Comparing Spoken Language Treatments for Minimally Verbal Preschoolers with Autism Spectrum Disorders

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ORIGINAL PAPER

Comparing Spoken Language Treatments for Minimally Verbal Preschoolers with Autism Spectrum Disorders

Rhea Paul · Daniel Campbell · Kimberly Gilbert · Ioanna Tsiouri

Abstract Preschoolers with severe autism and minimal speech were assigned either a discrete trial or a naturalistic language treatment, and parents of all participants also received in parent responsiveness training. After 12 weeks, both groups showed comparable improvement in number of spoken words produced, on average. Approximately half the children in each group achieved benchmarks for the first stage of functional spoken language development, as defined by Tager-Flusberg et al. (J Speech Lang Hear Res, 52: 643–652, 2009). Analyses of moderators of treatment suggest that joint attention moderates response to both treatments, and children with better receptive language pre-treatment do better with the naturalistic method, while those with lower receptive language show better response to the discrete trial treatment. The implications of these findings are discussed.

Keywords Autism · Language · Treatment · Intervention · Communication · Speech

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Children with autism spectrum disorder (ASD) are almost universally delayed in the acquisition of spoken language. Although rates of functional use of speech have increased in this population during the last decade (Rogers 2006), the acquisition of spoken language remains an especially important attainment for children with ASD. Children who do not acquire speech as a primary means of communication by school age tend to have restricted outcomes in terms of independence and integration (Howlin 2005). Therefore it is important to make every attempt to induce speech in preverbal children with ASD during the preschool period in order to maximize opportunities for social interactions with family and peers and participation in mainstream settings in school and later life. The motivation behind this study is to investigate the most effective ways to induce speech in minimally verbal children with ASD.

A variety of intervention approaches—from the most structured discrete trial instruction methods to more open-ended, child-centered methods—demonstrate some efficacy both for increasing communication and eliciting first words from nonspeaking young children with ASD (See National Research Council 2001; Paul 2008; Prelock et al. 2011; Rogers 2006 for review). One method that has a strong evidence base for eliciting first words from these children is Discrete Trial Training (DTT; Lovaas 1987) which makes use of the Skinnerian principles of operant learning (Skinner 1957). (Reichow and Wolery 2009) reviewed research using such methods for children with ASD and found that, although few studies consistently met standards for establishing evidence-based practice, 5/6 studies that met minimum criteria showed significant improvement for children receiving DTT for expressive language, based on effect size. Moreover, the four studies comparing DTT to other methods for improving spoken language all demonstrated greater gains in both expression and comprehension for the DTT intervention than the alternative treatment. Thus DTT approaches would appear to have some degree of efficacy for facilitating early language development. Nonetheless, DTT approaches have long been criticized (e.g., Delprato 2001; Smith 2001), particularly in the area of communication skills (Fey 1986; Owens 2009; Prizant and Wetherby 2005), due primarily to the fact that gains made often fail to generalize outside the training setting, to be used for spontaneous, functional communication, or to be maintained by the ordinary contingencies of daily life, when tangible reinforcement is removed (Fey 1986; Stokes and Baer 1977).

Another approach to inducing first words in non-speaking children with disabilities was developed in response to these shortcomings. Milieu Communication Training (MCT) has been supported in a range of studies of children with disabilities (e.g., (Hester et al. 1995; Yoder and Warren 2002) including children with ASD (e.g., Hancock and Kaiser 2002; Ross and Greer 2003; Christensen-Sandfort and Whinnery 2011; Yoder and Stone 2006). MCT aims to address some of the identified shortcomings of DTT by means of several strategies, including

1. teaching within natural environments (Kaiser et al. 1992), since research has demonstrated increases in generalization (Hancock and Kaiser 2002), maintenance (Spradlin and Siegel 1982), and spontaneous use of language (Yoder and Warren 2002) in natural environments over isolated clinical settings;
2. mand-modeling (Rogers-Warren and Warren 1980), or providing a model of desired communicative act and correcting child responses;
3. time delay, involving the adult's providing a stimulus and then waiting approximately 5–15 s, for a child-initiated response (Kaiser 2010);
4. incidental teaching strategies (Hancock and Kaiser 2002; Hart and Risley 1975) such as free play in which the child controls the teaching episodes by signaling interest in the environment, which the adult has organized so that access to desired objects is contingent upon solicitation of adult assistance, which is followed by both praise and access to desired outcomes. For example, an adult may "accidentally" forget to give a child milk during snack, then would give a prompt for the child to request it ("What do you need?"), praising the child for correct responses, and giving the child the milk (contingent access).

In their research on MCT with young children with ASD, Yoder and colleagues (e.g., Yoder and Stone 2006) have incorporated parent responsiveness training into the MCT intervention package, and have argued for the importance, in this context, of not only increasing child communicative initiations, but of providing responsive feedback to these initiations in order to effect lasting, functional change in communicative behavior.

One aim of the present study was to examine the usefulness of a DTT treatment that we believed would be especially efficacious for minimally verb children with ASD. A primary reason that some children who were tried on DTT to induce speech did not succeed was that they were unable to produce any vocal imitation. Vocal imitation is the necessary first step in a DTT approach, since only with some vocal behavior to shape can the child's behavior be modified toward speech. We believed that a DTT approach developed by (Tsiouri 2002) had potential to address this problem. This procedure, Rapid Motor Imitation Antecedent (RMIA) training, required the child to produce a series of simple motor imitations before being presented with opportunities to imitate verbal "mands" (requests) or "tacts" (labels). This instructional strategy utilized the child's motor imitation repertoire to facilitate the emergence of first instances of vocal imitation ("echoics"), which could then be shaped into verbal imitation and eventually to independent word production. The unique contribution of RMIA is hypothesized to reside in its capacity to induce vocal imitations through behavioral momentum (Mace et al. 1990; Nevin et al. 1983). Several researchers (e.g., Mace and Belfiore 1990; Mace et al. 1990) have demonstrated that behavioral momentum can be harnessed to elicit behaviors previously resistant to treatment, and have shown that when children's compliance with easy instructions was highly reinforced, compliance persisted when more difficult instructions, with which the children were normally non-compliant, were chained after a series of easy behaviors. Both Tsiouri and Greer (2003) and we (Paul 2009; Tsiouri et al. 2012) have been able to show, in published case series, that this momentum can, in fact, lead to production of first words in some minimally verb preschoolers with ASD.

Because so few DTT approaches have been subjected to experimental procedures such as controlled trials comparing them with alternative approaches, we also aimed to provide such a contrast in this study. Because of the known efficacy of MCT for increasing communication (and sometimes, speech) in minimally verb young children, we believed comparing RMIA to MCT would constitute a fair test of the relative efficacy of the two approaches and, at least, MCT would have positive benefits in increasing communication in participants who received this treatment. But, since most recent research on MCT had incorporated a parent responsiveness training component, as well as to address some of the limitations of DTT in terms of generalization, a parent responsiveness training component was included in BOTH interventions. Thus, the study contrasts two intervention packages, one consisting of RMIA plus parent responsiveness training, and the other of MCT with parent responsiveness training.

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We were also interested in the identification of pre-treatment characteristics of participants that could be associated with positive responses to each of these treatment packages. Research suggests that the relative efficacy of one treatment over another is likely to vary by pre-treatment child characteristics (National Research Council 2001; Yoder and Stone 2006). Thus, the identification of pre-treatment variables associated with enhanced response to one treatment or the other would aid in identification of treatments most likely to work best for particular children.

Thus, the package of intervention developed for this study included assignment of participants to one of two clinician-delivered interventions:

1. a DTT program enhanced with a behavioral momentum component (RMIA), to help children acquire the vocal/verbal imitation skills necessary for speech acquisition, or
2. an MCT program of naturalistic, play-based intervention.

Regardless of which intervention the child received, parents of all participants were provided with Parent Responsivity Training, following Yoder and Warren (2002).

The aims of the study were:

1. to determine whether either RMIA or MCT were more effective overall, in conjunction with parent responsiveness training, in eliciting spontaneous functional speech from minimally verbal preschoolers with ASD;
2. to examine pre-treatment subject characteristics as moderators of response to treatment in order to identify subject profiles that could predict better response to one treatment package or the other.

Methods

Participants

Participants were recruited through written and electronic media advertisements. Flyers and brochures were distributed to local special education departments and early intervention providers. Additional participants were recruited through the university's website. A speech-language pathologist screened all interested individuals. All participants' families completed informed consent procedures approved by the Institutional Review Board for the Protection of Human Subjects. Inclusion criteria were:

- DSM-IV-TR (2000) diagnosis of Autistic Disorder or PDD-NOS as conferred by an experienced clinical team and confirmed by scores within the autism spectrum range on the *Autism Diagnostic Observation Scale –Module 1* (Lord et al. 2000) administered by highly trained clinicians;
- spontaneous expressive vocabulary by parent report of fewer than 15 words as measured by the *Communication and Symbolic Behavior Scales*-Caregiver Questionnaire (Wetherby and Prizant 2003)—73 % of the participants had fewer than 5 words reported—*and* fewer than 8 intelligible words produced during a 20-min clinician-child play observation *Communication and Symbolic Behavior Scales*-Behavioral Observation (Wetherby and Prizant 2003)—91 % produced fewer than 5 words;
- expressive language age-equivalent of less than 18 months as measured by the *Vineland Adaptive Behavior Scales*—II (VABS-II; Sparrow et al. 2005) Expressive Language subdomain;
- non-verbal mental age of at least 12 months as measured by the *Mullen Scales of Early Learning* (Mullen 1995), Visual Reception subdomain;
- generalized motor imitation, which for the purposes of this study, was defined as the ability to accurately imitate a repertoire of motor actions using the (Meltzoff 1988) motor imitation procedure.

Exclusionary criteria consisted of any uncorrected vision or hearing disability. Table 1 provides a description of participants at their entrance into the intervention program. One-way analysis of variance revealed no significant differences between the two treatment groups on any of these pretreatment variables.

Assessment Procedures

Pre-treatment Assessment

Each participant completed two, 2-h evaluations to ensure they met entrance criteria for the study and to collect information on their pre-treatment level of functioning. The following standardized measures were included:

I. *Mullen Scales of Early Learning* (Mullen 1995) was used to establish nonverbal cognitive level;
II. *The Autism Diagnostic Observation Schedule*—Module 1 (*ADOS*; Gotham et al. 2008) was used to confirm diagnosis of ASD;
III. *Communication and Symbolic Behavior Scales*—Developmental Profile (*CSBS*; Wetherby and Prizant 2003) was used to assess frequency and types of spontaneous words used, frequency of joint attentional communicative acts, and frequency of symbolic play behaviors.

Each participant completed a motor imitation assessment (Meltzoff 1988), which included imitation of actions with objects (e.g., shaking a rattle), gross motor imitation (e.g., stomping feet, tapping knees), fine motor imitation

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Table 1 Participant characteristics

Rapid motor imitation antecendent (RMIA) Tx			Milieu communication training (MCT) Tx		
Subject	Age	Gender	Subject	Age	Gender
007TS	5.90	Female	005TS	3.64	Male
015TS	4.08	Female	008TS	2.71	Male
020TS	5.47	Male	016TS	2.80	Female
033TS	3.66	Male	049TS	3.70	Male
036TS	6.15	Male	070TS	2.63	Male
043TS	4.76	Female	074TS	4.14	Male
046TS	3.44	Male	077TS	3.49	Male
060TS	3.53	Female	061TS	3.15	Male
076TS	4.76	Male	075TS	3.22	Male
081TS	2.40	Male	078TS	4.88	Male
			079TS	3.32	Male
			080TS	4.56	Male

(e.g., touching nose, touching mouth), and oral motor imitation (e.g., opening mouth, smiling, puckering). Standardized measures were administered by a speech-language pathologist and licensed clinical psychologist. In addition to direct observation measures, parents completed questionnaires including the *Vineland Adaptive Behavior Scales*-II (Sparrow et al. 2005), the *MacArthur-Bates Communicative Development Inventory* (Fenson, et al. 2007), the Caregiver Questionnaire of the *CSBS*, and a description of current and previous intervention. Parents were also videorecorded while engaged in a 10 min play session with their children with a standard set of toys (following Yoder and Warren 2002), and the percentage of parental acts responsive to the child's focus was computed.

Follow-up and Maintenance Assessments

Within 2 weeks of the completion of the 36 treatment sessions, each child was re-assessed, using the same procedures as for pre-treatment assessment, with the exception of the *Mullen,* which was not re-administered at this time. Three to 6 months following the end of treatment the entire assessment battery, including the *Mullen,* was re-administered. Assessors at Follow-up and Maintenance were blind to the treatment assignment of the participants, and were different from the clinicians delivering the intervention as well as from the examiners at the Pre-treatment Assessment.

Pre-treatment procedures

Based on the responses to the motor imitation probes during Pre-treatment Assessment, participants who had generalized motor imitation in their repertoire (as defined by performance of 60 % correct or better on the motor imitation probes) were randomly assigned to either MCT or RMIA treatment.

Participants who were unable to imitate 60 % of actions during the Pre-Treatment Assessment were provided with ten, 30-min training sessions on motor imitation in order to develop their generalized motor imitation repertoire. A standard DTT format was used to teach the participants to independently and accurately imitate motor actions, through gradual prompt fading and reinforcement procedures, within a specific inter-response time (1 s). The goal for this training procedure was to teach the child to imitate at least 6 different motor actions (three gross and three fine) in sequence within 6–8 s. Following this training, children who achieved this criterion in motor imitation were randomized to one of the two treatments; however five children who did not achieve the criterion for motor imitation were non-randomly assigned to the MCT group, resulting in a design for this study that is only quasi-experimental, rather than a standard randomized controlled trial. Figure 1 summarizes the in-take procedure for this study.

Treatment Procedures

Participants assigned to one of the two treatments received 36 45-min sessions over the course of 12 weeks with certified speech-language pathologist (SLP) specifically trained in RMIA by the third author and in MCT by the fourth (all clinicians were trained in both approaches, with periodic retraining throughout the course of the study). Fidelity of treatment was monitored by having the each treatment's trainer (third and fourth authors) code, via video recording, a randomly selected sample of 10 % of the treatment sessions (clinicians were blind to which sessions were being rated for fidelity). This procedure revealed an average of 96 % agreement between clinician and consultant as to the appropriateness of the clinician's response to child behaviors within our established criteria for fidelity with RMIA treatment; and 92 % for MCT.

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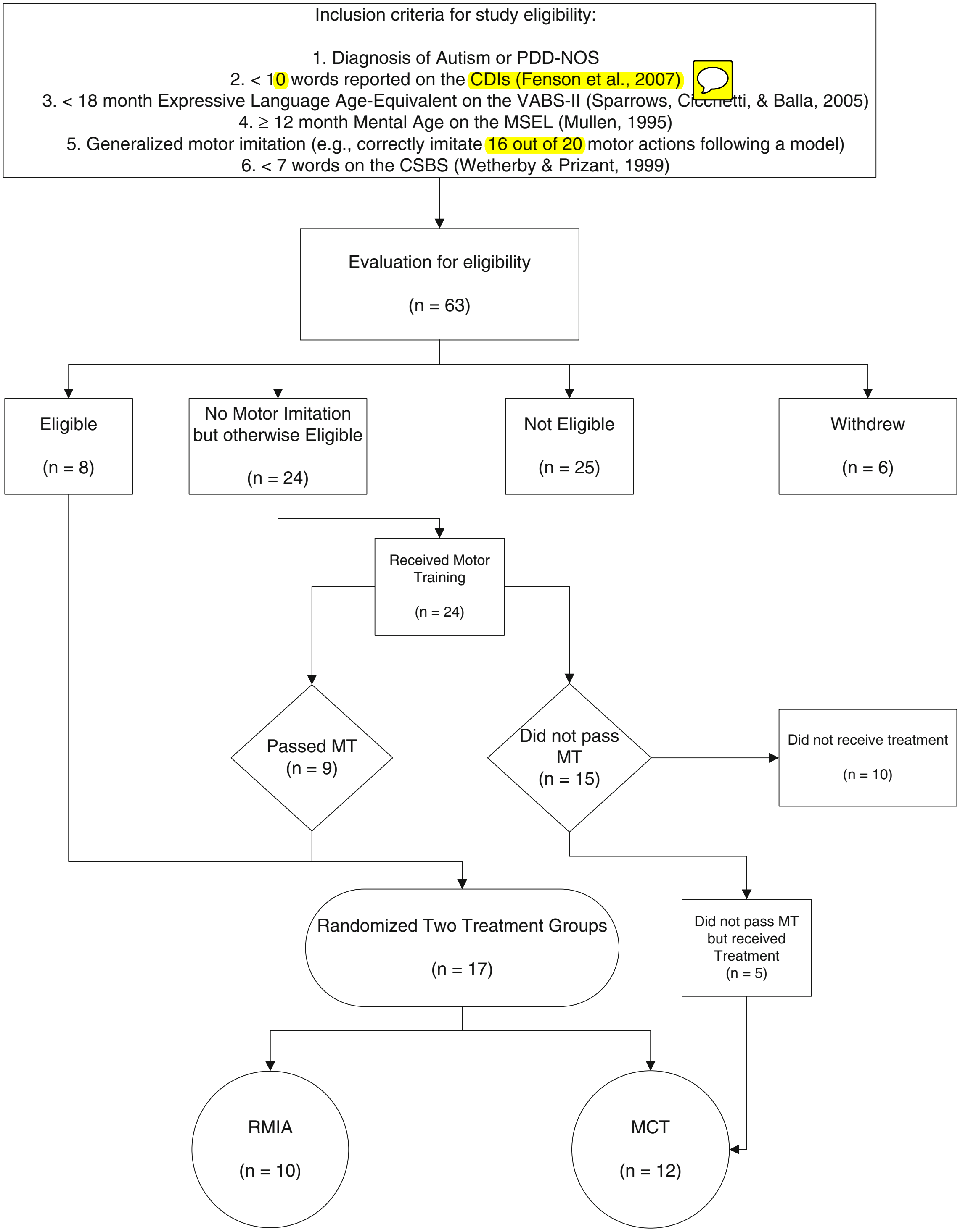

Fig. 1 Flow chart for study inclusion

RMIA training procedures

Preferred items used during treatment were selected individually for each participant, using a variation of the Multiple Stimulus Without Replacement Preference Assessment procedure (DeLeon and Iwata 1996) conducted before the onset of the study, as well as periodically throughout the intervention to ensure reinforcers remained powerful. The instructor obtained the participant's attention, then rapidly and randomly presented three large (hand and foot movements) and three small (pointing to parts of the face) motor actions with the antecedent, "Do this,"

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allowing the participant 1 s to respond to each action. The participant imitated actions one by one as they were presented. If the participant failed to imitate more than one action in the sequence within the 1 s. Time frame, the sequence was begun again. Immediately after the completion of the 6 motor actions, the instructor said the target word and displayed the target item (preferred items for requests and non-preferred for labels). The child was required to say the target word (or a predetermined approximation of the word, which was gradually shaped toward the target word through the course of the intervention) in order to receive the preferred item (for requests) or to receive a choice of two preferred items different from the target (for labels). Detailed descriptions of the RMIA procedures can be found in Tsiouri and Paul (2012).

Milieu Communication Training Procedures

During each session, the clinician attempted to establish play routines that were enjoyable and motivating to the child, and engineer the environment to include multiple motivating opportunities for the child to communicate, such as placing desired items in closed containers the child could not open without help, or requiring the indication of a choice between two playthings before access to any play objects was provided. When the child was highly motivated to communicate, clinicians attempted to stimulate initiating joint attention through time delay, and mand-modeling the use of recently learned communicative behaviors, focusing on spoken, rather than general communicative responses, and shaping earlier occurring communicative behaviors toward speech. More detailed description of the MCT can be found in Paul and Sutherland (2005), Warren and Yoder (1998), and Yoder and Stone (2006).

Parent Responsivity Training

To promote generalization of language learned in both clinician-delivered interventions provided in this study, procedures of Parent Responsiveness Training (Yoder and Warren 2002) were followed. At least one parent of each of the participants was required to attend 4, 2-h parent education classes. Parents completed the classes during the time their child was enrolled in treatment. Instruction was provided in the form of lecture, video, modeling and hands-on practice during class. Homework was assigned and then discussed during the next class. Parents were also provided with individual coaching. The purpose of the parent component was to guide parents to increase their use of responsive strategies to help their children engage in productive, interactive play with objects and to facilitate their children's communication and language development. It should be noted that Parent Responsivity Training, although an integral part of the treatment package provided in this study, cannot be considered an independent variable, since parents in both treatment groups received this training.

Results

Three sets of results are presented:

1. Descriptive statistics for average performance on several variables measuring language and communication before and after intervention for each treatment, with tests of differences before and after treatment within each group, and after treatment between the two treatment groups;
2. Proportions of children within each treatment group who met Tager-Flusberg et al.'s criteria (2009) for the attainment of functional spoken language after treatment;
3. An assessment of the effect of pre-treatment moderator variables on expressive language outcomes across the two treatments.

Changes Pre-Post Treatment

Table 2 presents the scores on variables collected immediately post-treatment (12 weeks following the pre-treatment assessment) and at the maintenance point (3–6 months following the post-treatment assessment). One-way Analysis of Variance (SPSS 19) revealed no significant differences between the two treatment groups' scores on any of the outcome variables at either the post-treatment or maintenance time point.

Paired t tests were then used to look for differences in our outcome variable of interest, spoken language output, between assessment time points within each treatment group. For the group that received RMIA, significantly more words were produced during the *CSBS* play session ($t = 2.9$ [9], $p < .02$, Cohen's (1988) $d = 1.7$ [very large]) and on the number of words said as reported by parents on the *CDI* ($t = 2.3$ [8], $p < .05$, Cohen's $d = 1.0$ [large]) at the post-treatment assessment relative to pre-treatment. There were no significant differences in these variables from post-treatment to the maintenance time point, but there was a significant difference between pre-treatment and maintenance for both CSBS ($t = 2.6$ [9], $p < .03$, Cohen's $d = .93$ [large]) and *CDI* ($t = 2.4$ [7], $p < .05$, Cohen's $d = 1.2$ [very large]) word counts. The same pattern of results was seen for the age-equivalent scores on the *Vineland Adaptive Behavior Scales* Expressive Language scale (pre-tx—post-tx: $t = 2.4$[8], $p < .04$, Cohen's $d = .82$ [large]; post-treatment—maintenance: NSD).

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Table 2 Description of participants at pre-treatment

Tx group	Mean (and SD) Age (yrs.)	% male	Mean (and SD) *Mullen* VR AE[1]	Mean (and SD) *VABS-II* EL AE[2]	Mean (and SD) *VABS-II* RL AE[3]	Mean (and SD) *CSBS*[4]: number of spoken words	Mean (and SD) reported words said on *CDI*[5]	Mean (and SD) number of joint attentional acts on *CSBS*	Mean (and SD) number of symbolic play acts on *CSBS*	Mean (and SD): % correctly imitated motor actions	% needing motor training	Mean (and SD) *ADOS-SA*[6]	Mean (and SD) PCI[7] %
RMIA	4.3 (1.2)	63.6	22.6 (4.6)	10.0 (4.8)	14.8 (8.2)	1.7 (2.3)	4.6 (5.7)	1.0 (1.3)	3.1 (3.9)	44.9 (28.2)	63.6	14.0 (3.8)	38.3 (15.7)
MCT	3.5 (0.8)	90.9	22.2 (5.6)	9.4 (0.6)	12.6 (8.6)	1.4 (2.2)	3.8 (3.6)	0.6 (0.9)	4.8 (4.2)	31.8 (30.7)	63.6	14.6 (3.9)	37.4 (19.3)

[1] *Mullen Scales of Early Learning* (Mullen 1995) Visual Reception Age-equivalent score (months)

[2] *Vineland Adaptive Behavior Scales-II* (Sparrow et al. 2005) Expressive Language Age-equivalent score (months)

[3] *Vineland Adaptive Behavior Scales-II* (Sparrow et al. 2005) Receptive Language Age-equivalent score (months)

[4] *Communication and Symbolic Behavior Scale-Developmental Profile* (Wetherby and Prizant 2003) Spoken Word (Type) Inventory during 20 min play session

[5] *MacArthur-Bates Communicative Development Inventory* (Fenson et al. 2007)

[6] *Autism Diagnostic Observation Scale-Module 1* (Lord et al. 2000) Social-Affective Algorithm score

[7] Parent-Child Interaction (Yoder and Warren 2002) percentage parents' responsive communication acts

Cohen (1988)

These data suggest that, on average, children who received RMIA produced more words and used more language in everyday situations after treatment than before, and these gains were maintained for at least 3–6 months.

Similar analyses were conducted for the children who received MCT. In this group, an analogous pattern of change was seen for the number of words produced on the CSBS (pre-tx- post tx: $t = 2.5[11]$, $p < .03$ (Cohen 1988) $d = .73$ [medium]; pre-tx—maintenance: $t = 2.5$ [7], $p < .04$, Cohen's $d = 1.2$ [very large]; post-tx-maintenance: NSD) and *CDI* (pre-tx- post tx: $t = 2.3[9]$, $p < .05$, Cohen's $d = .89$ [large]; pre-tx—maintenance: $t = 2.6$ [6], $p < .04$, Cohen's $d = 1.3$ [very large]; post-tx-maintenance: NSD). However, for the adaptive use of language on the *Vineland Adaptive Behavior Scales*-Expressive Language Scale none of the differences over time reached significance for the group receiving MCT. *CSBS* and *CDI* data are displayed in Figs. 2 and 3.

Proportion of Children Achieving Verbal Language Milestones

Tager-Flusberg et al. (2009) set out criteria for determining whether children with ASD undergoing an intervention for expressive language can be considered to have made progress from one broad stage of language development to the next. All children in the current study would be considered to be in the pre- or minimally verbal stage prior to intervention, producing infrequent communicative acts, using very few words, and no word combinations. All but one scored below 15 months on the Expressive Language Age Equivalent score of the *Vineland Adaptive Behavior Scales*

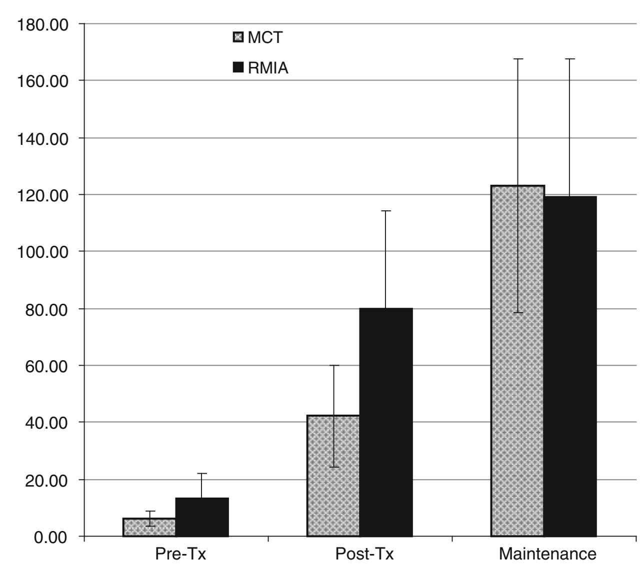

Fig. 2 Mean (and standard error) Number of words spoken by parent report on *CDI* (Fenson et al. 2007) at three time points

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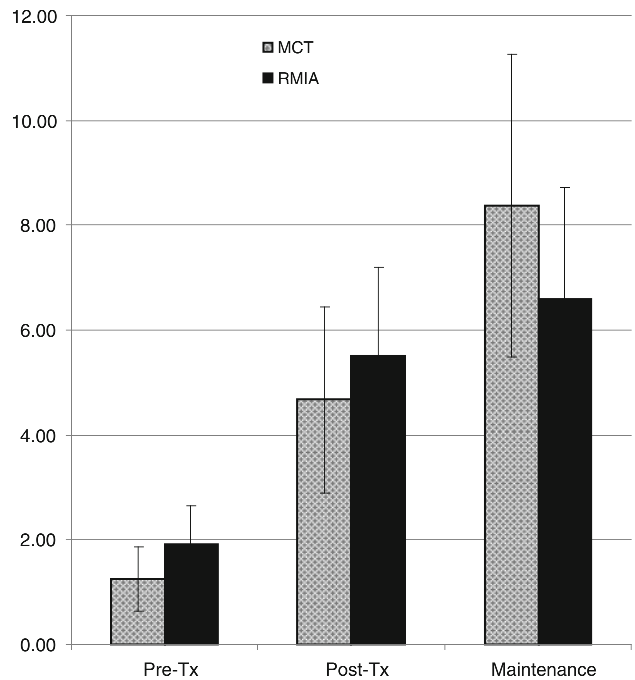

Fig. 3 Mean (and standard error) Number of words produced during *CSBS* Behavior Sample (Wetherby and Prizant 2003) at three time points

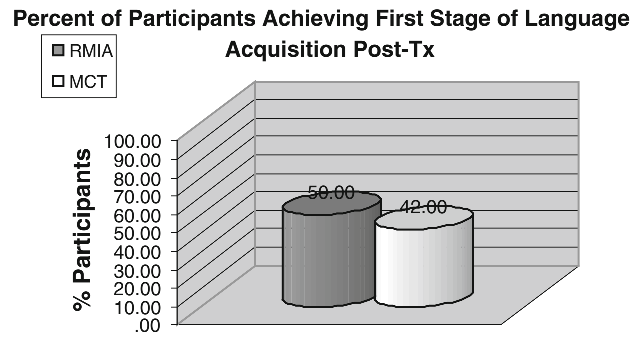

Fig. 4 Percent of participants in each treatment group who met Tager-Flusberg et al.'s (2009) criteria for first stage of language development at post-treatment

(one child scored at 18 months) before treatment. In order to be considered to have progressed to the next stage, that of first words, Tager-Flusberg et al. suggest the following criteria:

- Language age equivalent $\geq$ 15 months, or five different word types and 20 word tokens in spontaneous speech
- Production of consonant–vowel syllables, or production of 4 different consonants in spontaneous speech
- Expression of at least two different communication functions (e.g., request, comment, social interaction) with words in spontaneous speech.

We examined outcomes in the current study to determine how many participants in each group met these criteria. Five of the ten children who received RMIA met the benchmarks; all had *Vineland* Expressive Language Age-equivalents above 15 months (the child who started at 18 months achieved 30 months on this measure after 12 weeks of treatment), parent report of more than 35 words on the *CDI*; more than 7 different word types produced during a *CSBS* play session (all but one of the five were above 35 tokens), as well as expression of at least two different communicative intentions with words, and four different consonants used in CV syllables by the post-treatment assessment. All 5 retained or exceeded these levels at the maintenance assessment. For the group receiving MCT, 5 of the twelve children reached the benchmarks of *Vineland* Expressive Language Age-equivalents above 15 months, parent report of more than 20 words on the *CDI*; more than 5 different word types produced during a *CSBS* play session (all but one of the five were above 50 tokens), as well as expression of two different communicative intentions in words, and four different consonants used in CV syllables by the post-treatment assessment. Again, all 5 retained or exceeded these levels at the maintenance assessment. Figure 4 presents the percentage of participants in each group who achieved these milestones to acquire a basic form of functional spoken language after intervention.

Moderator Variable Analysis

To investigate possible moderating effects on response to treatment, we performed multivariate linear models in which *CDI* post-treatment was regressed on treatment group (represented as a dummy variable, with 0 = RMIA and 1 = MCT), a moderator covariate, and an interaction of treatment and moderator, using Preacher's calculator (Preacher et al. 2006; http://www.quantpsy.org/interact/mlr2.htm). The results of these analyses appear in Table 3. Examining these data suggests, first, that for all the purported moderators except age, the model provided a good fit to the data, as seen in the significant F statistics for these models. We then pursued further moderator analyses for the variables for which a good fit was attained.

When these variables—*Mullen* VR, EL and RL age-equivalent scores, Vineland EL and RL age-equivalent scores, % correct Motor Imitation, % parent responsiveness in Parent–Child Interaction, *CSBS* Joint Attention and Play—were used as moderators of treatment, only CSBS Joint Attention (JA) scores showed a main effect ($p < 01$). This effect suggests that children with higher JA pre-treatment scores pre-treatment did better than those with lower scores, regardless of which treatment was administered.

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Table 3 Outcome variables at post-treatment (Post-Tx) and maintenance (Maint.) time points

Treatment group	Mean (and SD) *Mullen* VR AE[1]		Mean (and SD) *VABS*-II EL AE[2]		Mean (and SD) *VABS*-II RL AE[3]		Mean (and SD) *CSBS*[4]: number of spoken words		Mean (and SD) *CDI*[5] number of spoken words by parent report	
	Post-Tx	Maint.	Post-Tx	Maint.	Post-Tx	Maint.	Post-Tx	Maint.	Post-Tx	Maint.
RMIA	*	30.0 (13.2)	1.2 (0.6)	1.6 (1.1)	1.3 (0.8)	1.7 (1.2)	5.1 (5.2)	6.6 (6.7)	88.6 (106.8)	119.3 (136.3)
MCT	*	30.5 (6.7)	1.1 (0.4)	3.0 (3.0)	1.4 (0.6)	3.4 (4.7)	5.0 (6.4)	8.4 (8.2)	75.1 (89.3)	121.1 (123.4)

[1] *Mullen Scales of Early Learning* (Mullen 1995) Visual Reception Age-equivalent score (months)

[2] *Vineland Adaptive Behavior Scales-II* (Sparrow et al. 2005) Expressive Language Age-equivalent score (months)

[3] *Vineland Adaptive Behavior Scales-II* (Sparrow et al. 2005) Receptive Language Age-equivalent score (months)

[4] *Communication and Symbolic Behavior Scale-Developmental Profile* (Wetherby and Prizant 2003) Spoken Word (Type) Inventory during 20 min. play session

[5] *MacArthur-Bates Communicative Development Inventory* (Fenson et al. 2007)

* Mullen data were not collected at Post-Treatment

Table 3 also shows that the interaction terms were not statistically significant for *Mullen* VR and EL, *Vineland* EL, % correct Motor Imitation, % parent responsiveness in Parent–Child Interaction, *CSBS* JA and Play, indicating that levels of these pre-treatment moderator variables did not affect the children's tendency to respond differentially to one of our two treatments or the other. For *Mullen* Receptive Language and *Vineland* Receptive Language age-equivalent scores, there were significant interaction effects in these analyses, at $p = 0.047$ and $p = 0.016$, respectively. To explore the interactions between these moderator variables and treatment response, we ran a Region of Significance (RoS) analysis (Bauer and Curran 2005, Preacher et al. 2006) to determine the range of values of the moderator for which the relationship between our *CDI* outcome and treatment was statistically significant. The *CDI*-treatment relationship for any given value of the moderator variable is described by the "simple intercept" and "simple slope," which are functions of the moderator that describe the effect of treatment on *CDI* for any particular value of the moderator; the region of significance is then defined to be the set of moderator values where the simple slope is significantly different from zero. These results are reported in Table 4.

The Region of Significance for *Mullen* Receptive Language was outside the interval from 0 to 18 months age-equivalent score, with a simple slope of -101.35 at the lower endpoint of this interval and 218.37 at the upper endpoint. Higher values of *Mullen* RL pre-treatment are thus correlated with a stronger response to treatment under MCT than under RMIA (because the simple slope is positive for these values), and lower values of *Mullen* RL are correlated with greater improvement under RMIA (because the simple slope is negative). For *Vineland* Receptive Language age-equivalent scores, the RoS was also outside the interval 0–18 months, with a simple slope of -173.19 at the lower endpoint and 77.91 at the upper endpoint. These values are consistent with the results for receptive language as measured by the *Mullen* and can be interpreted analogously. Moreover, together these results suggest that the cut-off score for deciding which treatment to employ is a receptive language age-equivalent of about 18 months; with those scoring lower more likely to succeed with RMIA while those scoring above an 18 month level likely to do better with MCT. Graphs of the RoS analyses for these moderator variables appear in Fig. 5.

Discussion

Results of this study suggest that, on average, minimally verbal preschoolers with ASD benefit from a relatively brief treatment package including parent responsivity training in conjunction with either

1. discrete trial treatment enhanced with a behavioral momentum component in the form of rapid motor imitation antecedent training (RMIA), or
2. milieu communication training (MCT) focused specifically on eliciting speech.

Gains made in these speech interventions were found to be maintained once the treatment concluded. Approximately half the children in each treatment group progressed from a classification of minimally verbal to the first stage of spoken language development as defined by Tager-Flusberg et al. (2009). This finding suggests that at least half of minimally verbal preschoolers like these with ASD do seem to have the capacity to acquire spoken language as a functional form of communication with focused intervention, strengthening the suggestion that this kind of intensive speech treatment should be provided during the preschool period (Tables 5 and 6).

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Table 4 Effect sizes of pair-wise comparisons across time points within treatment groups

Comparison	Cohen's d*	Effect Size descriptor[a]
Rapid motor imitation antecedent (RMIA) Tx		
CSBS[1]		
Pre-Post Tx[+]	1.7	Very large
Pre Tx-Maintenance[+]	.93	Large
Post *T*—Maintenance	.08	NS
CDI[2]		
Pre-Post Tx[+]	1.0	Large
Pre Tx-Maintenance[+]	1.2	Very large
Post Tx-Maintenance	.25	Small
VABS[3] expressive language		
Pre-Post Tx[+]	.82	Large
Pre Tx-Maintenance	.82	Large
Post Tx-Maintenance	.33	Small
Milieu communication training(MCT) Tx		
CSBS[1]		
Pre-Post Tx[+]	.73	Medium
Pre Tx-Maintenance[+]	1.2	Very large
Post Tx-Maintenance	.20	Small
CDI[2]		
Pre-Post Tx[+]	.89	Large
Pre Tx-Maintenance[+]	1.3	Very large
Post Tx-Maintenance[+]	.42	Small
VABS[3] expressive language		
Pre-Post Tx[+]	.64	Medium
Pre Tx-Maintenance[+]	.91	Large
Post Tx-Maintenance	.65	Medium

[a] Cohen (1988)

[+] Statistically significant difference ($p < .05$)

[1] *Communication and Symbolic behavior Scales-Developmental Profile* (Wetherby and Prizant 2003)

[2] *MacArthur-Bates Communicative Development Inventory* (Fenson et al. 2007)

[3] *Vineland Adaptive Behavior Scales-II* (Sparrow et al. 2005)

Our moderator analyses show, first, that children with better joint attention pre-treatment do better with either treatment than do those with very low joint attention. This finding supports others in the literature suggesting that language learning is mediated by joint attention (e.g., Mundy et al. 1990; Paul et al. 2008; Watt et al. 2006). In the context of the present study it suggests, further, that for minimally verbal children, those with some joint attention tend to respond to a treatment focused on eliciting spoken communication, particularly when it is combined with parent responsivity training. The frequency of joint attentional (JA) acts necessary to provide this mediation appears, in our data, to be quite low; 55 % of the participants in this sample showed NO JA during the *CSBS*. The 45 % who did produced between 1 and 4 JA acts during the 20 min *CSBS* behavior sample. Even this low level of JA initiation seems to enhance response to treatment focused on spoken language. Thus, any minimally verbal preschooler who shows some initiation of JA during a semi-structured play session would seem to be a good candidate for some focused intervention to elicit spoken communication.

Our analyses also suggest that the level of pre-treatment receptive language skill, as measured either directly on the *Mullen* or by parent report on the *Vineland*, moderates response to these two treatments differentially. Children who start out with relatively strong receptive skills do better in with MCT treatment; those who start out with relative lower receptive skills do better with RMIA. MCT treatment may work better for these relatively good comprehenders because they are more able to deduce linguistic information from relatively natural play-based interactions in which words and referents are saliently matched. The children with low receptive skills may do better in RMIA because the less natural, more intensely structured DTT interactions require less deductive ability and provides fewer stimuli to distract the child from the word referent relations being presented. The Region of Significance finding suggests that a receptive language level of about 18 months is necessary to derive most benefit from MCT; children with less receptive language, at least those who can be taught to produce motor imitation, may do better with RMIA.

Clinical Implications

As we have seen, both these treatments had positive effects, on average, for the severely impaired minimally verbal preschoolers in this study, and we were able to identify two elements to assist clinicians in matching children to treatments. That is, the study suggests that minimally verbal preschoolers with ASD with nonverbal levels above 12 months who show some, even very limited, expression of joint attention pretreatment are more likely to respond to a speech-focused treatment than those who do not. We would argue that any child meeting these criteria should receive an intensive speech-focused treatment, in addition to any transitional AAC program implemented, in order to maximize the child's opportunity to acquire spoken language during this critical preschool period. Children with virtually no joint attentional behaviors are less likely to respond to speech-focused treatment and may derive more benefit from an approach focused more intensely on AAC. Second, for children for whom speech-focused treatment appears indicated, those with receptive language scores above 18 months may do better with MCT, while those with lower levels of receptive language who are able to master motor imitation can be tried with RMIA. Our

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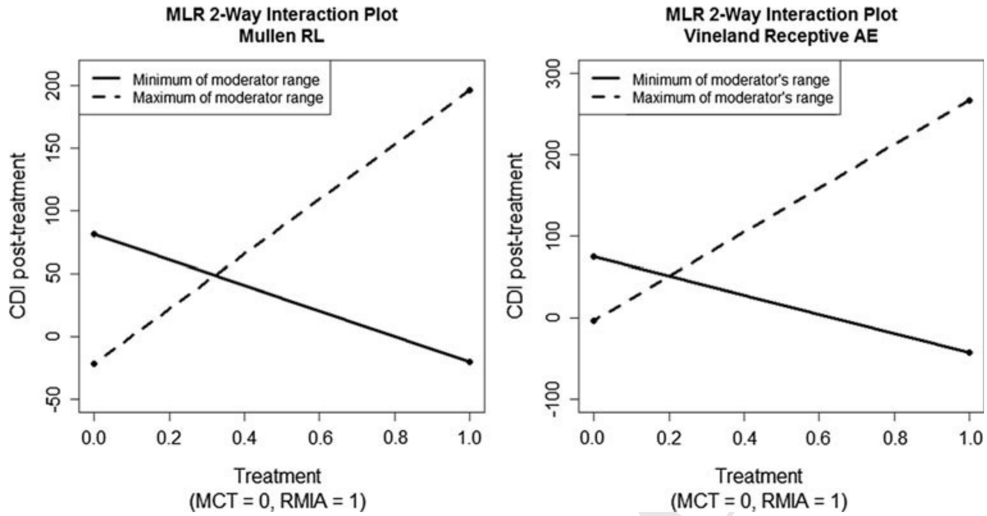

Fig. 5 *Plots* of the interaction effect of moderator variable and treatment on *CDI* post-treatment. The *plot* on the *left* shows the effect when the moderator variable is *Mullen* Receptive Language; the *plot* on the *right* is for *Vineland* Receptive AE score. For both *plots*, the *solid line* compares *CDI* post-treatment between the two treatments (MCT = 0, RMIA = 1) at the *lower end* of the moderator variable's range, and the *dashed line* depicts the same for the *upper end* of the moderator's range

Table 5 Results of regression analyses

Moderator variable	R^2	F statistic for model fit	Intercept	Main effect of treatment	Main effect of moderator	Tx-Moderator interaction
Age	.414	2.821	49.573	38.041	14.468	−32.288
Mullen VR	.510	4.158*	44.096	26.822	6.777	1.290
Mullen RL	.544	4.764**	38.812	29.976	−3.810	11.842*
Mullen EL	.668	8.035***	59.814*	−2.704	9.422	3.363
Vineland receptive AE	.621	6.154**	43.756	34.028	−26.634	132.535*
Vineland expressive AE	.478	3.429*	46.795	16.543	12.035	129.264
CSBS joint attention	.800	16.03***	51.150**	23.756	48.340*	20.763
CSBS play	.652	7.500***	34.600	57.257	8.000	8.751
Motor skills	.567	5.228**	49.775*	22.305	1.441	0.255
PCI resp.	.525	3.868*	45.681	44.608	−1.560	3.838

[1] parent report of expressive vocabulary size on the *MacArthur-Bates Communicative Development Inventory* (Fenson et al. 2007)

* Significance at the 0.05 level

** Significance at the 0.01 level

*** Significance at the 0.001 level

For each moderator variable, a linear regression model was fit with treatment (0 = MCT, 1 = RMIA), moderator, and treatment-moderator interaction as predictors and *CDI*[1] post-treatment as response. Moderator variables for which the interaction term's *p* value was less than 0.05 were investigated further using Region of Significance analysis

Table 6 Results of the Region of Significance analysis for moderators whose interaction with treatment is statistically significant

Moderator	Region of significance		Simple intercept at minimum	Simple slope at minimum	Simple intercept at maximum	Simple slope at maximum
	Minimum	Maximum				
Mullen RL	−158.10	5.60	81.07	−101.35	−21.81	218.38
Vineland receptive AE	5 months	17.6 months	74.12	−117.06	−3.65	269.94

For both measures, the region of significance is outside the interval

results suggest that 3-5 sessions per week for 3-6 months is a sufficient time frame to determine whether a child is responding to a treatment. It is always possible to try a second approach if an intensive trial of the first does not work, but these guidelines can be helpful in chosing an initial program for young children with ASD.

Apart from the guidance in choosing intervention approaches provided by this study, we believe it has a

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second set of implications. This study was motivated in part by a concern on our part that too many preschoolers with ASD who did not spontaneously acquire spoken communication were being assigned to augmentative and alternative modes of communication (AAC) approaches without a concentrated effort to elicit functional speech. We do not debate the value of AAC for many children with severe speech impairments, nor do we argue against the use of AAC as a transitional modality for young children with ASD or as a primary modality for older children who have not acquired speech. But we do believe that the unique learning challenges seen in ASD may constitute a special case when it comes to providing communicative opportunities for minimally verbal young children. That is, the deficits that are unique to early communication in ASD, including low level of social motivation inherent in the autistic syndrome, reduced attention to child-directed speech (Paul et al. 2007), immaturity of speech motor development (Gernsbacher et al. 2008), reduced engagement in reciprocal babbling (Paul et al. 2011), an inability to use gaze cues to discern the relations between a speaker's words and their intended referents (Baron-Cohen et al. 1997) and generally poor imitation skills (Rogers et al. 2005) may lead, in some children, to lack of sufficient attention to others' verbal output and motor speech patterns along with fewer attempts to use these patterns for communicative purposes. These conditions can result in a child's both trying less often and therefore getting less practice in articulating speech and tending to rely on less precise vocalizations and gestures for the few attempts that are made. If this view is correct, then intervention that actively focused attention on speech production and enabled the child to learn through intensive guided practice to produce a few accurate word forms, combined with parent training to provide distributed opportunities for the child to observe the connections between words and their referents in affectively engaging settings, may be enough to "turn on" the speech learning process, which may help explain why for the children in this study who responded to treatment, they tended to go on to acquire words that were not explicitly taught in the intervention (See Tsiouri et al. 2012 for details). We have referred to this process as a ''speech insight,'' which could, in the context of responsive parent interactions, lead not only to the use of newly learned words in generalized settings, but to an expansion of word use beyond those taught in the intervention, as the child begins to ''tune in'' to words in the environment, to see their connections to pleasing objects and activities through responsive parent interactions, and to use newly gained vocal output skills to practice and refine more word productions.

All this suggests that, for minimally verbal children with ASD, it may not be speech motor difficulty that obstructs the acquisition of useful speech, as some have suggested (e.g., Gernsbacher et al. 2008; Velleman et al. 2009). It may be, rather, the failure to seek out opportunities for reciprocal interactions mediated by vocal and verbal exchanges, to "tune in" to speech models, and to "tune up" production through emulation of significant others and extensive practice in myriad playful interactions. This "speech attunement" framework has been supported in several studies of early speech development in young children with ASD carried out in our laboratories (Schoen et al. 2009, 2011; Shriberg et al. 2011), which suggest that when young children with ASD learn to speak, their speech skills are commensurate with and driven by their language abilities and they show no evidence of apraxic or speech motor disorders in their verbal productions.

We would suggest, then, that the results of the current study should encourage clinicians to provide intensive, speech-focused intervention for minimally verbal preschoolers with ASD who show at least a modicum of joint attention behavior. For those with low receptive language and the capacity to learn motor imitation, RMIA may be a good choice as an initial intervention approach. For those with better receptive language but otherwise limited spoken output, MCT may be the more appropriate option. For those children without joint attention behaviors, a focus on AAC modalities should be accompanied by attempts to elicit the initiation of joint attention. When such behaviors do begin to emerge, it would make sense to attempt speech-focused treatment at that point in time.

We believe our results also argue for including training in parent responsiveness as an accompaniment (not a substitute) to clinician-delivered intervention. We believe for these severely involved preschoolers, direct, focused treatment—which requires carefully shaping vocal behavior into intelligible speech, choosing words to introduce that are within the child's phonological zone of proximal development, and withholding reinforcement when targets are not accurately met—necessitates the skill of a trained intervention agent. However, we also believe that expanding upon the gains made in these clinician-delivered sessions, by providing multiple opportunities for practice of spoken communication in an enjoyable interaction with highly positive affective valence with greatly enhance the effect of the clinician-delivered intervention. Although pretreatment parent responsiveness did not moderate treatment in our study, perhaps due to the small sample size, Aldred et al. (2012) recently reported that when parent responsiveness to children with ASD improved, children were more likely to show a positive effect of communication intervention. This finding supports our intuition that providing parent responsiveness training within our intervention packages led to greater improvement in children's response to the clinician-delivered treatment.

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Limitations and Future Research

A primary limitation of the current study was the small sample size. The strict entry criteria, involving very limited spoken language in conjunction with at least a 12 month level in nonverbal cognition, as well as the logistical difficulties of providing an intervention that required clinic attendance in addition to the child's ongoing school program, made recruitment difficult. The power to find differences in outcomes between the two treatments, as well as to identify moderators of response was thus limited. Future research with larger samples may enable more precise information about moderators that assist in matching children to specific treatment approaches. A second limitation was the decision to assign children non-randomly to the MCT condition if they could not master the motor imitation skills necessary for RMIA treatment. This resulted in our inability to use a completely randomized design, which limits the generalizability of the findings. Despite this difficulty, we believe that comparisons of differing treatment methods, including contrasting DTT methods with more naturalistic approaches, is an essential element of treatment research. Without such direct comparisons, more effective matching of children to treatments will not be feasible.

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