
A Randomized Comparison of the Effect of Two Prelinguistic Communication Interventions on the Acquisition of Spoken Communication in Preschoolers With ASD

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Purpose: This randomized group experiment compared the efficacy of 2 communication interventions (Responsive Education and Prelinguistic Milieu Teaching [RPMT] and the Picture Exchange Communication System [PECS]) on spoken communication in 36 preschoolers with autism spectrum disorders (ASD).

Method: Each treatment was delivered to children for a maximum total of 24 hr over a 6-month period. Spoken communication was assessed in a rigorous test of generalization at pretreatment, posttreatment, and 6-month follow-up periods.

Results: PECS was more successful than RPMT in increasing the number of nonimitative spoken communication acts and the number of different nonimitative words used at the posttreatment period. Considering growth over all 3 measurement periods, an exploratory analysis showed that growth rate of the number of different nonimitative words was faster in the PECS group than in the RPMT group for children who began treatment with relatively high object exploration. In contrast, analogous slopes were steeper in the RPMT group than in the PECS group for children who began treatment with relatively low object exploration.

KEY WORDS: autism, intervention, spoken language

The Interagency Autism Coordinating Committee “roadmap” set a long-term goal of helping 90% of children with autism spectrum disorders (ASD) to achieve useful speech by elementary school age (Department of Health and Human Services, 2004). The broad goal of “achieving speech” is probably based on results of several retrospective reports that identify “useful speech by age 5” as a consistently strong predictor of later adaptive functioning in individuals with ASD (DeMyer et al., 1973; Gillberg & Steffenburg, 1987; Kobayashi, Murata, & Yoshinaga, 1992; Rutter & Lockyer, 1967). “Useful speech” has been defined by some as “at least 5 communicative words used daily” (Venter, Lord, & Schopler, 1992). Others have required that the word use be “habitual” (DeMyer et al., 1973) and “nonimitative” (DeMyer et al., 1973; Kobayashi et al., 1992). Therefore, it is clear that useful speech has come to mean speech that is frequent, communicative, nonimitative, and referential.

For speech to be communicative, it must be used for the purpose of conveying a message to a social partner. The spoken words must also be

linked to specific referents (e.g., objects, actions, ideas) that are generally understood by adults in the culture. For communicative speech to be functional, however, it must also be frequent and flexible. Frequent spoken communication is important because the ability to speak is not functional if it is not used. However, using the same word repeatedly, or speaking only in imitation of others, is not as useful as using many different nonimitative words. Flexible spoken communication is thus demonstrated by using many different words. For the purpose of this paper, we refer to frequency of spontaneous, nonimitative spoken communication and number of different nonimitative words used as our two measures of “spoken communication.”

Two prerequisites for the development of speech are the motivation to convey a message to others (i.e., communicative intent) and the ability to think at a symbolic level (Bates, 1979). Many young children with ASD are deficient in both of these prerequisite skills (Prizant, Wetherby, & Rydell, 2000). There are several reasons why teaching the intent to communicate prior to teaching spoken communication may be particularly useful in facilitating the transition to linguistic spoken communication in children with ASD. First, teaching the intention to communicate (as shown by coordinating attention to an object and a person) may capitalize on nonverbal behaviors that are already in the child’s repertoire, and may therefore be more efficient than teaching the intent to communicate using a means that is also difficult for children with ASD (i.e., symbols; Prizant et al., 2000; Wilcox & Shannon, 1998). Second, some children with ASD use speech to inventory the environment or to self-regulate their own behavior, but not to communicate (Prizant et al., 2000). Teaching the intent to communicate may increase the probability that present and future speech will be used in a communicative manner. Third, increasing the frequency of intentional communication could increase the frequency with which children with ASD will receive linguistic mapping of their communicative messages, which may in turn facilitate their language acquisition. In fact, increased use of intentional communication has been shown to elicit linguistic input from parents of children with developmental delays (Yoder & Warren, 2001). Two communication intervention approaches that address the intent to communicate prior to targeting spoken communication are Responsive Education and Prelinguistic Milieu Teaching (RPMT; Yoder & Warren, 2002) and the Picture Exchange Communication System (PECS; Bondy & Frost, 1994).

RPMT is composed of two components: one for parents (responsive education) and one for children (Prelinguistic Milieu Teaching [PMT]). PMT is a child-led, play-based incidental teaching method designed to teach gestural, nonword vocal, gaze use, and, later, word use as forms of clear intentional communication for

turn-taking, requesting, and commenting pragmatic functions (Yoder & Warren, 1998, 1999). Responsive education for parents is designed to support parents in playing with and talking to their children in ways that are thought to facilitate children’s communication and language development (Yoder & Warren, 2002). There are two reasons why RPMT may facilitate language acquisition. First, one intervention technique in the child component of RPMT is the use of linguistic mapping (i.e., putting into words the child’s immediately preceding nonverbal message). Parents are instructed to use this technique in response to their children’s communication. Second, when children become sufficiently fluent in prelinguistic communication, Milieu Language Teaching is used as part of the child component of the RPMT package to facilitate spoken communication (Fey et al., 2005). Milieu Language Teaching uses prompts for verbal imitation and questions to evoke spoken communication.

The efficacy of components of RPMT on linguistic development has been tested in two randomized group experiments in children with developmental delays without autism. In children whose parents were more than 70% responsive to their children’s communication before the treatment began, staff-implemented PMT facilitated generalized receptive and expressive language that maintained 12 months after the end of treatment (Yoder & Warren, 1999, 2001). In a separate sample in which parent education was added to PMT, RPMT was effective in facilitating growth in generalized frequent and flexible spoken communication in children who were developmentally appropriate for prelinguistic goals (i.e., those with few vocal communication acts with consonants; Yoder & Warren, 2002). Additionally, the greater spoken communication gains in the affected RPMT subgroup maintained 12 months after the end of treatment (Yoder & Warren, 2002). However, the efficacy of RPMT in facilitating spoken communication has not yet been tested in children with autism.

PECS involves instructing children to make a request by teaching them to hand a picture of a desired object or food to a message recipient. Handing the picture to the adult shows coordinated attention to the object and the person, and constitutes an example of intentional communication. One potentially important aspect of PECS is the use of a second adult who is positioned behind the child. When the child attempts to directly acquire the desired object or food, this second adult physically prompts the child to pick up the picture and give it to the message recipient. Such prompts are faded as progress toward independent picture exchange is made.

There are three reasons why PECS may facilitate spoken communication. First, there is replicated evidence that coordinated attention elicits maternal linguistic input to preschoolers with developmental delays (Yoder & Munson, 1995; Yoder & Warren, 2001). Second, in Phase

IV of PECS (sentence strip exchange), the interventionist uses a cloze procedure (“I want ____”) to elicit the child’s production of the key word in the request. Third, linguistic mapping is used consistently after every picture exchange during the treatment, and parents are instructed to use linguistic mapping consistently after their children’s picture exchange.

PECS has been tested in two single-subject experimental design studies with children with ASD (Charlop-Christy, Carpenter, Le, LeBlanc, & Kellet, 2002; Ganz & Simpson, 2004). Both of these studies showed immediate increases in spoken communication in PECS training sessions or in probe sessions that were extremely similar to PECS training sessions. Unfortunately, neither study provided a strong test of the treatment effect in generalization sessions. Ideally, treatments will produce changes that are present with different people, materials, activities, and interaction styles than have been used in the treatments (Kaiser, Yoder, & Keetz, 1992).

When treatments are compared, it is frequently the case that one treatment works better for some children, while the other works better for other children (Yoder & Compton, 2004). When tested in the context of growth curve analysis, this phenomenon is expressed in terms of a statistical interaction between a pretreatment child characteristic and treatment group predicting the growth rate of the dependent variable. Such a statistical interaction means that between-treatment group differences in average growth rate vary as a function of the pretreatment variable. In this study, we examined whether pretreatment object exploration (a measure of interest in a variety of objects) predicted differential response to treatments. This variable was of interest because RPMT requires routines to be built around objects, and both treatments use access to requested objects as rewards for communication. If children are found to be deficient at treatment entry, RPMT interventionists teach children how to play with objects. PECS does not address play deficits. Therefore, we reasoned that children who needed play treatment (i.e., those with a low object exploration) would fare better in RPMT than in PECS. However, it was not clear which treatment would be superior for children with initially high interest in a variety of objects.

The purpose of the present study was to determine the relative efficacy of RPMT and PECS for facilitating spoken communication and nonimitative word use in young children with autism. Because both treatments have elements that could facilitate spoken communication and because no prior comparison of PECS versus RPMT has been made, no prediction regarding which treatment would be superior was possible. As an exploratory analysis, we examined whether relative efficacy of the two treatments would vary by pretreatment object exploration.

Method

Participants

Inclusion criteria for children were as follows: (a) a diagnosis of autistic disorder or pervasive developmental disorder—not otherwise specified (PDD-NOS), (b) chronological age between 18 and 60 months, and (c) evidence of being nonverbal or low verbal. Our criteria for nonverbal or low verbal status were as follows: fewer than 20 different words used cumulatively during three communication samples. In addition, parents were asked to make a verbal commitment to bring the child to a university-based clinic for three 20-min intervention sessions per week for 6 months. Children were excluded from the study if they demonstrated severe sensory or motor deficits or if the primary language spoken in the home was not English. Hearing screenings were obtained outside of the project prior to entering the study and revealed no evidence of hearing impairment other than delayed language.

One hundred twenty children were screened. Sixty families failed to meet the inclusion criteria. Twenty-one were unable to participate because of conflicts in scheduling treatments (5), excessive distance of the center from home (10), or unspecified reasons (6). Three children who qualified for the study and whose parents consented had siblings who also participated in the study. These 3 children were treated with the same treatment their sibling had received to prevent treatment contamination. Because these 3 children were not randomly assigned to groups, their data were not analyzed. The remaining 36 children were from different families and thus constituted independent units of analysis. These 36 children were randomized, received treatment, and provided data that were analyzed.

All 36 children had received prior clinical diagnoses on the autism spectrum: 33 with autism and 3 with PDD-NOS. To verify these diagnoses, the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000) was given. The ADOS was administered by examiners who had been trained and certified to use Module 1 of the ADOS. All 36 children received ADOS scores consistent with a classification of autism.

Descriptive information for the sample is presented in Table 1. On average, children were about 2½–3 years old and scored well below average on a measure of cognitive skills. The initial nonverbal status of the children is confirmed by the low number of spoken communication acts and by the low number of different nonimitative words observed during a communication assessment, which is described next. The children generally communicated infrequently, and primarily used nonverbal intentional communication when they did communicate. The median formal educational level of the primary parent

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

Variable	M	SD	Range
Chronological age (months)	33.6	8.4	21–54
Nonverbal mental age (months) ^a	18.6	3.7	11.5–26.5
Verbal mental age (months) ^a	11.9	2.8	7–19
Cognitive standard score ^{a,b}	51	5.3	48–67
Number of different nonimitative words used in SFPE ^c	0.17	0.56	0–3
Number of nonimitative spoken communication acts in SFPE ^c	0.25	0.84	0–4
Number of communication acts in SFPE ^c	8.4	10.5	0–56
Proportion of communication acts that are intentional communication in SFPE ^c	.89	.21	0–1.0
Proportion of communication acts that are spoken words in SFPE ^c	.05	.18	0–1.0

^aBased on the Mullen Scales of Early Learning (Mullen, 1992). ^bStandard scores under the possible minimum (i.e., 49) were assigned 48. ^cFifteen-minute semistructured free-play with examiner (SFPE).

was 3–4 years of college (range: 10th grade to more than 2 years of graduate school). Sixty-nine percent of the sample (25) was Caucasian, 22% (8) was African American, and the remainder reported “other.” Men made up 86% of the sample (31).

Overview

The study design was a randomized group experiment. The principal investigator used a computer program to randomly assign children to either RPMT or PECS. The sequence of assignment was concealed until after assignment occurred. Random assignment occurred after participants signed consent forms and qualified for the study. Group differences were examined for 58 pre-treatment child and parental variables to determine whether randomization was successful in creating equivalent groups prior to treatment. Additionally, group differences were tested for 4 variables that quantified participation in nonproject treatments. Fidelity of treatment implementation was obtained for both treatments. Finally, a correlational component to the design was used to determine if differential treatment response on growth curves of the number of different nonimitative words varied as a function of initial object exploration. This study was conducted in compliance with the Institutional Review Board, and all parents signed informed consent forms before any research procedures were conducted.

Children were tested with the ADOS and the Mullen Scales of Early Learning (Mullen, 1992) to describe the sample. Additionally, at entry into the study (Time 1), children were administered an examiner–child free-play session, the Developmental Play Assessment (Lifter, 2001), and a turn-taking measure. During the treatment phase (6 months), children attended three 20-min therapy sessions per week. Parents were offered up to 15 hr of training to complement what the children learned in therapy sessions. Parents filled out a questionnaire describing

the children’s participation in nonproject treatments every month during the treatment phase. The free-play measure was repeated at the end of the treatment phase (Time 2) and 6 months after the end of treatment (Time 3). The nonproject treatment questionnaire was repeated at Time 3.

Procedures

Semistructured free-play with examiner (SFPE). This 15-min session was the measurement procedure in which spoken communication was assessed. The examiner, interaction style, toys, and location used for this procedure were different from those used in the intervention session for either treatment method. Thus, it constituted a measure of generalization across several dimension types across which past research has found children with ASD to have difficulty generalizing (Alpert & Rogers Warren, 1985). During this procedure, developmentally appropriate objects (i.e., toy baby bottle, baby spoon, doll’s hair brush, two teacups, two saucers, teapot, female baby doll, four colored drumsticks, two cubes of foam rubber, baby rattle, car, baby’s blanket, and Fisher-Price Chatter Telephone pull toy) were placed in an accessible location on a table in front of where the child was seated. The examiner played with the same or similar toy as the child by imitating the child’s play. If the child did not attend to any toy for 10 s, the examiner selected an interesting object and used the object in a play schema that was at or below the cognitive play level observed for the child. Examiners verbally commented on the child’s or their own actions, and vocally imitated the child’s discrete vocalizations. Examiners were instructed not to use any type of communication prompt (e.g., no time delays, questions, or gestural prompts were allowed). One generalized toy PECS symbol was displayed on a small notebook with Velcro strips (i.e., a communication book), regardless of the child’s treatment assignment. The variables derived from

this procedure were the children's frequency of nonimitative spoken communication acts and the number of different nonimitative words spoken.

Developmental Play Assessment (DPA; Lifter, 2001). This procedure was administered at Time 1. An adapted version of the DPA was used. In this procedure, the examiner presents three sets of toys and allows the child to explore each set for approximately 5 min. During our adaptation of the DPA, the examiner is instructed not to model any play behaviors for the child, but is allowed to imitate the child's behaviors. The same procedure and toys are used with all participants. This procedure was coded for number of unique toys touched, our measure of initial object exploration.

Turn-taking. This procedure was adapted from one developed by Ousley (1997), and consists of seven separate activities that are presented with positive affect and a playful demeanor. This procedure was administered at the Time 1 period. For each activity, the examiner attracts the child's attention to an object, demonstrates an action, and then gives the object to the child. The goal of the examiner is to get the child to imitate the demonstrated action and give the object back to the examiner. The examiner indicates each turn by saying, "My turn" or "Your turn." If the child fails to imitate or give, the examiner prompts the desired response using physical prompts for the action or gestural/verbal prompts for gives, as needed. This cycle was repeated up to three times. The activities were as follows: squeezing a squeak toy, putting on sunglasses, playing peek-a-boo, putting a puppet on one's hand, banging blocks, beating a drum, and putting a ball into a small basketball goal. The variable of interest from this procedure was the children's frequency of object-exchange turns. This variable was the focus because children use giving an adult something as a desired response in both of the treatments, and giving is an early form of intentional communication, which is associated with later language (Yoder & Warren, 1998).

Treatments

Treatment sessions took place in a university clinic. Each treatment team was composed of a master's degree level professional and a bachelor of arts (BA) degree level paraprofessional. Each team was trained by one of the originators of the treatment models or by their trained representatives. BA-level paraprofessionals were carefully monitored by the master's level professionals. The professionals held either a master's degree in early childhood special education (RPMT team leader) or a master's degree in speech-language pathology (PECS team leader). Both treatments consisted of child and parent components. Children were offered three 20-min individual therapy sessions per week for 6 months (i.e., 72 sessions). Parents were asked to observe their children's therapy sessions. The master's level professionals offered parents up to 15 hr of sessions covering information that complemented the type of treatment their children were receiving. Table 2 presents some of the features that differentiate the two treatments.

PECS. PECS was developed by Bondy and Frost (1994) for children with ASD who are nonverbal or low verbal communicators. The two PECS team members participated in a 2-day workshop provided by two certified PECS clinicians. The implementation plan in this study was to use the clinic room as the "lead environment" and to teach the parent to support PECS use in the home, community, and school. All aspects of the PECS curriculum were followed within the constraints of this model. The PECS curriculum has six phases, beginning with the physically prompted exchange of a single picture without distractor pictures and ending with the exchange of a sentence strip in response to "What do you see"? A ratio of two adults to one child is used in Phases I (the physical exchange), II (self-initiating and persistence training), and IV (the sentence strip exchange). During these phases, one adult acts as the physical prompter (behind the child), and the other acts as the

Table 2. Summary of differences between features of RPMT and PECS.

Feature	RPMT	PECS
Positioning	On floor	Mostly in chair
Adult to child ratio phases	1:1	2:1 for at least Phases I, II, & IV; 1:1 for rest
Behaviors taught	Gestures, gaze, vocalizations, words	Picture exchange, words
General teaching approach	Incidental teaching	Discrete trial
Relative consistency of linguistic mapping	Moderate	High
When word use is explicitly prompted	After meeting prelinguistic fluency criteria	After Phase III
Types of prompts for spoken communication	Mands, explicit imitation prompts	Fill-in-the-blank prompts
Consequences for word use	Expansions, repetition, compliance	Repetition, compliance

Note. RPMT = Responsive Education and Prelinguistic Milieu Teaching; PECS = Picture Exchange Communication System.

message recipient (in front of the child). The two adults exchanged roles once the child became fluent in the skill being taught to increase the probability of across-person generalization. In the current study, if children mastered Phase VI (i.e., passing the sentence strip with “I see x” in response to the verbal question: “What do you see/hear?”), they were taught to use locative and adjective PECS symbols to request (e.g., “I want the *big* ball”) or respond to “What do you see?” Additionally, such high-functioning children were taught to use PECS to give directions, ask for nonpreferred items, and differentiate yes/no requests from yes/no labels (i.e., “Do you want this?” vs. “Is this a frog?”).

The parent component of the PECS treatment involved meeting at the parents’ convenience, which most frequently occurred immediately after the child’s treatment session. The primary content of the parent component was to discuss ways of promoting PECS use outside of the therapy room. Full details of the treatment are available in the training manual (Bondy & Frost, 1994).

RPMT. RPMT was designed to facilitate intentional communication for the three primary pragmatic functions during the prelinguistic period (i.e., requesting, commenting, and turn-taking) in young children with developmental delays (Yoder & Warren, 2002). The master’s level professional of this team was trained by one of the originators of the RPMT method. She had over 1 year of experience implementing RPMT at a competent level when the study began. She, in turn, trained the BA-level paraprofessional working with her. A 1:1 teaching format was used in RPMT sessions. A primary clinician worked with the child 2 days a week, while a secondary clinician worked with the child 1 day a week to increase the probability of across-person generalization.

During each session, the clinician first attempted to establish one or more play routines (i.e., turn-taking sequences around an object or activity) thought to be enjoyable and motivating to the child. When the child was highly motivated to communicate, the clinician used the least intrusive, but effective, communication prompts (e.g., saying, “Look at me”; moving her head to intersect the child’s gaze) to elicit requests for objects or actions. RPMT clinicians attempted to stimulate initiating joint attention through modeling the use of recently learned communicative behaviors for the declarative (i.e., initiating joint attention) function. Additional description of RPMT can be found in Yoder and Warren (1998). When children used at least one unprompted request and at least one unprompted initiating joint attention act per minute in treatment sessions, Milieu Language Teaching (Warren, 1991) was used to facilitate spoken communication. Milieu Language Teaching is similar to RPMT, except that it focuses on spoken language, rather than on prelinguistic, goals. Treatment manuals are available from the first author.

The purpose of the parent component of RPMT was to support parents in using responsive strategies to help their children engage in productive play with objects in a playful manner and to facilitate their children’s communication and language development. The Hanen Centre curriculum was followed for this component of the treatment (Sussman, 2001).

Fidelity of and Description of Treatment Implementation

Once per month, each clinician–child session was coded for fidelity of treatment. For RPMT, a staff member rated the session on a 3-point scale (3 = excellent) on the following components: clinician’s responsivity, relationship building, routine building, and use of appropriate prompting and consequence strategies. For PECS, a separate rating scale was used for each phase to measure the presence and quality of each treatment technique. The fidelity of treatment rating scales are available from the first author on request.

To describe the actual content covered in the parent sessions, the master’s level professional rated the extent to which each of five content areas was covered in the past 2 weeks on a scale ranging from 1 (*low proportion of session devoted to topic*) to 5 (*high proportion of session devoted to topic*). These content areas were (a) direct teaching and discussion of the treatment curriculum, (b) discussion of child’s therapy session while observing, (c) active listening about noncurriculum content, (d) development of therapy-related materials for home and community use, and (e) active listening about curriculum content. These ratings were completed every 2 weeks during the treatment phase and were averaged to yield an average emphasis of parent sessions by content area.

Additionally, at the end of the treatment phase, parents were asked to complete a questionnaire regarding their perception of the parent sessions. Questions addressed the degree to which each strategy (a) was covered adequately, (b) was important to the child’s development, and (c) was used frequently by the parent now (i.e., at the end of the study). Ratings were made on a 4-point scale, with responses ranging from 1 (*strongly agree*) to 4 (*strongly disagree*). The specific strategies assessed for RPMT were (a) speaking and waiting for child to communicate, (b) linguistic mapping of child’s communication, (c) sitting face to face when playing, (d) imitating the child’s sounds and actions, (e) playing and talking at the same speed as the child, and (f) responding to the child’s request. The specific strategies assessed for PECS were (a) linguistic mapping of the child’s communication (including PECS), (b) praising the child after communication attempts, (c) providing many opportunities for PECS use throughout the day, (d) allowing time for the child to communicate, and (e) establishing areas in the home for PECS symbols.

Nonproject Treatment Description

On a monthly basis during the treatment phase, quantitative and qualitative information about children's attendance to nonproject treatments (e.g., community-based speech therapy) was collected. Parents were asked to estimate the amount of time their child spent in different types of treatments. Two variables were computed: (a) the average number of hours per month in speech-language therapy and (b) the average number of hours per month in any therapy (including speech-language). These data were also collected at the 6-month follow-up, to determine the amount of treatments received in the 6 months following treatment.

Coding and Data Entry

Frequency of nonimitative spoken communication acts and the number of different nonimitative words were transcribed from videotaped records of the examiner-child free-play sessions at Times 1–3. A spoken communication act is defined as an utterance that contains one or more intelligible word approximation(s). A word approximation had to have a conventional and culturally defined form that referred to a referent in the physical or discourse context. To meet the criteria for a conventional form, the approximation to the adult word had to (a) contain at least one accurate consonant and vowel combination occurring in the correct position and (b) have either the correct number of syllables or a developmentally appropriate syllabic reduction or derivation. To meet the criterion for culturally defined form, the putative word had to be in the unabridged English dictionary. Each word in a spoken utterance was coded for whether it imitated any part of the immediately preceding adult utterance. The Systematic Analysis of Language Transcripts (SALT; Miller & Chapman, 1993) was used to count the frequency of nonimitative spoken acts. The number of different nonimitated words was counted by hand.

Object-exchange turns were coded at Time 1 from the turn-taking procedure. These acts were coded with the aid of a software program called Turn-taker (Tapp & Yoder, 2001). The specific child variable of interest was frequency of object-exchange turns. An object-exchange turn is defined by the child giving an object to the adult without being physically prompted to do so. This variable was used as a covariate for Time 3 outcomes because the results show that they were different between groups and covaried with Time 3 outcomes (see the Preliminary Analyses section).

Number of different toys touched was coded at Time 1 from the DPA. This behavior was coded with the aid of a software program called Play Coder (Tapp & Yoder, 2003). This variable was increased in value only when the child

touched a particular toy for the first time. This variable served as our measure of initial object exploration.

Additionally, all data in analysis spreadsheets were independently checked by re-entering the data and using an excel macro that "flagged" cells without exact matches. All flagged cells were checked a third time to determine the correct entry.

Reliability of Child-Coded Outcome and Covariate and Fidelity of Treatment Variables

Interobserver reliability was estimated on at least 20% of the coded data from all coded procedures at all three time periods. Reliability coding was conducted independently, and the reliability sample was selected randomly. Primary coders did not know which sessions were going to be checked for reliability. Estimates were derived on the same variable that was analyzed to address the primary research questions. Intraclass correlation coefficients (ICC) were used to estimate reliability for the outcome variables. ICC is the proportion of true score variance between people divided by total variance in the reliability sample (Cronbach, 1972). At Time 1, the average ICC was .86 ($SD = .14$). At Time 2, the average ICC was .92 ($SD = .10$). At Time 3, the average ICC was .98 ($SD = .007$).

Because fidelity of treatment scores is expected to be uniformly high (i.e., showing little variance among participants), ICC is not an appropriate index of reliability for these variables. Instead, interobserver agreement for independent ratings was calculated for 20% of the data, resulting in a mean interobserver agreement of .99 ($SD = .006$) for RPMT and .90 ($SD = .1$) for PECS. We required exact agreement when estimating agreement on fidelity of treatment variables.

Results

Preliminary Analyses

Examination of whether duration of the procedure covaried positively with frequency of the outcome. Because the length of the examiner-child free-play sessions occasionally varied due to child behavior problems, we examined whether duration of session was positively correlated with the frequency of nonimitative spoken communication acts or with the number of different nonimitative words used. If so, the outcome measures would be converted to rates rather than employ frequency counts (Cohen & Cohen, 1984). At Times 1, 2, and 3, frequencies of these variables were not significantly correlated with durations of the sessions from which they came. Therefore, frequency was the metric selected for all measurement periods.

Treatment description and fidelity. Nineteen children were assigned to PECS, and 17 children were assigned to RPMT. Children experienced an average of 20 hr of staff-implemented therapy (i.e., mean number of 20-min sessions = 60, $SD = .73$), with no significant differences between groups in attendance. Moreover, attendance to sessions was not significantly related to amount of change or individual differences in Time 2 or Time 3 outcomes and did not statistically interact with treatment group to predict any outcome. Likewise, there were no significant group differences in the number of people using the therapeutic techniques outside of therapy sessions ($M = 2.6$, $SD = 1.2$). Parents in the RPMT group chose to receive more hours of training ($M = 10.6$, $SD = 2.2$) than did parents in the PECS group ($M = 7.9$, $SD = 2.3$), $t(34) = 3.59$, $p < .01$, $d = 1.2$. However, the amount of parent training was not associated with any Time 2 or Time 3 outcome and did not interact with group to predict the Time 2 or Time 3 outcomes. Fidelity of child therapy sessions was measured using the average ratings from the monthly treatment session tapes. The rating scores were averaged across items and months. With a 3-point maximum, the average fidelity rating across participants for RPMT sessions was 2.99 ($SD = 0.017$), and the average fidelity rating for PECS sessions was 2.88 ($SD = 0.09$). The staff conducting the parent sessions indicated that the greatest emphasis during the parent sessions was on direct teaching and discussion of treatment curriculum.

Parent evaluations of the importance and use of different treatment strategies were made on a 4-point scale, with 4 indicating the most positive evaluation. As described previously, different strategies were rated by parents in the PECS and RPMT treatments. To summarize these results, we averaged across the different strategies to determine whether they were (a) adequately covered, (b) perceived as important to the child's development, and (c) used by the parent at the end of the treatment phase. For PECS, the average parents' rating was 3.7 ($SD = 0.34$), 3.8 ($SD = 0.38$), and 3.6 ($SD = 0.6$) for "adequately covered," "important to child's development," and "use frequently now," respectively. For RPMT, the average parents' rating was 3.7 ($SD = 0.28$), 3.8 ($SD = 0.36$), and 3.6 ($SD = 0.41$) for "adequately covered," "important to child's development," and "use frequently now," respectively. These data support a conclusion of a high level of treatment fidelity.

Examination of whether a covariate was needed and met assumptions for such analyses. Fifty-eight pretreatment variables and two nonproject treatment attendance variables were tested for group differences. Examples of variables included were severity of autism; cognitive impairment and level; language level and impairment; communication level broken down by form, function, and level of intentionality; motor imitation level; play level; demographic variables (e.g., age, gender, SES); and

parental responsivity. Only two pretreatment variables were different between treatment groups and correlated with Time 2 or Time 3 number of nonimitative spoken acts or Time 2 or Time 3 number of different nonimitative words. The Mullen expressive language standard score at Time 1 was significantly higher for the RPMT group than for the PECS group, $t(20.03) = -2.40$, $p = .02$, and was positively correlated with Time 2 number of nonimitative spoken communication acts, $r = .50$, $p = .002$, and Time 2 number of different nonimitative words used, $r = .48$, $p = .003$. Time 1 frequency of object-exchange turns was significantly higher for the PECS group than for the RPMT group, $t(27.70) = 2.65$, $p = .01$, and was positively correlated with Time 3 number of nonimitative spoken acts, $r = .40$, $p = .02$, and Time 3 number of different nonimitative words, $r = .38$, $p = .03$. The assumption of homogeneity of slopes was met for both potential covariates. Therefore, the Time 1 Mullen expressive language scores were statistically controlled in between-group tests on Time 2 spoken communication outcomes in endpoint analyses. Similarly, the Time 1 frequency of object-exchange turns was statistically controlled in between-group tests on Time 3 spoken communication outcomes in endpoint analyses. Neither covariate was significantly related to the slope in growth of number of different nonimitative words. Therefore, the growth curve analyses did not require a Time 1 covariate.

Description of nonproject treatment participation. As indicated earlier, the nonproject treatment variables collected during the treatment phase could not account for between-group differences at Time 2 or Time 3. However, providing descriptive information about nonproject treatment is an important part of describing the context in which children received RPMT or PECS, and thus may eventually prove valuable for the field in terms of delineating the contextual variables under which RPMT or PECS is effective (i.e., external validity concerns). During the treatment phase, children attended an average of 16.8 hr of treatment per month ($SD = 22.7$); 7.4 hr ($SD = 4.2$) of which were speech-language therapy. At the 6-month follow-up, children attended an average of 34.4 hr ($SD = 39$) of treatment per month; 9.3 hr ($SD = 5.9$) of which were speech-language therapy. This apparent increase in nonproject treatment from the treatment phase to the follow-up period was statistically significant for total treatment (including speech-language therapy), $t(34) = 3.30$, $p = .002$, and nonsignificant for speech-language therapy, $t(34) = 1.90$, $p = .07$. The change from treatment phase to follow-up (i.e., Time 3 [average of responses between Time 1 and Time 2]) did not differ by treatment group for all nonproject treatments, $F(1, 33) < 1$. However, the amount of change in nonproject speech therapy did vary by treatment speech therapy (i.e., a Time \times Treatment Group interaction), $F(1, 33) = 4.25$, $p = .05$, partial $\eta^2 = .11$. The average change in the PECS

Table 3. Means, standard deviations, and effect sizes for spoken communication variables at Times 1–3.

Variable	Time 1		Time 2		Time 3		<i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
Frequency of nonimitative spoken acts	0.25	0.84	2.2	3.9	5.5	10.4	1.15
Number of different nonimitative words	0.17	0.56	1.6	2.8	3	5.8	1.12

group was 4 hr ($SD = 6.9$), while the average change in the RPMT group was $-.3$ hr ($SD = 5.19$). Thus, the interaction was due to there being more change in nonproject speech therapy per month from the treatment phase to Time 3 for the PECS than for RPMT children. However, the change in nonproject treatment attendance from the treatment phase to Time 3 did not predict any Time 3 outcome or growth curve outcome. Time 3 nonproject treatment variables were not correlated with any Time 3 outcome or growth curve outcome.

Endpoint Analysis of Growth in the Outcomes

Table 3 indicates the descriptive statistics and the effect size of time on the dependent variables for this study. A repeated measures ANOVA showed that children increased in frequency of nonimitative spoken communication, $F(1, 35) = 6.90$, $p = .005$, and number of different nonimitative words used, $F(1, 35) = 7.60$, $p = .001$, from Time 1 to Time 3 during the examiner–child free-play session. It should be noted that this growth may or may not be due to the treatments. Other treatments or maturation could have accounted for this growth. The between-treatment-group differences (presented below) provide the test of whether the growth was due to the treatments.

Main Effects of Treatment

Because the groups were equivalent at the pretreatment period, and there was growth over time, the most

statistically powerful test of treatment main effects was a group comparison at the posttreatment period and follow-up periods (Cronbach & Furby, 1970). Two analyses of covariance (ANCOVAs) revealed a main effect in favor of PECS on the frequency of nonimitative spoken acts, $t(34) = 2.30$, $p = .03$, and the number of different nonimitative words, $t(34) = 2.10$, $p = .04$, at Time 2. These results indicate that the growth in spoken communication can be attributed primarily to the children who participated in the PECS intervention. Table 4 presents the adjusted descriptive statistics for the effects on children’s spoken communication. These effect sizes are moderate according to Cohen’s (1988) standards.

ANCOVAs were also conducted to test main effects of the treatments on the Time 3 outcomes. No significant between-group differences were found for frequency of nonimitative spoken acts, $F(1, 32) = 0.003$, $p = .96$, or the number of different nonimitative words used, $F(1, 32) = 0.009$, $p = .93$. Therefore, the previously found treatment effects did not maintain 6 months after the end of treatment. The descriptive statistics for this null finding are presented in Table 4.

Exploratory Test of Whether Overall Treatment Effects Varied by Initial Object Exploration

We used mixed-level modeling (i.e., hierarchical linear modeling; Raudenbush, Bryk, Cheong, & Congdon, 2001) to test whether initial object exploration statistically interacted with treatment group to predict slope of

Table 4. Adjusted group means and standard deviations for spoken communication at Time 2 and Time 3 controlling for Time 1 covariates.

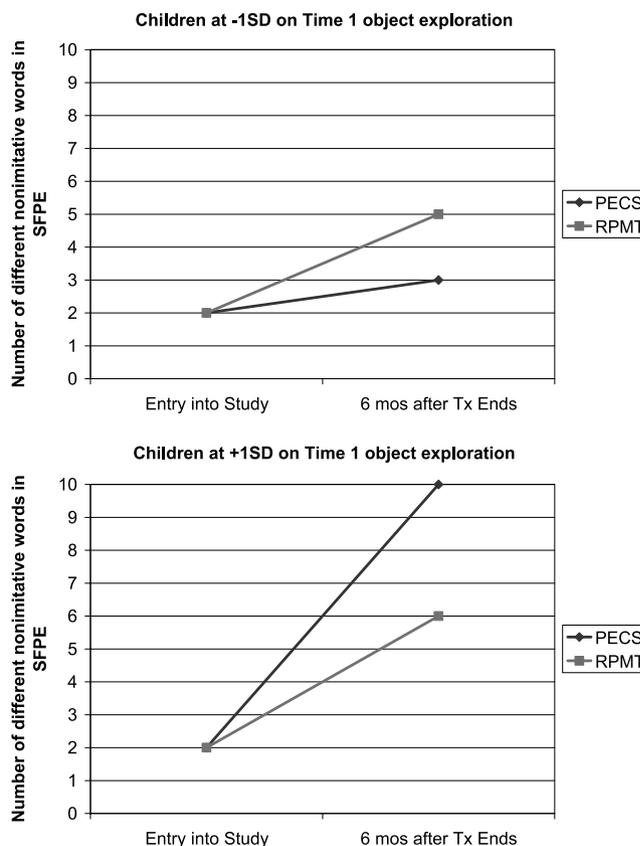
Outcome	PECS		RPMT		Cohen’s <i>d</i>
	Adjusted		Adjusted		
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
Frequency of nonimitative spoken acts at Time 2	3.6	4.8	0.6	4.8	0.63
Number of different nonimitative words at Time 2	2.4	3.6	0.6	3.6	0.50
Frequency of nonimitative spoken acts at Time 3	5.5	3.2	5.4	3.2	0.0
Number of different nonimitative words at Time 3	3.1	2.4	2.9	2.4	0.0

the growth curve for number of different nonimitative words used. This application of mixed-level models is designed to identify the values of the individual growth curve parameters (Level 1 analysis) and to identify the predictors of them (Level 2 analysis). Three measurement periods allow only a simple linear function to be fit for individual growth data. A simple linear function is described mathematically as an intercept and slope (i.e., growth rate). Our primary interest was in identifying predictors of growth rate (i.e., slope) for the number of different nonimitative words. We set the initial value for “time” at zero and subsequent values at “time from entry into the study.” This practice allows one to interpret the intercept as initial ability and to treat variance in intervals between measurements as an analyzed variable (Singer, 1998). We grand-mean-centered initial object exploration to reduce the intercorrelation with the product term between this variable and the dummy-coded treatment group (Bryk & Raudenbush, 1992). The full maximum likelihood estimation method was used to estimate the parameters. The statistical assumptions of mixed-level modeling were tested (e.g., Levels 1 and 2 homoscedasticity).

The first step of mixed-level modeling is to construct the Level 1 model and to determine whether mixed-level modeling is a reasonable way to identify predictors of growth in the dependent variable. Specifically, Level 1 analysis involves determining (a) the extent to which Level 1 growth curves fit individuals’ raw data for the outcome (i.e., the reliability of the slope parameter), (b) whether there was an average nonzero initial outcome score and nonzero growth in the outcome (i.e., significance of the fixed effect for intercept and slope), and (c) whether there was significant variance in the initial value and growth of the outcome variable (i.e., significance of the random effects for intercept and slope). The reliability of the slope parameter was .88. The fixed effects were nonsignificant for intercept, $p = .19$, and significant for slope, $t(33) = 3.05$, $p = .005$. The random effects were nonsignificant for intercept, $p > .5$, and significant for slope, $\chi^2(33, N = 36) = 277$, $p < .001$.

The second step is to test the fixed effect for the product term between initial interest in initial object exploration and treatment group predicting slope for growth in the number of different nonimitative words. The fixed effect was statistically significant after controlling for the effects of initial number of different nonimitative words and main effects for initial object exploration and treatment group, $t(29) = -2.70$, $p = .01$, pseudo R square change = .31 (Singer & Willet, 2003). Figure 1 illustrates this interaction, and also illustrates that children who were relatively low in initial object exploration benefited more from RPMT. In contrast, children who were relatively high in initial object exploration benefited more from PECS.

Figure 1. Illustration of the statistical interaction between initial interest in a variety of Objects \times Treatment predicting growth in number of different nonimitative words. REPMT = Responsive Education and Prelinguistic Milieu Teaching; PECS = Picture Exchange Communication System; SFPE = semistructured free-play with examiner.



Discussion

This randomized group experiment was conducted to test the relative efficacy of PECS versus RPMT on two aspects of spoken communication: frequency of nonimitative spoken communication acts and number of different nonimitative words spoken. Both dependent variables were measured in a context that required generalization to a new person, new toys, new activities, and new interaction style from those experienced in the treatment sessions. There was strong growth on both measures of spoken communication from Time 1 to Time 3, regardless of the treatment group. After controlling for initial differences between groups, there was a moderate treatment effect size favoring the PECS treatment for both measures of spoken communication at Time 2. These effect sizes compare favorably with those reported by Rosenthal and DiMatteo’s (2001) review of 24 meta-analyses, representing more than 500 studies in medicine and behavioral medicine, social and clinical

psychology, and organizational psychology. In this review, only one meta-analysis mean effect size exceeded those found here.

If we do not consider the initial characteristics of the children, no main effect for treatment was found 6 months after treatment ended. However, when we considered children's initial object exploration, maintained treatment effects were detected. PECS facilitated the number of different nonimitated words used in children with initially high object exploration. RPMT benefited children with initially low object exploration. Both treatments rely on access to objects as rewards for communication. RPMT relies on building routines around objects. Only RPMT teaches play with objects. Therefore, if children do not come to treatment with an interest in objects, they must be taught that objects are interesting. Otherwise, the initial advantage of PECS over RPMT eroded within 6 months after treatment ends. Although we do not have direct evidence of RPMT effects on play skills, these data are consistent with the hypothesis that the play-treatment component of RPMT is useful for these children. In contrast, if the child already perceives objects as reinforcing, then the superiority of PECS seen at Time 2 remains significant at Time 3.

The effect size for the conditional treatment effects on growth rate of lexical density was large according to Cohen's (1988) conventions. It should be noted that under some conditions, pseudo R^2 is uninterpretable (Singer & Willett, 2003). However, the data in this study did not fit those conditions. Therefore, it is interpretable as the proportion of explainable variance in the growth rate of lexical density that is explained by the treatments, initial object exploration, and their interaction.

It is useful to note that the reliability of the individual growth curves to the raw data was unusually high (.88), even though the growth curve was a simple linear function. This could have occurred because the time period covered was short (12 months) relative to the children's generally slow acquisition rate. These data should not be viewed as evidence that children with ASD do not have the curvilinear lexical development that is generally seen in typically developing children.

These treatment effects are important for several reasons. First, the acquisition of spoken communication is a very important accomplishment for children with ASD. "Useful speech by 5 years" is a replicated predictor of positive occupational and social outcomes in the autism population (DeMyer et al., 1973; Gillberg & Steffenburg, 1987; Kobayashi et al., 1992; Rutter & Lockyer, 1967). Moreover, spoken communication is widely regarded as a more efficient, portable, and widely understood means of communication than preverbal or nonspeech communication (Lloyd, Fuller, & Arvidson, 1997). Second, this study demonstrated a significant treatment effect for a

relatively low-intensity intervention. Both interventions involved three 20-min sessions per week over a 6-month period (i.e., a maximum of 24 hr). Third, this is the first study using a randomized experimental design to demonstrate that the superior language intervention affecting spoken communication varies by initial object exploration in children with ASD. This finding emphasizes the importance of targeting or considering object play skills when selecting goals and treatments for children with autism. If children have a sufficient interest in objects, PECS was sufficiently powerful to affect spoken communication, and this effect maintained 6 months after treatment ended. Although the effect took longer to be detected, RPMT was sufficiently powerful to affect similar spoken communication outcomes 6 months after treatment ended if children needed the play treatment that RPMT provided.

The present study has many strengths. Random assignment was used to assign children to treatments. Treatment groups were equivalent on 55 pretreatment variables and on both nonproject treatment attendance variables. The two variables that could have posed a threat to internal validity were statistically controlled. Even the two children who received only 47% and 57% of available sessions were included in the analysis, thus we met the "once randomized, always analyzed" rule of thumb. There was a very high level of treatment fidelity in both treatments. The outcomes were ecologically valid measures of spoken communication assessed within a context that required generalization across locations, persons, materials, activities, and interaction styles. It is important to note that this generalization context required examiners to use no prompts to communicate. Additionally, no environmental arrangement to elicit communication was used in the measurement context. Therefore, the findings were detected in contexts that did not provide much scaffolding for spoken communication. Finally, maintenance of the treatment effects was tested and detected. Such strong evidence of generalization and maintenance of treatment effects is quite rare in the intervention literature on children with ASD.

Although there are many advantages to using growth curve analyses to test conditional treatment effects, one disadvantage is that there is no currently accepted way to identify where it is along the continuum of initial object exploration that the treatments cause differential effects on linguistic mapping. These results point to a need for future development of such methods.

Additionally, the correlational component of the current design allows for the possibility that the children on whom the treatments had differential effects on the growth rate of lexical density could be better described by a variable that covaries with initial object exploration. Future work is needed to examine this possibility.

Another weakness of the study is that the examiners and coders were not blind to treatment assignment. However, we consider it unlikely that the nonblind status of examiners and coders accounted for the results for two reasons. First, the principal investigator is the primary author of the inferior treatment (RPMT). If a bias was present in the assessment or coding, it would be reasonable to expect the bias to favor RPMT. The mean differences at Time 2 favored PECS. Second, nonblind coders are unlikely to have affected the results due to the high interobserver reliability of the outcome variables. For reliability to be high even with biased coding due to knowledge of the treatment assignment to occur, the coders would have to be equally biased in the same direction, an unlikely occurrence. Third, it is extremely unlikely that the examiners would have altered their administration of the dependent variable procedure according to knowledge of children's treatment group and initial object exploration level. Examiners had no knowledge of the children's exploration scores or of the hypothesis that exploration may predict differential response to treatment.

Finally, because children who became fluent in prelinguistic communication transitioned into Milieu Language Teaching, it would be useful to know when and how many of the children made this transition. Precise information about these two points is not available in the present data. Future studies using RPMT should track this information precisely.

There are three ways that future replication research could improve upon the present study. First, future research would benefit from using two or three video cameras to allow free movement on the floor and still allow reliable and conceptually rigorous coding of spoken communication. There was greater postural similarity between treatment and testing contexts in the PECS than in the RPMT group. Children were seated during the examiner-child free-play to aid transcription and coding within the constraints of a single video angle. Using more than one camera angle would serve both practical and scientific concerns. Second, future fidelity of treatment measures should rely more heavily on direct observation of parent sessions and the use of metrics such as the number and percentage of correctly implemented teaching episodes during child sessions. The present use of parent and interventionist reports may have yielded data with questionable validity. Using rating scales may have masked individual variability across sessions. Third, adding procedural fidelity measures would improve the degree to which readers could be confident that examiners followed instructions and were consistent across participant characteristics and groups.

In summary, this internally valid comparison of two low-intensity prelinguistic treatments showed that PECS

had a more rapid effect on spoken communication than did RPMT. However, over the long run, relative treatment efficacy varied by initial object exploration level. If children began treatment with high object exploration, the initial advantage of PECS maintained 6 months after treatment ended. In contrast, if children began treatment with relatively low object exploration levels, RPMT facilitated a number of different nonimitative words faster than did PECS, and these effects maintained 6 months after the end of treatment. These data provide the basis for moving one step closer to the goal of matching treatments to individual characteristics of children with ASD. The generalized and maintained treatment results outcomes also provide an important step toward realizing the national goal of helping 90% of children with autism develop useful speech.

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A Randomized Comparison of the Effect of Two Prelinguistic Communication Interventions on the Acquisition of Spoken Communication in Preschoolers With ASD

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