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The Effects of Conditioning Three-Dimensional Stimuli on Identity Matching and Imitative Responses in Young Children With Autism Spectrum Disorder

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We tested the effects of conditioning 3-dimensional objects as reinforcers on imitation and match to sample responses of young children with autism. Three children between the ages of 2 and 4.8 years who attended a center-based Early Intervention or preschool program participated in the study. The 3-dimensional object conditioning procedure involved the participants visually tracking preferred and nonpreferred items that were placed under transparent and opaque cups. The cups were then rotated a set number of times per phase. Results showed that for all 3 participants, the 3-dimensional conditioning procedure was functionally related to increases in generalized 3-dimensional matching and object use imitation. Decreases in instructional trials to criterion were noted for 2 of the 3 participants as well. The results are discussed in terms of observing and attending and the effects on reliable assessment and programmatic planning.

Keywords: observing responses, conditioning, visual tracking, imitation, autism

A broadening of interests or an expansion of one's community of reinforcers, preferred activities, or objects involves conditioned reinforcement (Baer & Wolf, 1967; Greer, 2002). Conditioned reinforcement may occur when the pairing of a previously neutral stimulus with a primary or secondary (conditioned) reinforcer functions to establish the original stimulus as a reinforcer (Cooper, Heron, & Heward, 2007). When young children are exposed to many objects, events, and activities that are paired with previously preferred stimuli (e.g., mom's voice, certain foods and drinks, certain auditory stimuli), their communities of reinforcers may expand. When one's community of reinforcers is plentiful, observation of and interaction with one's environment may be maximized.

Often individuals with disabilities have limited communities of reinforcers, which may interfere with their ability to learn behaviors that are functional and necessary to enter into a social community. Cusps are these types of behaviors and have been described by Rosales-Ruiz and Baer (1996) as changes in individuals that enable them to come into direct contact with new contingencies that may lead to other learning opportunities. Foundational cusps required to support entry into a social community include key observing responses that are selected out by each individual's community of reinforcers, consisting of conditioned reinforcement for observing faces (looking at another face during conversation, when being spoken to, or in response to one's name being called; Maffei, Singer-Dudek, & Keohane, 2014), conditioned reinforcement for observing two-dimensional stimuli (visual tracking; Greer & Han, 2015; Pereira-Delgado, Greer, Speckman, & Goswami, 2009), and generalized imitation (imitating the novel behavior of others; Du &

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Greer, 2014). Each of these behaviors is considered a cusp because when each is present in an individual, that individual may access reinforcement (or punishment) in new ways (e.g., by observation of voices, faces, or objects; by imitating another's actions). If visual observation of one's environment is not a preferred activity, an individual might not look at faces, visually observe moving objects, imitate others' movements, or observe visual changes in one's environment. We argue that in natural environments these responses are essential to learning (Dinsmoor, 1985; Greer & Han, 2015; Tsai & Greer, 2006).

Observing responses are operant responses, such as looking, smelling, and touching, which are selected out by their consequences and appear to be essential in the development of early listener and speaker behaviors (Greer, Pistoljevic, Cahill, & Du, 2011; Keohane, Luke, & Greer, 2008; Keohane, Pereira-Delgado, & Greer, 2009; Longano & Greer, 2015). For some children with disabilities, conditioned reinforcement for observing specific types of environmental stimuli has been identified as missing (Keohane et al., 2008). The conditioning of specific stimuli, such as visual stimuli, can occasion individuals to observe aspects of their environment that then allow for the development of verbal capabilities and cusps (Keohane et al., 2008, 2009). Research has shown that the conditioning of stimuli to select out specific observing responses resulted in the acceleration of learning (Dinsmoor, 1985; Greer & Han, 2015; Greer et al., 2011; Tsai & Greer, 2006). If individuals do not observe and respond to visual stimuli, the likely effects will be difficulties across all learning environments and in the acquisition of early language. Teaching visual observing responses to environmental stimuli is a challenge for many of those working with children with autism and related disabilities. Lack of observing responses to instructors and instructional materials can also potentially affect the accuracy of assessment of skills children possess.

Most individuals acquire conditioned reinforcement for looking at visual stimuli under natural contingencies during very early life experiences (Fantz, 1958; Peeples & Teller, 1975; Stirnimann, 1944). As their visual acuity increases, infants physically respond to changes in their environment, including visually salient differences in presented stimuli (Fantz, 1958, 1961; Slater, 1995) and moving objects (Salman, Sharpe, Lillakas, Dennis, & Steinbach, 2006). Salman et al. (2006) reported that *smooth pursuit eye movement,* defined as "slow, conjugate eye movements that stabilize the image of a slowly moving small target on or near the fovea" (p. 139), is present in infants, and it appears that smooth pursuit eye movement improves after 2 months of age. Thus, it is expected that at slow tracking velocities, young children without visual dysfunctions are physically capable of visual tracking.

In an infant's first year of life, preference and novelty become variables in visual observing responses (Roder, Bushneil, & Sasseville, 2000). Fantz's (1964) research on infant visual inspection was the seminal study on what would be later termed *visual habituation.* The experiment showed that when presented with unchanged and novel stimuli (one to the right of midline and one to the left of midline) across trials, infants tend to look at the familiar stimuli, and then as trials progress, they begin to "prefer," or look at, the novel stimuli. The theory was that the infants' looking toward the familiar stimulus had "habituated." Roder et al. (2000) also studied infants' preferences for novelty and familiarity. Seventy-two infants within 10 days of being 4.5 months old were tested to determine which types of stimuli evoked visual responses, a measurement of preference. The participants were shown pictures of infant faces, everyday objects, and kaleidoscope patterns. The results showed that for the faces and objects stimuli, the infants demonstrated an initial robust familiarity preference that rather abruptly shifted to a novelty preference.

Humans' initial preference for familiar stimuli is evidenced by many of the behaviors emitted by neurotypical infants and young children. Between 0 and 7 months of age, infants orient toward a pacifier or bottle in view (Brigance, 2004). Between 9 months and 1.5 years of age infants begin to selectively model actions with objects, such as throwing a ball or rattling keys (Zimmerman, 2011). Finding preferred items that have been initially viewed and then hidden from sight is seen in 16-month-old children (Huttenlocher, Newcombe, & Sandberg, 1994). Thus, current research has supported that by age 1.5 years, typical development of visual observation responses includes orientation toward preferred or novel stimuli, tracking moving stimuli, and finding previously viewed hidden items.

It appears that, as a listener or as a speaker, in order for learning to occur, an individual must attend to the specific characteristics and salience of visual stimuli. Following the conditioning of visual stimuli as a reinforcer for observing responses, children acquired generalized visual match-to-sample (Greer & Han, 2015). Longano and Greer (2015) found that conditioned reinforcement for visual and auditory stimuli was necessary for the incidental acquisition of language. In order to learn the names of objects, an individual must attend to the spoken word for the object or auditory stimuli as well as the object itself, the visual stimulus (Horne & Lowe, 1996).

For many children with developmental delays and diagnoses of autism spectrum disorder (ASD), researchers have found that attention to and conditioned reinforcement for visual stimuli may not be present in their repertoires (Greer & Ross, 2008). When this is true, reliable assessment of current skills, which leads to an appropriate individualized education or family service plan, is difficult because *attention* limits correct responding. Also, the rate of learning and progress toward achieving academic and social goals can be slow and impeding.

Previous research has addressed teaching children with autism to make and maintain eye contact using prompting and overcorrection procedures (Foxx, 1977; Greer & Ross, 2007; Lovaas, 1977). Extrinsic prompts, however, can be difficult to fade and may evoke avoidance responses from some individuals for whom these types of prompting may be aversive (Carbone, O'Brien, Sweeney-Kerwin, & Albert, 2013). Also of concern is the generalizability of these taught responses across other settings and under novel conditions (Faye & Schuler, 1980). More recently, conditioning procedures that are designed to target specific observing responses, which generalize across settings and classes of stimuli, have been successful (Greer & Han, 2015; Maffei et al., 2014; Pereira-Delgado et al., 2009). In all of these studies, conditioning stimuli including faces and instructional materials as conditioned reinforcers led to increases in observing responses toward these stimuli across generalized conditions.

We assessed three children for specific observing responses toward common toys, common objects, and tabletop activity materials such as books and puzzles. If they oriented 1 s toward an item presented within 1 m of their eyes, a plus was recorded; otherwise minuses were recorded. Fewer than 50% correct responses for orienting responses, paired with low acquisition rates on four of the students' current programs targeting compliance and generalized imitation with and without objects (discussed later), were criteria for entry into the current experiment. We then implemented a three-dimensional conditioning protocol to determine whether this intervention was functionally related to increases in responses to several target match and imitation programs.

Method

Participants and Setting

Three male children, ranging in age from 2 to 5 years old and diagnosed with ASD by medical doctors, were selected to participate in the study due to low levels of observing responses to visual and auditory stimuli and low levels of correct responding across several prerequisite and foundational instructional programs. Table 1 provides a more detailed description of each participant. All three participants attended a special education preschool and Early Intervention center where the methodology was teaching as applied behavior analysis.

Setting

This study took place in a private, publicly funded preschool located in a suburb of a major metropolitan area. Probes for the presence or absence of the dependent variables were conducted in each participant's regular classroom in one-to-one settings. Each classroom was furnished with child-sized chairs and tables, and areas were designated for both one-to-one and small-group instruction. The three-dimensional conditioning protocol was conducted in each participant's daily classroom setting as well. The teachers and the participants sat in child-sized chairs and were next to or across from each other during probe conditions and during the implementation of the three-dimensional conditioning procedure.

Table 1
Description of Participants

Participant	Age	Classroom setting/ratio	Diagnosis	Test Scores
Participant A	4 years old	-Preschool Program - 5 hours, 5 day a week Center Based Program -6:1:2 Student/Teacher/TA ratio	Autism	PLS-4 Score Auditory Comprehension and Expressive Communication 50 standard score Percentile: 1% DAYC Scores Cognitive: 60 Communication <50
Participant B	2 years 2 months	-Early Intervention -2.5 Hours, 5 day a week Center Based Program -6:2:2 Student/Teacher/TA Ratio	Pervasive Developmental Disorder	-DAYC Scores Cognitive: 73 standard score Communication: 74 standard score Social: 66 standard score * *all scores fell in the poor or very poor range*
Participant C	4 years 10 months	-Preschool Program - 5 hours, 5 day a week Center Based Program -6:1:2 Student/Teacher/TA ratio	Autism	-PLS-5th Ed.: Auditory Comprehension and Expressive Communication: standard score 50 Vineland II: Adaptive: 54 standard score Communication: 52 standard score

Note. PLS-5th Ed. = Preschool Language Scale, Fifth Edition; DAYC= Developmental Assessment of Young Children Voress & Maddox, (2013); Vineland II = Vineland II Adaptive Behavior Rating Scale.

Materials

For the intervention, three transparent and three opaque cups were used, as were preferred and nonpreferred items. Preferred items typically consisted of chosen edibles and small toys, and nonpreferred items consisted of items that the participant had never chosen during preference assessments. A bin filled with novel items was often offered to the participants as part of preference assessments to identify preferred stimuli during intervention sessions if necessary. For probe sessions, the following materials were used during matching probes: (a) small objects that measured approximately 6 cm in length or height and 6 cm in width and (b) laminated pictures that measured 6 square cm. Some examples of target objects and pictures were a fish, apple, bear, and cup. Objects and pictures were chosen as materials for probes on the basis of the simplicity of the words and images and the typical commonality of the stimuli.

Experimental Design

A delayed multiple probe design (Heward, 1978; Horner & Baer, 1978) was used to test the effects of the three-dimensional conditioning protocol on the dependent measures. The design sequence allowed for Participants B and C to enter the experiment in a delayed fashion, in which preintervention probes were not conducted for them until effects of the protocol were observed for Participant A. The sequence therefore was implemented with preintervention probes conducted for Participant A first. The independent variable, the three-dimensional conditioning protocol, which included multiple phases (see Table 2), was then implemented for Participant A. Once he completed the three-dimensional conditioning protocol package, we conducted postintervention probes for Participant A and preintervention probes across dependent variables for Participants B and C. We then implemented the intervention protocol package for Participant B, which, as with Participant A, included several phases. In Phase 6 of the intervention procedure, Participant B did not master or meet criterion even after additional instructional tactics were presented. The experimenters then decided to conduct postintervention probes to determine whether the intervention protocol (following mastery of the

Table 2
Description of the Protocol Phases Sequence

Phase Sequence	Materials	# of Cups	# of Rotations	Movement
1	Transparent Cups	3	1	Reinforcer under a cup
2	Transparent Cups	3	2	Reinforcer under a cup
3	Transparent Cups	3	3	Reinforcer under a cup
4	Opaque Cups	3	1	Reinforcer under a cup
5	Opaque Cups	3	2	Reinforcer under a cup
6	Opaque Cups	3	3	Reinforcer under a cup
7	Opaque Cups	3	3	Non-preferred stimuli under a cup

Note. Intervening tactics were implemented for some of the participants if they were not mastering a given phase. Interventions included: prompting correct response and to rotate preferred and non-preferred items for phase 7. Graphs reflect phases in which such intervening tactics were implemented.

first five phases) had effects for Participant B on the dependent measures. A second set of preintervention probes was conducted for Participant C as well. We conducted postintervention probes before Participant C completed all of the phases of the protocol because he was aging out of his preschool program and transitioning to kindergarten. Delayed entry into the study for Participants B and C was a result of this experiment's being conducted in a classroom setting, in which procedures were implemented when and if students required specific interventions. Given the positive effects the procedure had for Participant A, a decision to implement the same protocol for Participants B and C was made.

Dependent Variables

Pre- and postintervention assessments were conducted to collect data on several dependent measures. The first set of dependent variables in this study were participants' responses to (a) 10 consequated trials of matching 10 different identical sets of objects, (b) 10 consequated trials of matching 10 different identical sets of pictures, (c) 10 consequated trials of matching 10 nonidentical objects, (d) 10 trials of 10 imitation responses, and (e) 10 trials of 10 imitation responses using objects. For trials that were consequated, reinforcers were delivered following correct responses and simple correction procedures were implemented following incorrect responses. For trials presented during the imitation and imitation with objects probes, no reinforcement or correction procedures were implemented following participants' correct and incorrect responses. There were no delivered consequences during imitation probes because the natural reinforcer for generalized imitating is correspondence between seeing and doing (Keohane et al., 2009). Therefore, prosthetic reinforcement would not be necessary if this cusp were present.

During all matching probes, the target stimulus was placed in a field of three with two rotating nonexemplars, and the vocal antecedent "Match . . ." was delivered. A correct response consisted of the participant's placing the sample object or picture with the matching comparison object or picture within 3 s. Reinforcement in the form of praise with preferred edibles, items, or activities was then delivered. An incorrect response consisted of the participant's placing the target object or picture with the wrong comparison, responding outside of 3 s, or emitting no response. A correction was given contingent upon incorrect responses. A correction consisted of (a) the experimenter representing the materials and showing the participant the correct response and then (b) the participant emitting the correct target response. Responses to corrections were not reinforced.

During imitation probes, the teacher modeled the target action and delivered the direction, "Do this." A correct response consisted of the participant's imitating the action with point-to-point correspondence within 3 s. An incorrect response consisted of the participant's emitting an action without correspondence to the model, responding outside of 3 s, or emitting no response. Imitation trials were not reinforced or corrected. The following responses were targeted during imitation probes: (a) generalized imitation (unconsequated): flap arms, tap leg, rub head, point to table, raise legs, point to hand, cover eyes, tap head, or nod and (b) object imitation (unconsequated): insert puzzle piece, hug baby, roll car, drink from cup, stack Lego, push toy, open book, wipe table, scribble on paper, or feed baby.

Prior to and after the intervention, data were analyzed for participants' progress on these four separate programs:

1. Instructional control: Target responses were to sit down, sit still, look here, and look at me (all presented with hand gestures to facilitate correct responding).
2. School routines: Target responses were to come here, go to the table, go to the toy area, and give me (an item; all presented with hand gestures to facilitate correct responding).
3. Selective imitation (imitative responses that likely have a history of social reinforcement): Four motor actions were modeled per phase. See Table 3 for individualized objectives for each participant; these were different responses from the ones tested during the probes for imitation.
4. Object use imitation: Four actions with objects were modeled per phase. See Table 3 for individualized objectives for each participant. These responses were different from the ones tested during the probes for object use imitation. Different operants were tested during the probe sessions to test whether generalized imitation had emerged. Each short-term objective consisted of four different responses.

The experimenters calculated the number of consequated trials, or opportunities to respond with teacher feedback, that were required for participants to meet short-term objectives across these four programs both prior to intervention and after the intervention was completed. The following is an example of one consequated trial: (a) The experimenter says to a participant, "Look here," and points to an object or picture, (b) the participant is either looking or not looking, and (c) the experimenter delivers either an approval and preferred item or activity for a correct response, or a simple correction for an incorrect response. We calculated consequated trials to short-term objective by analyzing 200 trials per program for a total of 800 prior to and following the protocol. We divided the number of trials by the number of short-term objectives achieved prior to and following the intervention.

Protocol to Condition Three-Dimensional Stimuli

Data were first collected on all dependent measures as a preintervention assessment. After data were collected and analyzed for all dependent

Table 3
Individualized Short Term Objectives and Actions Targeted for Participants A, B and C for Selective Imitation with and without Objects

Participant	Instructional Objective	Target Responses
A	Selective imitation	Clap Hands, Raise Arms Tap Table, Pat Lap
	Selective imitation with objects	Roll Train, Shake Maraca Ball in Bin, Stack block
B	Selective imitation	Clap Hands, Raise Arms Tap Table, Pat lap
	Selective imitation with objects	Roll Car Drop ball in bin Shake Maraca Pick up cup
C	Selective imitation	Raise Arms, Clap hands, Tap table, Stomp Feet
	Selective imitation with objects	Stack a block Insert pop bead Drop block in bin Roll train

measures, the intervention treatment package to condition three-dimensional stimuli was implemented.

At the start of each session and, when necessary, during the session, a preference assessment was presented to determine the participants' desired stimuli. This consisted of the experimenter's presenting several stimuli—toys, edibles, stickers, pictures—on the tabletop in front of the participant. Stimuli were selected on the basis of items the participant had selected in the past or were known to be reinforcers for him. Stimuli varied and were positioned in random order for each preference assessment. Because all of the participants were non-vocal–verbal, gestures toward the items such as pointing or attempting to take the items were considered "choice" responses. Once a potential reinforcer was identified, the experimenter began the cup rotation procedure.

The experimenter rotated either transparent or opaque cups, which were placed on top of the chosen item(s) for that trial. During each phase of the procedure, participants were required to visually track, or maintain eye contact with, the cups under which the chosen items were placed (except for the final phase, during which nonpreferred items were targeted for tracking responses). After the set number of cup rotations and the experimenter's vocal antecedent "Find it," the participants were required to pick up the cup to expose the item. A correct response was recorded as a plus if a participant visually tracked the cup or chosen item(s) for the required number of rotations and picked up the correct cup. Correct responses were followed by the experimenter's delivering praise and an edible or tangible reinforcer that was not the item that the participant had tracked. However, the participant had other opportunities throughout the session to receive the tracked items for emitting other desired behaviors (e.g., sitting in chair nicely, not emitting stereotypy, eye contact, responding to name) and by emitting correct responses to other antecedents but not contingent upon tracking the item. An incorrect response was recorded if a participant initially made eye contact with the target cup but did not maintain eye contact throughout the set number of cup rotations or if the participant did not pick up the cup to expose the item underneath.

A session consisted of 20 opportunities to track the rotated cups. Table 2 outlines the sequences of phases in this protocol. In order for the participants to move on to the next phase, they were required to respond with 80% accuracy for two consecutive sessions. For some phases, the experimenters made analytic decisions regarding the need for interventions on the basis of data trends within that phase. The experimenters followed a decision-tree protocol (Keohane & Greer, 2005) to determine whether to continue or intervene within a phase. Table 3 also notes some of the tactics that were implemented due to lack of progress within a phase of the protocol. Intervening tactics included stimulus and response prompts to evoke correct responses. Stimulus prompts included positioning the targeted cup closer to the child, and a response prompt used was using a gesture prompt pointing to the correct cup. In phases where nonpreferred stimuli were used and a tactic was necessary for progress, a fading procedure was implemented. This consisted of switching between using preferred and nonpreferred items until preferred items could be faded out.

Interobserver Agreement

An independent observer was present during 33% of the intervention sessions and 55% of the probe sessions. Observers had been trained on how to implement the protocol as well as how to record data. Observers recorded data on participant responses, and at the end of each probe or intervention session, they compared their data to the data collected by the experimenter who had conducted the session. Interobserver agreement was calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100. Point-to-point interobserver agreement was calculated at 100% for the intervention sessions and 95% for the probe sessions, with a range of 90% to 100%.

Results

Participant A met the long-term objective for the conditioning procedure after the 10th objective (see Figure 1). Compared to his responses during baseline probes, correct responses increased from 0% to 50% and from 20% to 60% for matching identical three-dimensional stimuli (see Figure 2) and object use imitation (see Figure 3), respectively. Participant A showed an

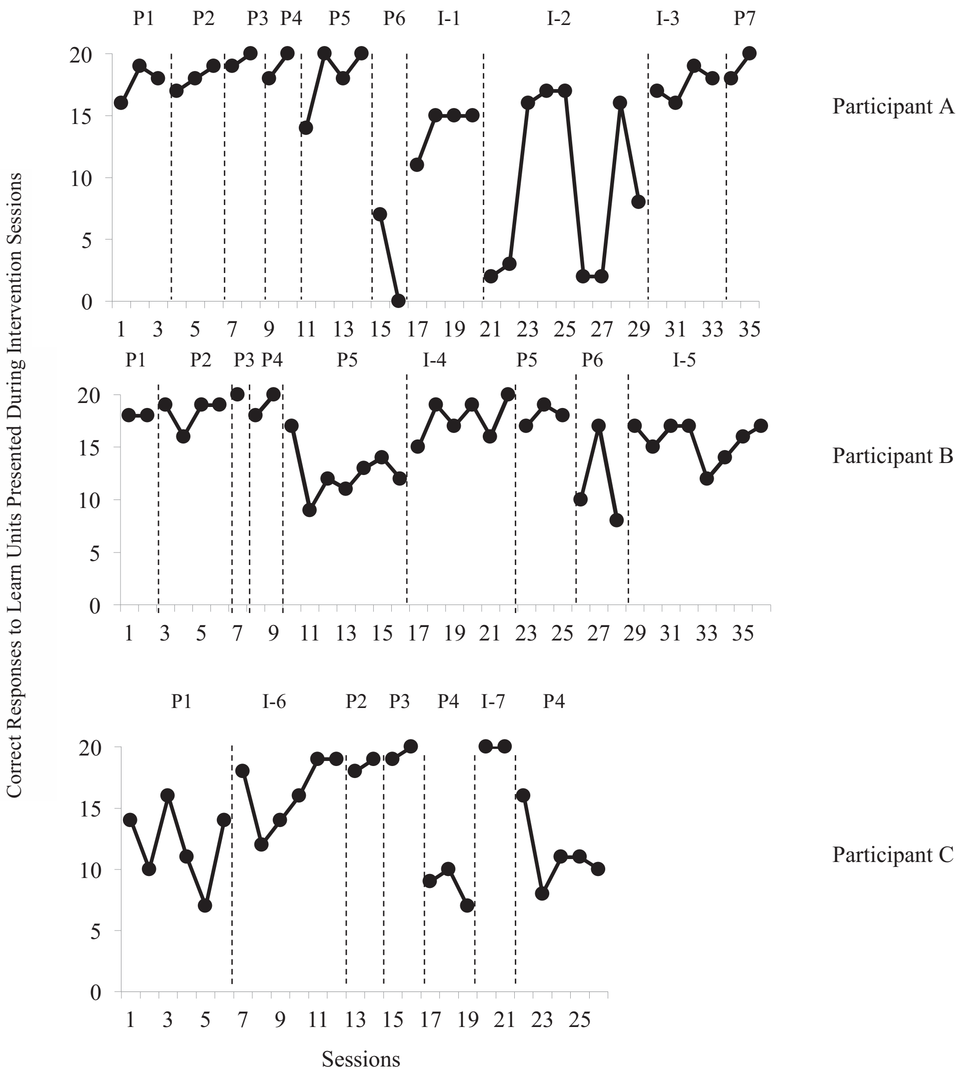

Figure 1. Correct responses to learn units presented during the Three-Dimensional Conditioning Protocol and required intervention sessions for Participants A, B, and C. Phases 1-3 represented transparent cups, reinforcer under the cup. Phase 1 consisted of 1 rotation; Phase 2 of 2 rotations; Phase 3 of 3 rotations. Phases 4-7 represented opaque cups. Phase 4 consisted of 1 rotation; Phase 5 of 2 rotations; Phase 6 of 3 rotations; Phase 7 of 4 rotations. Interventions 1, 4 and 6 consisted of a prompted correct response utilizing 3 opaque cups with a non-preferred stimulus under the cup. Interventions 2, 5 and 7 consisted of 3 opaque cups, 3 rotations with nonpreferred stimuli under the cup with a 2-second time delay before prompting the correct response; Intervention 3 of 3 opaque cups, 3 rotations, rotating non-preferred and preferred stimuli.

increase in correct responses from 0% to 30% for matching two-dimensional stimuli (see Figure 4) and from 0% to 50% for matching non-identical stimuli (see Figure 5). There were no effects of the protocol for generalized imitation responses (see Figure 6) or matching two-dimensional to three-dimensional stimuli (see Figure 7) for this participant. Postintervention probes were conducted for Participant B after 36 sessions of the protocol package (Phase 1 to

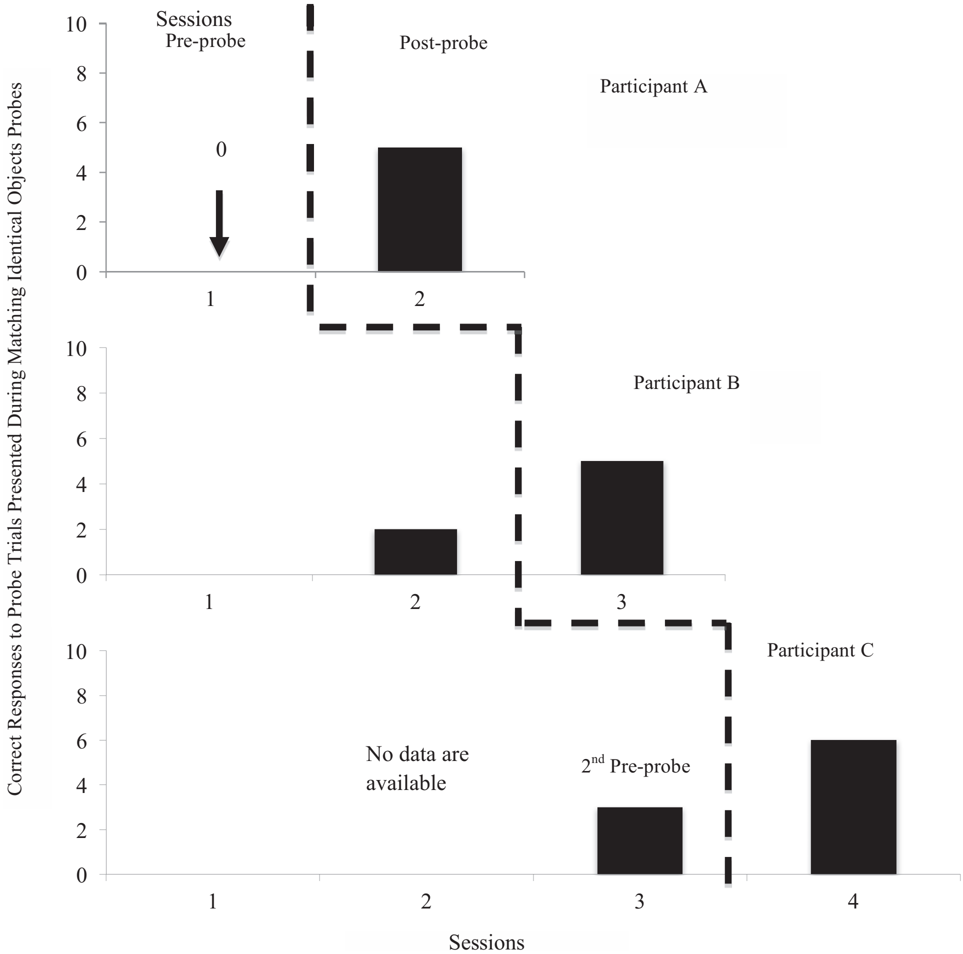

Figure 2. Correct responses for matching identical objects emitted by Participants A, B, and C during pre- and post-probe trials.

Phase 6). He did not perform to criterion levels in Phase 6 and thus did not complete the last two phases of the protocol.

Participant B showed increases in correct responses for all behaviors except matching two-dimensional to three-dimensional stimuli. Correct responses increased from 20% to 50% for matching three-dimensional stimuli, from 20% to 70% for object imitation, from 20% to 40% for matching two-dimensional stimuli, from 0% to 30% for matching nonidentical objects, from 0% to 30% for imitation, and from 10% to 50% for matching nonidentical objects.

Participant C never completed the protocol, due to discontinued enrollment in the program. Postintervention probes were conducted after the 27th session or after the participant completed only three phases of the protocol. For Participant C, correct responses increased from 30% to 60% for matching identical objects, from 40% to 60% and 50% to 60% respectively for object imitation, from 0% to 20% for imitation, and from 10% to 50% for matching nonidentical objects. He had one more correct response for object imitation, no increases in correct responses for matching identical pictures, and no increases in correct responses for matching objects to pictures following the protocol. The data also showed that for Participants A and B, the number of instructional trials to

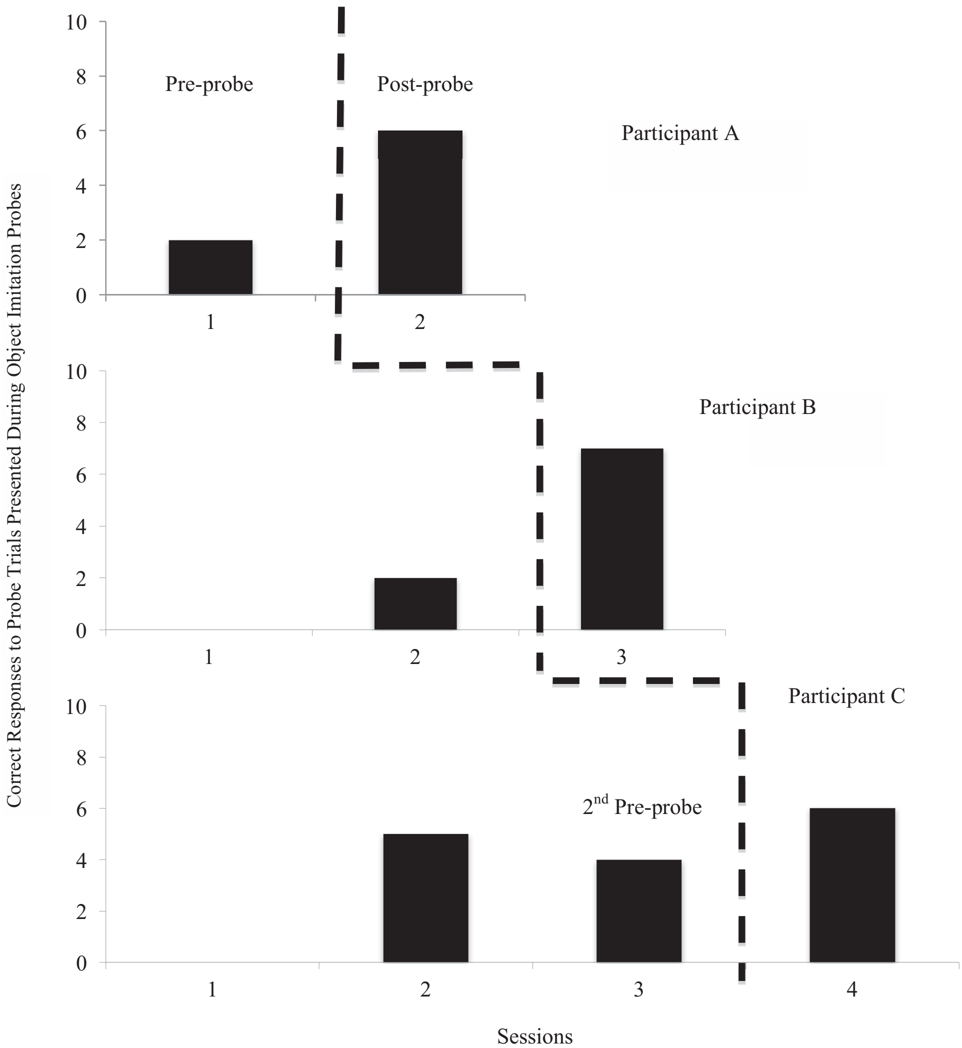

Figure 3. Correct responses for object imitation emitted by Participants A, B, and C during pre- and post-probe trials.

criterion achieved decreased following the protocol (see Figure 8). In other words, their rates of learning increased. Also, see Figure 9 for total numbers of correct responses pre- and postprotocol for all three participants.

Discussion

We tested the effects of a protocol to condition three-dimensional stimuli as reinforcers such that these stimuli would then select out observing responses for three young children with autism. Our results showed that for all three participants, effects of the procedure were demonstrated for certain repertoires but not others. All three participants showed increases in matching identical three-dimensional stimuli and object use imitation. Participants A and B also demonstrated increases in correct responses for matching two-dimensional stimuli. For the first three phases of the procedure, the participants were able to view the preferred items underneath the transparent cups throughout the rotations. When participants made and

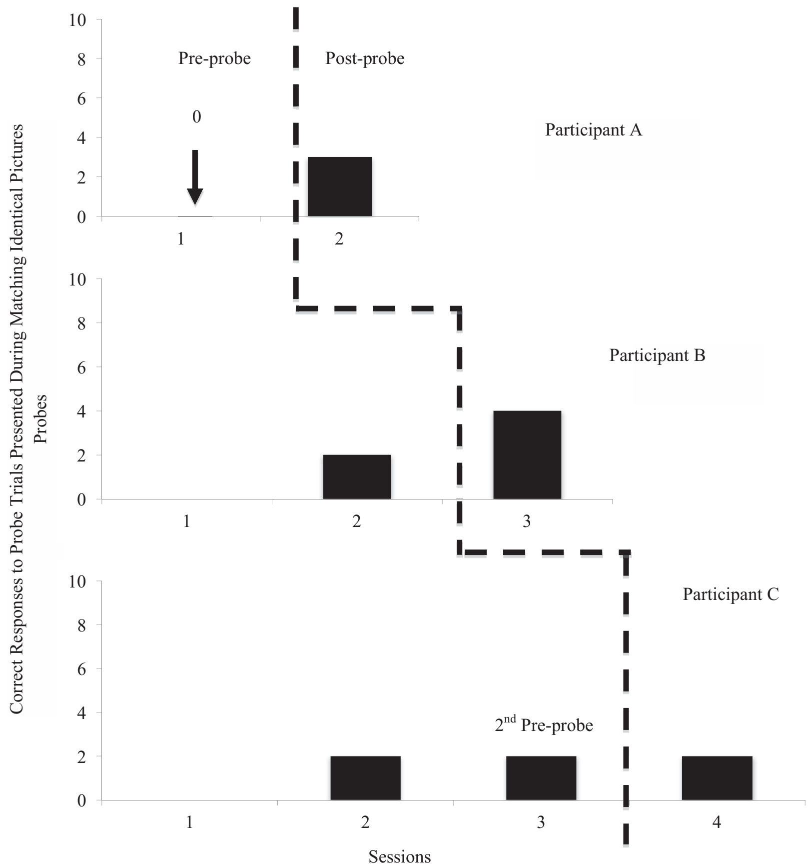

Figure 4. Correct responses for matching identical pictures emitted by Participants A, B, and C during pre- and post-probe trials.

maintained eye contact with each chosen visual stimulus for the preset number of rotations, the experimenter delivered social, edible, activity, and/or object reinforcers. Throughout the protocol, participants' visual tracking responses were paired with preferred stimuli and then were followed by the presentation of other preferred stimuli. This process likely served to condition neutral three-dimensional stimuli as reinforcers such that they now selected out the participants' observing responses. Once conditioned reinforcement for three-dimensional stimuli was present as an early verbal cusp, the participants had more correct responses to tasks during which they were required to observe presented stimuli. This effect was likely a result of both classical conditioning (the pairing between viewing the preferred item and tracking) and operant conditioning (the delivery of a different preferred item following a correct observing response). Once the participants were observing the instructors' hands and the stimuli that they presented, the right motivational conditions might then have been in place for the participants to begin to match identical stimuli and imitate object use. The participants were then attending to instructional materials, resulting in increases in correct responses to these tasks.

A limitation to some early eye contact interventions utilizing response prompts was the need to fade out the prompts, which at times proved difficult. At no time during the probe sessions did the participants receive any prompt procedures from the instructors or researchers. All recorded responses were emitted at an independent level.

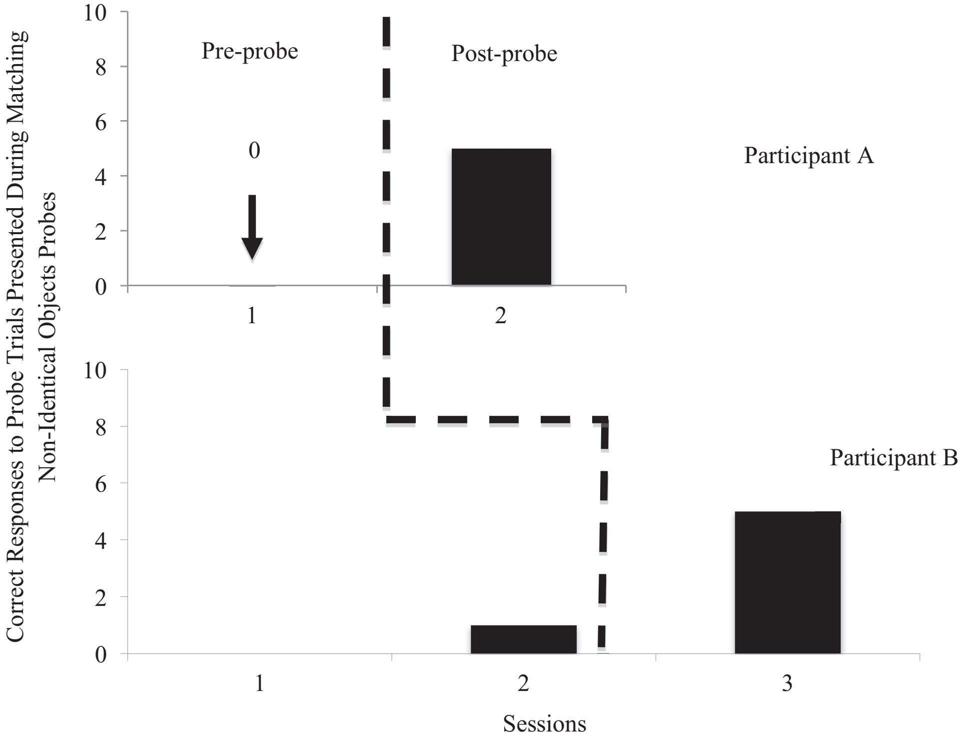

Figure 5. Correct responses for matching nonidentical objects emitted by Participants A and B during pre- and post-probe trials. Participant C data are unavailable.

Interobservers were trained to watch specifically for any cues, whether intentional or unintentional, from the instructors toward participants. This is noteworthy because prompt procedures, although certainly effective for some learners and for some skills and repertoires, sometimes are not easily faded; therefore, targeting independent responding is preferable when possible.

None of the participants reached 100% accuracy during any of the probes. However, the attainment of each skill or cusp was not the purpose of the intervention. We sought to increase the participants' observations of their environments such that they would increase responding to teacher presented instruction, and the data suggest that this did occur as a function of the treatment.

We also sought to increase reliable responding to assessment items. The reason that these students were chosen to be participants was their lack of observing responses to visual stimuli, which impeded our ability to conduct testing necessary to determine what their instructional objectives should be. Although formal and standardized testing does not alone determine developmental and educational goals and objectives, it is an important indicator of skills when used in conjunction with other types of assessment (i.e., direct observation, interview, informal assessment). Following our protocol, all three participants were able to be formally tested by their teachers using a criterion-referenced assessment, whereas beforehand reliable testing could not be conducted, due to lack of observing responses to presented stimuli. It was noted in all three participants' prior evaluations by their testers (scores are shown in Table 1) that the scores reported were judged to be a probable underestimate of true abilities because decreased "attention" limited responding.

We tested the effects of the protocol on two types of imitative responses. Prior to the protocol intervention, none of the three participants had learned to imitate selected actions with or without objects. In this study we included actions that are frequently observed in typical early childhood, such as waving and clapping hands. Infants receive adult attention

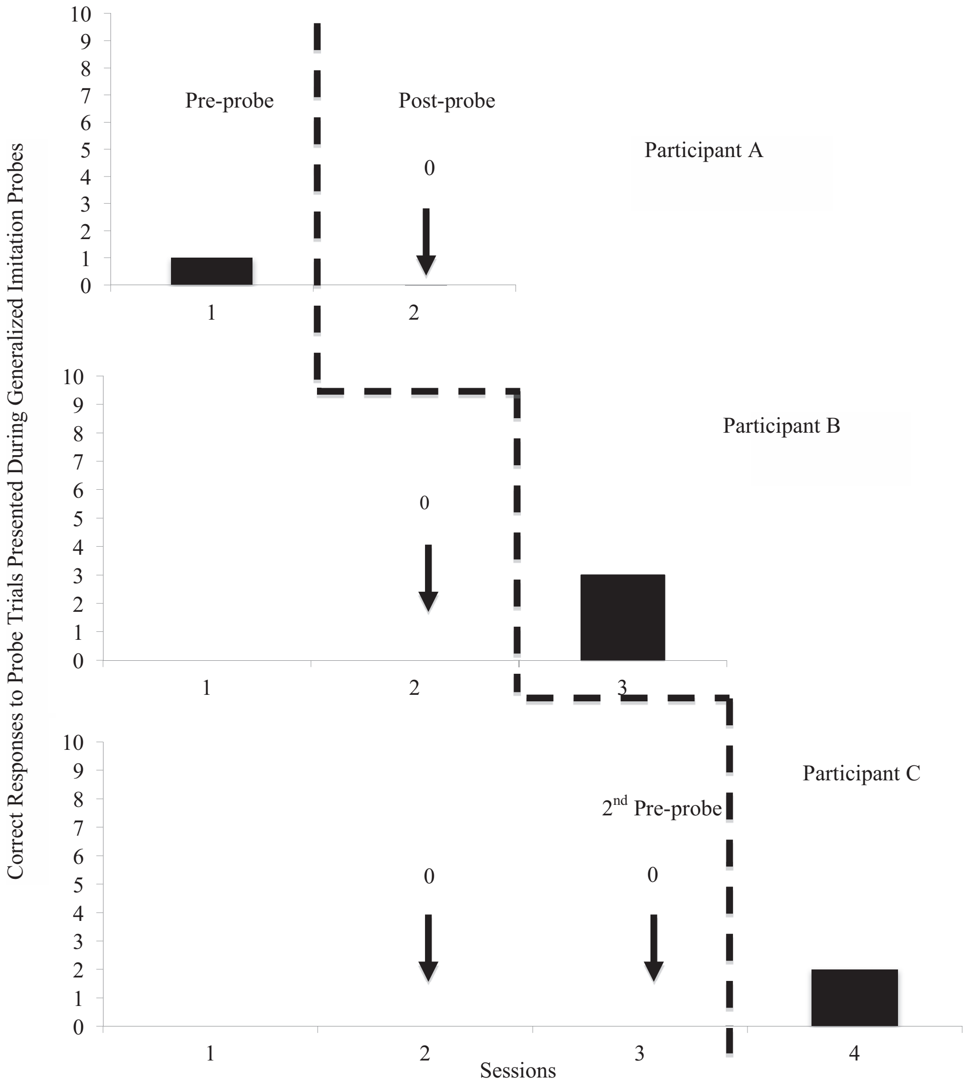

Figure 6. Correct responses for generalized imitation emitted by Participants A, B, and C during pre- and post-probe trials.

and approval for imitating these responses in social situations; thus, there is a history of generalized reinforcement associated with imitative responses such as these. Most children will acquire these common, selective imitative responses at very young ages; however, our three participants had not acquired specifically targeted imitative responses, even though they had been provided with many consequated trials and prompts. Following the protocol, not only did participants start to acquire the imitative responses that were directly taught (see Figure 9), but Participants B and C also showed increases in imitative responses that had not been directly taught (see Figure 6). Again, no prompts were provided under these conditions.

Several limitations to the current study are necessary to note, because they may have affected the overall findings. Only one participant, Participant A, received all phases of the protocol. Participants B did not meet criterion

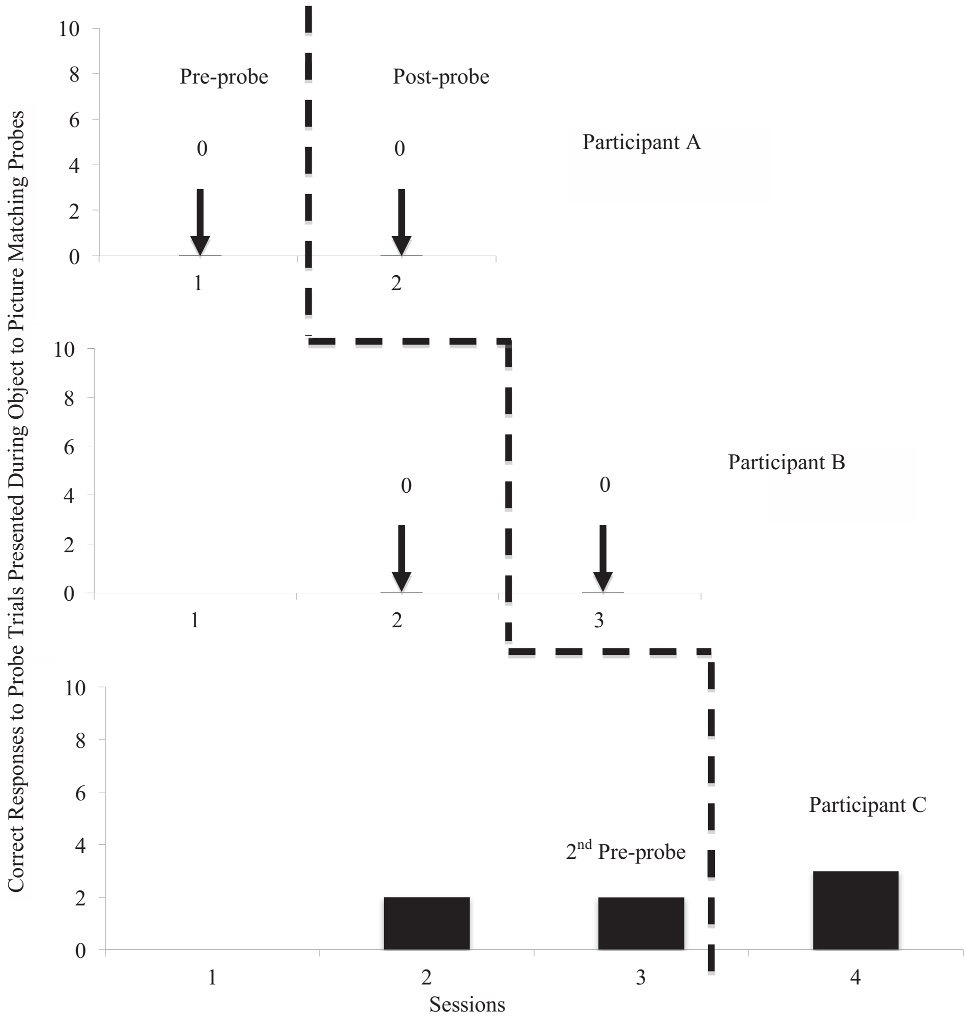

Figure 7. Correct responses for matching objects to pictures emitted by Participants A and B during pre- and post-probe trials.

on the last phase of the protocol, and Participant C graduated from the program in which the study took place before completing the protocol. We thus must question whether the results would have been more robust if Participants B and C had received all phases. Additionally, the fact that two out of three participants were unable to finish the protocol in its entirety call into question the feasibility of all phases of the protocol. Du, Broto, and Greer (2015) reported on a modified version of the conditioning three-dimensional-stimuli protocol. The changes in the protocol involved (a) rotating cups to a duration criterion per trial and (b) delivering the item under the cup as the consequence paired with praise. The results showed that for four preschool participants with ASD, there were increases in generalized matching and early observing responses. All participants received all phases of the protocol. The design of the protocol has since been revised, and the Du et al. (2015) protocol is now the standard procedure.

Another limitation to this study was that some of the dependent measures were not available for all participants. Consequated tri-

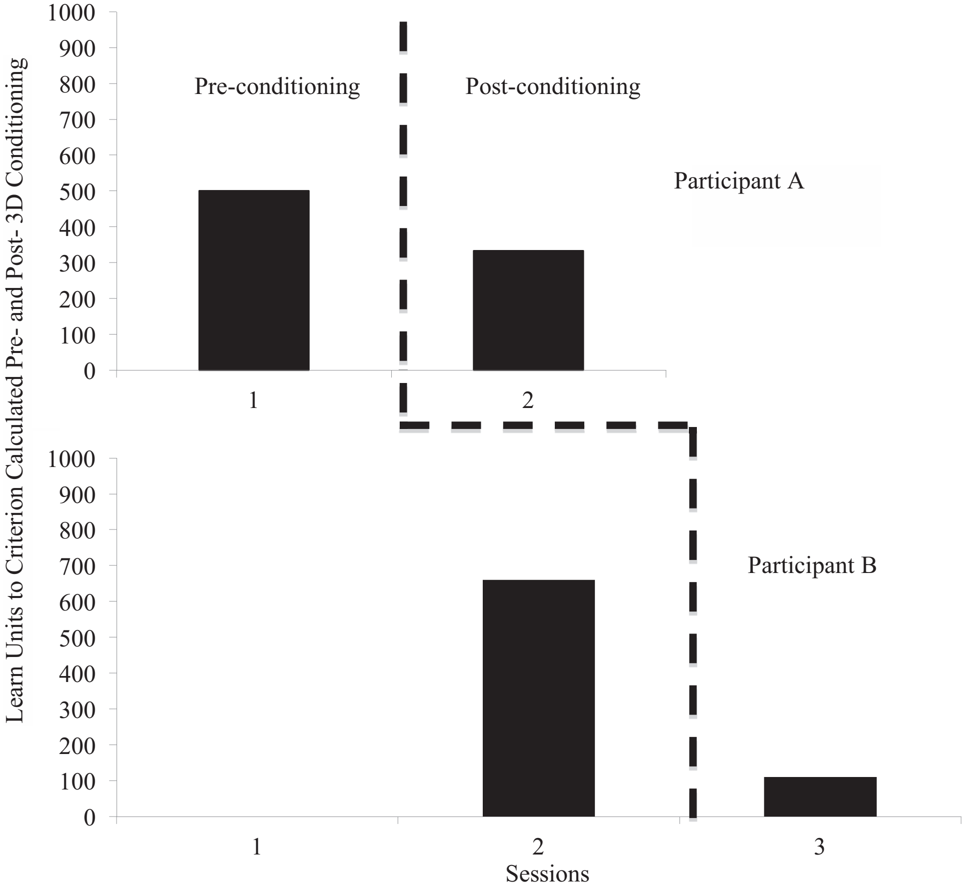

Figure 8. Learn units to criterion for 800 learn units pre- and post-conditioning 3D stimuli for object use imitation, matching identical objects, selective motor imitation and instructional control programs for Participants A and B. Participant C data are unavailable.

als to criterion data were not available for Participant C because he left the program. If these data had been available, this dependent measure may have supported an increase in rate of learning to a greater extent. Several interventions were implemented throughout the study when participants were having difficulty reaching criterion levels in certain phases of the protocol. These interventions differed across participants and thus could have had different effects for different participants. Although unlikely, this is a possibility.

The delayed manner in which the design was implemented also needs to be considered in regard to limitations. Initial per-intervention probes were not conducted for Participants B and C at the same time as for Participant A. Thus, maturation and acquisition of skills over time needs to be considered as a variable. However, when analyzing the data across all three participants, there is strong evidence that following exposure to the conditioning three-dimensional stimuli procedure, increases in the dependent measures were observed.

Future research in this area should involve measuring additional dependent variables such as independent toy play and visual observation in free-play settings. Because we are theorizing that visual observation of one's environment increased as a function of our protocol, it is possible that the protocol may have effects on these behaviors as well.

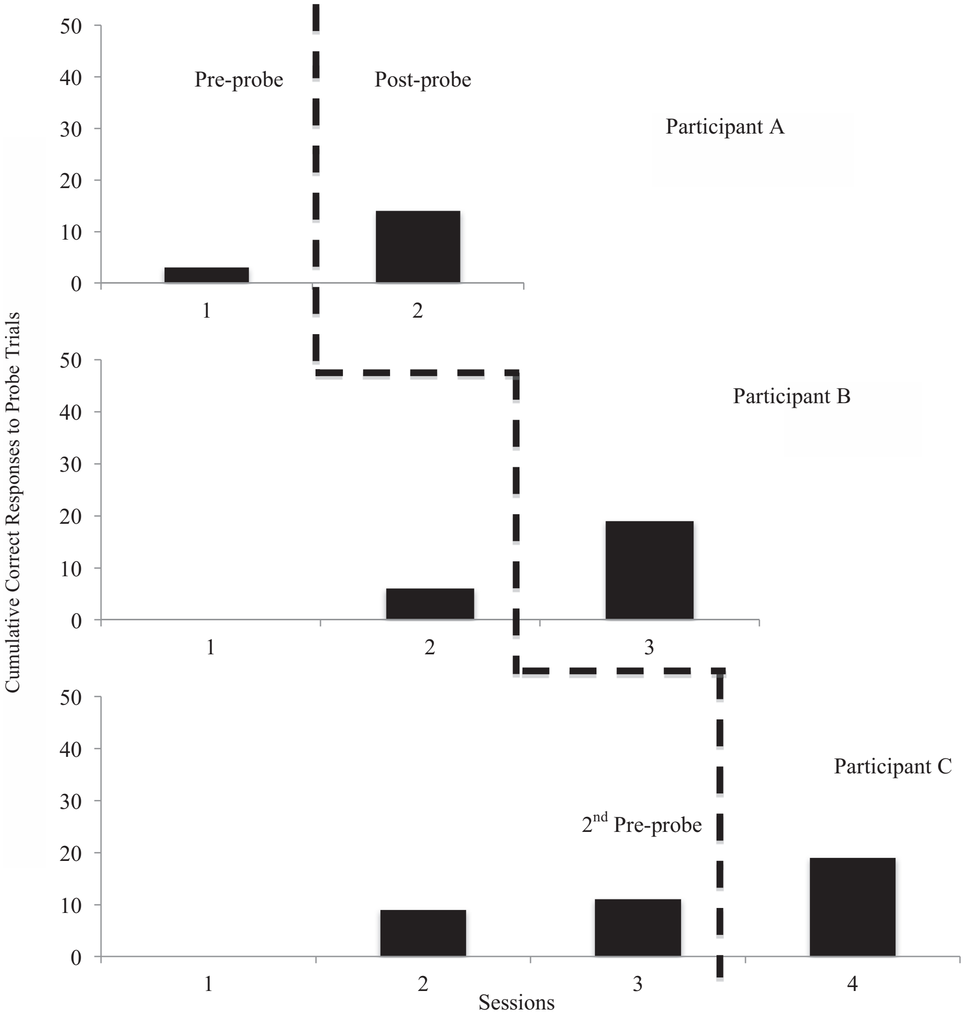

Figure 9. Cumulative correct responses to matching identical objects, matching identical pictures, generalized imitation, object use imitation, and matching pictures to objects probes for Participants A, B, and C.

Greer and Han (2015), Greer et al. (2011), and Tsai and Greer (2006) found that after targeted stimuli were conditioned as reinforcers and corresponding observing responses emerged, participants learned at accelerated rates. Similarly, we found that after three-dimensional stimuli acquired reinforcing properties and participants began to attend and visually track three-dimensional stimuli, learning was accelerated across instructional programs. Prior to the conditioning procedure, we measured and calculated the average number of instructional trials necessary to achieve an objective across imitation, matching, school routines, and instructional control responses for Participants A and B. Prior to the intervention procedure, both participants learned at slower rates and were presented with many instructional trials before mastering an objective or meeting the set criterion for an objective. Following the conditioning procedure, we observed a significant decrease in the number of instructional trials necessary for the participants to learn and master new objectives. Such findings indicate the importance of those early observing responses and the impact they have on learning. It appears that conditioned reinforcement for three-dimensional stimuli is a foundational and necessary cusp for early learning.

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