Research Article

Increasing Social Interaction Using Prelinguistic Milieu Teaching With Nonverbal School-Age Children With Autism

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Purpose: Children with autism display marked deficits in initiating and maintaining social interaction. Intervention using play routines can create a framework for developing and maintaining social interaction between these children and their communication partners.
Method: Six nonverbal 5- to 8-year-olds with autism were taught to engage in social interaction within salient play routines. Prelinguistic milieu teaching (PMT) techniques were used to teach the children to communicate intentionally during these routines. Intervention focused on the children's social interaction with an adult. The effects of intervention were evaluated using a multiple baseline design across participants.
Results: At study onset, the participants demonstrated few consistent interaction with others. With intervention,

all of the children improved their ability to sustain social interactions, as evidenced by an increase in the number of communicative interactions during play routines. Participants also increased their overall rate of initiated intentional communication.
Conclusion: Development of intentional prelinguistic communication within salient social routines creates opportunities for an adult to teach social and communication skills to young school-age children with autism who function at a nonverbal level.

Key Words: communication, prelinguistic, social interaction, autism, routine

A defining characteristic of children with autism is impairment in social interaction. Children with autism demonstrate limited social reciprocity and decreased use of nonverbal behaviors such as eye gaze, facial expression, body postures, and gestures to communicate and regulate social interaction (American Psychiatric Association, 1994). Furthermore, these children demonstrate overall lower rates of intentional communication compared to children who are developing typically (Chiang, Soong, Lin, & Rogers, 2008; Wetherby, Prizant, & Schuler, 2000). Intentional communication is defined as behaviors that are intended to communicate meaning to another person, knowing that the listener will receive the message and act on it (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Westling & Fox, 2004).

Recent studies suggest that in children with severe autism, deficits in the rate and appropriateness of intentional communication persist into older childhood (Maljaars, Noens, Jansen, Scholte, & van Berckelaer-Onnes, 2011). Infants who are developing typically begin to use these intentional communication behaviors with familiar communication partners between 9 and 12 months of age (Bates et al., 1979). In these younger children who are developing typically, means of conveying purposeful intent typically begin with nonverbal means such as pointing gestures and gradually develop into symbolic means, such as a spoken word for *cookie*. Because children with autism often do not develop these early intentional communication skills, they may develop inappropriate communication means, including idiosyncratic behaviors such as hand flapping or challenging behaviors such as hitting, as they grow older (Murphy et al., 2005, Schuler, Prizant, & Wetherby, 1997).

Early intentional communication is typically learned over time through natural social interaction with caregivers (Bakeman & Adamson, 1984; Barton & Tomasello, 1991; Gros-Louis, West, Goldstein, & King, 2006; Iverson & Thal, 1998). When children begin to communicate in order to achieve important functions in their environment, caregivers can potentially attend and respond to the children's communication attempts more accurately. The transactional

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theory of development (Sameroff, 1975) suggests that increases in children's initiation of communication may lead to increases in parent responsivity, resulting in further increases in the children's initiations. Within this theoretical framework, caregiver responses guide the shift to intentionality in children. For example, a child babbles sounds and looks toward her father. Her father gets very excited, picks her up, and talks to her. After several instances where the child randomly babbles and looks at her father, receiving a consistent contingent response, she may begin to associate making sounds and looking toward her father with being picked up. Thus, when she wants to be picked up, she may learn to look toward her father and produce sounds. These sounds become even more consistent when the father begins to respond only to certain sounds, such as *dada*. Eventually, consistent sounds and gestures begin to represent certain actions and objects in Sameroff's (1975) model.

Several behavioral characteristics that are common in children with autism may impede interactions with adults that are thought to be critical for the development of intentional communication skills. These characteristics include restricted interests, anxiety, self-stimulatory and/or self-injurious behaviors, heightened activity levels, attention deficits, minimal joint attention and symbolic play, resistance to change, and abnormal sensory responses (Paparella, Goods, Freeman, & Kasari, 2011; Schopler, Reichler, & Renner, 2010; Spiker, Lin, Van Dyke, & Wood, 2012). Additionally, the primary means of prelinguistic communication used in early social interaction in infants who are developing typically, such as eye gaze and gestures, have been found to be persisting core deficits in children with autism (Colgan et al., 2006; Mundy, Sigman, & Kasari, 1994; Sheinkopf, Mundy, Oller, & Steffens, 2000). Consequently, children with autism may have difficulty learning within natural social interaction and may never fully develop consistent and socially appropriate intentional communication skills. For children who remain nonverbal into their school-age years, the development of communication and social skills becomes even more complex. School-age children with severe autism who do not develop symbolic spoken language may have to rely solely on prelinguistic communication modes as their primary means of intentional communication. An important aspect of the complexity of learning communication skills for these children includes the necessity for functioning in both home and classroom environments on a consistent basis.

For both parents and school personnel, intervention targeting consistent and intelligible means of functional communication is a high priority for older children with severe autism. Yet, few methods have been evaluated for their efficacy in supporting the development of maximally functional communication for older, nonverbal children with autism (Goldstein, 2002). To make decisions about appropriate interventions for children with little or no means of functional communication, clinicians must consider the basic nature of communication acts. Such considerations would include (a) understanding of typical prelinguistic development, (b) effectiveness of the child's communication in terms of

recognition and interpretation of the communication attempts by communication partners, and (c) presence of research-based evidence to support the use of an intervention technique or program relative to the unique needs of children with autism functioning at a prelinguistic communication level.

Considering information on typical development in the context of transactional theory (Sameroff, 1975), early phases of intervention might focus on teaching easily identifiable communicative behaviors within purposeful social interaction (Mundy & Crowson, 1997; Whalen & Schreibman, 2003). Play routines have been shown to be particularly useful in teaching social interaction and intentional communication to young children (Kashinath, Woods, & Goldstein, 2006; Snow, Perlmann, & Nathan, 1987; Yoder & Davies, 1992). Play routines provide predictable interactions between a child and an adult that allow the child to observe clear models of the communicative process and to experience consistent, naturally reinforcing consequences (Bruner, 1983; McCormick, Loeb, & Schiefelbusch, 2003; Ratner & Bruner, 1978). Once the child shows the ability to engage a caregiver in these routines, adults can begin to expand the child's use of specific means of purposeful communication, including vocalizations and/or gestures. In chronologically older children with autism, salient play routines may provide a primary means of stimulating and learning to maintain intentional communication.

Of the many potential communication modalities to teach, three nonverbal behaviors stand out that emerge in early development and persist as important means of communication after the onset of spoken or linguistic communication is achieved: (a) vocalizations, (b) eye gaze, and (c) gestures. Warren et al. (2006) described these three behaviors as the "basic components of prelinguistic requesting and commenting acts" (p. 61). The successful use of prelingustic communication establishes an important foundation for future development of symbolic language; the use of words with consistent referents (Acredolo & Goodwyn, 1988; Brady, Marquis, Fleming, & McLean, 2004; Brady, Steeples, & Fleming, 2005; Calandrella & Wilcox, 2000; Iverson & Goldin-Meadow, 2005; McCathren, Yoder, & Warren, 1999; Smith, Mirenda, & Zaidman-Zait, 2007; Watt, Wetherby, & Shumway, 2006). This important transition in language acquisition was first proposed in the 1970s and has continued to be integrated into current theories of early language acquisition.

One intervention for teaching children to interact more consistently using nonverbal behaviors within routines is prelinguistic milieu teaching (PMT; Yoder & Warren, 1998). PMT is designed to increase children's use of intentional prelinguistic communication skills. PMT procedures are embedded in play routines within a child's natural environment (Warren et al., 2006). Adults use natural prompts and responses to encourage the child to make requests and comments through nonverbal means (e.g., vocalizations, eye gaze, and gestures).

A series of studies has been conducted to evaluate PMT with young children who show developmental language delays (e.g., Fey et al., 2006; Yoder & Stone, 2006a,

2006b; Yoder & Warren, 1998, 1999, 2001, 2002). In early single-subject research designs, children increased pragmatic skills such as requesting, commenting, and turn taking (Warren, Yoder, & Gazdag, 1993; Yoder, Warren, & Kim, 1994). Subsequent group designs supported the use of PMT for teaching intentional communication acts to young children with Down syndrome who have parents with high levels of responsivity (Fey et al., 2006). These children produced significantly more overall intentional communication acts compared to a control group receiving no treatment.

Available PMT studies are limited in terms of participant age ranges, disability categories, severity of language delay, and intellectual functioning. Most participants have been described as having mild-to-moderate intellectual disabilities. Children with more severe disabilities are more likely to remain at the prelinguistic communication level over prolonged periods (Mundy & Crowson, 1997). Only one study of PMT has involved chronologically older children with more severe disorders. Brady and Bashinski (2008) implemented a modified version of PMT with nine children who showed significant deficits, including vision and hearing loss. During intervention, all of the participants increased their rate of intentional communication.

Further evaluation of PMT protocols (Yoder & Warren, 1998) with children who are older with more severe disorders can potentially provide another intervention approach for building a consistent communication system. Accordingly, the purpose of this study was to expand the research on PMT to include school-age children with autism who exhibit severe and persisting levels of communication disability. The children were taught to use vocalizations, eye gaze, and gestures as means to intentionally communicate within functional play routines. A home setting was selected for the first step in evaluating PMT with these children as it was considered the most comfortable and natural setting in which to observe change in the child's intentional communication.

To examine the effects of PMT on the use of intentional communication in this population, two questions were addressed:

- What is the effect of PMT on the child's development of sustained intentional communication within a salient play routine (as measured by the total number of intentional communication acts taken during a routine)?

- What is the effect of PMT on the child's initiation of intentional communication (as measured by the rate of child-initiated communication acts)?

Method

Study Design

A multiple baseline design (Horner & Baer, 1978) where each child serves as his or her own control by comparing changes in rates of the dependent variables (e.g., child's communication acts) before and after the introduction of an independent variable (PMT) was used to determine treatment effects. A nonconcurrent multiple baseline design (Watson & Workman, 1981) was employed that allowed participating children to begin the study immediately after they were assessed. Although slightly less robust than a concurrent baseline, the establishment of all baseline durations before the beginning of data collection combined with a random assignment of participants strengthens the potential to demonstrate experimental control (Christ, 2007).

Baseline durations of 3–10 sessions were randomly selected for the six participants before beginning the study. The duration of baseline was assigned to each participant based on the order in which each began the study. For example, the first duration randomly selected was 5, so the first participant received five baseline sessions. The sixth and last duration selected was 3, so the sixth participant received three baseline sessions. All of the participants were included in the study with their assigned number of baseline sessions, regardless of whether baseline stability was achieved. In the event that a stable baseline was not obtained, the results would have been interpreted as inconclusive for that participant.

Participants

Six children with autism, ages 5–8 years, participated in this study. All of the children met the following inclusion criteria: (a) independent diagnosis of autism by an outside physician or psychologist; (b) English as the dominant language in the home; (c) lack of functional communication (i.e., no consistent use of vocalizations, eye gaze, or gestures to communicate); (d) normal levels of vision, hearing, and motor skills; and (e) developmental language age-equivalent <18 months for both receptive and expressive language. During the prestudy assessment, several measures were taken to verify the inclusion criteria and to obtain descriptive information.

First, the participants' parents were interviewed and were asked a series of questions regarding their child's communication skills in order to verify that their child did not already communicate frequently and clearly using either verbal or prelinguistic communication. The Childhood Autism Rating Scale (CARS; Schopler et al., 1993) was scored to classify the severity of the child's autism. The Receptive–Expressive Emergent Language Scale, Third Edition (REEL–3; Bzoch, League, & Brown, 2003) was administered via parent interview to obtain a developmental age equivalent for receptive and expressive language. Because the REEL–3 is normed only on children up to age 3, the standard scores and percentile ranks could not be determined. However, age equivalents were determined by scoring all test items and converting the raw scores to age equivalents. This was considered an appropriate measure because of the severity of the language impairments in the participants in our study. Currently, no standardized instruments exist for assessing prelinguistic language skills in older children, and this method of classification is consistent with other studies that have examined this population (e.g.,

Keen, Sigafoos, & Woodyatt, 2001). Both the autism severity rating obtained from the CARS and the age-equivalent scores obtained from the REEL–3 were used only to verify inclusion criteria and obtain descriptive information about the participants. All of the participants were classified as having moderate-to-severe levels of autism, with total CARS scores ranging from 38 to 48. All of the participants demonstrated an expressive language score between 5 and 9 months and a receptive language score between 5 and 12 months. Table 1 displays individual descriptions and test scores for each participant. To protect confidentiality, all of the participants are referred to by a code name.

Setting and Routines

All of the play sessions were conducted in each participant's home, with a parent or guardian present. Toys and materials that were part of the child's natural home environment were used to support techniques employed with PMT. Potential routines were selected before the study based on recommendations by the parents obtained during a parent interview and observations of the child's play. The play routines developed with each child are listed and described in Table 2. It is important to note that two of the routines, books and puzzles, had a finite number of pages or pieces and were thus not open ended. With these routines, the routine was simply continued either by restarting the same book or puzzle or by moving to a second book or puzzle.

All of the participants showed unique profiles in their development of social routines. For example, Adam enjoyed a wide variety of routines that involved physical movement, including sliding and spinning. Cody preferred to engage with a toy (such as a figurine) and responded well when the adult attempted to join him in playing with the toy. Ben engaged in multiple routines with a single object, making it somewhat difficult for the adult to know which routine he was trying to initiate. Furthermore, the adult had to be careful not to appear to be placing demands on him while creating the context for the activity or Ben would try to escape from the room. Sam preferred to stay in the same place during the sessions. Most of his routines allowed him to lounge on the couch, chair, or bed. Lily liked to constantly move around the house and yard. Her most successful routines involved the adult facilitating her movement in some way, such as pushing her in a stroller, rocking her in a hammock, or rolling her across a room. Chad's routines were very simplistic and involved basic movements, such as covering with a blanket or squishing with a pillow. He engaged in constant self-stimulation by holding and tapping a clothes hanger, which meant that his routines had to allow him to hold the hanger.

Procedure

All of the sessions lasted 25–30 min. When a child completed the predetermined number of baseline sessions (ranging from 3 to 10 as previously described), intervention began at the next scheduled session. All of the children received 14 treatment sessions (two per week). A follow-up phase was conducted after a 4- to 6-week break to evaluate whether the communication skills gained in intervention were maintained. The initial evaluation, baseline sessions, and treatment sessions were conducted by the first author, who is a licensed speech-language pathologist and board-certified behavior analyst with experience with PMT intervention. In the following descriptions of the study, this author will be referred to as "the adult."

Baseline. Before intervention, baseline or pretreatment sessions were conducted to establish a measure of each participant's communication skills. During these baseline sessions, the adult interacted naturally without explicitly using PMT techniques or routines. The adult maintained close proximity to the child (within 6 ft) and maintained nonverbal attention to the child's activity (watching the child closely). The adult did not prompt or cue the child to communicate or attempt to initiate any play routines. If the child initiated communication, the adult responded in a natural way, such as making a neutral comment (e.g., "Oh. I see."). Specific PMT techniques, such as imitating the child, giving specific acknowledgment (e.g., "You looked at me!"), or verbal recasting, were not used during the baseline sessions. The only PMT technique that was potentially used during baseline was the delivery of a requested object, defined as a natural consequence in PMT. Compliance with the child's

Table 1. Participant descriptions.

Participant	Age (years;months)	Ethnicity	CARS total score	Expressive language[a] (in months)	Receptive language[a] (in months)
Chad	8;3	Pacific Islander	48	6	5
Cody	5;4	Hispanic	38	7	12
Adam	5;9	Asian	40	9	9
Sam	7;5	White	40	8	8
Ben	5;1	Hispanic	46	5	6
Lily	7;6	Asian	49	8	8

Note. CARS = Childhood Autism Rating Scale (Schopler, Reichler, & Renner, 1993).

[a]Language age equivalent is calculated based on raw scores from the Receptive and Expressive Emergent Language Scales, Third Edition (REEL–3; Bzoch, League, & Brown, 2003).

Table 2. Play routines used in the intervention.

Participant	Play routine/child communication
Chad	Blanket: requested blanket to be thrown over him Ball: requested to sit on top of large exercise ball and bounce Squish game: requested adult to squish with pillow or ball while lying prone on bed Chase: requested adult to chase him around room Musical toys: requested adult to activate music Foot squeeze: requested adult to massage/squeeze feet
Cody	Toy figurines: requested figurine to jump off furniture, fly, etc. Cars: requested adult to push or roll toy car to him Chase: requested adult to chase around room Tickles: requested adult to tickle stomach Squish game: requested adult to squish him with pillow while laying on couch Puzzles: requested individual pieces of puzzles Blanket: requested adult to pull him while sitting/lying on blanket
Adam	Cart rides: requested to be pushed around room in toy car he sat in Blanket: requested blanket to be thrown over him Slide: requested to go down the slide (indoor play slide) Tumbling on mat: requested assistance with rolling in somersault Books: requested to read book and then each page to be turned Piggy-back rides: requested to be carried across the room and flopped onto bed Chair spins: requested adult to spin office chair Ball: requested adult to throw or roll ball
Sam	Squish game: requested adult to squish him with pillow while laying on couch Tickles: requested adult to tickle stomach Dancing: requested adult to hold hands, sing and dance (e.g. ring round rosie) Ball: requested adult to throw or roll ball up in the air Trampoline: requested adult to hold hands while jumping (small indoor trampoline)
Ben	Swing: requested adult to push swing (on outdoor swing set) Tumbling on mats/pillows: requested to run and jump into mats/pillow pile Ball: requested to sit on top of large exercise ball and bounce Squish game: requested adult to squish with pillow or ball while lying prone on mat Chase: requested adult to chase around room Spinning: requested adult to pick him up from behind and spin him around in circle Piggy toes: requested adult to do "5 little piggies" rhyme while squeezing toes Blanket: requested adult to pull him while sitting/lying on blanket Blanket: requested blanket to be thrown over him
Lily	Hammock: requested to be pushed in backyard hammock Ball: requested to sit on top of large exercise ball and bounce Blanket: requested blanket to be thrown over her Tumbling on mats/pillows: requested to run and jump into mats/pillow pile Brushing: requested adult to rub hands and feet with therapy brush Cart rides: requested to be pushed around yard in stroller Piggy toes: requested adult to do "5 little piggies" rhyme while squeezing toes Slide: requested to go down the slide (small outdoor play slide)

requests was viewed as a natural and typical response to the child and not as a specific teaching procedure when used in the absence of the other techniques.

Intervention. During the intervention sessions, each child was taught to use vocalizations, gestures, and eye gaze using PMT techniques previously described in research protocols and textbooks (McCauley & Fey, 2006). PMT is designed to create a context that promotes communication. This process has been termed the "enabling context" in previous PMT research (Warren et al., 2006). The enabling context is established primarily by arranging the environment and using play routines with the goal of creating opportunities for the child to initiate communication (e.g., preferred items were placed in sight but out of the child's reach).

Intervention procedures were embedded in social play routines. The adult followed the child's attention and motivation (within the arranged environment) and imitated the child's vocalizations. The child's pattern was interrupted and the adult attempted to engage the child in turn taking. For example, if the child engaged in repetitive play with a ball, the adult would attempt to join and make the play interactive by creating a game of "catch" with the ball. Once a routine was initiated, the adult conducted a series of teaching episodes where a specific child behavior was taught using a sequence of prompts, models, and natural consequences, as described in PMT studies. A teaching episode generally began with the adult creating a situation in which the child was likely to communicate and ended with a natural consequence

(Warren et al., 2006). "Natural consequences" included responding accordingly to a request or smiling and nodding when the child communicated (e.g., the adult delivered a drink when the child pointed to it). Teaching episodes were implemented at an average rate of 1 per min (Warren, 2005).

Typically, a gestural and/or verbal prompt was given if the child did not attempt communication after an opportunity was created. Intervention "prompts" included verbal or gestural cues that it was the child's turn to communicate (e.g., the adult would act surprised and point to an item). After a prompt, the adult paused briefly to allow the child time to respond. If the child did not respond to the prompt within a few seconds, the adult modeled an appropriate response. "Models" included examples of gestures and vocalizations that the child was not prompted to directly imitate (e.g., the adult would say and sign "ball" while playing with the ball). If the child still did not engage in the target behavior, the adult continued with the interaction or routine. The adult attempted to avoid using a directive manner when prompting. Descriptions and examples of the PMT techniques used in our study are provided in Table 3.

The intervention included only PMT techniques. Responsivity education (RE), a parent training component added in some of the more recent studies described as RE/PMT, was not implemented. Because this is the first study using PMT with this population, it was considered important to examine the efficacy of the PMT techniques specifically before considering the impact of additional parent education.

Follow-up. Six weeks after the intervention concluded, two to three more intervention sessions were conducted in order to observe maintenance of the targeted skills. During the break in intervention, there was no contact between the adult and child. Parents were not instructed to use PMT and were not formally trained on how to implement PMT techniques. However, because a parent was present during all of the intervention sessions and questions were answered as they occurred, it is anticipated that the parents could have incidentally used some of the treatment techniques. PMT interactions during the follow-up were identical to those during the intervention.

Data Collection and Coding

All assessment, baseline, intervention, and follow-up sessions were videotaped for data collection purposes. A video camera was set up by the adult before each session.

If the child moved to another room, then the adult moved the camera to that other room as unobtrusively as possible. After each session, all of the videos were reviewed and coded in a university laboratory. Approximately half of the videos were coded by the adult and half by a graduate research assistant (RA). Because of the increased risk of bias emerging from the adult serving as one of the primary coders, one third of the sessions were coded a second time by additional RAs in order to establish reliability. More detail on this calculation can be found in the Reliability section.

During the video review, all of the intentional communication acts, defined as any attempt that the child made to interact with the adult within the social routine using vocalizations, gestures, or eye gaze, were coded. Coding included the *time* of the communication act, ordinal *sequence* of the communication act within the routine, *initiation* by child or adult, *form* of communication (i.e., vocalization, gesture, and/or eye gaze) used, and whether each form was *spontaneous or prompted.*

Within each play routine or activity, the child could communicate only once and move on to another activity or he could engage in multiple communication acts within the same routine. The first research question regarding the effect of PMT on the child's development of sustained social interaction was measured by calculating the maximum number of child communication acts within any routine during the session. Communication acts were counted successively when the child maintained focus within the same social activity. Each communication act was numbered to denote its sequence within the activity. For example, the child's first act within an activity was marked with a *1*. If the child maintained focus on that activity, the next event was marked as a *2* and so on. If the child stopped participating and another activity was begun, then the numbering started again, and the first new act was marked as a *1*. The total number of acts for each routine was calculated. If the child engaged in the same routine more than once, each instance of that routine was counted separately. The single routine with the highest number of communication acts maintaining that occurrence of the routine was identified as the data point for that session.

To measure the effect of PMT on the rate of child-initiated intentional communications, the rate of child-initiated communication acts during the entire session (across all routines) was counted using the definition of a communication act noted above. A child's intentional

Table 3. Description of adult intervention techniques used in the study.

Procedure	Technique	Example
Prompts	Verbal cue	Adult asks, "What do you want?"
	Gestural cue	Adult opens and raises hands quizzically when the child attends to a toy nearby.
Models	Gesture model	Adult models a point to a bottle of bubbles on a shelf.
	Vocal model	Adult models the sound "m" while waving a blanket over the child's head.
Natural consequences	Compliance	Adult delivers a cup that the child indicated by pointing to it.
	Imitation	Adult immediately echoes the sound "b" that the child made during vocal play.
	Recast	Adult says "ball" when the child points to it.

communication act was counted if the child spontaneously initiated communicative interaction with the adult without any prompting or models. Rate per minute was calculated by dividing the total number of child-initiated communication acts by the total number of minutes in the session. Because acts could not be counted if the child's head was out of range of the video, any time period that the child was off camera was not included in the total session time.

Data Analysis

Within the current research design, results are evaluated through visual analysis and effect size calculation. Determination of effect with visual analysis methods is based on the change in variability, trend, and level of data between phases (Kazdin, 1982). Data *trends* describe the direction of the data points across time. Trend describes whether the behaviors are stable, increasing, or decreasing. *Variability* describes the variance in the data points in terms of the measurement. Finally, *level* describes the average measurement of the data points in each phase. An effect would be noted if the data show (a) low, stable rates of the behavior in baseline, and (b) an increasing trend and overall increase in the level of the data after introduction of the independent variable (intervention).

Although visual analysis is the preferred method in single-subject design, nonregressive effect size calculations can add support to the findings and are useful for disseminating information to individuals who are less familiar with single-subject analysis (Campbell, 2004; Kazdin, 1982; Olive & Smith, 2005). The effect size chosen for this analysis is the improvement rate difference (IRD; Parker, Vannest, & Brown, 2009). IRD is the difference in proportion of higher or "improved" scores between the baseline and intervention phases. IRD is calculated as the difference between two independent proportions (Parker et al., 2009) and is computationally identical to the "relative risk" statistic in logistic regression analysis. Relative risk has been promoted as an acceptable method for determining treatment efficacy in medicine (Higgins & Green, 2011).

Data were analyzed using Number Cruncher Statistical Software (Hintze, 2002), which provides a dedicated meta-analysis module for risk analysis. Each raw data set was analyzed for the number of overlapping points between phases. Overlapping data (for an AB contrast) are defined as the fewest data points that would have to be removed from either phase A or B in order to eliminate all data overlap between them. Data points tied across phases also were defined as not overlapping. The software also provides exact bootstrap confidence intervals. Average effect sizes are automatically calculated across groups and subgroups, with individual IRDs weighted by the inverse of the variance for each proportion. Parker et al. (2009) indicated that IRD benchmarks suggest a strong or large effect for sizes >0.70 and moderate effects for IRD values of 0.50–0.69. The current design meets or exceeds minimum standards for the number of data points in the baseline and intervention phases (Kratochwill et al., 2010). However, analysis of

data arrays with few data points can result in low precision. In such cases, effect size estimates may have large confidence intervals around obtained IRD estimates. Therefore, all IRD estimates will be expressed with 95% confidence intervals.

Reliability

Reliability was measured by assessing interobserver agreement (IOA) or comparing observations of outcome variables between separate observers. This process involved double coding sessions in order to reduce the risk of subjectivity and bias that might occur with only one observer. IOA coding was conducted by two graduate student RAs who were blind to the study hypothesis and treatment conditions. Reliability coding was conducted for 25%–40% of the baseline sessions (1–3 sessions) and 29% of the intervention sessions (4 sessions) for all of the participants. The variation in percentage of baseline sessions observed was because each participant had a different number of total baseline sessions. Sessions were randomly selected from the hard drive files stored in the laboratory and were burned onto a DVD. To ensure that observers were blind to the treatment conditions, the baseline and intervention sessions were intermixed and were presented in random order.

IOA was evaluated through two indices: percent agreement and prevalence and bias adjusted kappa (PABAK; Byrt, Bishop, & Carlin, 1993). These indices are designed to assess exact agreement between observers. Both indices were calculated separately for each of the outcome variables. To determine the number of acts to maintain social interaction within a routine, the highest number of child acts in a single routine per session was compared between observers. For rate of initiation of intentional communication, observer agreement was calculated by counting each occurrence of intentional communication per minute and comparing this total between observers for each session. In both cases, the lower number was divided by the larger number and then multiplied by 100. For maximum number of communication acts in a routine, agreement was 100% for the baseline sessions. For the intervention sessions, average agreement across participants was 83%, with a range of 78%–87%. For rate of initiated intentional communication, agreement was also 100% for all of the baseline sessions. For the intervention sessions, average agreement was 89%, with a range of 83%–93%. Given that agreement of 75% suggests an acceptable level of accuracy for simultaneous data collection of several different behaviors (Cooper, Heron, & Heward, 1987), all percentages suggest high levels of accuracy for coding of the study variables.

PABAK was also used to calculate reliability. PABAK is calculated using the same conceptual formula, $(P_O – P_C)/(1 – P_C)$, as Cohen's κ (Cohen, 1960). However, chance agreement (P_C) is based only on the number of scale categories rather than on the proportion of agreements expected to occur by chance in κ. PABAK was chosen to evaluate reliability in the current study because measurement of the dependent variable relies exclusively on the recording of

behavioral events rather than on the recording of events and nonevents. Because no measurement of nonevents occurred, the agreement matrix is left with an empty cell. This measurement decision yields κ scores with unintuitive negative results. PABAK results were 61% across the children for acts to maintain social interaction and 81% for rate of initiation of intentional communication. PABAK is evaluated similarly to κ (Byrt et al., 1993), with an acceptable level of agreement set at .60 (Altman, 1991)

Treatment Fidelity

Treatment fidelity involves determination of the accuracy of intervention implementation. Accurate application of PMT techniques was evaluated relative to each separate teaching episode surrounding a child's communication act. As described in available descriptions of PMT, a teaching episode includes the sequence of prompts, models, and natural consequences involved with one child communication act (Warren et al., 2006). A teaching episode generally includes (a) contriving a situation in which the child will be likely to communicate, (b) using a specific technique (prompt or model) if necessary, and (c) responding to the child's communication attempt (compliance, initiation, or recast). Thus, each child communication act was reviewed and rated on whether or not the adult correctly implemented the following techniques during that episode:

- *Enabling context:* The speech-language pathologist (SLP) created a situation in which the participant was likely to communicate and waited for the child to make a communication attempt. The SLP followed the child's lead for motivation of routine.

- *Prompting:* If the child did not initiate an interaction, the SLP used appropriate prompts to attempt to get the child to communicate in the desired way. The SLP used no more than two discrete prompts before moving on with the interaction. If the child initiated the communication, no prompts were used.

- *Response to communication:* The SLP responded in an appropriate way to the child's attempt to communicate. Appropriate responses included imitating the child, giving the child a desired item/activity, or recasting with an appropriate word for what the child was trying to communicate.

Treatment fidelity was rated on the same sessions that were used to code reliability (27% of the intervention sessions) by graduate RAs trained in PMT procedures. Treatment fidelity was calculated for each of the three variables by dividing the number of episodes with correct implementation by the total number of episodes and multiplying by 100%. Average treatment fidelity for the adult creating an enabling context was 100% for all participants. Average treatment fidelity for the adult's use of appropriate prompting was 100% for all participants. Average treatment fidelity for adult response to child communication was 98% overall and ranged from 94% to 100% across participants. These high

percentages offer support that the intervention was conducted accurately (Cooper et al., 1987).

Social Validation

Social validity was measured by comparing the scaled rating between baseline and intervention for items that represent both social–emotional and practical aspects of intervention. Twenty-four graduate student raters answered seven questions that were adapted from a social validation assessment using a 5-point Likert-type scale (Lancioni et al., 2002). The questions inquired about whether the intervention was pleasant, beneficial, rehabilitative, and generalizable. The raters were blind to the study hypothesis and session number. They were shown a 4-min video of a baseline and a treatment session for each participant in random order. Social validity was assessed by examining the changes in scaled ratings on social validation items before and during treatment (baseline ratings vs. treatment ratings) averaged for each item across all participants. The intervention would be considered more socially valid if the questions were rated higher (e.g., more pleasant and beneficial) for intervention and lower for baseline. A *T* test for matched pairs revealed statistical significance for each of the seven items examining social validity. Effect size calculations also indicated moderate-to-large effect sizes for all of the rated items.

Results

To address the first study question, "What is the effect of PMT on the participant's development of sustained social interaction within a salient play routine?" the number of acts that the children used to maintain social interaction during each routine was examined. Figure 1 displays the maximum number of child acts to maintain social interaction during a single social routine in each session. All of the participants demonstrated an increase in the maximum number of communication acts in a routine per session. In baseline, they demonstrated steady, low rates of intentional communication but little ability to maintain a single routine during a session (average range = 0.3–2.5 acts). This low level of interaction would suggest that they did not consistently participate in play routines before treatment, consistent with parent reports during the interviews that were conducted in the initial assessment. During intervention, participants demonstrated visible improvement, at least tripling their average maximum number of communication acts per routine as compared to baseline (average range = 7.5–17.3 acts).

Individual trends and changes in level were variable across participants. Adam and Cody, for example, demonstrated the steadiest upward trend during intervention, whereas Chad and Sam showed the most variable change. Both showed more immediate robust change in level, yet highly variable data throughout intervention. Ben and Lily demonstrated modest increases in level but relatively flat trends during intervention overall. Follow-up data suggest that most of the participants were able to maintain their increased ability to sustain interaction during a routine even
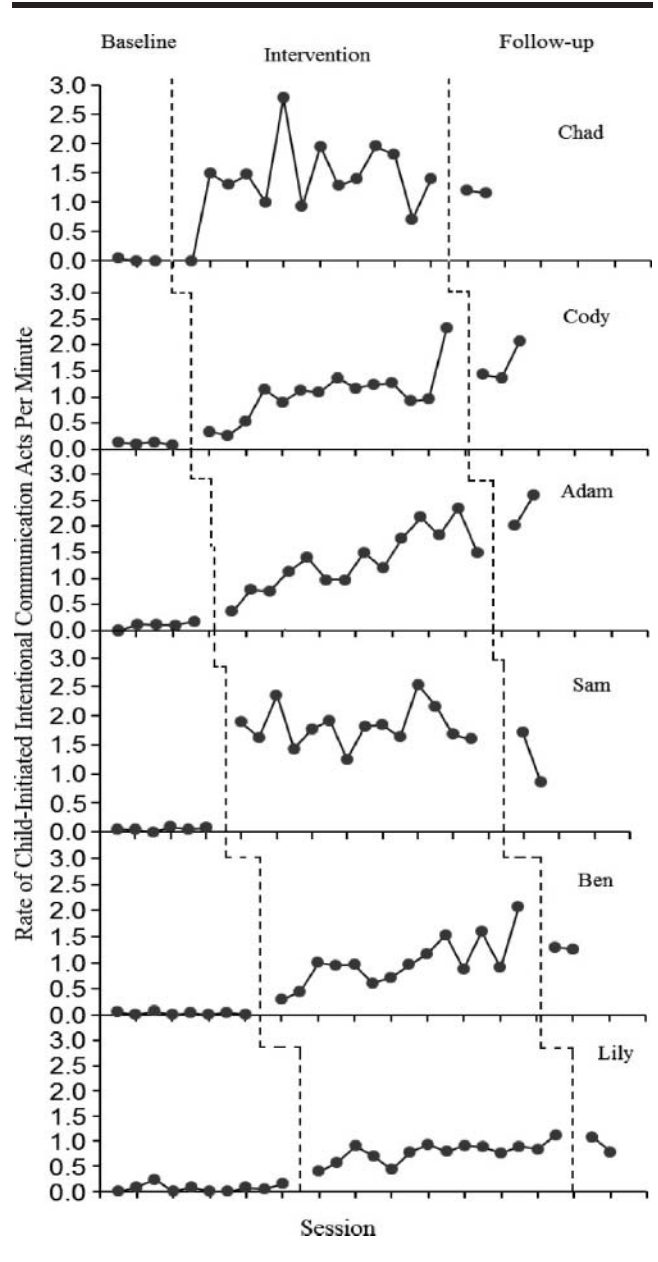
Figure 1. Maximum number of child acts to maintain social interactions per session.

Figure 2. Rate of child-initiated communication acts per minute.
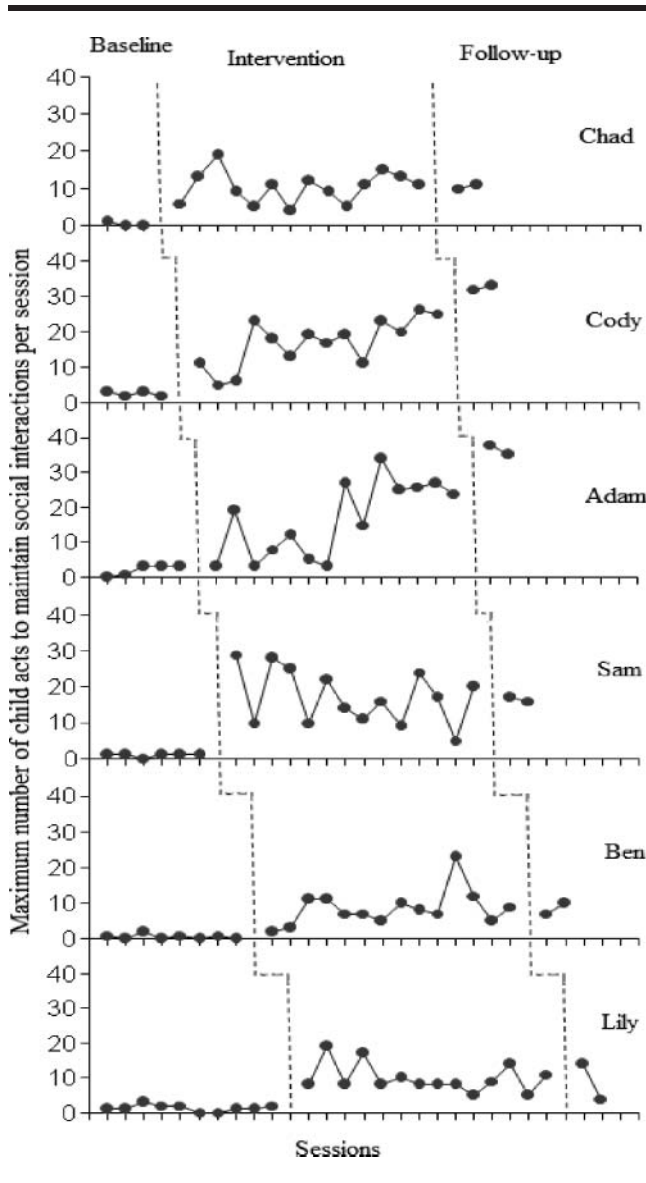
after a 6-week break from intervention. Cody and Adam actually increased their number of communication acts during the follow-up sessions.

The second question, "What is the effect of PMT on the participant's initiation of social interaction?" was measured in rate per minute by counting the number of times the child initiated communication with the adult during each session divided by the number of minutes in the session. Figure 2 displays the frequency of child-initiated communication acts per session across all participants. The trend for all participants was stable in baseline, with almost no attempted communication during the baseline sessions. The maximum rate of initiated communication for any participant was .2 during the entire condition; only a few

baseline sessions achieved .1 attempts per minute. These results are consistent with parent reports of each child's typical communication.

Results suggest that the participants did not demonstrate intentional communication before intervention. During intervention, all six children increased in the rates of initiation of intentional communication compared to baseline. Adam, for example, demonstrated a gradually increasing trend, eventually reaching the goal of 2 communication acts per minute. Cody and Ben showed gradual increases that stabilized at around 1.5 acts per minute. Sam demonstrated a large jump in level, to around 2 acts per minute, and a stable

trend throughout intervention. Lily achieved a very slowly increasing trend and a smaller increase to an average of 1 act per minute. Chad demonstrated increased but highly variable rates during intervention. He reached the rate of 2 communication attempts per minute during several sessions. All of the participants maintained or increased their rates of communication during follow-up.

Effect Size Calculation

Calculation of effect size further supports the interpretation of increases between baseline and treatment (see Table 4). Each IRD effect size is expressed with the lower and upper bound limits of a 95% confidence interval (CI) in brackets. The average IRD for child initiation of intentional communication is .87 CI_{95} [.77, .97], with a range of scores from .68 CI_{95} [.38, .99] to .92 CI_{95} [.77, 1.00]. The average IRD value for this outcome can be interpreted as an 87% improvement between baseline and intervention phases in maintaining social interaction. The average IRD for acts to maintain social interaction is .90 CI_{95} [.81, .98], with a range of scores from .78 CI_{95} [.42, 1.00] to .92 CI_{95} [.77, 1.00]. The average IRD value for child acts to maintain social interaction can be interpreted as a 90% improvement between baseline and intervention phases. These scores would suggest a moderate-to-high effect size for all participants across both outcome variables.

Discussion

The goal of this study was to examine the use of PMT intervention in a population of school-age children who had been diagnosed with moderate-to-severe autism and severe communication delays. The primary premise of PMT is that prelinguistic communication provides the foundation for the development of future linguistic communication (e. g., Brady et al., 2005; Iverson & Goldin-Meadow, 2005; Smith et al., 2007). However, older children who continue to demonstrate severe communication deficits may not have the potential to develop linguistic communication. When children show persistence of prelinguistic communication into school age, educators face the question of whether to use a functional or developmental approach to communication intervention. The primary purpose of teaching

intentional communication would be to achieve a consistent and clear means of communicative intent. However, if a child has the potential to eventually develop linguistic communication forms, teaching him or her to communicate using prelinguistic forms may pave the way.

Interpretation of Results

Warren et al. (2006) proposed that the first goal of PMT is to establish routines to serve as the context for communication acts. Among the six older children in the study, Adam, Cody, and Sam were the most likely to have established the ability to sustain a routine long enough to have multiple opportunities to communicate with a partner following PMT intervention. Within a social routine, an adult would consistently be able to prompt communication with these three children and fade the prompts as the routine continued. These three children should likely be prepared for the next step of PMT (Warren et al., 2006), which focuses on increasing overall rates of use of gestures and vocalizations.

The potential for PMT effects for Ben, Chad, and Lily were less clear. Each of these children demonstrated the potential to maintain interaction, as indicated by their increase in number of acts per routine during some sessions. However, because they did not continue to steadily increase the number of acts during routines throughout intervention, their individualized salient play routines using PMT techniques may not allow a therapist to continually expand their communication in subsequent sessions. This outcome would potentially indicate a reduced prognosis for success in developing prelinguistic communication using PMT intervention.

However, the results of our second question (increasing rate of intentional communication) were surprising. All of the participants demonstrated increases in the rate of overall intentional communication attempts during the intervention, and most maintained these increases during follow-up. PMT research (Warren et al., 2006) suggests an ultimate goal of at least 2 acts per minute, at which time the child would be ready to advance to linguistic means of communication. Based on their increased rates of intentional communication, all of the participants except Lily might soon be ready for more linguistically oriented approaches to communication intervention. The number of acts per

Table 4. Improvement rate difference (IRD) results by participant for initiation of intentional communication and acts to maintain social interaction.

Participant	Initiation of intentional communication			Acts to maintain social interaction		
	IRD	Low CI (95%)	High CI (95%)	IRD	Low CI (95%)	High CI (95%)
Chad	0.84	0.51	1.00	0.78	0.42	1.00
Cody	0.87	0.59	1.00	0.86	0.59	1.00
Adam	0.68	0.38	0.99	0.88	0.64	1.00
Sam	0.90	0.68	1.00	0.90	0.68	1.00
Ben	0.83	0.58	1.00	0.91	0.74	1.00
Lily	0.92	0.77	1.00	0.92	0.77	1.00

Note. CI = confidence interval. The aggregate IRD of initiation of intentional communication and acts to maintain social interaction = .88 CI_{95} [.82, .95].

routine shown by Chad and Ben actually were sufficient to develop the target rates of intentional prelinguistic communication in this study.

Overall, a PMT intervention for school-age children with severe autism accompanied by severe and persisting communication disabilities may provide an avenue toward improved overall functioning. Clearly, the types of salient play routines may differ from those employed with younger children. Even if symbolic communication is not achieved, the impact of developing clear, consistent means of communication is beneficial. Achievement of consistent prelinguistic communication capacities may enable a wider range of overall functional interactions within the child's social environment. With a consistent set of communication capacities that are easily understood by others, children who operate at prelinguistic communication skill levels can achieve means to communicate consistently in the absence of symbolically based linguistic abilities. In the case of older, nonverbal children who may not ever develop complex spoken language, an increase in communication skills might be quantified by the frequency of initiated communication acts with an adult caregiver. Over time, the child's increase in clear and transparent means of communication and the parent or caregiver's increasing responsiveness interact to mutually create more complex and consistent interactions (Sameroff, 1975; Tomasello, 2003).

Clinical Implications

Direct communication intervention using PMT techniques was successful in teaching older children with low levels of developmental function to increase their intentional communication in salient social interaction within a natural communication environment. All six participants increased their rate of initiation of intentional prelinguistic communication acts as well as the duration of their interactions during routines. Routines were modifiable to fit individual child sensory or physical preferences as well as individual preferences for specific toys. These positive findings have implications for treatment planning for older children with severe communication delays. Appropriate goals for these children may include teaching easily identifiable communicative behaviors within purposeful social interaction. Using developmentally appropriate play materials and routines, PMT may be an appropriate intervention for teaching such skills.

The setting for intervention is also an important issue for this older population with more severe disabilities. In our study, intervention was conducted in each child's natural home environment. However, these activities could be easily implemented in a variety of settings. In particular, generalization to classroom settings where these children spend a majority of their structured learning time could provide an important second location for reinforcing the gains demonstrated in this study within a home setting. Intervention objectives, such as increasing the rate of social interaction and communication, are important for the child to master in as many daily environments as possible. Teachers and parents could cooperate in supporting routines that are socially significant for the child in both situations.

However, implementation of PMT was not without challenges for this group of children. Play routines typically used with children at younger developmental levels, such as *pat-a-cake* or *peek-a-boo,* were not socially appropriate for these older children. Additionally, several behavioral characteristics common in children with autism impeded the development of social play routines within the intervention process. Children with autism often engage in challenging behaviors. For example, Chad engaged in high rates of self-injurious head-hitting behaviors that disrupted the flow of routines. Additionally, some children with autism exhibit resistance to change, which may make it difficult to enhance or build on steps within social routines. For example, Sam sometimes became rigid about completing all of his routines in a particular order. Instead of continuing one routine for a period of time, he wanted to communicate once within the first routine (e.g., blanket), then go to the second routine (e.g., jumping), and then to the third routine (e.g., catch a ball). Finally, many children with autism have comorbid medical disorders. Lily, for example, had a seizure disorder. On days that she had a seizure, Lily was sensitive to overstimulation and avoided interactions.

In single-subject research with only six participants, statistical correlation of participant variables to changes in dependent variables could not be calculated. However, several pretreatment variables were identified that might have had an impact on these participants' responses to intervention. Lower autistic severity ratings and higher developmental language ages were characteristic of the best performers in this cohort. Thus, the best candidates for this intervention may be those who (a) have a developmental language level of 9–12 months, (b) demonstrate less severe autism symptoms, and (c) engage in low rates of challenging behaviors. Chronological age did not appear to be influential in this group of children.

Limitations and Future Research

This study indicated positive results for PMT intervention on the rate and maintenance of communication of these nonverbal school-age children with autism. However, the study is an initial exploration of the impact of PMT in this population. There are limitations that must be considered before these results can be generalized to this older population with more severe disabilities.

First, in multiple baseline design, experimental control or "effects" are determined when there are marked changes in the dependent variable between baseline and intervention conditions (Kazdin, 1982). Here, the independent variable was implementation of the PMT "package" intervention during play routines that were salient to older children. The baseline condition involved the absence of all PMT techniques (with the potential exception of providing requested items). Clear effects or increases in child communication acts and initiation of communication were observed during intervention. However, one might question the extent

of the children's communication skills during baseline. Perhaps they already had the skills but were simply not demonstrating them due to lack of appropriate context. As a control, parents were interviewed about their child's communication skills before study onset. The low frequency of target behaviors observed across participants during baseline was consistent with the parents' reports. Additionally, visual analysis of the data showed that the majority of participants demonstrated a gradual increase in the targeted skills during intervention. This trend might suggest that the children were actually "learning" the communication skills rather than simply demonstrating what they already knew. Sam was the exception. He immediately increased his communication at the onset of intervention. He potentially had the most latent communication abilities. Future research might include more rigorous examination of the child's communicative interaction with a caregiver during baseline or before the study as well as a more critical analysis of the individual components of the intervention.

Secondly, no measures of generalization were taken. Generalization of these results is limited by the small number of participants, settings, and adults involved. Only six participants were involved, and only one participant was female. More research with a larger group of participants is needed to more fully understand the range and types of individual variation within group trends for these children. A broader age range of children from diverse cultural groups is also needed to validly extend these results to other cultural groups. Future research should also incorporate the parent involvement component, RE, that is used in conjunction with PMT intervention. In addition, a critical next step would be to evaluate the effects of PMT intervention implemented directly in the classroom setting.

Finally, the primary researcher was also the intervention agent and one of the data coders, creating a risk of subjectivity and bias, in that the implementer was not blind to the study hypothesis. However, reliability data were collected on ~30% of the sessions to control for this bias, reliability coders were blind to the study hypotheses, and sessions chosen for reliability were randomly selected. The researcher did not know which sessions would be used for reliability while implementing intervention. High rates of agreement were obtained between the primary and reliability coding results, suggesting that these results are unbiased and accurate. Nonetheless, future research should include implementation of the intervention and data coding by persons who are blind to the study hypotheses, including teachers, therapists, or parents.

Overall, these results indicate that implementation of PMT techniques (Yoder & Warren, 1998) was successful in increasing communication acts and initiation of communication skills using salient play routines in six school-age children with autism who were functioning at a prelinguistic level. This preliminary investigation indicates promise for the use of PMT as an intervention approach with this population of children who have severe and persisting levels of deficit in the development of stable and understandable means of communication.

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