2012

Enhancing the Application and Evaluation of a Discrete Trial Intervention Package for Eliciting First Words in Preverbal Preschoolers with ASD

Ioanna Tsiouri
Larisa University Hospital, Greece

Elizabeth Schoen Simmons
Yale University

Rhea Paul
Sacred Heart University, paulr4@sacredheart.edu

Recommended Citation

Tsiouri, Ioanna, Elizabeth Schoen Simmons, and Rhea Paul. "Enhancing the Application and Evaluation of a Discrete Trial Intervention Package for Eliciting First Words in Preverbal Preschoolers with ASD." *Journal of Autism and Developmental Disorders* 42:7 (2012), 1281-1293.

J Autism Dev Disord
DOI 10.1007/s10803-011-1358-y

ORIGINAL PAPER

Enhancing the Application and Evaluation of a Discrete Trial Intervention Package for Eliciting First Words in Preverbal Preschoolers with ASD

Ioanna Tsiouri · Elizabeth Schoen Simmons · Rhea Paul

Abstract This study evaluates the effectiveness of an intervention package including a discrete trial program (Rapid Motor Imitation Antecedent Training (Tsiouri and Greer, J Behav Educat 12:185–206, 2003) combined with parent education for eliciting first words in children with ASD who had little or no spoken language. Evaluation of the approach includes specific intervention targets and functional spoken language outcomes (Tager-Flusberg et al., J Speech Lang Hear Res 52:643–652, 2009). Results suggest that RMIA, with parent training, catalyzes development of verbal imitation and production for some children. Three of five participants acquired word production within the DTT framework and achieved milestones of early functional spoken language use (Tager-Flusberg et al., J Speech Lang Hear Res 52:643–652, 2009). The implications of these findings for understanding the role of discrete trial approaches to language intervention are discussed.

Keywords Speech · Imitation · Intervention · ABA · Discrete trial training

I. Tsiouri
Department of Psychiatry, University Hospital of Larissa, Larissa, Greece

E. Schoen Simmons (✉) · R. Paul
Child Study Center, Yale University, 40 Temple Street, Suite 7D, New Haven, CT 06510, USA
e-mail: elizabeth.schoen@yale.edu

R. Paul
e-mail: rhea.paul@yale.edu

Published online: 15 September 2011

Introduction

Children with autism spectrum disorder (ASD) are almost universally delayed in the acquisition of spoken language. Until recently, 40–50% were reportedly unable to use speech as a primary means of communication (Tager-Flusberg et al. 2005), although this proportion is reported to have decreased to 20–30% (Rogers 2006) in the past 5 years. Despite this positive development, 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).

A variety of intervention approaches have been applied to eliciting first spoken words in preverbal children with ASD (See Rogers 2006; Paul 2008; Prelock et al. 2011, for review). One method that has a strong evidence base for eliciting first words from these children is Discrete Trial Training (DTT). This method, first employed by (Lovaas 1987) with this population, makes use of the Skinnerian principles of operant learning and his functional account of language (Skinner 1957), using highly structured, drill-like activities which involve shaping, prompting, prompt fading, and tangible reinforcement strategies.

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; Owens 2009; Norris and Hoffman 1993), particularly for the development of communication skills, due primarily to the fact that gains made often fail to generalize outside the training setting, and may not be maintained by the ordinary contingencies of daily life, when tangible reinforcement is removed (Stokes and Baer 1977). Smith (2001) has emphasized the need to enhance outcomes of DTT by providing generalization training to ensure new behaviors become integrated into natural environments. Although there are a variety of approaches to training for generalization (e.g., Costello 1983; Horner et al. 1988; Stokes et al. 1974), the employment of parents as agents of generalization for young children has both intuitive appeal and has received some support in the literature (e.g., Kashinath et al. 2006; Yoder and Warren 2002).

These facts led us to develop an intervention package that would take advantage of the demonstrated efficacy of DTT in eliciting first words and combine it with a naturalistic approach to enhance generalization and maintenance of newly learned skills. Yoder and Warren (2002) had demonstrated that a naturalistic communication intervention approach, combined with training parents to provide responsive interactions in the home setting, was effective in improving and generalizing communication and language when delivered to young children with developmental disabilities. We aimed to enhance the known efficacy of DTT for eliciting first words with Yoder and Warren's Parent Responsivity Training in order to achieve greater generalization than is typically seen in DTT programs. In this way, we aimed to capitalize on the advantages of DTT, while mitigating its disadvantages by building generalization training into the child's intervention experience. Thus we created an intervention package that included clinician-delivered DTT intervention as well as Yoder and Warren's Parent Responsivity Training (PRT) program.

An additional enhancement was made to standard DTT intervention for first words. Many children with ASD experience inordinate difficulty in imitating vocal and verbal stimuli (Rogers et al. 2005), making the first step to word production, the imitation of vocal stimuli, extremely difficult to achieve. Nevin et al. (1983) used the term *behavioral momentum* to describe the resistance of behavior to a change or to reinforcement conditions. 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. They 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. In general, behavioral momentum supports the notion that if children could produce a rapid series of easy behaviors, and were then asked to follow these with a more difficult one, the difficult new behavior could be catalyzed by the momentum of compliance with the earlier, easy behaviors.

Tsiouri and Greer (2003) developed an instructional strategy for eliciting first words in children with ASD that incorporates this notion of behavioral momentum. Their procedure, developed by Williams and Greer (1993), 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. Tsiouri and Greer's (2003) Rapid Motor Imitation Antecedent procedure (RMIA), involves teaching the child to imitate a series of fairly easy motor actions in rapid succession. Once rapid motor imitation is established, the child is asked to imitate a vocal antecedent (word) that functions as a request or label immediately after the correct imitation of motor actions. The child must produce the motor sequence, then imitate the word in order to gain access to a preferred item (for requests) or have access to a choice of preferred items paired with social praise (for labels). Tsiouri and Greer (2003) were able to show, in a published case series, that this momentum did, in fact, lead to production of first words in preverbal preschoolers with ASD.

Thus, the package of intervention developed for this study included a clinician-delivered DTT program enhanced with both a behavioral momentum (rapid motor imitation) component, to help children acquire the vocal/verbal imitation skills necessary for speech acquisition, as well as with a Parent Responsivity Training component aimed at assisting with generalization and maintenance of verbal gains.

The testing of the efficacy of this package of intervention was designed not only to assess the value of these enhancements to basic DTT. It was also aimed at illuminating some of the processes that lead to prolonged preverbal status in this population. Some researchers (Gernsbacher et al. 2008; Rogers et al. 2006) have attributed difficulty in acquiring spoken language in ASD to an apraxic deficit, perhaps mediated by the mirror neuron system which recent research (Perkins et al. 2010) has suggested is dysfunctional in individuals with ASD. However, an alternative impediment to speech development has been suggested (Paul et al. 2008; Shriberg et al. 2011). In this view, referred to by Shriberg et al. (2011) as the "speech attunement" position, children with ASD may experience insufficient opportunities to focus on and practice the development of articulatory-motor patterns with adequate motivation and feedback to allow the acquisition of automatized motor schemes for word production. That is, the low level of social motivation inherent in the autistic syndrome combined with reduced attention to child-directed speech (Paul et al. 2007), immaturity of speech motor development (Gernsbacher et al. 2008), and generally poor imitation skills (Rogers et al. 2005) may lead, in some children, to lack of sufficient attention to others' speech and consequent limited and frustratingly unsuccessful attempts to emulate ambient language forms. If this view is correct, then an intervention that enabled the child to learn through intensive guided practice to produce a few articulatorily accurate word forms, combined with parent training to provide distributed opportunities to observe the connections between words and their referents in affectively engaging settings, could lead to a "speech insight." That is, a child who was previously unable to pronounce words easily as a result of generalized motor and imitation delay, who was inattentive to speech and unable to use gaze cues to discern the relations between a speaker's words and their intended referents (Baron-Cohen et al. 1997), and who was generally less interested in interactions with caregivers and therefore experienced sub-optimal frequency and quality of interactions, might, once the ability to connect referents with his own articulations was established through DTT training, understand rather suddenly that pronounced words stand for things. This "speech insight" could, in the context of responsive parent interactions, lead not only to the use of new 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 articulatory motor skills to practice and refine more word productions. If this scenario were the case, we would predict that once children learned to say some words in the DTT program, they would not only generalize those words, but would acquire other words more rapidly, and use them more frequently and functionally.

One way to test this hypothesis is to employ the criteria set out by Tager-Flusberg et al. (2009) for evaluating whether intervention programs for speech communication achieve specified levels of functional language. Their system employs broad stages of communicative development, as defined by not only the number of words in the child's expressive vocabulary, but also by the degree to which these words are used spontaneously for multiple communicative purposes, are intelligible, and show adequate levels of frequency of use and expansion toward multi-word production to correspond to levels seen in typical development. If a "speech insight" were emerging as a result of this intervention package, we could expect to see broader changes in participants' functional communication than simply the generalization of the specific words taught in the program.

Method

Participants

The first five participants to complete RMIA treatment as part of a larger randomized controlled trial contrasting two interventions for the elicitation of first words in preverbal children with ASD (Paul 2009) served as subjects for the present report. Their ages were three to 6 years. They 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: a DSM-IV-TR (American Psychiatric Association 2000) diagnosis of Autistic Disorder or PDD-NOS, spontaneous expressive vocabulary by parent report of fewer than 10 words as measured by the *MacArthur-Bates Communicative Development Inventories* (CDIs; Fenson et al. 2007) and fewer than 10 words produced during a 20-min clinician-child play observation (*Communication and Symbolic Behavior Scales* Behavioral Observation, Wetherby and Prizant 2003), an 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, a non-verbal mental age of at least 12 months as measured by the *Mullen Scales of Early Learning* (MSEL; Mullen 1995) Visual Reception subdomain, and generalized motor imitation, which for the purposes of this study, was defined as the ability to accurately imitate a repertoire of motor actions, following an examiner's model. Exclusionary criteria consisted of any uncorrected vision or hearing disability. Table 1 provides a description of participants at their entrance into the intervention program.

Assessment Procedures

Pre-Treatment Assessment

Each participant completed two, 2-h evaluations to ensure they met entrance criteria for the study and to collect

Table 1 Description of participants

Participant number	Chronological age (years: months) at eligibility assessment	Gender	Measure (during eligibility assessment)			Motor assessment: % correctly imitated actions	Required motor training
			MSEL visual reception AE[a]	VABS-II expressive language AE[a]	CSBS: number of spoken words		
07TS	5: 11	F	25	9	1	64	No
15TS	4: 1	F	25	10	2	60	No
20TS	5: 6	M	31	12	7[b]	94	No
33TS	3: 8	M	16	10	4	14	Yes
36TS	6: 2	M	26	7	1	43	Yes

[a] Age equivalent in months

[b] "Words" produced by subject #20 were completely unintelligible, and counted only because parents provided interpretation. It was not clear to examiners whether these were true word approximations or merely vocalizations

information on their pre-treatment level of functioning. The following standardized measures were included:

I. *Mullen Scales of Early Learning* (MSEL; Mullen 1995) was used to establish nonverbal cognitive level;
II. *The Autism Diagnostic Observation Schedule*—Module 1 (ADOS; Gotham et al. 2007) was used to confirm diagnosis of ASD;
III. *Communication and Symbolic Behavior Scales*—Developmental Profile (CSBS; Wetherby and Prizant 2003) was used to assess spontaneous communication and word use.

Each participant also 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 (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 *VABS*-II (Sparrow et al. 2005), the *CDIs* (Fenson et al. 2007) and a description of current and previous intervention.

Follow-Up and Maintenance Assessments

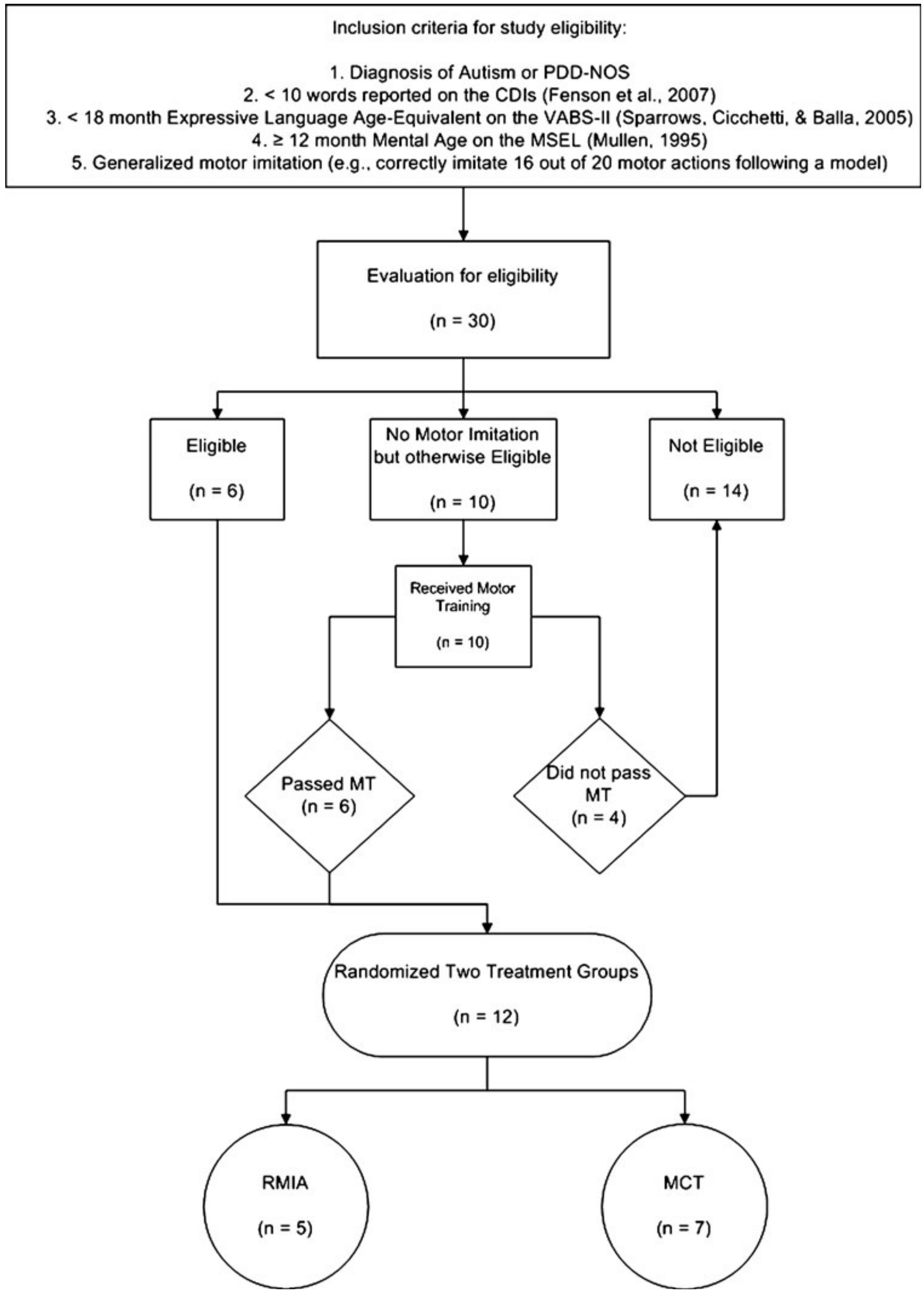
Within 2 weeks of the completion of the 36 RMIA treatment sessions, each child was re-assessed, using the same procedures as for pre-treatment assessment, with the exception of the *MSEL,* which was not re-administered at this time. Six months following the end of RMIA treatment the entire assessment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

Pre-Treatment Procedures (Motor Imitation Training)

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) proceeded to motor imitation timings to assess their rate of performance. Based on Tsiouri and Greer (2003), timings were repeated until the participant could produce 28 motor actions per minute and could perform three gross and three fine motor actions consistently within 6–8 s.

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. Two of the participants reported on here (33 and 36) required this motor training. Standard discrete trial training format was used to teach the two 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 or to reach the fluency rate criterion of 28 actions per minute. If 10 training sessions had elapsed without achieving this level of performance the participant was excluded from the study. The five children reported here all achieved this level of motor imitation, 3 without motor training, and 2 following 10 sessions of motor training. However, it should be noted that there were children who otherwise met criteria for inclusion in the study but were not able to achieve generalized motor imitation within 10 training sessions who were excluded from participation. Figure 1 summarizes the in-take procedure for this study.

Fig. 1 Flowchart of study in-take process



Treatment Procedures

Setting and Materials

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.

Dependent variables were defined as per Skinner's (1957) functional analysis of language:

I. *Echoic requests*: words or word approximations that the participants emitted when the researcher presented an echoic model, in the presence of a highly preferred item from which the participant had previously been deprived.

II. *Independent requests*: words or word approximations that the participants emitted spontaneously this time, in the presence of the same highly preferred item from which they had previously been deprived.
III. *Echoic labels*: words or word approximations that the participant emitted when the researcher presented an echoic model, in the presence of a non-preferred item.
IV. *Independent labels*: words or word approximations that the participants emitted spontaneously in the presence of a non-preferred item.

In addition, dependent variables not directly linked to the experimental design of the study were used to assess the production of words in natural settings at the follow-up and maintenance assessments, during the CSBS observational sample, as well as overall expressive vocabulary size as reported by parents on the CDI.

Rapid Motor Imitation Antecedent (RMIA)

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," 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).

When two consecutive correct echoic productions of the instructor's verbal model were emitted by the participant, the rapid motor imitation antecedent was removed, and the instructor presented only the verbal model with the corresponding preferred or non preferred item. When five consecutive correct echoic responses to a verbal model alone were produced by the child, the instructor presented the item for the child to request or label independently, without a verbal model. When children produced an intelligible request or label in 10 consecutive trials correctly independently without a verbal model, the word was considered "mastered." If at any stage the participant failed to produce a correct response twice in a row, the instructor returned to the previous level of the treatment (see Fig. 2). Instructors tracked each response (or lack of response) to each proffered opportunity throughout the intervention. Figure 2 outlines the RMIA procedure (based on Tsiouri and Greer 2003; Williams and Greer 1993).

Each participant received 36, 50-min sessions of RMIA instruction provided by a certified speech-language

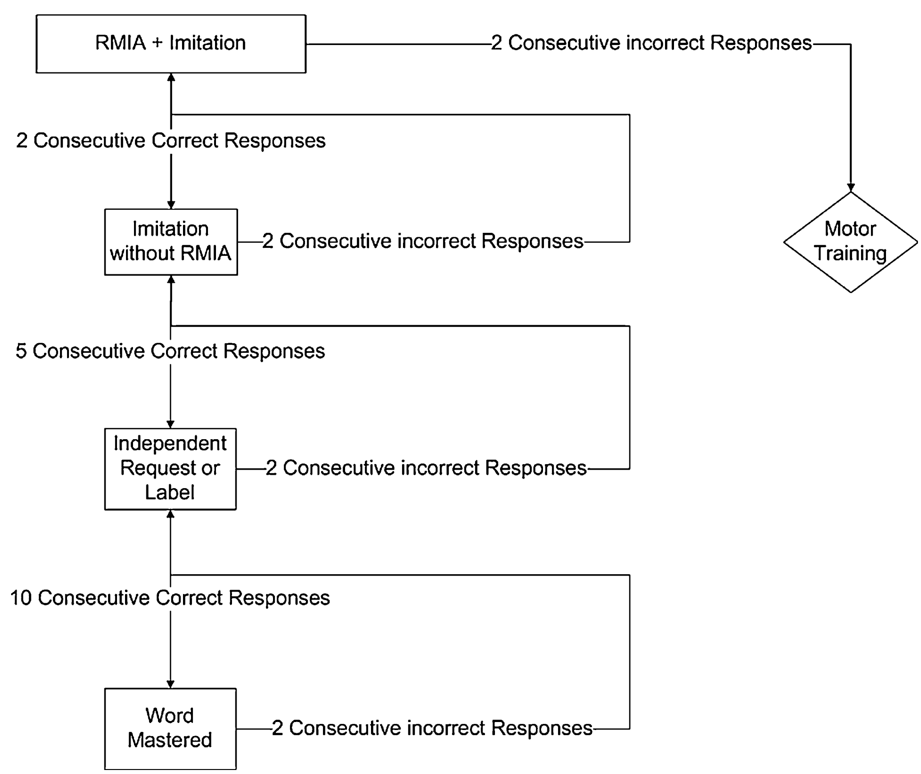


Fig. 2 RMIA treatment procedure flowchart

pathologist with intensive training in RMIA procedures provided by the first author.

Parent Responsivity Training

To promote generalization of language learned in the highly structured intervention 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. 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. Parent Responsivity Training (PRT) was not directly linked to the experimental design, since parents received training independent of whether the child was under baseline or treatment conditions for RMIA treatment; nor was there a contrasting condition in which PRT was not administered.

Treatment Fidelity Monitoring

Fidelity of treatment was monitored by having the first author code a randomly selected sample of 20% of the RMIA sessions of each participant. This procedure revealed an average of 96% inter-rater agreement with both stimulus presentation and response coding across participants (range of agreement: 86–100%).

Experimental Design and Procedures

Two sets of data were recorded for each participant, one across all requests and one across all labels taught. In addition, data were collected at Baseline, Treatment, and Post-treatment for each word taught for each participant. Each request or label form was initially taught through standard DTT procedures (Baseline). Then during treatment, RMIA was added to standard DTT and during post-treatment standard DTT procedures alone were reintroduced. Before going into details regarding the procedures for each experimental condition we feel obliged to make a few comments regarding the adequacy of the experimental control of the designs that were applied.

Typically, in a multiple baseline across-behaviors design, behaviors are measured over time to provide baselines against which changes from the staggered introduction of the independent variable to each of the behaviors measured can be evaluated. Therefore, introducing the independent variable to one of the behaviors and producing maximum change to this behavior against the other behaviors that are under baseline condition is the way to demonstrate adequate experimental control. To achieve this type of experimental control, longer baseline sessions need to be collected in order for the independent variable to be gradually introduced to each behavior and demonstrate maximum change against the rest of the behaviors that remain under baseline conditions. In our case, baseline assessment was conducted in order to assess whether the participants had already achieved production of the target word (request or label) in their repertoire. However, since the participants did not have vocal-verbal imitation in their repertoire there were a lot of behavior management issues during baseline because of incorrect responses. Although the authors were aware of the need to conduct longer baseline sessions for each word taught, it was decided to limit the baseline sessions to one or two 20 trial sessions for each word, for ethical purposes, to avoid the participant's frustration and the frequent behavioral problems that baseline conditions can create. The authors are aware of the limitations that this poses in terms of experimental control and therefore do not claim to have conducted a standard multiple baseline experimental design. However, we believe the replication of the Baseline/Treatment/Post-treatment design across many different words taught provides evidence of the efficacy of the RMIA treatment despite the limited baseline data collected. Nonetheless, we will treat these data primarily as series of a single-subject design, given the limited experimental control imposed by the logistics of the present study.

Results

Participants' Performance in RMIA Treatment

Table 2 summarizes study results, displaying number of correct responses per number of opportunities (and percentages) for echoic and independent requests and labels in each experimental condition for each participant. Figure 3 illustrates the percentage of correct echoic and independent labels and requests for each participant across treatment conditions (Typically data on multiple baselines are presented with line graphs, but because of the nature of the RMIA treatment, instructional opportunities for echoic and independent requests and labels could not be kept the same across sessions, since they were "child driven" depending on their correct responses. For this reason bar graphs were chosen to help the reader better understand the progress made by the participants). The number of opportunities and correct responses for echoic and independent requests and labels for each word taught to each of the five participants are available upon request.

Table 2 Summary of results: number of correct responses/number of opportunities (and percentage) in each instructional condition at each time point for each participant

Participant number	Requests taught (Mastered)	Labels taught (Mastered)	Time point	Instructional condition			
				Echoic requests	Independent requests	Echoic labels	Independent labels
7	10 (4)	4 (3)	Baseline	5/200 (2%)	3/200 (1%)	0/80 (0%)	0/80 (0%)
			Treatment	360/569 (63%)	81/118 (91%)	275/399 (78%)	100/146 (69%)
			Post-treatment[a]	23/27 (87%)	44/58 (79%)	35/48 (58%)	41/54 (85%)
15	13 (6)	11 (10)	Baseline	56/340 (16%)	10/340 (2%)	26/220 (11%)	3/220 (1%)
			Treatment	955/1054 (90%)	298/615 (50%)	538/603 (89%)	225/351 (64%)
			Post-treatment[a]	30/30 (100%)	51/57 (89%)	39/40 (97%)	90/100 (90%)
20	21 (20)	12 (9)	Baseline	57/480 (11%)	6/480 (1%)	10/240 (4%)	0/240 (0%)
			Treatment	755/1041 (72%)	403/469 (85%)	436/569 (83%)	252/312 (80%)
			Post-treatment[a]	70/73 (96%)	228/233 (98%)	36/38 (94%)	126/130 (96%)
33	3 (0)	4 (4)	Baseline	11/180 (6%)	1/180 (.5%)	7/300 (2%)	1/300 (.3%)
			Treatment	60/177 (33%)	11/38 (28%)	846/1508 (56%)	117/240 (48%)
			Post-treatment[a]	–	–	104/192 (54%)	73/96 (74%)
36	2 (1)	3 (1)	Baseline	3/120 (2%)	2/120 (1%)	0/100 (0%)	0/100 (0%)
			Treatment	144/339 (42%)	65/84 (77%)	467/1530 (30%)	109/178 (61%)
			Post-treatment[a]	6/6 (100%)	25/31 (80%)	6/6 (100%)	25/30 (83%)

[a] Post-treatment here refers to the re-assessment of each word mastered during treatment that occurred within the context of the treatment program

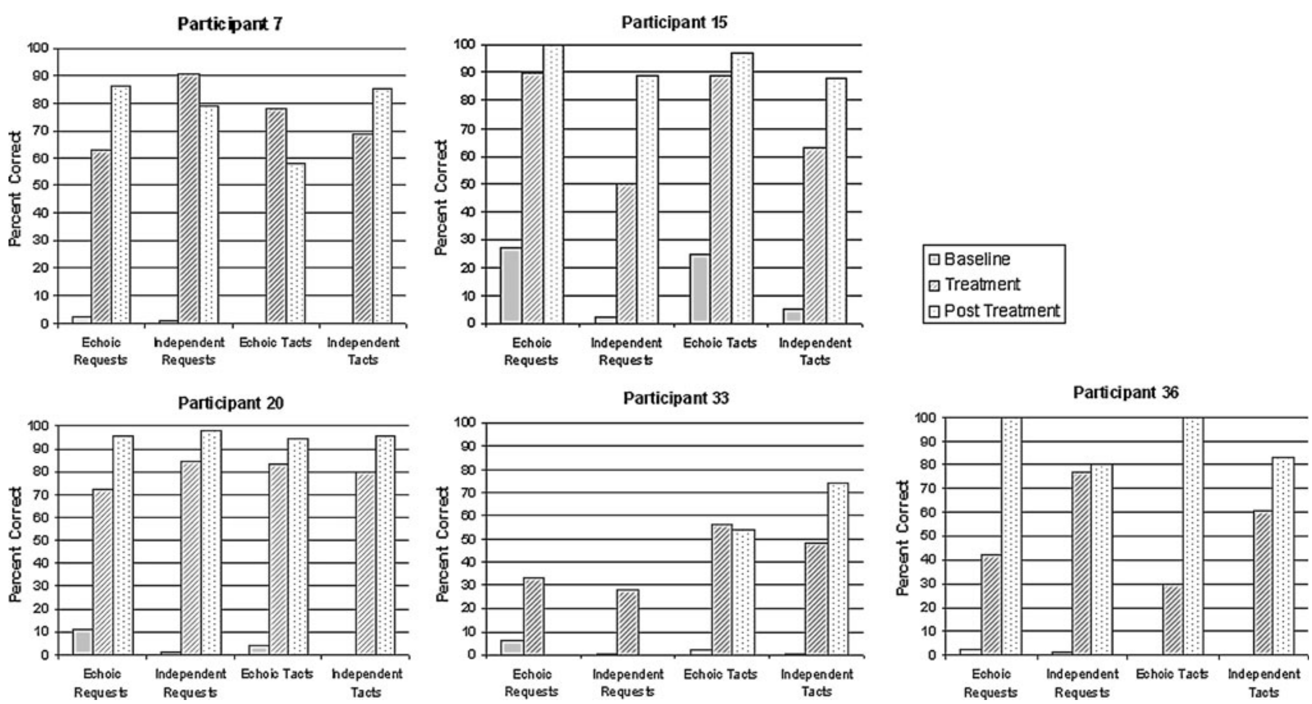


Fig. 3 Percentage of correct echoic and independent labels and requests by five participants across baseline, treatment and post treatment conditions

Review of these data reveals that all participants benefited to some degree from the treatment. There were increases in the percentage of correct word productions across both request and label functions for all five participants. Not all participants benefited from the treatment equally, however, when considering the number of words that they mastered and the number of instructional opportunities they needed per word mastered. Participants 7, 15, and 20 reached criterion for mastery on a moderate number of words, both as requests and labels. Participants #33 and #36 mastered fewer, with #33 mastering no requests at all.

Applying Benchmarks of Functional Language Use

In order to consider this treatment successful in terms defined by Tager-Flusberg et al. (2009), it is necessary to show that, beyond performing at high levels of correct response within the RMIA framework, participants also show meaningful growth in their use of language in natural, functional situations. Tager-Flusberg et al. identified benchmarks of language performance to consider when attempting to demonstrate that single words taught within a structured intervention program translate into the first stage of developmentally appropriate functional language use. These include:

I. Vocabulary: use of at least 5 different words and at least 20 total spontaneous (non-echoed) words directed to others in appropriate natural contexts;
II. Speech sound production: use of at least 4 different consonants in meaningful consonant vowel syllables;
III. Communication: use of at least two different communication functions in natural interactions.

We investigated the appearance of these benchmarks by comparing language use in natural contexts before treatment with that at the evaluations immediately following the treatment program and 3–6 months after the treatment program was terminated. Figure 3 presents the results on spontaneous use of words during the behavioral sample of the *Communication and Symbolic Behavior Scales*-Developmental Profile Behavior Sample, a semi-structured play session between the child and a clinician blind to the subject's treatment status. Figure 4 shows that three of the five participants (#15, 20, and 33) showed spontaneous use of at least five different words in this brief natural context. Moreover, Fig. 5 demonstrates that these same three participants each produced over 50 different words by parent report on the *Communicative Development Inventory* (Fenson et al. 2007). One of these children, #20, had also begun using multiword-word phrases by the maintenance assessment, according to both parent report and data collected by blind clinicians during the CSBS Behavioral Sample. (It should be noted that this participant's parents reported 25 words on the CDI at the pre-assessment. However, discussion with them revealed that these "words" were unintelligible and represented their interpretations of his intents; moreover, these "words" were not used consistently across contexts. Because his vocal output

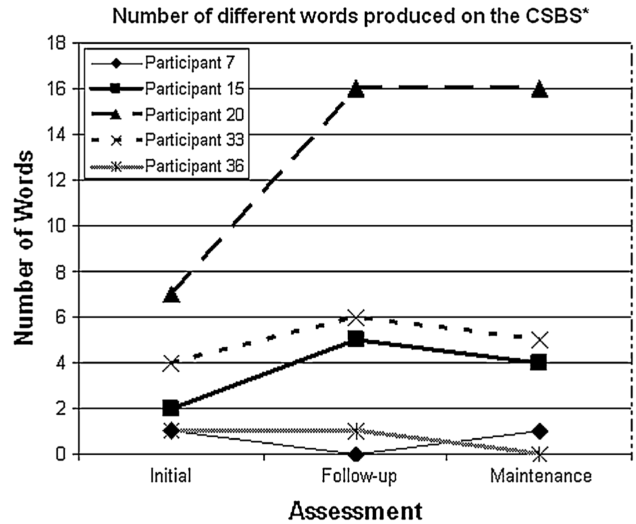


Fig. 4 Spontaneous word production during structured play session by five participants, pre-treatment, immediately after treatment, 3–6 months after end of treatment. *Asterisk* Communication and symbolic behavior scales-developmental profile behavioral sample (Wetherby and Prizant 2003). *NB*: Participant # 20 was reported by parents to produce 7 words during the CSBS interview at the pre-treatment assessment, and these data are reported here. However, these "words" were completely unintelligible to examiners, and were scored only by means of parental interpretation. Whether #20 was truly producing word approximations or simply vocalizing was unclear to us at the outset of the study; therefore he was included in the study. Words produced at follow-up and maintenance visits were intelligible to parents and blinded clinicians

was also completely unintelligible to examiners pre-treatment, he was allowed to remain in the study) (Fig. 5).

Data from the Speech section of the *Communication and Symbolic Behavior Scales*-Developmental Profile Behavior Sample, which provides an inventory of consonants, showed that 4/5 participants, with the exception of #36, produced 4 different consonants in CV syllables by the assessment following treatment, and maintained these sounds at 3–6 months following treatment.

With regard to the use of words for communicative purposes, all participants scored at or below the 12 month level on the *Vineland Adaptive Behavior Scale* (Sparrow et al. 2005) Expressive Language Domain prior to treatment, indicating none was using words to communicate on a regular, daily basis prior to treatment. Following treatment, data from parent report on item #13 on the *Vineland Adaptive Behavior Scales*-Expressive Language domain ("child says one-word requests"), as well as from the CSBS Behavior Sample indicated that 4/5 participants (all but #7) used one-word requests spontaneously in natural situations immediately following treatment, and #7 was using them by the maintenance assessment. Of the participants who used one-word requests spontaneously at the Follow-up assessment, all four maintained them to the 3–6 month follow-up. Data from blind clinician ratings on

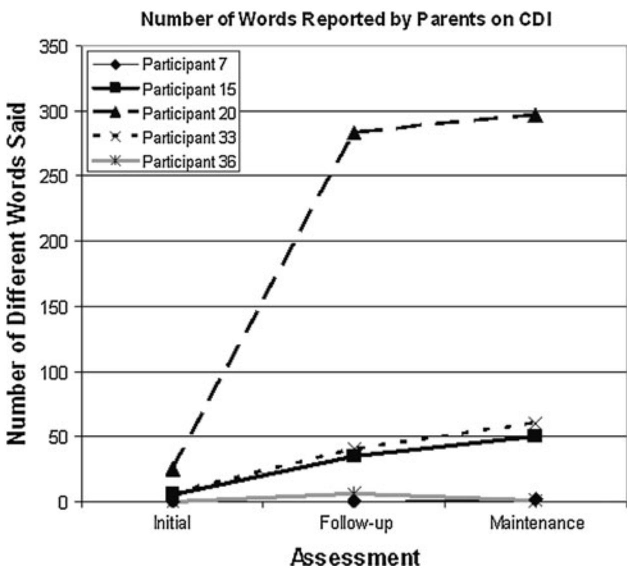


Fig. 5 Number of word productions based on parental report from the CDI by five participants, pre-treatment, immediately after treatment, 3–6 months after end of treatment. *Asterisk* MacArthur-bates communicative development inventory (Fenson et al. 2007). Words understood and said. *NB*: Participant #20 was reported by parents to produce 25 words on the CDI at the pre-treatment assessment, and these data are reported here. However, discussion with parents revealed that these "words" were unintelligible and represented guesses made by the family according to the context in which a vocalization occurred. These words were not used consistently across contexts. The words reported for #20 in Fig. 4 were also unintelligible, and were scored only by means of parental interpretation. Whether #20 was truly producing word approximations or simply vocalizing was unclear to us at the outset of the study; therefore he was included in the study. Words produced at follow-up and maintenance visits were intelligible to parents and blinded clinicians

the CSBS Behavior Sample indicate that 4/5 participants (all but #7) expressed joint attentional functions (e.g., "fish," to call attention to a toy) at both the follow-up and maintenance assessments, and participants #7 and 36 were both reported for the first time by parents to be able to "name three objects" on the *Vineland Adaptive Behavior Scales*-Expressive Language domain (item #12), following treatment. Participants #15, 20, and 33 also used words to express other communicative functions on the CSBS sample, including greetings ("hi," "bye"), counting, acknowledging ("Wow!"), and requesting information ("Why?") at both follow-up and maintenance.

Thus it would appear that 3/5 participants could be considered to have achieved all benchmarks of functional language use for the first stage of spoken language development, characterized by spontaneous, meaningful, other-directed use of more than 20 intelligible single words expressed for a variety of communicative purposes, as established by Tager-Flusberg et al. (2009). One of these participants (#20) was emerging into the multiword stage of development as of the maintenance assessment, and has since progressed to sentence production. It is noteworthy that this subject, though still producing articulation errors, was producing intelligible words according to both parent report and blind clinician observation at the follow-up and maintenance assessment, whereas his productions had been unintelligible to listeners outside the family before intervention. The other two participants (#7, 36), although mastering only a few words in the course of the intervention, did nonetheless begin using a few words for requests and for joint attentional purposes after the treatment. Although they did not meet Tager-Flusberg et al. (2009) criteria for functional language use, they were both requesting and labeling objects with words spontaneously at least occasionally in natural situations. Finally, it should be noted that the words used in spontaneous production were not only the words taught during the intervention. Participants #15, 20, and 33 all produced 50 or more words by parent report at the maintenance assessment, although none had mastered more than 30 words during the treatment. Thus, they were using words that had not been acquired as a result of the RMIA instruction.

Discussion

This report, first, replicates findings of Tsiouri and Greer (2003) that Rapid Motor Imitation Antecedents, when integrated within a DTT approach to teach initial spoken words is effective in eliciting first words from preschoolers with ASD who show extremely limited verbal language production (both imitative and spontaneous). If the concept of a "speech insight" has any validity, one advantage that DTT approaches may provide to children with ASD is the provision of motivation sufficient to focus attention on speech models, in settings where the pairings between words and their referents are clear and compelling. The shaping procedures characteristic of DTT instruction, which allow the child to produce at first relatively gross approximations of target words that are gradually required to move closer to adult forms through carefully sequenced stages, may be especially facilitative for children who face this constellation of obstacles to spoken language acquisition. The unique contribution of RMIA may rest in its capacity to catalyze vocal imitations through behavioral momentum provided by motor imitation, which then allow the child to produce vocal approximations that can be shaped. In other words, the behavioral momentum produced by rapid imitation of sequences of simple motor actions, eventually chained to a verbal stimulus seems, in this study as it did in the earlier one, to catalyze the development of verbal imitation and subsequently of verbal production. In addition, the intensive use and enhancement of the children's motor imitation repertoire, through RMIA, may have strengthened the basic imitation repertoire, often extremely limited in children with ASD, that follows the rule "do as the model does". This generative response class might have led to the emergence of first instances of vocal imitation, the repertoire that was previously missing from these children. Once vocal imitation emerged, the children were able to develop their articulatory accuracy and spontaneous language use further through standard DTT training and opportunities for generalization provided by responsive parental input. Participant #20 may be a good example of the child who had some intentions to communicate pre-treatment, but whose poor attention to speech, delayed motor and imitation ability, and reduced interest and persistence in interactive behavior prolonged his failure to "tune up" speech production to render it generally intelligible without the benefit of shaping and focused practice.

All the children in the present study showed mastery of at least a few new words when RMIA was integrated with standard DTT instruction. However, not all children benefited equally from this treatment package. Three of the five children showed greater levels of success, in terms of number of words mastered, as well as both the number of instructional opportunities needed before a word was mastered and generalized to spontaneous language use. These findings merit further discussion, in order to better understand which children are more likely to benefit from this treatment.

There were few differences among the children in terms of pre-treatment non-verbal cognitive ability. As Table 1 shows, although two of the children who derived the most benefit from the intervention (#15, 20) had high non-verbal cognition relative to the group as a whole, one (#33) had lower non-verbal ability than the two children (#7, 36) who derived less benefit. Non-verbal cognitive level, then, does not seem to be the primary determiner of response to this intervention. The three children who achieved functional speech (#15, 20, 33) produced a few words during the CSBS play session (See Table 1) prior to treatment, whereas the children who showed less progress (#7, 36) each produced only one word prior to treatment, suggesting the children who derived most benefit had more vocal/verbal behavior to begin with than those who did not. These findings replicate earlier reports that amount of vocalization pre-treatment is associated with response to language intervention (Warren and Yoder 1998). Of the two children who required motor training, one achieved functional spoken language (#33) while the other did not (36). Of the three who did not require motor training (#7, 15, 20), two (#7, 20) achieved functional language use while one did not. Although other researchers have reported that motor imitation ability predicted response to language intervention (Yoder and Stone 2006), in this sample it appears that so long as children are able to acquire motor imitation skills with training, they have a chance at benefiting from the intervention, even if motor imitation is very low initially. These observations suggest that children who produce some vocal behavior, show nonverbal cognition at least at the 12 month level, and have or are able to acquire motor imitation after a brief period of training can derive some benefit from this intervention package.

Anecdotally, behavioral observation of the children during intervention suggested that instructional control issues, as well as low levels of motivation toward any external rewards, related to the variability in outcome. That is, the children who showed lower levels of progress generally had more difficulty complying with the demands of the instructional situation and showed fleeting interest in objects, making it difficult to find preferred items that functioned as reinforcers for any length of time.

It is also the case that the two oldest children were the two who showed the least progress, highlighting earlier reports that the longer a child goes without acquiring functional spoken language, the less likely this acquisition becomes. Still, Participant #20 was 5 1/2 at the start of the study and showed a steeper gain than the two youngest children. Pickett et al. (2009) have reported finding a large number of case reports of school-aged children with ASD who acquired spoken language for the first time, primarily in response to DTT instruction, suggesting that although chances of acquiring speech decrease with increasing age they do not disappear entirely. Even our two oldest participants did master, and begin using, a few words.

It is also of interest to note that it was not always the case that participants learned words for requests more easily than they learned labels. Participant #33, for example, did not master any requests, but mastered all 4 labels that he was taught during treatment. Participants #7 and #15 also mastered more labels than requests. This finding agrees with Tsiouri and Greer (2003), who reported labels are sometimes easier for pre-verbal participants to acquire than requests because many different preferred items are available during the labeling condition, whereas participants had to maintain interest in the specific preferred item that was used to teach requests. Participants #20 and #36, on the other hand, performed better on requests (20/21 and 1/2, respectively) than labels (9/12 and 1/3, respectively). Both these children showed sustained interest in a range of preferred items during request instruction.

Limitations and Future Directions

The role of the parent training in the outcome of the RMIA treatment cannot be definitively assessed in this study, since there was no control condition in which children received only one intervention or the other. The three children who showed the greatest success within the RMIA intervention context also showed the greatest growth in spontaneous word use in natural settings, so it may be the case that they would have done just as well with RMIA intervention only. However, the tendency of discrete trial programs to produce high levels of target form production within the structured teaching setting without generalization to spontaneous use has long been reported (e.g., Delprato 2001; Stokes and Baer 1977), and it is at least possible that RMIA instruction alone might have had the same limitation. Moreover, even though only three of the five participants achieved early stages of functional spoken language use defined by Tager-Flusberg et al. (2009) criteria, the other two also showed some, more limited increases in spontaneous use of single word requests and comments outside the treatment setting. Only further empirical studies directly contrasting RMIA/DTT instruction with and without parent training, following a multiple baseline single case design or a group design format in which two groups receive RMIA/DTT but only one of the groups receives concomitant parent training can resolve this question. Similarly, we cannot legitimately claim that it was the behavioral momentum created by rapid motor imitation, rather than the standard DTT training, that was responsible for eliciting first words, since we did not contrast DTT with and without RMIA. Further research using single-subject, multiple baseline designs is needed to resolve these questions.

Clinical Implications

The present results suggest that RMIA may be a useful intervention tool to supplement other approaches to increasing the communicative skills of children in the earliest stage of spoken language development with ASD. Specifically, RMIA appears to be appropriate to use with preschool children with no or very limited verbal output, who have non-verbal mental ages above 1 year, who produce some vocal output, and have acquired or can learn motor imitation skills in a short training period. For children with ASD who meet these criteria, for whom other approaches to inducing speech communication have not been successful, an intervention package including RMIA and parent responsiveness training seems appropriate to try.

Acknowledgments This research was supported by funding from the Autism Speaks Foundation and National Institute of Deafness and Communication Disorders grant K24 HD045576 to the third author. We wish to thank Moira Lewis, Megan Lyons, Sarita Austin, Lauren Berkovits, Yael Fuerst, Brittany Butler, and Allison Lee for their myriad contributions to this research, as well as the children and families who participated in this research. Special thanks go to the teachers and administrators at the Skane School in Bridgeport, CT and the Helene Grant School in New Haven, CT.

References

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed., text revision). Washington, DC: American Psychiatric Association.

Baron-Cohen, S., Baldwin, D., & Crowson, M. (1997). Do children with autism use the speaker's direction of gaze strategy to crack the code of language? *Child Development, 68*, 48–57.

Costello, J. (1983). Generalization across settings: Language intervention with children. In J. Miller, D. Yoder, & R. Schiefelbusch (Eds.), *Contemporary issues in language intervention*. Rockville, MD: American Speech-Language-Hearing Association.

DeLeon, I., & Iwata, B. (1996). Evaluation of a multiple-stimulus presentation format for assessing reinforcer preferences. *Journal of Applied Behavior Analysis, 29*, 519–532.

Delprato, D. J. (2001). Comparisons of discrete-trial and normalized behavioral language intervention for young children with autism. *Journal of Autism and Developmental Disorders, 31*(3), 315–325.

Fenson, L., Marchman, V., Thal, D., Dale, P., Reznick, J., & Bates, E. (2007). *MacArthur-Bates communicative development inventories-III*. Baltimore, MD: Brooks Publishing.

Gernsbacher, M. A., Sauer, E. A., Geye, H. M., Schweigert, E. K., & Goldsmith, H. H. (2008). Infant and toddler oral- and manual-motor skills predict later speech fluency in autism. *Journal of Child Psychology and Psychiatry, 49*(1), 43–50.

Gotham, K., Risi, S., Pickles, A., & Lord, C. (2007). The autism diagnostic observation schedule: Revised algorithms for improved diagnostic validity. *Journal of Autism and Developmental Disorders, 37*, 613–627.

Hart, B., & Risley, T. (1975). Incidental teaching of language in the preschool. *Journal of Applied Behavior Analysis, 8*, 411–420.

Horner, R. H., Dunlap, G., & Koegel, R. L. (Eds.). (1988). *Generalization and maintenance: Life-style changes in applied settings*. Baltimore: Paul H. Brookes.

Howlin, P. (2005). Outcomes in autism spectrum disorders. In F. Volkmar, R. Paul, A. Klin, & D. Cohen (Eds.), *Handbook of autism and pervasive developmental disorders* (Vol. 1, pp. 201–222). New York, NY: Wiley.

Kashinath, S., Woods, J., & Goldstein, H. (2006). Enhancing generalized teaching strategy use in daily routines by caregivers of children with autism. *Journal of Speech and Hearing Research, 49*, 466–485.

Lovaas, O. I. (1987). Behavioral treatment and normal educational and intellectual functioning in young autistic children. *Journal of Consulting and Clinical Psychology, 55*(1), 3–9.

Mace, F. C., & Belfiore, P. (1990). Behavioral momentum in the treatment of escape-motivated stereotypy. *Journal of Applied Behavioral Analysis, 23*, 507–514.

Mace, F. C., Lalli, J. S., Shea, M. C., Pinter, E., West, B. J., Roberts, M., et al. (1990). The momentum of human behavior in a natural setting. *Journal of Experimental Analysis of Behavior, 54*, 163–172.

Meltzoff, A. (1988). Infant imitation after a 1-week delay: Long-term memory for novel acts and multiple stimuli. *Developmental Psychology, 24*, 470–476.

Mullen, E. M. (1995). *Mullen scales of early learning*. Circle Pines, MN: American Guidance Services.

Nevin, J. A., Mandell, C., & Atak, J. R. (1983). The analysis of behavioral momentum. *Journal of Experimental Analysis of Behavior, 39*, 49–59.

Norris, J., & Hoffman, P. (1993). *Whole language intervention for school-age children*. San diego, CA: Singular.

Owens, R. (2009). *Language disorders: A functional approach to assessment and intervention* (5th ed.). Boston: Allyn and Bacon.

Paul, R. (2008). Intervention to improve communication in ASD. *Clinics in Child and Adolescent Psychiatry of North America, 17*, 835–856.

Paul, R. (2009). Talk to Me: Issues in acquiring spoken language for young children with autism spectrum disorders. *ASHA Leader, 14*(14), 10–13.

Paul, R., Bianchi, N., Augustyn, A., & Volkmar, F. (2008). Production of syllable stress in speakers with autism spectrum disorders. *Research in Autism Spectrum Disorders, 2*, 110–124.

Paul, R., Chawarska, K., Fowler, C., Cicchetti, D., & Volkmar, F. (2007). Listen, my children and you shall hear: Auditory preferences in toddlers with ASD. *Journal of Speech, Language, and Hearing Research, 50*, 1350–1364.

Perkins, T., Stokes, M., McGillivray, J., & Bittar, R. (2010). Mirror neuron dysfunction in autism spectrum disorders. *Journal of Clinical Neuroscience, 17*, 1239–1243.

Pickett, E., Pullara, O., O'Grady, J., & Gordon, B. (2009). Speech acquisition in older nonverbal individuals with autism: A review of features, methods, and prognosis. *Cognitive and Behavioral Neurology, 22*(1), 1–21.

Prelock, P., Paul, R., & Allen, E. (2011). Evidence-based treatments in communication for children with autism spectrum disorders. In F. Volkmar & B. Reichow (Eds.), *Evidence-based treatments in autism spectrum disorders*. New York, NY: Guilford Press.

Reichow, B., & Wolery, M. (2009). Comprehensive synthesis of early intensive behavioral interventions for young children with autism based on the UCLA young autism project model. *Journal of Autism and Developmental Disorders, 39*, 23–41.

Rogers, S. (2006). Evidence-based intervention for language development in young children with autism. In T. C. W. Stone (Ed.), *Social and communication development in autism spectrum disorders: Early identification, diagnosis, and intervention*. New York, NY: Guilford.

Rogers, S., Cook, I., & Meryl, A. (2005). Imitation and play in autism. In F. Volkmar, R. Paul, A. Klin, & D. Cohen (Eds.), *Handbook of autism and pervasive developmental disorders* (Vol. 1, pp. 382–405). New York: Wiley.

Rogers, S. J., Hayden, D., Hepburn, S., Charlifue-Smith, R., Hall, T., & Hayes, A. (2006). Teaching young nonverbal children with autism useful speech: A pilot study of the Denver model and PROMPT interventions. *Journal of Autism and Developmental Disorders, 36*(8), 1007–1024.

Shriberg, L., Paul, R., Black, L., & van Santen, J. (2011). The hypothesis of apraxia of speech in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 41*, 405–426.

Skinner, B. F. (1957). *Verbal behavior*. Englewood Cliffs, ND: Prentice Hall.

Smith, T. (2001). Discrete trial training in the treatment of autism. *Focus on Autism and Other Developmental Disabilities, 16*, 86–92.

Sparrow, S., Cicchetti, D., & Balla, D. A. (2005). *Vineland adaptive behavior scales–II*. San Antonio, TX: Pearson Assessment.

Stokes, T., & Baer, D. (1977). An implicit technology of generalization. *Journal of Applied Behavior Analysis, 10*, 349–367.

Stokes, T., Baer, D., & Jackson, R. (1974). Programming the generalization of a greeting response in four retarded children. *Journal of Applied Behavior Analysis, 7*, 599–610.

Tager-Flusberg, H., Paul, R., & Lord, C. (2005). Language and communication in autism. In F. Volkmar, R. Paul, A. Klin, & D. Cohen (Eds.), *Handbook of autism and pervasive developmental disorders* (3rd ed., Vol. 1, pp. 335–364). New York: Wiley.

Tager-Flusberg, H., Rogers, S., Cooper, J., Landa, R., Lord, C., Paul, R., et al. (2009). Defining spoken language benchmarks and selecting measures of expressive language development for young children with autism spectrum disorders. *Journal of Speech, Language, and Hearing Research, 52*, 643–652.

Tsiouri, I., & Greer, D. (2003). Inducing vocal verbal behavior in children with severe language delays through rapid motor imitation responding. *Journal of Behavioral Education, 12*, 185–206.

Warren, S., & Yoder, P. (1998). Facilitating the transition from preintentional to intentional communication. In A. Wetherby, S. Warren, & J. Reichle (Eds.), *Transitions in prelinguistic communication* (pp. 365–384). Baltimore, MD: Paul H. Brookes.

Wetherby, A., & Prizant, B. (2003). *Communication and symbolic behavior scales: Developmental profile* (1st normed edn.) Baltimore, MD: Paul H. Brookes Publishing Co.

Williams, G., & Greer, D. (1993). A comparison of verbal-behavior and linguistic-communication curricula for training developmentally delayed adolescents to acquire and maintain vocal speech. *Behaviorology, 1*, 31–46.

Yoder, P., & Stone, W. (2006). Randomized comparison of two communication interventions for preschoolers with autism spectrum disorders. *Journal of Consulting and Clinical Psychology, 74*, 426–435.

Yoder, P., & Warren, S. F. (2002). Effects of prelinguistic milieu teaching and parent responsivity education on dyads involving children with intellectual disabilities. *Journal of Speech, Language, and Hearing Research, 45*, 1158–1174.