of the intervention.

Secondary Study Purposes

Previous research suggests that some factors may mediate or moderate the outcomes of RE/PMT (e.g., the presence/absence of DS). Thus, for our secondary objectives, we sought to determine the extent to which a small set of previously identified mediators and moderators in fact accounted for significant variance in the longitudinal data. The secondary study purposes were as follows:

1. To determine the extent to which long-term treatment effects vary as a function of the presence/absence of DS.
2. To determine the extent to which long-term treatment effects vary as a function of parent pretreatment variables (e.g., mothers' educational attainment).
3. To determine whether parental responsivity at Time 1 moderated treatment effects on child communication at Times 2, 3, and 4 or whether parental responsivity at Time 2 mediated treatment effects on child communication at Times 3 and 4.

Method

Participants

Children. Fifty-one children with developmental delays who were between the ages of 24 and 33 months participated. At the study outset (i.e., Time 1), each child

had (a) a Mental Development Index below 70 on the Bayley Scales of Infant Development (Mental Scales, 2nd ed.; Bayley, 1993), (b) no diagnosis of autism, (c) 10 or fewer words on the MCDI Infant Scale (Fenson et al., 1991), (d) normal vision and hearing, with or without correction, and (e) motor skills sufficient to support use of basic gestures, such as pointing.

Children were referred by local providers of speech-language and other services. As in Yoder and Warren's (2001, 2002) studies, all children received some form of intervention in the community. These services were continued throughout the study, and no child withdrew from an existing program to participate in the project interventions. After a phone screening interview with the project administrator, interested parents brought their children to the University of Kansas Medical Center to obtain more information about the project, sign the informed consent form, and have their children's nonverbal cognition assessed. Eighty-six children were examined in this manner.

The staff psychologist who administered the Bayley Scales of Infant Development also provided an assessment of the children's use of autistic-like behaviors. One child was excluded because he had a score in the clearly autistic range (above 36) on the Childhood Autism Rating Scale (Schopler, Reichler, & Renner, 1988). All but 1 participant passed a hearing screening in both ears at 25 dB at 500, 1000, and 2000 Hz. The exceptional child passed the hearing screening with her bilateral hearing aids in place.

Qualifying children participated on another day in four communication sampling contexts, three of which were repeated at 6-month (Time 3) and 12-month (Time 4) posttreatment and, therefore, represent the primary data sources for the current investigation. The first of these four samples, collected only at Times 1 and 2, included the Communication Temptations and Book Sharing components of the CSBS (Wetherby & Prizant, 1993). The second sample was a free-play sample between the child and parent. The third sample, the parent–child interaction (PCX), was a 15-min structured interaction between a parent and the child. The fourth sample, the examiner–child interaction (ECX), was a 15-min interaction between the child and an unfamiliar examiner. All sessions were video- and audiotaped through a one-way mirror, using an analogue VHS camera and a high-fidelity VHS video recorder with two-channel sound. After digital capturing, the taped samples were coded using the Noldus Observer, Version 4.1 (Noldus Information Technology, 2002). The Observer is a computer-based system that enables the user to associate points on the video file with behavior codes, which can then be counted and analyzed.

At each time point, the primary caregiver completed a version of the MCDI (Fenson et al., 1991). At Times 1 and 2, children were approximately 26–32 months of age, and caregivers were asked to complete the Words and Gestures version of this inventory. The Words and Gestures version provides a list of words, and parents are instructed to indicate whether the word is understood by the child and in a separate column to indicate whether the word is said by the child. We modified these instructions by asking parents also to indicate whether the child signed the word. By Time 3, the children were around 38 months of age, and the Words and Sentences version was administered because it was more appropriate for this age. All of the vocabulary items presented in the Words and Gestures inventory are also presented in the Words and Sentences version. In addition, the Words and Sentences version presents questions about beginning word combinations. The Words and Sentences form does not ask about words understood, however, so data regarding reported comprehension were only available for the first two time points.

To qualify for the study, children had to make limited use of intentional communication acts. Children were excluded if their rates of acts per minute in the CSBS were greater than 1.16 for imperative acts, 1.17 for declarative acts, 1.28 for canonical vocalizations, and 2.12 for the total number of acts. Evidence from previous research (Yoder & Warren, 2002) indicates that children producing rates in excess of these limits typically proceed to linguistic communication within a short period of time and hence would not be appropriate candidates for this intervention.

The average age at Time 1 for the 51 children who qualified was approximately 26 months. Of these children, 26 had developmental delays associated with DS. Eight other children had an identified developmental disorder. Specifically, 1 had Trisomy 8, 1 had a mitochondrial disorder, 1 had microcephaly, 1 experienced a right cerebro-vascular accident at birth, 1 had renal disease, 1 had a repaired cleft palate, 1 had Angelman's syndrome, and 1 had fragile X syndrome. The remaining 17 children had developmental delays of unknown etiology. Other details of the sample can be found in Fey et al.'s (2006) study.

Group assignment. This study was designed as a randomized clinical trial, which is the most rigorous known method to test the absolute and relative affects of an intervention (Shadish, Cook, & Campbell, 2002). After all initial testing for a qualifying child was complete, the child was assigned at random to one of two groups using a computerized randomization program developed at Vanderbilt University. Group assignment was always revealed by the senior project associate in the presence of at least one member of the research team. Children in the first group received RE/PMT over the first 6 months of the study. The RE/PMT group ($n = 25$) was contrasted with the second group, a control group, that received no

project-based treatment over the first 6 months of the trial (n = 26). All children followed the protocol for the group to which they originally were assigned. However, 1 child in the control group moved away 2 months into the final 6-month period. This child's Time 4 data were collected prior to leaving the study and were included in all analyses. Thus, we performed intention-to-treat analyses of our study questions.

Preexperimental child variables. The randomly assigned RE/PMT and control groups were compared on 24 preexperimental variables, including the children's Time 1 performance on each of six dependent variables (described below). The means, standard deviations, and p values are provided for these 24 variables in Table 1. The groups did not differ significantly on any of the measures (all ts < 1.70, ps > .09). Yoder and Warren (2002) found that response to treatment varied depending on whether the child had DS. In this study, the groups were identical on this variable, with 13 children with DS in the RE/PMT group and 13 children with DS in the control group. Overall then, the randomly determined treatment groups were comparable at the start of the investigation.

One of our planned analyses dealt with the effects of treatment on children with and without DS. Because of this, we were also concerned with the effects of randomization on the group assignments of children within the subgroup of participants with DS and within the group of children with other etiologies. Only one of the entire set of 24 variables reliably distinguished the subgroup of children with DS who received RE/PMT from the subgroup with DS in the control group. Within the DS group, prior to any project intervention, the parents of children in the RE/PMT group had lower overall stress levels than did the parents of children in the control group, as measured by the Parenting Stress Index (Abidin, 1995). However, there were no correlations between this measure and any of the outcome variables at any time (all rs < .41, all ps > .05). Within the group of children with other etiologies, there were no significant differences between the RE/PMT and control groups on the preexperimental measures (all ts < 1.97, ps > .06).

RE/PMT Procedures

The intervention procedures are well described elsewhere (Fey et al., 2006). Thus, only a brief summary is presented here.

RE. Over the initial 6-month study treatment period, a specially trained speech-language pathologist (SLP) delivered RE to parents of children in the RE/PMT group. Parents were scheduled to receive eight, 1-hr individual sessions of RE (M = 7.72 sessions, SD = 0.89). The RE was modeled closely after the "Hanen" method described in *It Takes Two to Talk—The Hanen Program for Parents* (Manolson, 1992) and was completed by an SLP who was Hanen certified. The basic goal of RE was not to teach parents how to implement PMT but rather to teach them to recognize their children's communicative attempts and to respond to their children's communication in meaningful ways. Thus, the goals of RE were to (a) make parents more aware of their children's nonintentional and intentional communication acts, (b) help parents to wait for their children's attempts to communicate, (c) teach parents to follow their children's attentional lead, and (d) encourage parents to follow their children's communication acts with language that repeated and extended their children's apparent meanings. To reach these goals, the SLP used role-playing, videoclips of therapist–child interactions and on-line critiques of videotaped PCXs. Additionally, parents were given the book *You Make the Difference in Helping Your Child Learn* (Manolson, Ward, & Dodington, 1995) and were asked to read one or more chapters for each visit.

PMT. PMT was delivered to the children in the RE/PMT group by a certified SLP. Twenty-minute PMT sessions were scheduled in the children's homes and/or in their day-care facilities 4 days per week (M = 3.32 weekly sessions, SD = 0.29). The basic goal of PMT is to teach children to use nonverbal communicative acts that utilize combinations of (a) gestures, (b) vocalizations, and (c) eye gazing that shifts from referents of interest to a communication partner (Fey et al., 2006). The PMT intervention procedures are embedded into naturalistic therapist–child interactions. As part of the PMT procedure, the clinician creates opportunities for communication by arranging the child's environment. This can be achieved in many different ways but is typically done by placing a desired object out of the child's reach, surprising the child, or interrupting an established routine. The clinician then follows the child's lead by observing the child's attempts to obtain and manipulate the toys, waiting for the child to respond, and responding verbally and nonverbally to the child's communication and noncommunication acts.

During the initial 6-month period, 9 of the 25 children in the RE/PMT group, including 3 with DS, exceeded the prelinguistic communication criteria used to qualify for the study (see the earlier *Participants* section). Clinicians developed language goals, such as words and semantic relations, for these children and implemented milieu language teaching (MT, see below) to obtain these goals. This graduation from PMT to MT occurred after the 9 children involved had received 17–74 PMT sessions (M = 46). This is about half the average of 80 PMT sessions that were attended during the intervention period by the RE/PMT group as a whole.

Later Booster Treatment Procedures

Although all children were enrolled in some form of communication intervention at the end of the initial

Table 1. Preexperimental (i.e., Time 1) characteristics of the RE/PMT (n = 25) and CON (n = 26) groups and probability of observed t value.

Preexperimental variable	Group	*M*	*SD*	*p*
No. of children with DS	RE/PMT	13.00		
	CON	13.00		
Chronological age	RE/PMT	26.20	2.81	.41
	CON	25.58	2.50	
Maternal education (years)	RE/PMT	14.56	1.96	.43
	CON	15.12	2.92	
No. of siblings	RE/PMT	1.72	1.43	.24
	CON	1.31	1.05	
Bayley raw score	RE/PMT	98.64	9.86	.96
	CON	98.50	7.94	
Male/female ratio	RE/PMT	1.77/1.00		.21
	CON	0.86/1.00		
Proportion African American or Asian	RE/PMT	0.16		.48
	CON	0.07		
MCDI words understood (maternal report)	RE/PMT	97.92	69.35	.73
	CON	105.88	93.34	
MCDI words produced (SLP report)	RE/PMT	4.36	2.58	.94
	CON	4.42	2.92	
Monthly speech service hours	RE/PMT	3.94	1.77	.23
	CON	4.65	2.37	
Monthly total service hours	RE/PMT	13.50	5.55	.71
	CON	12.92	5.60	
PSI: Child domain	RE/PMT	99.36	22.63	.10
	CON	110.59	22.61	
PSI: Parent domain	RE/PMT	111.48	26.76	.73
	CON	113.77	16.34	
PSI: Total score	RE/PMT	210.84	47.02	.27
	CON	224.36	34.04	
Initial consonants in inventory	RE/PMT	5.76	2.83	.60
	CON	5.38	2.19	
Final consonants in inventory	RE/PMT	0.60	0.76	.50
	CON	0.77	0.99	
CSBS–PIs: Time 1	RE/PMT	0.69	0.31	.18
	CON	0.85	0.52	
CSBS–PDs: Time 1	RE/PMT	0.66	0.56	.49
	CON	0.80	0.55	
CSBS–IAs: Time 1	RE/PMT	1.62	0.73	.22
	CON	1.88	0.80	
CSBS–CVs: Time 1	RE/PMT	0.25	0.29	.64
	CON	0.29	0.29	
PCX–PIs: Time 1	RE/PMT	0.67	0.51	.75
	CON	0.72	0.45	
PCX–PDs: Time 1	RE/PMT	0.68	0.72	.61
	CON	0.78	0.71	
PCX–IAs: Time 1	RE/PMT	1.59	1.15	.65
	CON	1.72	0.93	
PCX–CVs: Time 1	RE/PMT	0.29	0.47	.94
	CON	0.30	0.35	

Note. RE = responsivity education; PMT = prelinguistic milieu teaching; CON = control; DS = Down syndrome; MCDI = MacArthur Communicative Development Inventory; SLP = speech-language pathologist; PSI = Parenting Stress Index; CSBS = Communication and Symbolic Behavior Scales; PIs = proto-imperatives; PDs = proto-declaratives; IAs = intentional acts; CVs = canonical vocalizations; PCX = parent–child interaction.

period (i.e., at Time 2), no project intervention was provided for the 6-month period between Times 2 and 3. By Time 3, all children were at least 3 years old and, therefore, were receiving school-based communication intervention under Part B of the Individuals with Disabilities Act (RE/PMT: $M = 4.93$ hr per month, $SD = 3.48$; control: $M = 3.45$ hr per month, $SD = 1.53$ [$p = .06$]). On the basis of information reported by the children's SLPs ($n = 46$), the focus of children's interventions ranged from verbal communication only to prelinguistic communication (see Table 2 for a breakdown of the intervention focus for each treatment group). Overall, services available were limited, they varied considerably from child to child, and we had no control over their quantity or quality. Therefore, at Time 3, 6 months after the discontinuation of RE/PMT, we began a booster intervention for all children. This helped us to gain some degree of control over the children's language-based services and ensured that all children received at least a modicum of high-quality service focusing on language between Times 3 and 4. This limited intervention, provided as a supplement to Part B services offered in the schools, included six planned RE sessions for the parents and one weekly 45-min MT session over the course of 6 months. This intervention is described briefly below.

RE. Parents in both the RE/PMT and control groups were scheduled to receive six, 1-hr individual RE sessions as part of the booster intervention ($M = 5.33$ sessions, $SD = 0.97$). The RE administered to parents during this final treatment period was the same as that delivered to parents of children in the RE/PMT group during the first 6 months of the study, with one exception: The primary focus of the booster intervention RE was on the parents learning RE procedures for responding to and supporting early language as opposed to prelinguistic communication. The approach taken was modeled after The Hanen Program for Parents (Girolametto & Weitzman, 2006) and was taught by a Hanen-certified SLP. Similar to the RE delivered to parents of children in the RE/PMT group during the first 6 months, parents were not taught to utilize MT procedures during the later RE treatment. Instead, parents were taught to recognize their children's communication attempts, to increase the frequency of their interactions with their children, and to follow to their children's vocal and verbal acts with their compliance and related verbal responses.

Table 2. Nonproject treatment focus for each experimental group at Time 3.

Nonproject treatment focus	Group	*n*
Verbal	RE/PMT	11
	CON	15
Sign	RE/PMT	2
	CON	2
Graphic	RE/PMT	1
	CON	1
Verbal + Sign	RE/PMT	5
	CON	5
Sign + Graphic	RE/PMT	1
	CON	1
Verbal + Graphic	RE/PMT	0
	CON	1
Prelinguistic	RE/PMT	0
	CON	1

MT. MT is an approach to teaching words and early grammatical constructions that uses relatively intrusive methods, such as imitation prompts, that are embedded into ongoing conversations with children in naturalistic contexts (e.g., play routines). This approach is based on teaching about topics in which the child shows an interest, using naturally occurring reinforcers, such as adult attention and compliance. MT has been well described elsewhere (e.g., Warren & Bambara, 1989). There is a substantial body of evidence supporting its effectiveness, especially for lexical and early grammatical intervention targets (Hancock & Kaiser, 2006; Kaiser, Yoder, & Keetz, 1992). Finally, conceptually and procedurally it complements PMT (Warren & Yoder, 1997), differing only in a few procedures that reflect its central focus on language goals as opposed to nonverbal communicative acts.

MT sessions were scheduled to take place in the children's homes or day-care facilities once per week for a 45-min period. Over the 6-month period, children in both groups averaged 20.6 sessions ($SD = 3.42$). All intervention sessions were conducted by research assistants, including both graduate students in speech-language pathology and certified SLPs. The clinicians identified specific early language goals for each child and used the MT techniques to teach these skills during each weekly session. All of the goals focused on verbal communication, either single words or word combinations. For some of the children in the study, their nonproject speech-language interventions targeted the use of signs. During project intervention sessions, our clinicians responded positively to children's sign productions, but signs or any other use of augmentative/alternative communication were not explicitly targeted by the clinicians. This was done to limit treatment variability across participants.

Fidelity of Treatment

Four separate procedures were used to maintain the fidelity of the PMT and MT procedures. First, the investigators and clinicians met on a weekly basis to discuss the clinicians' selection of goals and treatment implementation. Second, during both PMT and MT, children were videotaped working with their primary

clinician. Recordings were made of the entire PMT sessions approximately once per month during the initial RE/PMT period. Twenty-minute segments of the MT sessions were recorded approximately every 6 weeks during the 12- to 28-month period. Portions of these sessions were observed and discussed during the weekly investigator/clinician meetings. Third, after compiling a collection of videotaped PMT and MT sessions, one of the investigators copied them to CDs so that at least one example of each type of intervention appeared on each CD. Three graduate assistants who were unaware of the specific treatment and goals for each child viewed 10-min segments of each treatment session on the CDs. After each segment, the assistant judged (a) whether the clinician was employing PMT or MT and (b) which of five intermediate objectives for PMT or three objectives for MT were being addressed primarily. The assistants correctly distinguished PMT from MT sessions for 93% of the sessions and selected the intermediate objective designated by the clinician as the first or second priority goal for 90% of the sessions. This procedure verifies that observers blind to the type of interventions that the clinicians were attempting to provide were able to reliably distinguish PMT from MT and successfully identify the clinicians' intended goals for the PMT and MT sessions.

Because the treatments delivered to the children were individualized, there is potential for considerable variability within teaching sessions. To help quantify the treatments delivered to the children in PMT sessions between Times 1 and 2 and MT treatment sessions between Times 3 and 4, we further analyzed a randomly selected set of the videotaped treatment segments. On each tape, we identified the number of "successful" PMT episodes and the overall number of MT episodes. Successful PMT teaching episodes were observed at an average rate of 1.37 episodes per minute (SD = 0.76, range = 0.19–2.67) on the basis of 21 randomly selected PMT sessions (details of the identification of PMT episodes can be found in Fey et al.'s, 2006, study). The MT episodes coded included cases in which the clinician presented a specified MT prompt (e.g., time delay, query, model). For cases in which the child responded with the target word (i.e., "successful" episodes), the clinician had to follow the child's response in a recast for the episode to be counted. For cases in which the child did not respond with the target word or word combination (i.e., "unsuccessful" episodes), the clinician must have provided the child with at least one additional prompt to give the child another opportunity to produce the target word or word combination. When these criteria were applied, the average rate of MT teaching episodes observed was 1.33 episodes per minute (SD = 0.72, range = 0–2.99) on the basis of 82 randomly selected 20-min samples of MT sessions.

Communication Sample Contexts

The data reported in the present analysis were collected in and conflated across a brief parent–child free-play sample, a more structured PCX sample, and an ECX sample. The PCX and the ECX were two contexts also used by Yoder and Warren (1998, 2001, 2002) in their earlier research on the effects of PMT and RE/PMT. Project examiners were blind to children's group assignments at Time 1, but they may have been aware of the child's group status at other test periods. In this study, rather than evaluating children's performance in each sample, we sought to enhance the representativeness and reliability of our sample by pooling child data from all three contexts. Parent responsivity data were obtained from the free-play and PCX contexts.

The free-play sample was a 5-min interaction between the child and parent playing as they wished with toys selected from a small set available to each dyad. The PCX sample included three 5-min segments involving the parents and their children. The examiner left the room after providing the instructions for each segment. In Segment 1, examiners presented parents with three bags of toys that were difficult to open. Parents played with a toy until their children appeared interested. Then, they put the toy back in the bag and gave the closed bag to the children. Parents were told to allow their children to play with the toys only after their children indicated a need for help in opening the bag. Some children required their parents to select an additional toy, but some played with the same toy for the entire segment. Each additional toy was introduced in the same manner as the first.

In Segment 2, examiners placed a cup of juice and a jar of Cheerios on the table out of the children's reach. The parents were instructed not to give the snack to their children until they requested the juice or Cheerios. Periodically, throughout the snack time, an examiner made a slinky bounce from the ceiling or a timed recording of novel sounds began playing on a tape recorder. The examiner instructed the parents to wait for their children to react before they attended to or commented on these events.

In Segment 3, the parents played with one of three toys provided until the children requested a turn. Following the request, parents allowed their children to play freely with the toy. Parents were allowed to switch toys if their children seemed to lose interest. At regular intervals, as parents and their children played, novel recordings were played on a tape recorder. At the end of the session, the examiner narrowly opened the door to the room and blew bubbles inside. As in Segment 2, the examiner instructed the parents to wait for a reaction from their child before they attended overtly to these events.

In the ECX sample, children engaged with an unfamiliar examiner in a relatively unstructured 15-min

free-play session. The adult examiner conducting the session was not the child's project clinician, and no toys were used from the PMT or MT intervention sessions. The toys used included a baby doll, bottle, blanket, car, hairbrush, and spoon; two teacups with saucers; four wooden sticks; two sponges; and a telephone pull toy. The examiner played with the child using toys of the child's choosing. To play with the child, the examiner was instructed to be a responder rather than an initiator or demonstrator of play. Thus, the examiner imitated what the child did and commented on the play. The examiner avoided using directives to guide child actions or communication and avoided modeling levels of play higher than the child had used during the session.

Dependent Variables

Child variables. For this study, we examined three child communication variables. One of these variables, rate of intentional communication acts per minute, was the variable observed to change in response to treatment in Fey et al.'s (2006) study. The second child variable was lexical density (i.e., the number of different words the child produced per minute). This variable was not included in Fey et al.'s analysis because the majority of the children were primarily prelinguistic at Times 1 and 2. The third variable was the total number of words said or signed according to the MCDI (Fenson et al., 1991).

Three types of intentional communication acts were coded as follows: requests, declaratives, and "other" acts. For requests, the child had neutral or positive affect while requesting that the adult perform some act or service (excluding rejections and protests). Declaratives were nonimitated intentional acts that focused the adult's attention and/or shared positive or neutral affect about objects or events. "Other" acts included social responses (e.g., words or gestures indicating "yes," "no," "please," and "hi"), requests or commands accompanied by negative affect (e.g., protests), and acts that could not unambiguously be judged as requests or declaratives. Acts that included words, conventional gestures (e.g., waving, pointing, and head nodding), and some nonconventional gestures (e.g., giving and showing) were judged to be inherently intentional whether the child looked at the adult's face. In other cases, communication acts were judged to be intentional when either a vocalization or a gesture (or both) was combined with gaze alternation between the object/event and the adult's face.

The second child variable, lexical density, reflected the rate of different words used spontaneously by the child per minute in the three sampling contexts. Because many of the children's speech abilities were so limited, they were often difficult to understand. Therefore, we applied very conservative criteria to the identification of words. First, the following phonetic and semantic criteria were used to identify the child's vocalizations as word candidates:

1. The vocalization contains a vowel nucleus that is functionally equivalent to the adult target vowel.
2. The vocalization contains one or more target consonants or child-like consonant substitutions of the target word in the appropriate position.
3. The transcriber determines that the child is using the word in a semantically and pragmatically conventional manner.
4. The word candidate does not immediately follow the adult's production of the same word, rendering it an imitation.
5. It does not have the same phonetic shape as another word transcribed within a sample during the same test period.

Word candidates were included in the word count only when they met one or more of the following additional criteria: (a) the child used a similar pronunciation of the word spontaneously or imitatively on a separate occasion during the same or a prior test period, (b) the child's parent had reported that the child used the word spontaneously on the MCDI, which was completed during the same or a prior assessment, or (c) the child's SLP had indicated that the child used the word spontaneously during a phone interview that was part of the Time 1 assessment.

The third measure, the MCDI, was filled out by the primary caregiver every 6 months at each testing session. This variable reflects the total number of words spoken or signed recognized by the parent at each time period.

Parent variable. The variable used to evaluate parental response to intervention was the percentage of child communication acts that were followed by responsive parent communication, or *parent responsivity*. This variable included parental recodes and topically appropriate statements by parents. To count as an instance of a parental recode, the adult response had to refer explicitly to the child's intended referent and the child's intended function. Thus, in response to a child pointing to a slinky bouncing down from the ceiling, the adult might provide the recode "That's a slinky," "You see the slinky," "You like that slinky," or "Slinky." Topically appropriate responses were those that maintained the child's focus but did not refer explicitly to both the child's referent and intent. Responses to the pointing example above, such as "Oh look at that," would be included as a topically appropriate parental utterance.

Coding Reliability

Coding child behaviors. Intentional communication acts occurring in the free-play, PCX, and ECX samples

were identified and coded by graduate research assistants using the Noldus Observer, Version 4.1 (Noldus Information Technology, 2002). Two assistants, one of whom was blind to the children's group assignments, coded each sample. The primary judge first coded the sample for the presence of intentional communication acts, act type (i.e., declarative, imperative, other), and words produced. Then, the transcript was stripped of information about act type and words produced and passed to the secondary judge. This judge worked independently to verify or reject the intentional acts identified by the primary judge and added or removed acts to the transcript, as needed. She also added information to the transcript about act types and words produced. Agreement for the identification of intentional communication acts between the primary and secondary judges' codes using this method was 87.7% (*SD* = 15.2) for the free-play sample, 88.2% (*SD* = 10.2) for the PCX sample, and 87.7% (*SD* = 9.4) for the ECX sample.

For this study, the primary dependent language variable from the observational samples was lexical density or rate of different words per minute. For each independent judge's transcripts, the number of spontaneous word types was calculated. To determine the interjudge reliability for word identifications, intraclass correlation coefficients (ICCs; using the consistency definition; SPSS, 2006) were calculated for lexical density as determined by each independent judge at each time period and in each context. The ICCs were high, with scores ranging from .79 to .98, indicating that differences in the judge's independent transcription of words had little effect on the participants' relative standings on our measure of number of different words produced per minute.

The primary and secondary judges discussed and modified each disagreement concerning nonverbal communication acts as they deemed appropriate. In all cases, the blinded coder made the final coding decision. Group comparisons of total communication acts produced were based on this final consensus transcript.

The transcripts for both judges then were compared by two additional coders who were not blind to group assignment. The purpose of this examination was to identify any discrepancies between primary and secondary judges and to determine whether the "words" transcribed met all criteria for words as described above. Children's words that were not agreed upon by the judges or did not meet the criteria were not included in final transcripts, which served as the basis for all group comparisons of lexical density.

To determine whether this procedure biased the data, the final lexical-density scores for each sample were compared with the scores of the primary independent judge. Consistency definition ICCs were extremely high, ranging from .80 to .98. These strong correlations indicate that differences in the final lexical-density measure and those based on the transcript of the primary judge had an extremely small effect on the relative performances of participants.

Coding parent behaviors. A graduate assistant who was blind to participant group assignments coded the parents' responses to their children's communication acts in the free-play and PCX samples. Using transcripts of the coded child intentional acts in these samples, the assistant coded all parental recodes and topically appropriate responses that immediately followed each child act. Approximately 33% of samples (n = 86) were selected at random and coded by a second judge, who was, in some cases, aware of each child's group participation. To evaluate reliability for the identification of parental recodes and topical responses, we applied the consistency definition for the ICC (McGraw & Wong, 1996; Weunsch, 2007). Reliability in this case was strong, with single-rater ICCs across all assessment periods ranging from .91 to .98.

Statistical Analyses

We performed repeated measures analyses of variance using the general linear model to determine whether RE/PMT treatment had a significant effect on growth in child communication and language development over four time points. This included tests at the pretest assessment (Time 1), immediately following intervention (Time 2), at 6 months after the conclusion of the intervention (Time 3), and at 12 months after the conclusion of the intervention (Time 4). Four models (one for each of the dependent variables of interest) were examined: intentional communication acts, lexical density (i.e., number of different words per minute), MCDI spoken or signed words, and parental responsivity. Analyses of covariance were used to control for initial differences in cognitive ability as measured by the Bayley Scales of Infant Development for the child outcomes. For the parental responsivity model, scores at Time 1 were used as a covariate, and the change over time was modeled over just three time points. Additional terms in the models were a repeated measures factor for time with three or four levels and a between-subjects factor for treatment group with two levels (RE/PMT and control).

Because of the earlier findings of Yoder and Warren (2002) indicating differential effects based on diagnosis of DS, we also added a between-subjects factor for diagnosis with two levels (DS and no DS). The Treatment Group × Diagnosis × Time interactions on each of the variables were examined. Nonsignificant terms were dropped from the models in order of the highest p values until only statistically significant terms or terms involved in significant interactions were left.

To test the moderating effects of RE and parent responsivity on child communication growth at Times 2,

3, and 4, RE and Time 1 parent responsivity were added separately to the models as covariates. An additional set of analyses was conducted with child communication (intentional communication acts, lexical density, and MCDI words said or signed) at Times 3 and 4 as the outcome variables in univariate analyses of variance. The mediating influence of parent responsivity was assessed by adding Time 2 parent responsivity to the models as a covariate. The Treatment × Parent Responsivity interactions were the effects of interest tested in each of these analyses.

Results

This study had two primary purposes. First, we sought to determine the extent to which RE/PMT has longitudinal effects on children's communication (i.e., rate of intentional communication) and language development (i.e., lexical density and spoken or signed words from the MCDI) at 6 and 12 months after the conclusion of the intervention. Initial analyses revealed a consistent pattern of results across each of the three sampling contexts. Therefore, to examine these issues, we combined the child data from three language sampling contexts: the free-play, the PCX, and the ECX contexts. Second, we sought to determine the extent to which RE/PMT has longitudinal effects on parent behaviors (i.e., rate of parental responsivity) 6 and 12 months after the conclusion of the intervention. All the data to examine this issue came from the PCX and free-play contexts.

For all four dependent variables, the Diagnosis × Treatment Group × Time interaction was not significant (p values ranged from .51 to .87), and effect sizes were small (see Table 3), indicating that the effect of treatment on child communication and parental responsivity over time did not significantly differ by diagnosis when controlling for initial Bayley scores. Therefore, regardless of diagnosis, all children were combined in the analyses to examine the effect of treatment.

Intentional Communication Acts

The test for the Time × Treatment Group interaction indicated that treatment did not have a significant effect on gains made over time in the use of intentional communication acts. See Table 3 for a summary of the F test and Figure 1 for the adjusted means and 95% confidence intervals. A significant effect of time indicates that the children did experience growth in rates of intentional act, but these increases were not related to the children's participation in RE/PMT. See Table 3 for a summary of the effect of time.

Lexical Density

The test for the Time × Treatment interaction when controlling for initial Bayley scores was not statistically significant, indicating that treatment did not significantly effect changes in lexical density over time. The F test, adjusted means, and 95% confidence intervals are presented in Table 3 and Figure 2. However, lexical density did change significantly over time when controlling for initial Bayley scores, regardless of the child's treatment group. When the effect of time was examined without controlling for initial Bayley scores, the effect of time was also highly significant.

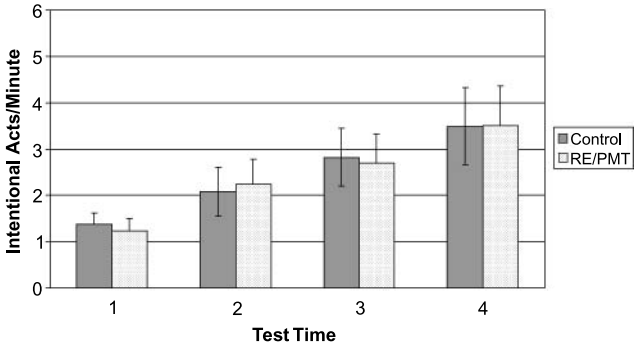
Table 3. Summary of ANCOVA tests performed on adjusted means.

Variable	*df*s	*F*	*p*	Partial η^2
Time × Diagnosis × Treatment Group interactions				
IAs[a]	2.16, 99.13	0.70	.51	.02
Lexical density[a]	1.55, 71.45	0.10	.86	.002
MCDI total[a]	1.33, 56.99	0.06	.87	.001
Responsivity[b]	1.97, 84.86	0.37	.69	.01
Time × Treatment Group interactions				
IAs[a]	1.94, 93.18	0.23	.79	.01
Lexical density[a]	1.46, 70.26	0.14	.80	.01
MCDI total[a]	1.27, 57.08	0.20	.72	.01
Responsivity[b]	1.97, 88.59	0.44	.65	.01
Time effect				
IAs[a]	1.96, 95.77	3.39	.04	.07
Lexical density[a]	1.47, 71.85	8.80	.001	.15
MCDI total[a]	1.28, 58.79	5.72	.014	.11
Responsivity[b]	1.96, 90.53	6.22	.003	.12

Note. ANCOVA = analysis of covariance.

[a]Time 1 Bayley raw score served as the covariate. [b]Time 1 parent responsivity served as the covariate.

Figure 1. Adjusted means for intentional communication acts over Time × Treatment Group (the covariate in the model is the Bayley raw score at Time 1, *M* = 98.61). Error bars represent the upper and lower boundaries of the 95% confidence intervals. RE = responsivity education; PMT = prelinguistic milieu teaching.



MCDI Spoken or Signed Words

Once again, the test for the Time × Treatment Group interaction for MCDI spoken and signed words was not statistically significant. The *F* test, adjusted means, and 95% confidence intervals are presented in Table 3 and Figure 3. This finding indicates that treatment did not significantly effect changes in reported vocabulary production after controlling for differences in initial Bayley scores. The effect for time across all of the children was statistically significant, indicating that the number of reported spoken or signed words changed significantly over time, regardless of the child's treatment group when controlling for Bayley scores at Time 1.

Parental Responsivity

Parent responsivity over Times 2, 3, and 4 did not differ across treatment groups, as the Time × Treatment Group interaction was not statistically significant. The effect of time when controlling for responsivity scores at Time 1 was significant, indicating that parent responsivity increased across time when controlling for initial differences in responsivity. The *F* test results are presented in Table 3. Figure 4 illustrates unadjusted means and 95% confidence intervals around those means. Unadjusted values are reported so that meaningful data for Time 1 could be included along with that for Times 2, 3, and 4.

Figure 2. Adjusted means for lexical density over Time × Treatment Group (the covariate in the model is the Bayley raw score at Time 1, *M* = 98.61). Error bars represent the upper and lower boundaries of the 95% confidence intervals.

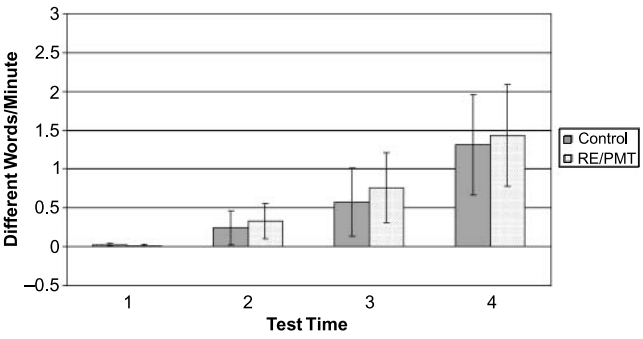
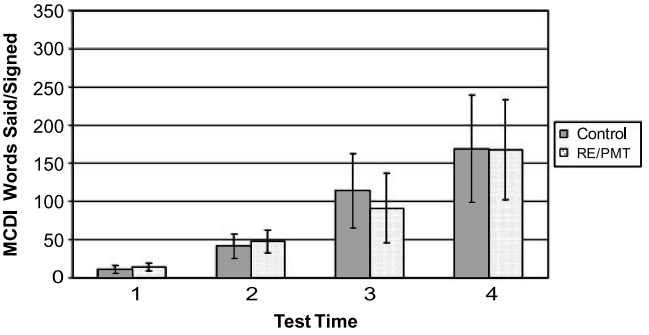


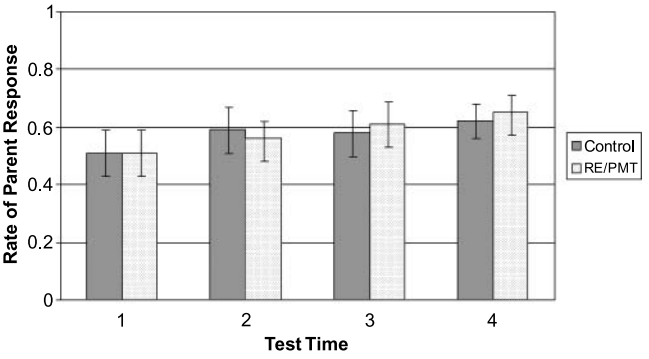
Figure 3. Adjusted means for MacArthur Communicative Development Inventory (MCDI) spoken or signed words over Time × Treatment Group (the covariate in the model is the Bayley raw score at Time 1, *M* = 98.61). Error bars represent the upper and lower boundaries of the 95% confidence intervals.



Effects of DS, Maternal Education, and Parental Responsivity on Child Communication

The study had three secondary purposes. First, we sought to determine the extent to which longitudinal treatment effects varied as a function of the presence or absence of DS. Second, we sought to determine the

Figure 4. Observed parental responsivity means over Time × Treatment Group. Error bars represent the upper and lower boundaries of the 95% confidence intervals.



extent to which longitudinal treatment effects varied as a function of maternal education attainment. Third, we sought to determine whether parental responsivity at Time 1 moderated effects on child communication at Times 2, 3, and 4 and whether parental responsivity at Time 2 mediated effects on child communication at Times 3 and 4.

DS

In the earlier presentation of results, we reported that there were no significant Time × Treatment Group × Diagnosis interactions for any of the four dependent variables (*p*s = .51–.99), so the treatment did not differentially affect children with a diagnosis of DS and their parents. It should be noted, however, that there was a significant Diagnosis × Time interaction when controlling for initial Bayley scores for the following variables: intentional communication acts, $F(2.19, 105.27) = 9.89$, $p < .001$, partial $\eta^2 = .17$ (see Figure 5); lexical density, $F(1.56, 74.86) = 8.82$, $p = .001$, partial $\eta^2 = .16$ (see Figure 6); and MCDI spoken or signed words, $F(1.40, 62.80) = 8.71$, $p = .002$, partial $\eta^2 = .16$ (see Figure 7). These large effects indicate a lower rate of growth for all three variables for children with DS relative to children with other diagnoses, irrespective of treatment group assignment.

Maternal Education

The Time × Treatment Group × Maternal Education interaction at Time 1 was not significant for intentional communication acts ($p = .95$), lexical density ($p = .43$), and MCDI ($p = .29$). In all cases, the effect sizes were also small (partial $\eta^2 = .001$, .015, and .026, respectively), indicating that children's response to treatment was not related to their mothers' level of education.

Figure 5. Adjusted means for intentional communication acts over Time × Diagnosis (the covariate in the model is the Bayley raw score at Time 1, *M* = 98.61). Error bars represent the upper and lower boundaries of the 95% confidence intervals. DS = Down syndrome.

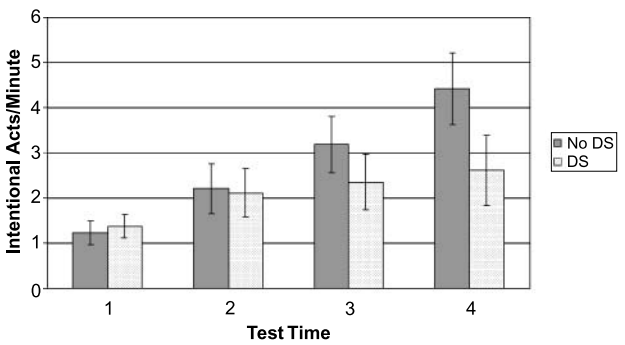
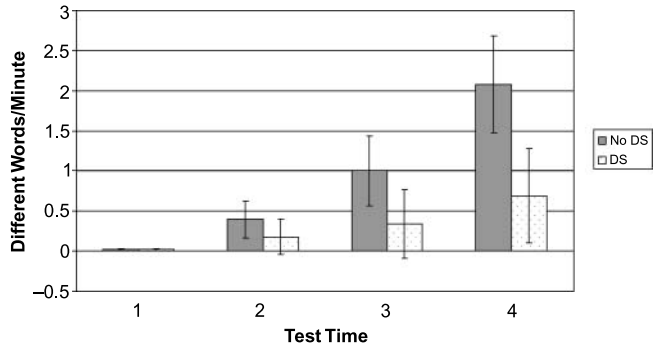


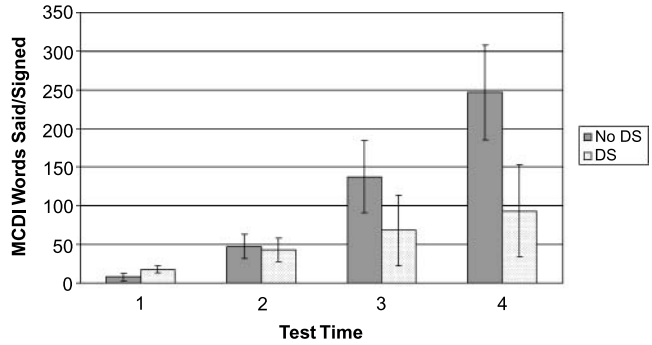
Figure 6. Adjusted means for lexical density over Time × Diagnosis (the covariate in the model is the Bayley raw score at Time 1, *M* = 98.61). Error bars represent the upper and lower boundaries of the 95% confidence intervals.



Parent Responsivity as a Predictor

The Time × Treatment Group × Percentage Use of Parental Responsivity at Time 1 interaction was nonsignificant for intentional communication acts ($p = .99$), lexical density ($p = .76$), and MCDI spoken or signed words ($p = .69$) when the outcome variables at Times 2, 3, and 4 were in the model. Effect sizes were very small, indicating that parents' tendencies to follow their children's communication acts with responsive communication did not moderate the effects of treatment on communication and lexical development. Furthermore, responsivity at Time 1 did not have a significant effect on child language outcomes independent of treatment group, as the Time × Responsivity interaction was not significant for intentional communication acts ($p = .26$), lexical density ($p = .55$), and MCDI spoken or signed words ($p = .22$). Effect sizes were small for all three variables.

Figure 7. Adjusted means for MCDI spoken or signed words over Time × Diagnosis (the covariate in the model is the Bayley raw score at Time 1, *M* = 98.61). Error bars represent the upper and lower boundaries of the 95% confidence intervals.



Similarly, in univariate analyses of variance, the Treatment Group × Percentage Use of Parental Responsivity at Time 2 interaction, after RE/PMT parents had completed a course of RE, was not significant for intentional communication acts at both Times 3 and 4 (*p*s = .73 and .72, respectively). Effect sizes were small (partial η^2 = .003 and .003, respectively), indicating that the effects of RE/PMT on the children's communication growth did not covary with their parents' posttreatment tendencies to follow child communication acts with appropriate responses to those acts. Furthermore, the effect of responsivity, independent of treatment group, was not significant for intentional communication acts at Time 3 (p = .75) and Time 4 (p = .91). The Treatment Group × Use of Parental Responsivity at Time 2 interaction was also not significant for lexical density at Times 3 and 4 (*p*s = .65 and .095, respectively). Effect sizes were once again small (partial η^2 = .001 and .005, respectively), suggesting that children's rates of word usage following RE/PMT did not depend on the frequency with which the parents recoded or responded topically to their children's acts at Time 2. Once again, the effect of responsivity, independent of treatment group, was not significant for lexical density at Times 3 and Time 4 (*p*s = .75 and .98, respectively). The effects for MCDI were similar in that the Treatment Group × Parental Responsivity interactions were not significant at Times 3 and Time 4 (*p*s = .620 and .445, respectively). The effect of responsivity, independent of treatment group, was also not significant at each time point (*p*s = .750 and .706, respectively).

Gender

To more fully evaluate the influence of child predictors on response to the intervention, we determined whether the effect of treatment was different on the basis of gender. Gender × Treatment Group × Time interactions were not significant for each of the child language outcomes (intentional communication acts, p = .11; lexical density, p = .16; and MCDI, p = .11). Partial eta-squared values were all less than .06, indicating small effects.

We also determined whether there were gender differences in communication growth irrespective of treatment group. Gender effects were not significant for intentional communication acts (p = .46), lexical density (p = .78), and MCDI (p = .40), indicating that male and female communication skills over the course of the study were not significantly different from one another.

Discussion

The basic clinical implication of the transactional theory of development is that when an active child and a responsive environment come together, learning accelerates, and performances of the partners change in ways that should motivate and sustain further learning. RE/PMT is a clinical effort to enhance the prelinguistic or early linguistic child's communication skills on the one hand and to ensure high levels of parental responsiveness to the child on the other. Yoder and Warren (2002) provided meaningful, if modest, effects demonstrating that the two-pronged RE/PMT formula can change communication and language behavior over the short and the longer term for some children, such as those who produce relatively few comments and do not have DS. Fey et al. (2006) modified the RE/PMT approach of Yoder and Warren and observed changes in the rate of communication in a group of toddlers that included a large contingent of children with and without DS. Our primary objective in the present investigation was to test the transactional effects of RE/PMT by examining our participants at two additional time points, 6 and 12 months after we discontinued RE/PMT. For the first 6-month postintervention period (i.e., from Time 2 to Time 3), children and parents received no project-based intervention, although they continued to receive approximately 1 hr per week of speech-language services primarily through school programs. There was considerable variation, however, in the quality and quantity of intervention provided at this time. Therefore, over the second 6-month postintervention period (i.e., from Time 3 to Time 4), we provided a booster intervention to children in both the RE/PMT and control groups and their parents. This intervention was intentionally limited in its intensity and duration; nevertheless, if the effects of 6 months of RE/PMT had been maintained 6 months after initial treatment, children in the RE/PMT group should have benefited substantially more from this language intervention than the control group on the basis of transactional theory. In sum, on the basis of both theoretical and empirical factors, we hypothesized that the children who had received RE/PMT would significantly outperform children who had not received RE/PMT at both later time points.

To test for our hypothesized effects, we combined the data from three language sampling contexts: a brief free-play sample involving the child and parent, the PCX sample, and the ECX sample (a relatively unstructured child–examiner sample at each time point). On the basis of our analyses of these data, we found no evidence that the main effect for intentional communication acts observed by Fey et al. (2006) was maintained 6 months after treatment was completed or that any other significant effects on children's language learning had emerged by this time. As was the case for our RE/PMT group overall, we found no evidence of an advantage at Times 3 or 4 for the children with DS who received the early RE/PMT. On the other hand, we found no evidence that children in this group were negatively impacted by the intervention. This is important because Yoder and Warren

(2002) presented evidence of a possible limit on the rate of communication development of children with DS in the RE/PMT group relative to children with DS in the control group. Fortunately, over the short term, as indicated in our earlier report (Fey et al., 2006), RE/PMT showed no signs of having a negative long-term impact for children with DS in the present investigation and in fact showed the same positive pattern of effects as children without DS. In general, however, regardless of whether they received early RE/PMT, children with DS showed significantly less development than did children without DS by Times 3 and 4 for all three measures (i.e., intentional communication acts, lexical density, and spoken or signed words on the MCDI). We comment on this finding later.

Yoder and Warren (1998, 2001) reported significant interactions between PMT and differential levels of maternal education and parental responsivity to child communication. Higher levels of maternal education and parent responsivity in combination with 6 months of PMT interacted to yield greater communication and language development over time. In the present study, we found no interaction effects of maternal education and RE/PMT on communication and language development at Times 2, 3, and 4. Similarly, whether sampled before 6 months of treatment (Time 1) or after the treatment (Time 2), parental responsivity did not interact with the intervention to produce greater effects on the children's development of communication acts or words over time. Thus, unlike results reported by Yoder and Warren (1998), we observed no evidence of either moderating or mediating effects of parent responsivity to child utterances on the children's response to treatment. This might have been due, in part, to differences between the participants in the two studies. Yoder and Warren's (1998) initial study had a much more diverse sample in terms of educational background and parenting styles than we had in the present study. In that study, parents on average had only a high school education, whereas on average parents in the current study had completed 2 or more years of college. Parents in Yoder and Warren's study also were lower on their measure of parental responsivity on average, but they also had much more variance on this measure than in the current study. This greater degree of variance in parental responsivity may have been an important ingredient in the identification of a moderating effect by this variable in Yoder and Warren's study. The relatively higher level of parent responsivity combined with less variance may have effectively muted any mediating or moderating role in the present study.

Study Limitations That May Have Led to Non-Effects

A number of known potential limitations in our investigation could have minimized our ability to detect significant effects. First, perhaps the greatest weakness of this study is that we discontinued the CSBS sampling context after Time 2. This was deemed necessary because some of the prompts and activities in the CSBS appeared to be developmentally inappropriate for at least some of our participants by the Time 3 and Time 4 samplings. At the time this decision was made, we had no way of knowing that the only immediate effects of RE/PMT observed at Time 2 would be in this CSBS context (Fey et al., 2006). Because of this, we cannot be certain that our RE/PMT group would not have outperformed the control group on one or more of our child participant variables had we observed them in the CSBS context at Times 3 and 4. Because we observed no effects in the individual or combined free-play, PCX, and ECX conditions in the present study, however, we can only conclude that any real benefits of RE/PMT that might have been measurable in the CSBS were not strong enough to generalize to the RE/PMT children's communication repertoires in a way that affected their later performance in the free-play, PCX, and ECX contexts.

Second, RE/PMT was offered as a supplement to services that study participants were receiving largely through the schools under the Individuals with Disabilities Act Part C. Thus, we tested it more as a supplement to existing services than as an isolated intervention. This is a study weakness that is difficult to avoid because of ethical concerns involved in taking children out of existing services to participate in an experimental intervention. The biggest measurement problem that this causes, of course, is that the background interventions might have been having effects on control as well as RE/PMT participants, minimizing our ability to detect changes due specifically to RE/PMT. There is no way to completely nullify this argument. If it is true, however, it is difficult to explain the later effects observed by Yoder and Warren (2001, 2002) in studies that suffered from the same methodological difficulty. Furthermore, if it is true, one would conclude that the presumed yet not measured effects of RE/PMT were rather small.

A third factor that can limit the sensitivity to statistically reliable effects is lack of statistical power. Although our study was relatively large by language intervention study standards, an N of 51 is still small in an absolute sense and could have limited our ability to detect real effects in the data. However, a quick examination of the effect sizes reported in the Results section indicates that this is not the case. Regardless of measure, the observed treatment main effects and interactions were uniformly small and clinically nonsignificant. The effect sizes, partial eta-squared, were never even as high as .02 for the Time × Treatment Group interactions, the tests most crucial for overall effects of intervention, on any measure. It is no doubt true that a large enough N would have led to a significant outcome even with our

small effects. However, this would be true theoretically in every statistical analysis, unless the comparison groups were literally the same in all meaningful ways, a condition not likely to arise even with the most rigorous random sampling procedures. In any case, any effects that were missed with our statistical analysis because of low power had to have been small and clinically nonsignificant.

Fourth, because the children in this study were generally weak communicators with poor articulation skills, we adopted a consensus procedure for verifying word productions. Although the judges in our word checks made every effort to be objective in these analyses, they were not blind to the children's group assignments in most cases. This may be judged by some as a significant weakness of the study, but it does not appear to be sufficient to explain the lack of effects associated with our intervention. For example, in an analysis of 276 randomized controlled trials in 26 meta-analyses, Balk et al. (2002) found that blinding of testers and judges in clinical trials was not generally related to treatment effects. When it did appear to matter, however, blinding reduced rather than increased the size of intervention effects. Thus, our inability to ensure blinding of all of our testers and coders is more likely to have decreased the size of our effects than to have increased effects.

Fifth, our measures were generally quite conservative. For example, to qualify as a nonverbal intentional act, a child had to either produce a conventional gesture entailing attention to both object and adult (e.g., giving or showing) or had to combine a look to an object and the adult with a nonconventional gesture (e.g., proximal point or a reach) or vocalization. However, our measure of intentional communication acts was fundamentally the same as that used by Yoder and Warren (2001, 2002). More important, it was precisely the same as that used in the study of Fey et al. (2006), in which a significant effect was observed in the CSBS context at Time 2.

Our criteria for determining word status for the lexical-density measure also were very conservative. This could have made this measure insensitive to change. We cannot rule this possibility out altogether, although we view it as unlikely for three reasons. First, although our definition of words may have undercredited the words some children produced, there is no reason to believe that our potentially deflated estimates of word usage would have differentially affected our experimental groups. Thus, clinically significant effects on the use of new words still should have been identifiable despite the deflation. Second, our finding on lexical density is perfectly consistent with our findings regarding the parent reporting of words used on the MCDI, a measure that has been shown to be sensitive to language intervention in other studies (Girolametto, Pearce, & Weitzman, 1996; Girolametto, Weitzman, & Clements Baartman, 1998; They consistently showed effects of time, indicating growth over the experimental period, and they also consistently yielded Diagnostic Group × Time interactions, indicating that more growth was observed for children without DS than for children with DS.

Finally, it is possible that our treatment was not delivered to the children and parents in a sufficiently faithful manner to yield the anticipated effects. On the surface, this argument appears weak because an immediate effect on the rate of intentional communication acts was measured and reported by Fey et al. (2006). Still, one could argue that the limitation of this effect to the CSBS context and its relatively modest size were the result of inadequate provision of either RE or PMT. Our efforts to measure and maintain the treatment standards for PMT suggest to us that this argument does not apply to this intervention. We held weekly staff meetings in which clinicians and investigators watched videotapes of intervention sessions and thoroughly discussed any questions or problems that arose while correcting any departures from the protocol. Monthly videotaped observations of each child in PMT showed that blinded observers could accurately judge the goals being addressed in PMT and MT sessions. Finally, our measured rates of successful teaching episodes indicate that PMT procedures were generally delivered in the manner and frequency described by the developers of the approach (Yoder & Warren, 1993) and intended by the investigators of this study (Fey et al., 2006).

On the other hand, it is much more difficult to evaluate procedural validity of RE. Many of the parents were uncomfortable being videotaped in situations in which they were learning and practicing new skills. In fact, several consented to be videotaped to review and evaluate their own behavior with their child as part of the intervention only when we agreed that they could keep the videotapes at their homes. Thus, systematic inspection and evaluation of RE services were not implemented in this study. Our clinicians who provided RE were all American Speech-Language-Hearing-Association-certified SLPs who were also certified to use the "Hanen" procedures described in *It Takes Two to Talk—The Hanen Program for Parents* (Manolson, 1992), but our eight-session, individual parent intervention was not the same as the Hanen Program. Although Fey et al. (2006) observed effects of RE among parents of children who did not have DS at Time 2, immediately after the RE was delivered, we found no differences between groups in parent responsivity at Time 3, 6 months after the RE had been completed. Thus, it remains possible that our clinicians delivering RE did not present the intervention in a package that was sufficiently robust to maintain parental sensitivity to child change. Without such changes in parental sensitivity, effects of RE/PMT may have been minimized. There were also no differences between groups in parent responsivity at Time 4; however, this data

collection point occurred immediately after both groups had received six RE sessions. Therefore, we would not necessarily expect to find a significant group difference in parent behaviors at Time 4.

Slow Development Associated With DS

It is not surprising that the children with DS showed significantly less development in all three dependent variables over time compared with children without DS. The children with and without DS were similar on pretreatment variables thought to be associated with language development, such as cognitive levels and parent education. However, the poor development in prelinguistic and early linguistic skills observed in the children with DS is consistent with the well-documented later language problems associated with DS. Delays (often severe) in onset of vocabulary and rate of vocabulary in comparison with typically developing children have been reported (Mervis & Becerra, 2003; Miller, 1999). Other researchers have reported that older children with DS typically show patterns of slow growth in expressive syntax and morphology (Chapman, Schwartz, & Kay-Raining Bird, 1991; Eadie, Fey, Douglas, & Parsons, 2002). Furthermore, Girolametto et al. (1998) found a much less robust and generalized outcome when a parent-based vocabulary intervention was provided to children with DS than did Girolametto et al. (1996), who applied the same focused stimulation approach with a group of late talkers. Thus, children with DS tend to develop language forms slower than do other groups with developmental delays with or without intervention.

Although prelinguistic communication has been described as a relative strength in children with DS (Sigman & Ruskin, 1999), our findings suggest that development in prelinguistic communication is also slower than might be predicted among children with DS who are not already frequent communicators or word users by approximately 24 months of age. It should be noted, however, that the rates of intentional communication acts observed in children with DS at Times 3 and 4 have been associated with more advanced word use in typically developing children (Wetherby, Cain, Yonclas, & Walker, 1988). This suggests that the transition from prelinguistic to linguistic communication is particularly problematic for many children with DS. Further exploration of the nature of early language development in children with DS appears warranted.

There were just 4 children with DS in Yoder and Warren's (2001) study, as compared with 26 in the present study. The results of the present study—along with those of Yoder and Warren (2002), which were also based on a sample with a substantial number of children with DS—suggest that any moderating or mediating effects of parental responsivity may be relatively muted for children with DS. This muting may be due to the extreme challenge of expressive language learning for children with DS. This issue warrants further investigation.

Clinical Implications

The results reported by Fey et al. (2006) suggest that a 6-month course of RE/PMT implemented at a low intensity as a supplement to approximately a 1-hr weekly community-based intervention can have a significant, but modest, impact on prelinguistic communication development. Nevertheless, the results reported in this study indicate that at the duration and intensity provided, the modest early gains caused by RE/PMT will not be maintained or generalized to other contexts or to other general measures of language development, such as lexical density. At present, we recommend that clinicians who employ this approach extend intervention beyond 6 months and, if possible, employ longer and/or more frequent training sessions. It is important to note, however, that there are no empirical data on effects of longer duration or high intensities at this point in time (Warren, Fey, & Yoder, 2007).

A basic premise of the RE/PMT approach is that it will prepare preverbal children to acquire the social and linguistic requisites for verbal learning. On the basis of this premise, the ultimate test of RE/PMT effects should be its impact on later verbal learning. Our study provides no support that RE/PMT had such an impact. This does not necessarily mean that the basic RE/PMT premise is invalid. We do not know what effects we might have observed had we implemented RE/PMT at a greater intensity per week or had we not stopped an apparently successful treatment after 6 months. Taken together, the results of this study and its predecessors (e.g., Yoder & Warren, 2001, 2002) provide cumulative evidence that RE/PMT results in relatively modest and short-term effects when implemented at low dosage (e.g., 1 hr per week for 6 months). We are proceeding to evaluate the approach by administering it at greater intensity levels and over longer treatment periods.

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