Analysis Verbal Behav (2014) 30:148–159
DOI 10.1007/s40616-014-0014-y

A|B|A|I
Association for Behavior Analysis International

An Investigation of Stimulus Pairing and Listener Training to Establish Emergent Intraverbals in Children with Autism

Mary Vallinger-Brown · Rocío Rosales

Published online: 6 June 2014

Abstract We examined two methods to facilitate the emergence of untaught intraverbal responses to children with autism. Listener behavior training (LT) involved reinforcement of a selection-based response following presentation of an array of pictures on an iPad® and an auditory instruction describing a characteristic of the picture. Stimulus pairing (SP) involved presentation of one picture in isolation on the iPad® and an auditory instruction describing a characteristic of the picture. Participants were not required to emit an overt vocal response during SP. Results indicate both procedures were effective at producing some untaught intraverbal responses, but a transfer of stimulus control procedure was required for two of the three participants to meet mastery criterion. Results are discussed in terms of necessary prerequisite skills for each procedure, and the requirement of an overt or echoic response to help facilitate the emergence of intraverbals.

Keywords Intraverbals · Derived relations · Listener training · Stimulus pairing

Introduction

The intraverbal is defined as an operant under the control of a verbal stimulus that has no point-to-point correspondence or formal similarity with the response and is maintained by nonspecific reinforcement (Skinner 1957, p. 71). Common examples of elementary intraverbals include filling in words to songs or nursery rhymes, completing fill-in-the-blank statements, and answering questions. The intraverbal is considered one of the most essential, yet difficult verbal operants for children with autism to acquire (Sundberg and Michael 2001). For this reason, several different procedures have been examined to teach intraverbal behavior to this population including transfer of stimulus control (Ingvarsson and Hollobaugh 2011; Partington and Bailey 1993; Vendora, Meunier, and Mackay 2009), match-to-sample or listener training (Miguel, Petursdottir, and Carr 2005; Petursdottir, Carr, Lechago, and Almason 2008a; Petursdottir, Olafsdottir, and Aradottir 2008b), multiple exemplar instruction (MEI; Fiorile and Greer 2007; Greer, Yuan, and Gautreaux 2005; Nuzzolo-Gomez and Greer 2004), and tact training (Coon and Miguel 2012; Dounavi 2011; May, Hawkins, and Dymond 2012).

It is important to note that transfer of stimulus control procedures are typically implemented to directly teach intraverbal responses, while listener training, MEI, and training other verbal operants (i.e., tacts) are examined for their efficacy to establish *emergent* or untrained intraverbal responses. For example, matching-to-sample or listener training has demonstrated efficacy to establish emergent intraverbals to typically developing children (Miguel et al. 2005; Petursdottir et al. 2008b), and children with autism (Keintz, Miguel, Kao, & Finn 2011). The procedure involves a selection-based response whereby the learner is presented with an array of stimuli (e.g., scissors, chair, and lamp) and required to select one or multiple stimuli following presentation of an instruction ("point to the one you use to cut paper"). Following training,

M. Vallinger-Brown
Youngstown State University, Youngstown, OH, USA

R. Rosales (✉)
Department of Psychology, University of Massachusetts Lowell, 113 Wilder Street, Suite 300, Lowell, MA 01854, USA
e-mail: rocio_rosales@uml.edu

experimenters probe to see if untaught speaker behavior emerges without further training (e.g., a response to the question, "What do you use to cut paper?").

Results on the emergence of untaught intraverbals following listener behavior training (LT) have been mixed. While some studies have reported failures following LT (Miguel et al. 2005; Petursdottir et al. 2008a), at least two studies demonstrated the emergence of some untaught intraverbals following LT to teach a small foreign language vocabulary to typically developing children (Petursdottir et al. 2008a) and relations between coins and their values to children with autism (Keintz et al. 2011). Petursdottir et al. (2008a) required participants to emit a selection-based response (e.g., "Point to the one that is called (*x*) in Spanish") followed by probes for bidirectional intraverbal responses [e.g., "What does (Spanish name) mean in Icelandic?" and "What is (Icelandic name) in Spanish?"]). Results indicated some intraverbal responses emerged following LT, but relations were not always bidirectional. Keintz and colleagues (2011) also required a selection-based response to teach conditional discriminations of dictated names and coins, values of coins with the actual coins, and dictated values and printed values of coins. Intraverbal probes included: "what coin is worth (*x*) cents?" or "how much is (*x*) worth?" Results indicated correct intraverbal responses emerged for one of two participants.

A second procedure with some demonstrated efficacy to establish emergent verbal behavior is a stimulus pairing (SP) or respondent-type training procedure (Leader and Barnes-Holmes 2001a). This procedure involves presentation of a visual stimulus in isolation, followed by a brief inter-stimulus interval, and a second visual (or auditory) stimulus. Regardless of whether the stimuli are visual–visual or auditory–visual, no overt response is required of the learner. Leader and Barnes-Holmes (2001b) demonstrated the efficacy of this procedure to teach relationships between fractions and decimals to 24 typically developing 5-year-old children. Rosales, Rehfeldt, and Huffman (2012) examined the effectiveness of SP to teach a small vocabulary set to typically developing preschool children learning English as a second language. Results indicated that some tact and listener relations emerged following SP; however, not all relations emerged reliably. Most recently, Takahashi, Yamamoto, and Noro (2011) replicated this procedure to teach two boys with autism relations among names (printed words), faces, and Kanji symbols. Two visual stimuli (faces and printed words) were paired in succession on a computer screen for one participant, while an auditory and visual stimulus (Kanji symbol plus corresponding auditory stimulus) were presented to a second participant. Following SP, subsequent MTS tests were administered to assess emergent relations among stimuli. Results indicated the SP procedure was effective in producing increases in correct responses across all participants.

Despite the aforementioned studies, research on LT and SP procedures to teach intraverbal behavior to students with autism remains limited. Information on the relative efficacy of these two procedures may help shed light on best practices for instruction delivery for children with autism. For example, if SP is an effective teaching method, it may be helpful to incorporate this procedure into ongoing instruction since it integrates aspects of a typical academic learning environment (e.g., observe instruction and recall information). Therefore, the purpose of the present study was to compare the relative effectiveness of LT and SP to establish emergent intraverbal behavior in children with autism.

Method

Participants, Setting, and Materials

Three children enrolled at a therapeutic center for children with autism participated in the study. All participants were Caucasian males with an educational diagnosis of autism on their individualized education plan (IEP). Carl (4 years old), Aaron (5 years old), and John (7 years old) all scored in the Level 2 range on the intraverbal subsection of the verbal behavior milestones assessment and placement program (VB-MAPP; Sundberg 2008) and had an established mand and tact repertoire (Level 3 for Aaron, Level 2 for Carl and John on the VB-MAPP). All participants had at least 1 year of experience with discrete trial training (DTT) and demonstrated behaviors to indicate instructional control (i.e., did not engage in problem behavior and attended to materials presented during one-on-one instruction for at least 20 consecutive minutes). Participants did not have a previous learning history with SP, but may have had some exposure to procedures similar to that employed in LT given their history with DTT. They had minimal, if any, formal intraverbal instruction prior to the start of the study.

All sessions were conducted in a classroom workspace (3.04 by 3.04 m) with minimal distractions 4–5 days/week and lasted approximately 15–20 min. The therapist sat next to participants at a child sized table with two chairs and presented materials on an Apple iPad® using Microsoft Powerpoint®. Three stimulus sets with six questions per set were created based on the participants' current treatment plan and informed by the assessment for basic language and learning skills-revised (ABLLS-R, Partington and Sundberg 1998; see Tables 1 and 2). Stimulus sets were similar in difficulty (i.e., responses contained only one word, and ranged from one to two syllables—with one exception, *refrigerator*) and were counterbalanced across participants (i.e., Set 1 was assigned to LT and Set 2 to SP for Aaron, and these assignments were switched for John and Carl; John and Carl had the same stimulus sets). All verbal stimuli contained the word "what" to begin the question. In addition, at least one question from the same category per training condition (i.e., "what season do you pick up the leaves?" in the SP set and "what season do the flowers bloom?" in the LT set) was incorporated into each set. Each stimulus was presented twice in a quasi-random order to yield 12-trial blocks. Data were collected using paper and pencil on data sheets created by the experimenter prior to the start of the study. Corresponding visual images were downloaded from a Google© internet search and resized to 7.62 by 5.08 cm.

Table 1 Stimulus sets for John and Carl

Intraverbal probe	Correct response
LT	
(1) What coin is worth 5 cents?	Nickel
(2) What state do you live in?	Ohio
(3) What season do the flowers bloom?	Spring
(4) What do you do when you're happy?	Smile
(5) What coin is worth 25 cents?	Quarter
(6) What do you use to heat up food?	Microwave
SP	
(1) What coin is worth 10 cents?	Dime
(2) What do you do when you're angry?	Yell
(3) What do you use to tell time?	Clock
(4) What season do you pick up the leaves?	Fall
(5) What coin is worth 1 cent?	Penny
(6) What do you find on top of the house?	Roof

Table 2 Stimulus sets for Aaron

Intraverbal probe	Correct response
LT	
(1) What coin is worth 1 cent?	Penny
(2) What do you find on top of the house?	Roof
(3) What season do you pick up the leaves?	Fall
(4) What do you do when you're angry?	Yell
(5) What coin is worth 10 cents?	Dime
(6) What do you use to tell time?	Clock
SP	
(1) What do you do when you're happy?	Smile
(2) What shines in the sky in the day?	Sun
(3) What keeps food cold?	Refrigerator
(4) What season do the flowers bloom?	Spring
(5) What coin is worth 5 cents?	Nickel
(6) What coin is worth 25 cents?	Quarter

A token economy was implemented for one participant, John, following six trial blocks with little to no increase in the number of correct responses emitted per session when only behavior-specific praise was provided contingent on correct independent responding. Prior to the start of the study, John was taught to use a token economy during his everyday classroom instruction, and this token economy was used in the classroom throughout the duration of the study. The token economy used during training sessions was identical to that used during classroom instruction. Tokens were purple stars attached to a token board using hook-and-loop tape. John selected a back-up reinforcer prior to the start of each session. Preferred items included as back-up reinforcers were identified via a multiple stimulus without replacement preference assessment (DeLeon and Iwata 1996).

Reinforcement schedules matched that of the other two participants during each condition. Specifically, John earned one token contingent on correct independent responses on an FR1 schedule of reinforcement during LT and intraverbal training conditions (see below). He earned tokens on a VI 1 min schedule of reinforcement during pretest and posttest sessions and on a VI 30 s schedule during the SP training condition contingent on attending behavior (attending was defined as the participants' bottom-making contact with the chair and the presence of eye contact with the training materials). Eye contact was defined as participants gazing in the direction of the stimuli on the screen for three

consecutive seconds after pressing the sound icon to play the auditory instruction. John earned access to the preferred item he had selected after five tokens were earned. An interval timer application for iPhone® was used in order to program the VI 1 min schedule of reinforcement. A vibration occurred to signal the delivery of reinforcement. A VI schedule was selected to facilitate the delivery of reinforcement by the experimenter (the iPhone application indicated when reinforcement should be delivered, so the experimenter did not need to track the number of responses emitted) and to ensure that participants could not predict when reinforcement would be delivered.

Carl and Aaron were on the same schedules of reinforcement as indicated above, but no tokens were provided. Instead, behavior-specific praise was provided contingent on correct independent responses during LT or for attending behavior during SP and pretest/posttest conditions (e.g., "I like how you're looking at the pictures!"). During all conditions, Carl and Aaron were provided with an opportunity to take a 3–4 min break and play with a preferred item of their choice following each 12-trial block. The selection and identification of preferred items was identical to that described for John. Prior to the start of the study, classroom observations and teacher report suggested that Carl and Aaron readily worked for praise during both one-on-one and group instruction. John's teachers often used back-up reinforcers in addition to praise. Praise seemed to function as a reinforcer for Carl and Aaron, as evidenced by an increase in number of correct responses during LT.

Experimental Design, Response Measurement, and Interobserver Agreement

We used a nonconcurrent multiple probe design across participants (Watson and Workman 1981) and adapted alternating treatments design (Sindelar, Rosenberg, and Wilson 1985). The adapted alternating treatments design helped to compare the efficacy of the two training procedures (SP and LT). The multiple probe design served to further control for threats to internal validity (such as history and maturation) by demonstrating that the two training procedures were responsible for increases in correct responding. Pretest and posttest probes were conducted to examine the emergence of untaught intraverbal responses. Pretest probes were initially conducted for each set to be trained. The number of pretest probes for participants were determined prior to the start of the study and randomly assigned to a participant upon entering the study. Training sessions for both experimental conditions were conducted simultaneously following pretest probes, but with different stimulus sets. Two trial blocks (i.e., one 12-trial block for the LT set, one trial block for the SP set) were conducted per session with the order of presentation alternated. Each 12-trial block targeted only one training condition. This was followed by posttest probes, direct intraverbal training (if needed), and follow-up.

The primary dependent variable was the number of correct intraverbal responses emitted following training in each procedure. A correct response was defined as a vocalization that corresponded to the question posed and emitted within 10 s following presentation of a discriminative stimulus. For example, upon presentation of the instruction, "What coin is worth 10 cents?," a correct response was scored if participants said "Dime" within 10 s. An incorrect response was defined as a vocalization that did not correspond to the question posed or responses emitted following 10 s after presentation of the discriminative stimulus. Participants were provided with one opportunity to respond, nonresponses were scored as errors, and only the first response was scored.

A second trained observer scored participant responses during 58 % of all sessions for Aaron (M= 98.4 %, range 83.3–100 %); 52 % of sessions for John (M= 96.5 %, range 88.3–100 %); and 46 % of sessions for Carl (M= 98.8 %, range 91.6–100 %). Interobserver agreement (IOA) was calculated using an exact agreement method. The number of agreements was divided by the number of agreements plus disagreements and multiplied by 100 to yield a percentage for each trial block. Procedural integrity measures were also scored to ensure all training procedures were implemented consistently by the experimenter. A second trained observer scored the experimenter responses using a checklist created for the purpose of this study (available from the second author upon request). Examples of scored responses included: experimenter cleared the work area and prevented access to preferred items; the experimenter asked participants one question at a time; and the experimenter gave participants 10 s to respond. Data were summarized by summing the correctly implemented responses divided by the total number of available responses per trial block and multiplying by 100 to yield a percentage. Treatment integrity data were collected during 33 % of all sessions for Aaron (M=99.6 %, range

93.0–100 %), 32 % of all sessions for John (M = 99.8 %, range 97.0–100 %), and 33 % of sessions for Carl (100 %).

Procedure

Pretraining

The general procedure is outlined in Fig. 3. Prior to the start of the study, participants received instructions on the steps needed to navigate the iPad® during training sessions (i.e., point to a blank screen; press an arrow on the touch screen to advance slides, press an icon on the screen to listen to an auditory stimulus). Participants also learned to respond to instructions provided during LT, but with pictures unrelated to the study (i.e., "Point to dog/cat/bird, etc."). One pretraining session was conducted per participant; participants progressed to the next training phase as long as they could independently navigate the iPad® and respond to the experimenter's instructions. Due to previous exposure to the iPad®, all participants completed this phase in one session.

Tact Training

Tact training was conducted with all stimuli to be used during the SP and LT experimental conditions. This ensured that all participants could tact the stimuli used during training. Specifically, the experimenter presented each picture on the iPad® in isolation with the instruction, "What is it?" Stimuli were presented in 12-trial blocks with the order of presentation determined prior to each session in a quasi-random order. Reinforcement in the form of praise was provided for correct responses. Corrective feedback in the form of an echoic prompt followed by another opportunity to respond was provided for incorrect responses. Echoic prompts were faded using a graduated time-delay procedure and continued until participants responded correctly and independently for one complete 12-trial block. All participants met this criterion following seven or fewer trial blocks.

Pretest/Posttest Probes

Pretest and posttest intraverbal probes were conducted in 12-trial blocks with the order of presentation assigned in a quasi-random fashion prior to the start of the study. The experimenter cleared the work area of materials and ensured participants were making eye contact with the experimenter. The experimenter asked participants one question at a time (e.g., "What season do the flowers bloom?"), waited 5–10 s for a response, recorded participants' response, and moved on to the next question. There were no consequences for correct or incorrect responding.

Following the predetermined number of pretest probes and stable responding, participants were exposed to the two training conditions as described below. Posttest probes were conducted following each SP and LT trial block (for John and Carl). If intraverbal responses did not meet a predetermined mastery criterion of 11/12 correct independent responses following five SP sessions or following mastery criterion of LT (11/12 correct listener responses), training continued until participants met a failure criterion for both of these procedures. Failure criterion was defined as four consecutive trial blocks with no more than one additional correct intraverbal response. Once participants met this criterion, direct intraverbal training was conducted as described below. This procedure varied slightly for Aaron; posttest probes were conducted immediately following each SP session in the same manner as pretest probes; however, posttest probes for LT were not conducted until he met mastery criterion for LT.

Listener Training

Listener training was conducted in 12 trial blocks, with each stimulus presented twice in a quasi-random order. Six pictures were arranged and presented equidistant from one another on a square containing three rows with two stimuli per row on the iPad®. During LT, only one picture corresponded to the stimuli used during training (see Fig. 1). The PowerPoint® presentation with all of the stimuli presented was created prior to the start of the study, and the experimenter ensured the order of stimuli was randomized prior to the start of each session.

The session began when the experimenter provided the following instructions to participants: "You are going to see some pictures on the screen. When I tell you to start, point to the screen to show me you are ready to begin." An observing response was required (e.g., pointing to a blank white screen on the iPad® and then an arrow to advance to the next slide) followed by presentation of six stimuli on the screen and an instruction by the experimenter to touch a sound icon (only if participants did not complete this response independently) that delivered an instruction (e.g., "Point to the one

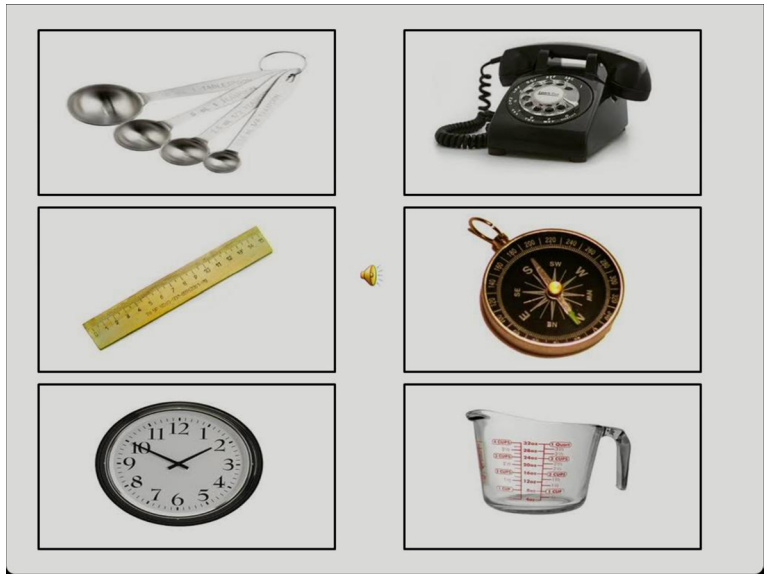

Fig. 1 Screenshot of stimulus presentation during LT

you use to tell time"). A correct response was scored if participants pointed to the appropriate stimulus (e.g., a clock in this example) within 10 s following the instruction. Only one opportunity to respond was provided and only the first response was scored. Nonresponding constituted an incorrect response. Correct responses were followed by descriptive praise delivered by the experimenter (e.g., "Yes, you use a clock to tell time!") and a token (for John only). Incorrect responses were followed by a gestural (e.g., point) prompt by the experimenter and another opportunity to respond.

Stimulus Pairing

Stimulus pairing was conducted in 12 trial blocks, with each stimulus presented twice in a quasi-random order. The PowerPoint® presentation with all the stimuli presented during this condition was created and the experimenter ensured the order of stimuli was randomized prior to the start of each session. The session began when the experimenter provided the following instructions to participants, "You are going to see some pictures on the screen. When I tell you to start, point to the screen to show me you are ready to begin."

Participants were required to emit the same observing response described for LT above. The observing response produced an auditory stimulus (i.e., "A penny is worth 1 cent" if the visual stimulus on the screen was a penny). The visual stimulus remained on the screen while participants played the auditory stimulus. Following presentation of the auditory stimulus, the visual stimulus remained on the screen until participants advanced to the next slide. The time between the presentation of the visual stimulus and the presentation of the auditory stimulus (interstimulus interval) varied in length because participants were required to press the sound icon to deliver the auditory stimulus. Following this presentation, a 3-s inter-trial interval was introduced before the next auditory–visual stimulus presented on the screen (see Fig. 2).

There was no overt response requirement throughout this experimental condition. The experimenter sat by participants during each session and provided reinforcement in the form of praise for Carl and Aaron and a token for John as described above. The experimenter also recorded if participants made eye contact with the stimuli during each trial and if he engaged in echoic behavior (i.e., repeating the auditory stimulus).

Direct Intraverbal Training

If participants did not meet mastery criterion for intraverbal responses during posttest probes and met the failure criterion described above, a transfer of stimulus control procedure was implemented to directly teach intraverbal responses (see Fig. 3). Training was conducted in 12-trial blocks with the order of presentation randomized prior to each session. Correct responses (defined in the same manner described for pretest probes above) were immediately followed by

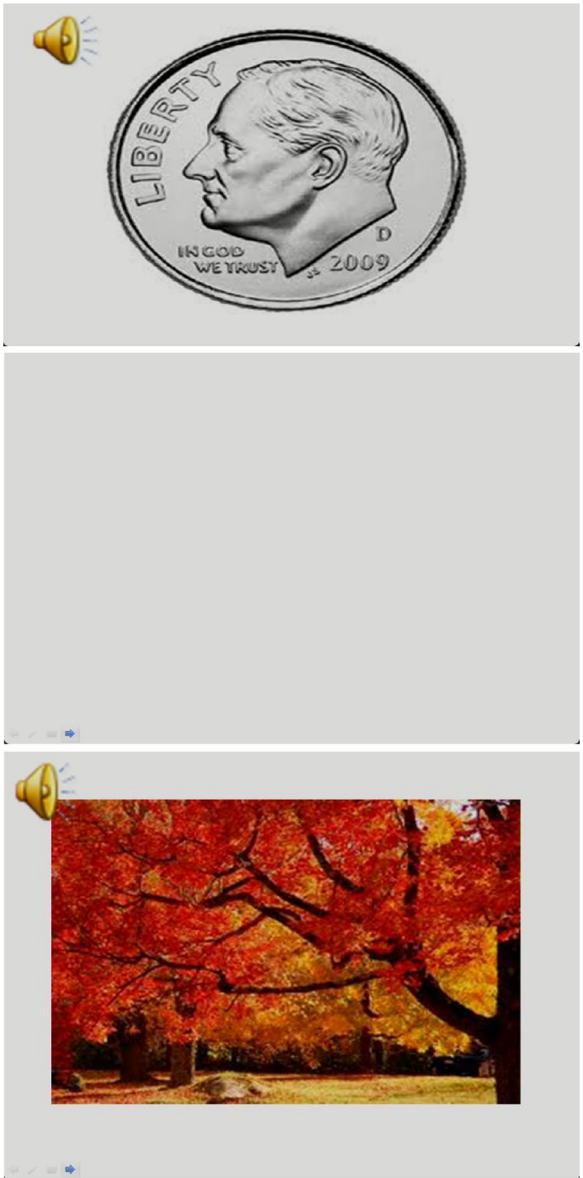

Fig. 2 Screenshot of stimulus presentation during SP (images shown in successive order)

descriptive praise and a token (for John only). Incorrect responses were immediately followed by an echoic prompt (i.e., "Clock" for the discriminative stimulus "What do you use to tell time?") and another opportunity to respond. In addition, a prompt delay procedure was implemented whereby the experimenter initially provided the echoic prompt immediately, followed by a delay of 1 s before the prompt was provided. Time delay was gradually increased by 1 s every two trials until 10 s. This training continued until participants met a mastery criterion of 11/12 correct intraverbal responses.

Novel Instructor Probes

Following mastery criterion during either posttest probes or direct intraverbal training, generalization probes were conducted. These probes were identical to pretest and posttest probes as described above, but were presented by three instructors that were not part of the participants' natural environment. The probes were conducted in the same setting as training, but occurred across three different days for Aaron and Carl. Novel instructor probes were not conducted with John due to the school year ending before data collection was complete.

Follow-Up

Follow-up probes were conducted in the same manner as pretest and posttest probes by the experimenter 2–4 weeks following the last posttest probe for Aaron only. He did not receive any exposure to the experimental procedures following posttests or before maintenance probes were conducted.

Results

Overall results indicate some intraverbal responding that emerged following both LT and SP experimental conditions, but the number of correct responses varied across participants (see Fig. 4). LT resulted in more emergent intraverbal responses compared to SP for two participants (eight compared to two and four for Carl and John, respectively). Aaron met and exceeded the mastery criterion in both experimental conditions, but subsequent follow-up probes indicated more correct responses for the LT stimulus set. In sum, two of the three participants required direct intraverbal training to meet the predetermined mastery criterion.

As shown in Fig. 4, Aaron's correct responses during pretest probes ranged from zero to four. Training data are not graphed, but Aaron required six trial blocks to meet the mastery criterion of 11/12 correct responses for listener responding; and a total of five trial blocks of SP were completed before posttest probes for intraverbal responses were conducted. Aaron met and exceeded the mastery criterion during posttest probes for both

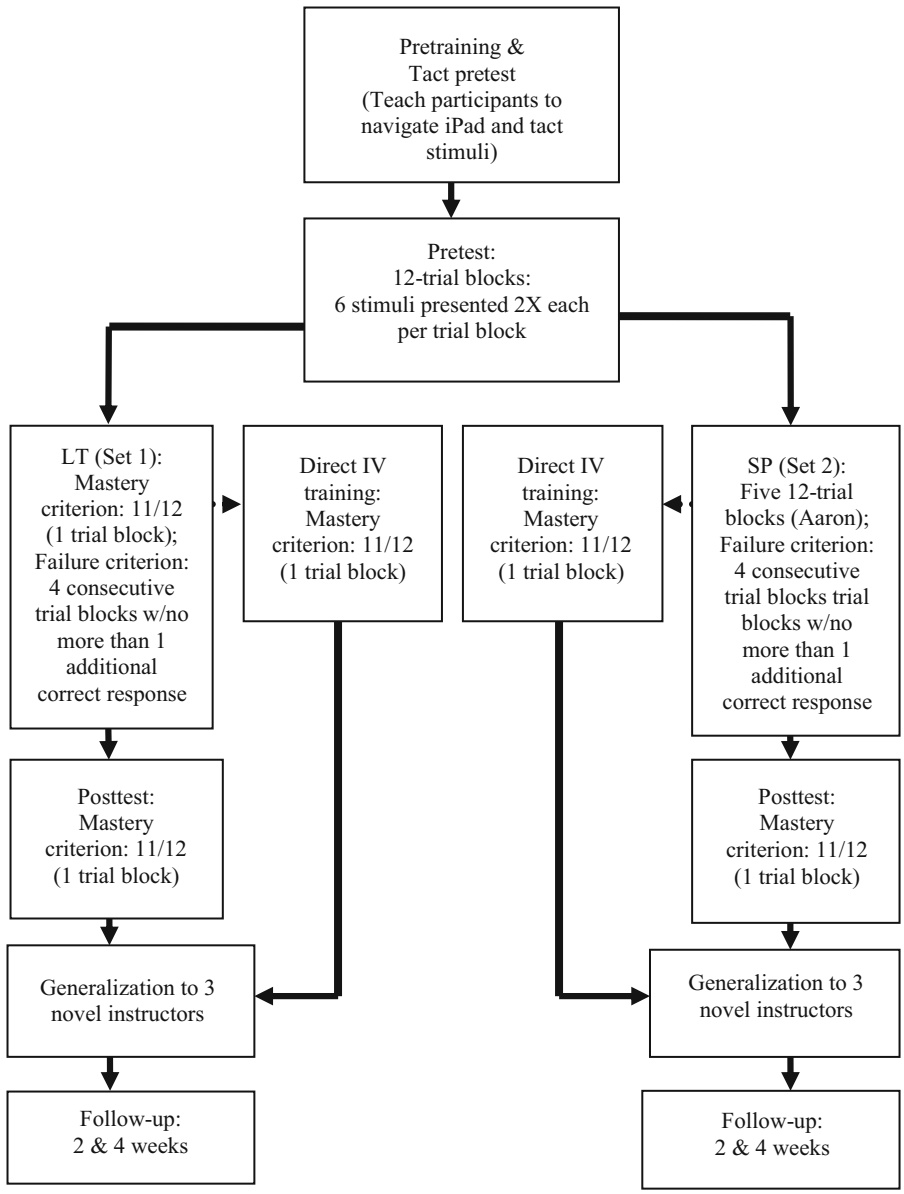

Fig. 3 Sample flow chart of experimental conditions

conditions (e.g., 12/12 correct responses). This level of responding maintained during all follow-up probes with three instructors and at 2- and 4-week follow-up. During LT, Aaron emitted tacts for the target stimulus during an average of 9/12 trials; during SP, he made eye contact with the screen on average 11/12 trials, and echoed the instruction on average 11/12 trials (data not graphed).

For John, the number of correct intraverbal responses ranged from zero to two during pretest probes (see Fig. 4). A total of 13 trial blocks were conducted before he met mastery criterion for listener responses (data not graphed). During LT, John emitted tacts for the target stimulus of an average of 4/12 trials. A total of 12 trial blocks were conducted in SP before direct intraverbal training was initiated. During SP, John made eye contact with the target stimulus on average 10/12 trials and echoed the instruction on average 5/12 trials. John's correct intraverbal responses ranged between two and eight during posttest probes following each LT and SP experimental condition, even after meeting the mastery criterion for

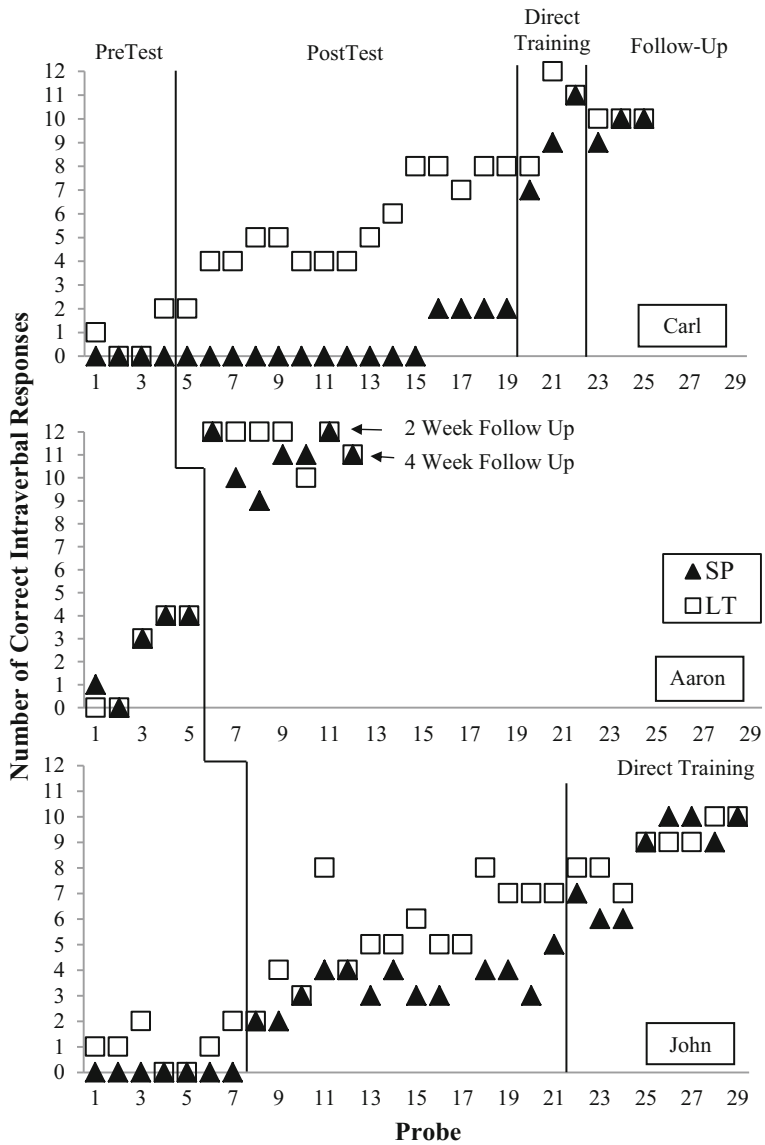

Fig. 4 Number of correct intraverbal responses for Carl, Aaron, and John during pretest, posttest, and direct training

listener responding. A total of nine direct intraverbal training sessions were conducted before training was terminated with John due to the near school year ending. John did not meet the mastery criterion of 11/12 correct intraverbal responses. However, he did reach 10/12 correct intraverbal responses for both sets and responded correctly to each intraverbal probe at least one time.

Finally, Carl's number of correct intraverbal responses ranged from zero to two during pretest probes (see Fig. 4). A total of 16 trial blocks were conducted before Carl met the mastery criterion for listener responding (data not graphed). During LT, he emitted tacts for the target stimulus on average 5/12 trials. A total of 15 trial blocks were conducted in SP before direct intraverbal training was initiated. During SP, Carl made eye contact with the target stimulus on average 11/12 trials and echoed the instruction on average 10/12 trials. Carl's correct intraverbal responses ranged between four and eight during posttest probes following each LT and SP experimental condition, even after mastery criterion for listener training had been met. A total of three sessions were conducted before Carl met the mastery criterion for intraverbal responses during the direct intraverbal training condition. Carl's responses decreased during the follow-up probes (i.e., 9, 10, and

10 for probes conducted by a different instructor with the SP set; and 10 for all three probes conducted by a different instructor with the LT set).

Discussion

These results support previous research that indicates LT may be an effective procedure to produce emergent intraverbal responses (Keintz et al. 2011; Petursdottir et al. 2008a). The findings counter those of Miguel et al. (2005) and Petursdottir et al. (2008a), but it is important to note that the present study did not target thematically related intraverbals (e.g., grouping items by category) which may help account for the difference in results. Results of this study also partially support prior research on SP to establish emergent verbal behavior (Rosales et al. 2012; Takahashi et al. 2011). In the current study, the SP condition was most successful with one participant, Aaron. Future research should examine participants' characteristics to determine if there are prerequisite skills a learner must have in order to benefit from specific method of instruction such as SP. For example, Aaron had a more extensive verbal behavior repertoire than either John or Carl prior to the start of the study as evidenced by scores on the VB-MAPP. Specifically, Aaron scored in Level 3 of listener and tact subsections of the VB-MAPP; whereas John and Carl both scored in Level 2 in these subsections. John and Carl both required 16 trial blocks to meet the mastery criterion for LT, while Aaron required only six trial blocks to meet the same criterion. Based on these results, it appears that an established listener repertoire on its own may not be sufficient to predict success in emergent intraverbal responses following LT for the same response.

Another factor that may have influenced the relative efficacy of the two training conditions was participants' overt vocal behavior during training. Specifically, Aaron engaged in more overt echoic responses on average during both training conditions (e.g., repeating the instruction or tacting the picture) when compared to John and Carl. These two participants emitted few, if any, overt vocal responses during training (e.g., 4–5 out of 12 tacts on average per trial block LT). Of importance, the intraverbal responses that did not emerge for both John and Carl corresponded to the stimuli for which an overt vocal response was never recorded. These findings suggest that an overt response may play a role in the emergence of untaught verbal behavior.

Other researchers have examined the role of mediating verbal behavior, more specifically *naming* in the development of emergent relations (e.g., Eikeseth and Smith 1992; Horne and Lowe 1996; Horne, Lowe, and Randle 2004). It may be plausible that Aaron's success with the SP condition is partially attributed to his vocal (echoic) responses throughout training. That is, echoing the instruction during both LT and SP may have helped Aaron attend to the visual stimulus and practice the correct response that would be required of him during intraverbal probes. Although we did not always directly observe him tacting the comparison stimuli, it is plausible that he did so covertly as a listener response was emitted. Given that contingent reinforcement was delivered for correct independent responses during LT, some accidental reinforcement of intraverbal responses may have occurred during this training. Interestingly, John and Carl did not engage in as many echoic or tact responses and also did not meet the mastery criterion for emergent intraverbal responses during posttest probes.

These results suggest that it may be important to evaluate a learner's echoic and tact repertoire in addition to joint attention and attending skills to determine if they are necessary for LT or SP training procedures to be effective in the emergence of intraverbal responses. Since we did not directly observe participants echoing sample stimuli and tacting comparison stimuli, this analysis is speculative. However, future studies may be designed to specifically evaluate the role of an echoic response (e.g., requirement to repeat the instruction) and tacts (e.g., requirement to label the picture) on emergent intraverbal responses in learners with ASD.

The findings of this study should be interpreted with caution given some limitations. First, there were slight procedural differences for Aaron compared to John and Carl. That is, although an intraverbal probe was conducted following each SP session for all participants, intraverbal probes following LT sessions were only conducted for John and Carl. Future research should further examine the number of trial blocks necessary for each of these procedures before the emergence of untaught responses is demonstrated.

Second, inter-trial intervals during the SP training condition may have differed due to technical difficulties with the iPad®. Although each slide was preset to advance after 3 s, the participants sometimes pressed on the arrow to advance the slides prior to this time requirement. Third, it is unknown what part of the verbal

stimuli evoked correct responses during intraverbal probes. For instance, in the question "what season do flowers bloom?," the verbal stimuli season, flowers, and bloom were all present and unique to this specific question. Therefore, it is possible that one or multiple verbal stimuli came to exert discriminative control over the participants' intraverbal responses. Future research should examine if the two procedures differ with regard to the stimuli that come to exert control over the intraverbal responses, and the factors contributing to the establishment of such functions (i.e., if participants echoing certain words during training is indicative of that word acquiring stimulus control over responding).

Lastly, these results are preliminary and no conclusive statements can be made with respect to the relative effectiveness of each training procedure due to the limited amount of data we have collected. Direct and systematic replications are necessary to further evaluate the relative effectiveness of each training condition. Future research may examine the potential role of multiple exemplars to help establish emergent intraverbal behavior when both LT and SP training conditions are implemented. Previous research has demonstrated success when multiple exemplar instruction is used to facilitate the emergence of mands (Nuzzolo-Gomez & Greer 2004) and tacts (Fiorile and Greer 2007; Nuzzolo-Gomez & Greer 2005). However, fewer studies have specifically evaluated the role of MEI to establish emergent intraverbal behavior (Greer et al. 2005). Given the limited number of studies in both LT and SP to teach or establish intraverbal repertoires, a wide range of applications remain to be explored.

Acknowledgments The first author (MVB) completed this project as a master's thesis under supervision of the second author to fulfill graduation requirements for the Applied Behavior Analysis program at Youngstown State University. We thank Amanda Gillen and Kristopher Brown for their assistance with reliability data collection.

References

Coon, J. T., & Miguel, C. F. (2012). The role of increased exposure to transfer-of-stimulus-control procedures on the acquisition of intraverbal behavior. *Journal of Applied Behavior Analysis, 45*, 657–666. doi:10.1901/jaba.2012.45-657.

DeLeon, I. G., & Iwata, B. A. (1996). Evaluation of a multiple-stimulus presentation format for assessing reinforcer preferences. *Journal of Applied Behavior Analysis, 29*, 519–532. doi:10.1901/jaba.1996.29-519.

Dounavi, A. (2011). A comparison between tact and intraverbal training in the acquisition of a foreign language. *European Journal of Behavior Analysis, 12*, 239–248.

Eikeseth, S., & Smith, T. (1992). The development of functional and equivalence classes in high-functioning autistic children: The role of naming. *Journal of the Experimental Analysis of Behavior, 58*, 123–133. doi:10.1901/jeab.1992.58-123.

Fiorile, C. A., & Greer, R. D. (2007). The induction of naming in children with no prior tact responses as a function of multiple exemplar histories of instruction. *The Analysis of Verbal Behavior, 23*, 71–87.

Greer, R. D., Yuan, L., & Gautreaux, G. (2005). Novel dictation and intraverbal responses as a function of a multiple exemplar instructional history. *The Analysis of Verbal Behavior, 21*, 99–116.

Horne, P. J., & Lowe, C. F. (1996). On the origins of naming and other symbolic behavior. *Journal of the Experimental Analysis of Behavior, 65*, 185–241. doi:10.1901/jeab.1996.65-185.

Horne, P. J., Lowe, C. F., & Randle, V. R. L. (2004). Naming and categorization in young children: II. Listener behavior training. *Journal of the Experimental Analysis of Behavior, 81*, 267–288. doi:10.1901/jeab/2004.81-267.

Ingvarsson, E. T., & Hollobaugh, T. (2011). A comparison of prompting tactics to establish intraverbals in children with autism. *Journal of Applied Behavior Analysis, 44*, 659–664. doi:10.1901/jaba.2011.44-659.

Keintz, K. S., Miguel, C. F., Kao, B., & Finn, H. E. (2011). Using conditional discrimination training to produce emergent relations between coins and their values in children with autism. *Journal of Applied Behavior Analysis, 44*, 909–913. doi:10.1901/jaba.2011.44-909.

Leader, G., & Barnes-Holmes, D. (2001a). Matching-to-sample and respondent type training as methods for producing equivalence relations: Isolating the critical variable. *The Psychological Record, 51*, 429–444.

Leader, G., & Barnes-Holmes, D. (2001b). Establishing fraction-decimal equivalence using a respondent-type training procedure. *The Psychological Record, 51*, 151–165.

May, R. J., Hawkins, E., & Dymond, S. (2012). Brief report: Effects of tact training on emergent intraverbal vocal responses in adolescents with autism. *Journal of Autism and Developmental Disorders, 43*, 996–1004. doi:10.1007/s10803-012-1632-7.

Miguel, C. F., Petursdottir, A. I., & Carr, J. E. (2005). The effects of multiple-tact and receptive-discrimination training on the acquisition of intraverbal behavior. *The Analysis of Verbal Behavior, 21*, 27–41.

Nuzzolo-Gomez, R., & Greer, R. D. (2004). Emergence of untaught mands or tacts of novel adjective-object pairs as a function of instructional history. *The Analysis of Verbal Behavior, 20*, 63–76.

Partington, J. W., & Bailey, J. S. (1993). Teaching intraverbal behavior to preschool children. *The Analysis of Verbal Behavior, 11*, 9–18.

Partington, J. W., & Sundberg, M. L. (1998). *Assessment of basic language and learning skills (The ABLLS): An assessment for language delayed students*. Pleasant Hill: Behavior Analysts.

Petursdottir, A. I., Carr, J. E., Lechago, S. A., & Almason, S. M. (2008a). An evaluation of intraverbal training and listener

training for teaching categorization skills. *Journal of Applied Behavior Analysis, 41*, 53–68.

Petursdottir, A. I., Olafsdottir, A. R., & Aradottir, B. (2008b). The effects of tact and listener training on the emergence of bidirectional intraverbal relations. *Journal of Applied Behavior Analysis, 41*, 411–415. doi:10.1901/jaba.2008.41-411.

Rosales, R., Rehfeldt, R. A., & Huffman, N. (2012). Examining the utility of the stimulus pairing observation procedure with preschool children learning a second language. *Journal of Applied Behavior Analysis, 45*, 173–177. doi:10.1901/jaba.2012.45-173.

Sindelar, P. T., Rosenberg, M. S., & Wilson, R. J. (1985). An adapted alternating treatments design for instructional research. *Education and Treatment of Children, 8*, 67–76.

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

Sundberg, M. L. (2008). *Verbal behavior milestones assessment and placement program: The VB-MAPP*. Concord: AVB Press.

Sundberg, M. L., & Michael, J. (2001). The benefits of Skinner's analysis of verbal behavior for children with autism. *Behavior Modification, 25*, 698–724. doi:10.1177/0145445501255003.

Takahashi, K., Yamamoto, J., & Noro, F. (2011). Stimulus pairing training in children with autism spectrum disorder. *Research in Autism Spectrum Disorders, 5*, 547–553.

Vendora, J., Meunier, L., & Mackay, H. (2009). Teaching intraverbal behavior to children with autism: A comparison of textual and echoic prompts. *The Analysis of Verbal Behavior, 25*, 79–86.

Watson, P. J., & Workman, E. A. (1981). The non-concurrent multiple baseline across-individuals design: An extension of the traditional multiple baseline design. *Journal of Behavior Therapy and Experimental Psychiatry, 12*, 257–259.