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A FURTHER EVALUATION OF PICTURE PROMPTS DURING AUDITORY-VISUAL CONDITIONAL DISCRIMINATION TRAINING

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This study was a systematic replication and extension of Fisher, Kodak, and Moore (2007), in which a picture prompt embedded into a least-to-most prompting sequence facilitated acquisition of auditory-visual conditional discriminations. Participants were 4 children who had been diagnosed with autism; 2 had limited prior receptive skills, and 2 had more advanced receptive skills. We used a balanced design to compare the effects of picture prompts, pointing prompts, and either trial-and-error learning or a no-reinforcement condition. In addition, we assessed the emergence of vocal tacts for the 2 participants who had prior tact repertoires. Picture prompts enhanced acquisition for all participants, but there were no differential effects on tact emergence. The results support a generality of the effect reported by Fisher et al. and suggest that a variety of learners may benefit from the incorporation of picture prompts into auditory-visual conditional discrimination training.

Key words: autism, children, conditional discrimination, listener behavior, prompts

Instructional programs that aim to establish appropriate nonverbal responding to spoken words or sentences are often referred to as listener training (e.g., Greer & Ross, 2008; Sundberg & Partington, 1998) or receptive language training (e.g., Lovaas, 2003; Maurice, Green, & Luce, 1996). These programs address important language skill components that typically developing children appear to acquire effortlessly via interactions with caregivers (Hart & Risley, 1975), but must often be taught explicitly to children who have developmental delays.

Many listener skills involve auditory-visual conditional discriminations. For example, to respond appropriately to the instructions "pick up the ball" and "pick up the car," the auditory stimuli "ball" and "car" must each result in the learner picking up the correct object from among all the objects that he or she sees. Thus, reinforcement for selecting a particular visual stimulus is conditional on the presence of a particular auditory stimulus. The manner in which these discriminations are commonly taught (e.g., Greer & Ross, 2008; Lovaas, 2003; Maurice et al., 1996; Sundberg & Partington, 1998) may be described as match-to-sample training, in which the teacher's spoken instruction serves as a sample stimulus, and the comparison stimuli consist of objects or pictures that are presented to the learner in an array. From the point of view of the learner who has not yet acquired the relevant discriminations, the matching task is arbitrary in the

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sense that the correct comparison (e.g., a picture of a ball) for each sample stimulus (e.g., the spoken word "ball") is topographically different from the sample stimulus itself (i.e., a picture is different from a spoken word).

Teachers and behavioral therapists often may encounter difficulties when they attempt to teach auditory-visual and other arbitrary conditional discriminations to individuals who have little prior experience with arbitrary matching to sample. Such difficulties have been observed among individuals with developmental disabilities (e.g., McIlvane, Dube, Kledaras, Iennaco, & Stoddard, 1990; Pérez-González & Williams, 2002; Saunders & Spradlin, 1989) as well as young, typically developing children (e.g., Augustson & Dougher, 1991; Pilgrim, Jackson, & Galizio, 2000; Zygmont, Lazar, Dube, & McIlvane, 1992). Various procedures to remediate conditional discrimination training failures have been described in the literature. However, some of these procedures, such as instructions (e.g., Pilgrim et al., 2000) and naming of the sample stimulus (Pilgrim et al., 2000; Saunders & Spradlin, 1990, 1993), either require verbal skills or are not easily applicable to discriminations that involve spoken words as auditory samples. Other procedures apply more readily to teaching listener skills. For example, blocked-trial arrangements have been shown to result in successful acquisition of auditory-visual discriminations by participants with prior histories of failure (Pérez-González & Williams, 2002; Williams, Pérez-González, & Queiroz, 2005). This procedure involves alternating large trial blocks (e.g., 32 trials) in which each block of trials targets a single sample–comparison relation (e.g., "dog" in one block of trials and "cat" in another block of trials), followed by a gradual reduction in the number of trials per block until the samples are presented in random order. However, implementation of this procedure may be quite cumbersome.

The literature on early intervention for children with autism describes several ways in which a therapist may prompt correct comparison selection during auditory-visual conditional discrimination training. For example, the therapist may model a correct response by pointing to the positive comparison (i.e., a picture that corresponds to the vocal stimulus presented by the experimenter; e.g., Lovaas, 2003), or the therapist may position the positive comparison closer to the learner than the negative comparisons (e.g., Sundberg & Partington, 1998). Few studies appear to have examined the possibility of remediating acquisition failures by manipulating prompting tactics; however, Fisher, Kodak, and Moore (2007) evaluated the use of an identity-matching task to prompt correct comparison selection. In the identity-matching condition (hereafter referred to as a picture prompt condition), the experimenter first presented a vocal instruction (e.g., "Point to book") and gave the participant an opportunity to respond independently by pointing to one of four pictures. If a correct independent response did not occur, the experimenter presented a picture that was identical to the picture that served as the positive comparison in the array, tacted the item in the picture, and repeated the verbal instruction (e.g., "This is a book. Point to book"). If the participant did not respond correctly to the picture prompt, a correct response was physically guided. This prompt sequence was compared to a condition with a model prompt (i.e., the experimenter pointed to the correct comparison). In addition, a control condition was conducted under extinction. The participants were two children with autism who had histories of slow or no acquisition of auditory-visual conditional discriminations. Both participants showed enhanced acquisition with the picture prompt compared to the pointing prompt, although some acquisition occurred in the pointing prompt condition. In a subsequent study that examined the utility of functional assessment methods to select instructional variables (Kodak, Fisher, Clements, Paden, & Dickes,

2011), picture prompts alone and picture prompts combined with a blocked-trial arrangement resulted in the acquisition of auditory-visual conditional discriminations for two participants who previously had failed to respond to position prompts during the functional analysis. These results further supported the use of picture prompts during auditory-visual conditional discrimination training.

Fisher et al. (2007) proposed that the picture prompt facilitated transfer of stimulus control because it enhanced the participants' discrimination of the relevant features of the comparison stimuli. This is a plausible suggestion, given that a learner can respond correctly to a pointing or position prompt without actually attending to the comparison stimulus itself. For example, after the experimenter models pointing to the far left stimulus, the learner may imitate the response of pointing to the stimulus in that position without actually observing the characteristics of the stimulus itself. By contrast, a correct response to a picture prompt (e.g., a picture of a cat) requires attending to the characteristics of the positive comparison stimulus (e.g., an identical picture of a cat) and discriminating it from the negative comparison stimuli (e.g., pictures of a dog and a horse).

The purposes of the present study were to replicate Fisher et al. (2007) and to address some potential limitations of that study. The authors acknowledged that they did not use a balanced design to arrange the presentations of comparison stimuli. In a balanced design, each comparison stimulus is presented an equal number of times as a positive comparison for a particular sample and as a negative comparison for each of the other samples. According to Green (2001), deviations from this arrangement can result in unwanted sources of stimulus control that may interfere with acquisition. As a result, it cannot be ruled out that the effects of picture prompts would be obscured if comparison presentations were arranged in an optimal manner. In addition, for one of Fisher et al.'s participants, none of the negative comparisons served as positive comparisons in other trials. This arrangement could result in learning that selection of certain comparison stimuli is reinforced and the selection of others is not, leading to apparent mastery when the learner's selection responses are not under the control of the sample stimulus (Green). Finally, Fisher et al. presented comparison stimuli to the participant prior to the presentation of sample stimuli, whereas Green recommended the opposite arrangement.

In the present study, we used a balanced design to arrange the presentation of comparison stimuli and withheld presentation of the comparison stimuli in each trial until after we presented sample stimuli, except during a procedural modification for one participant. In addition, we sought to extend Fisher et al. (2007) in three ways. First, we included a trial-and-error condition for two of four participants, in which we reinforced correct responses but withheld reinforcement and presented the next trial after incorrect responses. This condition permitted us to evaluate the unique contribution of the pointing prompt on acquisition. Second, we evaluated whether picture prompts might enhance acquisition for learners with existing auditory-visual conditional discrimination repertoires as well as beginning learners, because auditory-visual match-to-sample training is often employed to teach complex academic skills to more advanced learners (e.g., de Rose, de Souza, & Hanna, 1996; LeBlanc, Miguel, Cummings, Goldsmith, & Carr, 2003). Thus, the study included two participants who had prior receptive labeling repertoires and two participants who did not. Third, we compared the effects of the prompting conditions on the emergence of untrained tacts (i.e., verbal responses under the discriminative control of nonverbal stimuli; Skinner, 1957) for the two higher functioning participants. We conducted this assessment because the picture prompt sequence used by

Fisher et al. involves the explicit modeling of a tact of the depicted object (i.e., saying "This is —" while pointing to the object). Such modeling, by itself, may sometimes result in the emergence of new tacts among children with autism who have existing tact repertoires (Valentino & Shillingsburg, 2011). Thus, it might be reasonable to expect the picture prompt condition to result in greater tact emergence than the pointing prompt condition.

METHOD

Participants and Setting

The participants were four children who had been diagnosed with autism and who attended a center-based program that provided intensive behavior-analytic intervention. Kelly and Chris were of Caucasian origin and were early learners who had limited success with previous training in receptive identification. Kelly was 3 years 11 months old when the study commenced, and she had attended the program 2 days per week for 4.5 months prior to participation. At the time of her entry into the study, she had mastered one auditory-visual conditional discrimination program that involved receptively identifying high-preference items, but she did not identify items that were not highly preferred. She had not acquired any vocal verbal operants, but she used a picture-based communication system to request preferred items and activities. An independent clinician conducted standardized tests with Kelly 2.5 months prior to the start of the study. Her IQ was measured at 50 using the Wechsler Preschool and Primary Scale of Intelligence-III (WPPSI-III). Her standard score on the Peabody Picture Vocabulary Test (4th ed.; PPVT-4) was 36 (age-equivalent score < 2.0). Kelly's standard score on the Expressive One-Word Picture Vocabulary Test (EOWPVT) was < 55 (age-equivalent score < 1.0).

Chris was 3 years 9 months old at the start of the study and also had been attending the program 2 days per week for 4.5 months. He had not mastered any receptive or expressive programs; however, he used a picture-based communication system to request some preferred items and activities. The same independent clinician conducted the same standardized tests with Chris 2.5 months prior to the start of the study. His IQ was measured at 42, his standard PPVT-4 score was 20 (age-equivalent score < 2.0), and his standard EOWPVT score was < 55 (age-equivalent score < 1.0).

The other two participants, Seth and Spencer, were of Hispanic origin and had more well-developed auditory-visual conditional discrimination repertoires and less severe language impairments than Kelly and Chris. Seth was 4 years 5 months old when the study commenced, and he had attended the program 2 days per week for 9 months prior to the study. Expressive skills at the time of entry into the study included vocalizing identifiable speech sounds, spontaneously saying words or approximations of words, imitating sounds, and manding and tacting preferred items and food. Receptive skills consisted of following instructions in routine situations and following one-step instructions. As with the other participants, an independent clinician conducted standardized tests with Seth; however, these tests were conducted 9 months prior to his entry into the study. At that time, Seth's IQ score was 65 according to the Reynolds Intellectual Assessment Scales (RIAS). His standard PPVT-4 score was 60 (age-equivalent score < 2.0), and his standard expressive vocabulary score was 58 (age-equivalent score < 2.0) using the Expressive Vocabulary Test (2nd ed.; EVT). Due to an emphasis on treatment of problem behavior, his early intervention programming did not formally target auditory-visual conditional discriminations during the 9 months of intervention prior to his entry into the study. However, a pretest (see below) suggested that by the time of entry, Seth differed from Kelly and Chris in that he had acquired a receptive labeling repertoire that included a variety of common items. Because Seth displayed multiple topographies of problem

Table 1
Stimuli for Kelly and Chris

Participant	Prompting conditions		
	Trial and error	Pointing	Picture
Kelly	Giraffe	Broom	Dress
	Tacos	Guitar	Gloves
	Motorcycle	Helicopter	Hammer
	Watermelon	Sailboat	Chicken
Chris	Bicycle	Dress	Giraffe
	Broom	Gloves	Tacos
	Butter	Hammer	Motorcycle
	Sailboat	Chicken	Watermelon

Table 2
Stimuli for Seth and Spencer

Participant	Prompting conditions		
	No reinforcement	Pointing	Picture
Seth	Congo	Georgia	Finland
	Fiji	Korea	Haiti
	Germany	Spain	Vietnam
	Greenland	Togo	Zambia
Spencer	Latvia	Fiji	Australia
	Uruguay	Korea	Congo
	Vietnam	Sweden	Georgia
	Zambia	Togo	India

behavior when he was admitted to the early intervention program, it is possible that a lack of cooperation contributed to his low PPVT-4 age-equivalent score at that time.

Spencer was 4 years 8 months old at the beginning of the study, and he had attended the program 3 days per week for 1 year and 6 months prior to the study. Receptive skills included identification of body parts, objects, pictures, clothing, sizes, and colors, all of which he acquired after his entry into the program. Expressive skills included vocalizing identifiable speech sounds, spontaneously saying words, and labeling body parts, vehicles, food, clothing, toys, furniture, letters, sizes, and shapes. Intraverbal skills consisted of rote counting, filling in an item's name given its function, and naming items when given their class. An independent clinician conducted standardized tests with Spencer 1 year and 3 months prior to the start of the study (shortly after his entry into the program). His IQ score was 57 (using the WPPSI-III), his standard PPVT-4 score was 31 (age-equivalent score $<$ 2.0), and his standard EOWPVT score was $<$ 55 (age-equivalent score $=$ 1.2). These tests were readministered a few months after the conclusion of the current study, and his IQ score had increased to 92, his PPVT-4 standard score increased to 78 (age-equivalent score $=$ 3.5), and his EOWPVT score increased to 87 (age-equivalent score $=$ 3.11).

All sessions took place in the participants' typical learning environment at their early intervention center, and lasted approximately 15 to 20 min. One to two sessions were conducted per day, 2 to 3 days per week. The experimenter sat next to the participant, and a secondary observer, if present, sat behind and to one side of the participant.

Materials

Visual comparison stimuli for Kelly and Chris consisted of laminated cards (8.2 cm by 6.4 cm) that contained photographs of objects, and vocally presented sample stimuli consisted of the conventional names of the objects. The stimuli assigned to each condition for Kelly and Chris are shown in Table 1. Prior to each session, the experimenter arranged an array of seven food items horizontally on the table in front of the participant, with the location of each item varying unsystematically across sessions. The experimenter instructed the participant to pick one item and delivered the first food item that the participant selected throughout the remainder of the session.

Visual comparison stimuli for Seth and Spencer consisted of 12 laminated picture cards (7.5 cm by 5 cm) of national flags, and vocally presented sample stimuli consisted of the corresponding names of the countries. Table 2 shows the stimuli assigned to each condition for Seth and Spencer.

Response Measurement and Interobserver Agreement

During sessions, unprompted correct responses, correct responses following the first

prompt, and physically guided responses were recorded on data sheets. During each trial, an unprompted correct response was recorded if the participant touched the positive comparison stimulus within 5 s of the presentation of the sample stimulus. A correct prompted response was recorded if the participant touched the positive comparison within 5 s of the presentation of either a pointing or a picture prompt, depending on the condition. The observers recorded a physically guided response if the experimenter physically guided the participant to touch the positive comparison.

During tact probe trials, the observers recorded correct and incorrect responses on data sheets. Correct responses were recorded if the participant emitted the correct tact within 5 s of the presentation of the instruction (i.e., "What is this?"). The observer scored the participant's first response as correct or incorrect. If the participant did not emit a vocalization within 5 s of the experimenter presenting the instruction, the trial was scored as incorrect.

An independent observer collected interobserver agreement data on comparison selection (unprompted, prompted, or physically guided) during at least 30% of all training sessions, and on vocal tacts (correct or incorrect) during at least 87% of tact probes. The second observer collected interobserver agreement data either live during sessions or subsequently from video. For each trial, we scored an agreement if both observers scored the participant's response identically as unprompted, prompted, or physically guided. We calculated interobserver agreement by dividing the number of agreements by the number of trials and converting the result to a percentage. Mean agreement was 98% for Kelly (range, 81% to 100%) and 100% for Chris. Seth's mean agreement was 98% (range, 81% to 100%) during prompting sessions and 100% during tact probes. Spencer's mean agreement was 99% (range, 92% to 100%) during prompting sessions and 100% during tact probes.

Procedure

Design. We conducted a stimulus pretest to identify 12 sample–comparison relations that were not already in the participants' repertoires. The relations identified in the pretest were divided into three sets of four and were randomly assigned each set to one of three experimental conditions: (a) picture prompt, (b) pointing prompt, and (c) control (trial and error for Chris and Kelly and no reinforcement for Seth and Spencer). We chose a no-reinforcement control condition for Seth and Spencer because they had existing auditory-visual conditional discrimination repertoires. As a result, it seemed possible that they might acquire new discriminations through trial and error, limiting the ability of a trial-and-error condition to control for acquisition outside the experiment.

We compared acquisition of auditory-visual conditional discriminations in the three conditions using an adapted alternating treatments design (Sindelar, Rosenberg, & Wilson, 1985). The order of conditions was randomized within groups of three sessions, and continued until (a) the mastery criterion was met in one or more conditions and data were stable in the other conditions or (b) the data were stable in all three conditions and a clear separation of the conditions was evident via visual inspection. For Seth and Spencer, emergent tacts were probed following every sixth instructional session.

Pretest. To select auditory-visual conditional discriminations that occurred at chance level, the experimenter conducted pretests with each participant with 24 sample–comparison relations of common objects and their names. The pretest consisted of four 24-trial sessions in which each auditory sample stimulus was presented once. Sample stimuli consisted of "touch" followed by one of 24 object names (e.g., "touch bike"). Each trial commenced with the presentation of the sample stimulus, followed by the presentation of the four visual comparison stimuli in horizontal alignment on

the table in front of the participant. One of the stimuli was the positive comparison. The three negative comparisons were nontarget stimuli that never served as the positive comparison. That is, each trial included four comparison stimuli that were not presented in any other trial during that session. Thus, we included a total of 96 nontarget visual stimuli in the test. The location of the positive comparison (i.e., to the far left, middle left, middle right, or far right) was counterbalanced across trials. Following the presentation of the comparison stimuli, the experimenter repeated the vocal sample stimulus every 2 s until the participant touched one of the comparison stimuli or a maximum of 5 s had elapsed. No consequences were provided for correct or incorrect responses; instead, the experimenter simply proceeded to the next trial. To maintain motivation, we interspersed pretest trials with previously mastered tasks (e.g., motor imitation and identity-matching trials with two- and three-dimensional stimuli) that were presented after every two or three trials. Correct responses on these trials resulted in the delivery of a small piece of a preferred food item.

For Seth and Spencer, we terminated the original pretest after two sessions, because both participants' correct responses were substantially above chance level (81% correct for Seth and 90% correct for Spencer), suggesting that they had existing auditory-visual conditional discrimination repertoires that involved many common objects and their names. As a result, Seth and Spencer received a new pretest with different stimuli (flags and corresponding country names). This pretest was identical to the first except that only 15 sample–comparison relations (i.e., relations between flags and country names) were tested.

For each participant, we used the pretest results to select 12 sample–comparison relations for inclusion in the experiment from among those to which the participant made no more than one correct response (of four possible correct responses) on the pretest. We then separated the 12 sample–comparison relations into three groups of four, using random assignment with the restriction that two stimuli in the same group could not have a high degree of visual similarity (e.g., two different flags composed of three vertical stripes). Finally, we randomly assigned the three groups of stimuli to the three experimental conditions.

Echoic pretest. Following the stimulus pretest for Seth and Spencer, a 12-trial echoic pretest was conducted under extinction. The purpose of this test was to ensure that the participant could vocalize the responses defined as correct in the tact probes. The experimenter instructed the participant to vocalize the name of each country in the three stimulus sets (e.g., "say Togo"). After a vocal response from the participant (either correct or incorrect), the experimenter proceeded to the next trial. Echoic trials were interspersed with reinforced trials consisting of already mastered tasks (e.g., motor imitation, tacts of colors and animals, simple intraverbals). Both participants could correctly vocalize all names.

Instructional arrangement. Regardless of the condition in effect, each instructional session consisted of 16 trials that targeted four sample–comparison relations. The four vocal sample stimuli were presented four times each in blocks of four trials that contained one presentation of each sample stimulus, with presentation order varying across blocks. The presentation of sample and comparison stimuli in each trial was identical to the pretest. However, during training, the experimenter presented the same four visual comparison stimuli in each trial. Therefore, each visual stimulus served as a positive comparison in four trials and as a negative comparison in 12 trials with the other three sample stimuli, resulting in a balanced design. The acquisition criterion was three of five consecutive sessions with unprompted correct responses in at least 14 of 16 trials (87.5%). During all three conditions, if the participant failed to make a correct unprompted response in two or three consecutive trials, a

previously mastered task was presented in the same manner as during the pretest.

Picture prompt condition. In each trial, if the participant touched the positive comparison within 5 s of the presentation of the sample stimulus without first touching another stimulus, the experimenter delivered praise and a small food item. After the participant had consumed the food, the experimenter proceeded to the next trial. If the participant made an incorrect response or did not respond within 5 s of the sample stimulus, the experimenter held up a duplicate picture of the positive comparison and said, "This is — [while pointing to the picture in hand], point to — [while gesturing to the comparison stimuli]." If the participant pointed to the positive comparison within 5 s of the prompt, he or she received praise, but no food item was delivered. If the participant pointed to a different comparison or did not respond within 5 s of the provided prompt, the experimenter repeated the sample stimulus "Point to —" and physically guided him or her to touch the correct comparison. Following physical guidance, the experimenter proceeded to the next trial without providing praise or other consequences.

Pointing prompt condition. The procedures were identical to the picture prompt condition, except that the first prompt in the sequence was a pointing prompt. That is, if the participant made an incorrect response or did not respond within 5 s of the sample stimulus, the experimenter delivered the instruction "Point to — like this" and modeled a correct response by pointing to the positive comparison.

Trial and error. No prompts were provided in this condition. If the participant failed to make a correct, unprompted response within 5 s of the presentation of the sample stimulus, the experimenter simply proceeded to the next trial. Consequences for correct responses were the same as in the picture prompt and the pointing prompt conditions.

No reinforcement. The procedures were identical to the trial-and-error condition, except that this condition was conducted under extinction. Therefore, after a selection response (i.e., either incorrect or correct) or no response within 5 s of the sample stimulus, the experimenter proceeded to the next trial.

Tact probes. Tact probes were conducted under extinction following every sixth session for Seth and Spencer only. Tact probes consisted of 12 trials in which we randomly presented each of the 12 target comparison stimuli as a discriminative stimulus once. The experimenter presented the discriminative stimulus to the participant prior to the instruction "What flag is this?" After a vocal response (either correct or incorrect), the experimenter proceeded to the next trial. Tact probe trials were interspersed with already mastered tacts every two or three trials and correct responses to mastered tacts were reinforced.

RESULTS

Figure 1 shows the percentage of unprompted correct responses in each session for all participants. Kelly's correct responding in the picture prompt condition quickly increased above the trial-and-error condition, and exceeded 80% by the ninth picture prompting session. In spite of prolonged training, however, accuracy did not increase further. At the end of the evaluation, she typically responded correctly in 75% of the trials in each session, which was similar to the terminal performance by participants in Fisher et al. (2007). Kelly's performance in the pointing prompt condition also increased above the trial-and-error condition but lagged behind the picture prompt condition. Performance in the trial-and-error condition remained at chance level throughout the evaluation. Physical guidance was used 28 times in the picture prompt condition (6% of all trials) and three times (0.6%) in the pointing prompt condition.

Chris's performance in the picture prompt and the pointing prompt conditions began to increase above the trial-and-error condition

after five to six sessions in each condition. Further slight increases were observed briefly in the picture prompt condition, followed by a drop in performance to slightly above chance level. From Session 35 to Session 69, accuracy was similar in all three conditions and only slightly exceeded chance level. During this time, Chris's performance tended to be more accurate in the first half than in the second half of each session. In addition, noncompliance that resulted in physical guidance occurred increasingly toward the end of the session. As a result, we reduced the number of trials per session from 16 to 8, starting with Session 65. The acquisition criterion remained three of five consecutive sessions with unprompted correct responses in 87.5% of the trials (seven of eight). As soon as we reduced the session length, responding rose to mastery level in the picture prompt condition, and Chris met the acquisition criterion after five eight-trial sessions. Increases also were observed in the pointing prompt and the trial-and-error conditions, but accuracy remained lower than in the picture prompt condition. Physical guidance was used 33 times (9.2%) in the picture prompt condition and 53 times (13.5%) in the pointing prompt condition.

For Seth, no differential effects of the prompting procedures were observed in the first 57 sessions, and performance remained around chance level in all conditions. During these sessions, he often responded immediately after the presentation of the comparison stimuli, suggesting that he might not have scanned the full array of stimuli before responding. As a result, we implemented a procedural change that consisted of presenting the comparison stimuli before the sample stimulus (as was the case in Fisher et al., 2007) and ensuring that Seth was attending to the comparison stimuli (i.e., oriented towards the stimuli with eyes open and hands in lap) before the sample stimulus was presented. After this procedural change, correct responses increased in the picture prompt condition. In the

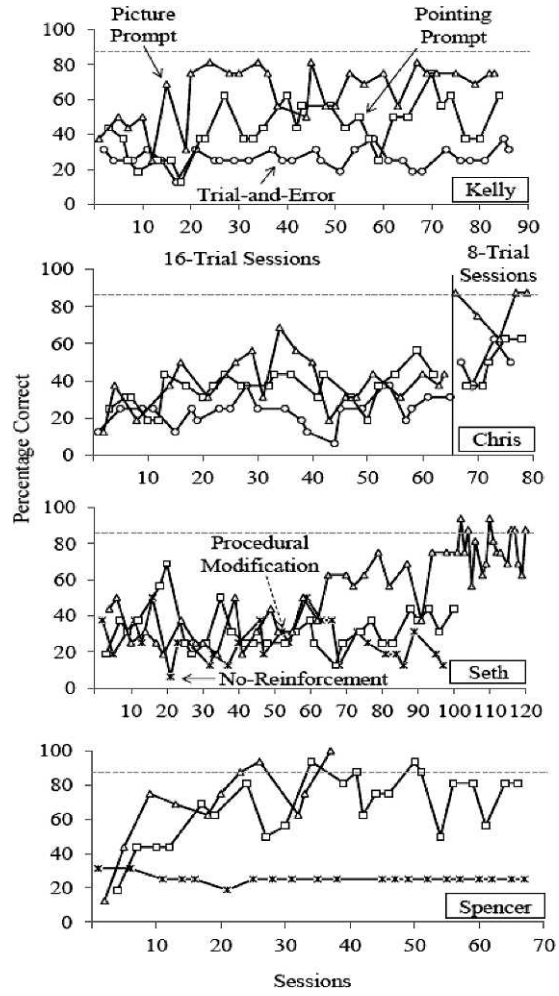

Figure 1. The percentage of unprompted correct responses for Kelly, Chris, Seth, and Spencer.

pointing prompt condition, performance remained only slightly above chance level, but was elevated above the control condition. Similar to Kelly, Seth's performance in the picture prompt condition stabilized at approximately 75%. At this time, the pointing prompt and no-reinforcement sessions were discontinued, but picture prompt sessions continued. This was done to determine whether criterion-level responding might be achieved with more frequent sessions, because Seth's attendance at the treatment center 2 days per week resulted in exposure to each condition only once or twice

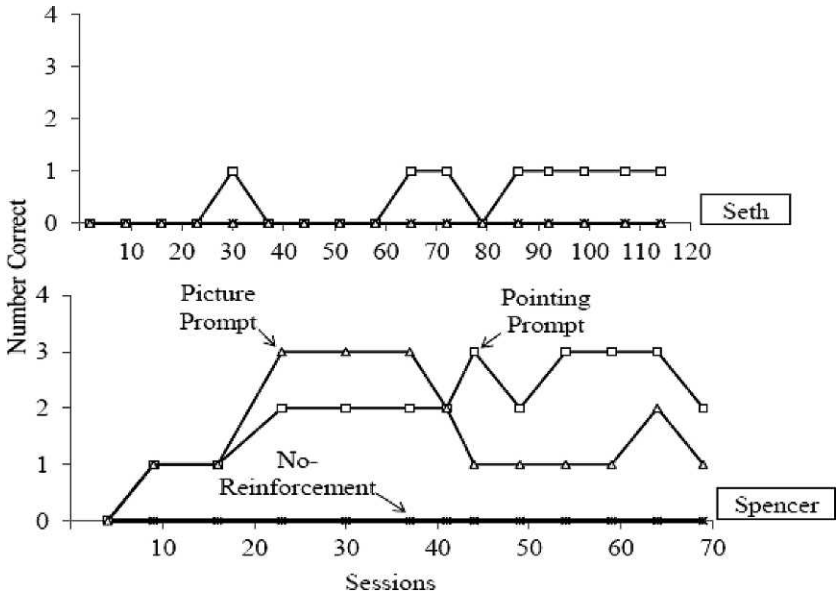

Figure 2. The number of correct responses during tact probes for Seth and Spencer.

per week. He met the acquisition criterion in the picture prompt condition. He required physical guidance three times, all in the picture prompt condition.

Spencer's percentage of correct responses during training sessions quickly began to increase above the control condition in both the picture prompt and the pointing prompt conditions. However, acquisition was faster in the picture prompt condition, and the mastery criterion was met after 11 sessions. Training continued in the pointing prompt condition for 13 additional sessions, but the mastery criterion was not met. Physical guidance was never used.

Figure 2 shows the number of correct responses in each tact probe session for Seth and Spencer. For Seth, no tacts emerged in any of the three conditions. he responded correctly in some of the tact probes with stimuli from the pointing prompt condition. However, each of these correct responses occurred as a result of Seth emitting the same vocal response ("To-go") in each trial, suggesting that the response was not under the control of the appropriate visual stimulus. For Spencer, tacts emerged for visual stimuli from both the picture and pointing prompt conditions. At the time the mastery criterion was met in the picture prompt condition, Spencer correctly tacted three of four stimuli from that condition. However, these tacts were not maintained after training was discontinued, possibly due to extinction. The number of correct tacts of stimuli from the pointing prompt condition increased from two to three of four in several of the later tact probes. Thus, the picture prompt and the pointing prompt conditions ultimately had a similar effect on emergent tacts; however, tacts emerged earlier in the picture prompt condition, probably due to faster acquisition of the auditory-visual conditional discriminations in that condition.

DISCUSSION

The effects of picture prompts on the acquisition of auditory-visual discriminations (Fisher et al., 2007) were replicated with four children who had been diagnosed with autism spectrum disorders. Kelly and Chris were similar to Fisher et al.'s participants, in that they had not previously been successful in

auditory-visual conditional discrimination training. Seth and Spencer, by contrast, had relatively more extensive listener repertoires that included a number of auditory-visual conditional discriminations. Chris and Seth required procedural modifications before we observed acquisition in any condition, and these modifications should be considered when interpreting the results. However, once these modifications were in place, picture prompts produced faster acquisition than pointing prompts, as they did for the other two participants. The results support the generality of the effect reported by Fisher et al., and suggest that picture prompts may continue to enhance acquisition when comparison stimulus presentations are arranged in such a way as to optimize the establishment of stimulus control (Green, 2001).

Replication of the findings reported by Fisher et al. (2007) and Kodak et al. (2011) across participants and intervention sites is significant in light of evidence that suggests that the effects of specific prompting tactics may be sensitive to the instructional histories of individual learners (Coon & Miguel, 2012). In turn, it has been hypothesized that differences in instructional histories may lead to discrepant results when the same procedures are compared at different intervention sites (Ingvarsson & Le, 2011). In the present study, however, none of the participants were known to have prior histories of listener training with picture prompts. It is possible that in the context of auditory-visual conditional discrimination training, picture prompts are likely to produce a greater effect than pointing prompts regardless of history. This may be because a correct response to a picture prompt necessitates discriminating features of the selected comparison from other comparisons, whereas a correct response to a pointing prompt necessitates discriminating only where the therapist points. For Chris, pointing prompts did not produce an effect over trial and error, which may suggest that he failed to attend to the stimuli that he selected when prompted.

Fisher et al. (2007) discussed their findings in the context of research on differential observing responses (DORs). In a match-to-sample task, a DOR refers to an observing response to the sample stimulus that differs depending on which sample is presented. For example, in a visual-visual task, a DOR may consist of matching each sample stimulus to an identical stimulus before the subject is permitted to select an arbitrarily related comparison (Dube & McIlvane, 1999; Walpole, Roscoe, & Dube, 2007). Such DORs are extraneous to the target sample–comparison relations, but they may serve to promote observation of relevant features of each sample stimulus. Fisher et al. proposed that the identity-matching response involved in responding to a picture prompt in an auditory-visual task might also be thought of as a DOR; specifically, a DOR to the comparison stimuli as opposed to the sample stimuli. The picture prompt, however, differs from the identity-matching DORs used in previous studies (Dube & McIlvane, 1999; Walpole et al., 2007) in that it is not extraneous to the target sample–comparison relation. Unlike a sample DOR, the picture prompt inherently guides the selection of a comparison. As a result, picture prompts differ from sample DORs in that they are not appropriate for presentation in each trial throughout training, because control over correct comparison selection must ultimately transfer to the auditory samples. It may be of interest to note that, in prior studies that evaluated identity-matching DORs to sample stimuli (Dube & McIlvane, 1999; Walpole et al., 2007), the DORs increased the accuracy of comparison selection only as long as they were required in each trial. Accuracy decreased when the DOR requirement was withdrawn from all trials. In the present study and that of Fisher et al., by contrast, the participants ultimately responded with high accuracy in the absence of the picture prompt. Future research might assess whether

this difference occurred because (a) picture prompts promote attention to the comparison stimuli instead of the sample stimuli, or (b) each trial began with an opportunity for an independent response, giving the participants frequent opportunities to respond in the absence of a DOR requirement. In addition, future research might examine the possibility of further enhancing the effects of picture prompts by adding a DOR to the auditory sample stimulus (e.g., an echoic response).

Although the picture prompt condition involved the experimenter's explicit modeling of tacts (e.g., "This is Togo," while pointing to the flag of Togo), it did not enhance emergence of tacts for Seth or Spencer. No tacts emerged for Seth, whose verbal repertoire was not as strong as Spencer's and included a limited number of tacts at the beginning of the experiment. It may be speculated that Seth lacked a prerequisite skill, such as naming (e.g., Horne & Lowe, 1996) or a prerequisite instructional history such as multiple-exemplar training (e.g., Barnes-Holmes, Barnes-Holmes, & Cullinan, 2000) for the emergence of untrained tacts. Because Seth's intraverbal skills were limited, it is also possible that the instruction presented during tact probe trials was too complex. Each tact probe consisted of a fairly complex antecedent verbal stimulus (e.g., "What flag is this?"); therefore, it is possible these results were in part indicative of Seth's limited intraverbal repertoire rather than a failure of tact emergence.

The different prompting procedures did not appear to influence the emergence of tacts after Spencer had acquired the auditory-visual conditional discriminations. However, tacts emerged earlier in the picture prompt condition than in the pointing prompt condition, likely due to faster acquisition in that condition. Thus, the picture prompt condition was more efficient than the pointing prompt condition in terms of establishing both tacts and listener behavior for Spencer. Nevertheless, his correct tacts of stimuli in the picture prompt condition decreased following training, which may not be surprising given that no attempt was made to maintain them. A potential limitation of his assessment is that we did not continue tact probes in the pointing prompt condition following mastery to determine if correct tacts would also decrease in that condition after discontinuation of training.

Seth's procedural modification warrants comment. We followed Green's (2001) recommendation for match-to-sample training. That is, we withheld the presentation of comparison stimuli until the learner observed the sample stimulus. Seth, however, appeared to benefit from a procedure in which the presentation of each sample stimulus was withheld until he had observed the comparison stimuli (similar to Fisher et al., 2007). This finding is consistent with previous research in which similar delayed-sample procedures have been found to increase accuracy in match-to-sample tasks compared to procedures in which the sample is presented first (Doughty & Saunders, 2009; McIlvane, Kledaras, Stoddard, & Dube, 1990). Future research might further investigate the conditions under which each procedure is more likely to benefit a learner.

In the present study, we attempted to follow the procedures described by Fisher et al. (2007) closely, except for the use of a balanced design and the trial-and-error control condition for two participants. However, two additional differences should be noted. In the present study, unprompted correct responses were followed by praise and a piece of a preferred food item, whereas prompted responses produced praise only. Fisher et al., by contrast, did not report use of praise along with the delivery of preferred items following correct responses, and prompted responses did not produce any consequences. In addition, after two or three consecutive error trials in the present study, the experimenter delivered a food item contingent on an unrelated, previously mastered correct response. This contingent interspersal procedure was intended to help maintain participa-

tion in sessions by ensuring that the participants earned food frequently, even when they made many errors. However, we cannot rule out that these trials may have impeded acquisition, because the presentation of an easy task contingent on a series of error responses could potentially reinforce errors. This limitation should be both kept in mind when interpreting the results and addressed in future studies.

Other potential limitations should be noted. First, as in Fisher et al. (2007), the picture prompt was accompanied by two presentations of the verbal sample stimulus (e.g., "This is book; point to book") whereas the pointing prompt was accompanied by only one (e.g., "Point to book like this"). Thus, we are unable to determine whether increased exposure to the sample stimuli contributed to the effects of the picture prompt on acquisition, and future research should control for this variable. However, the overall amount of exposure to the sample stimuli may be somewhat similar across conditions, because prompting was much more often necessary in the pointing prompt than in the picture prompt condition, resulting in additional exposures to the sample stimuli. Second, although all stimuli in all conditions were associated with equally low levels of responding on the pretest, we did not conduct a baseline to verify that similar levels of correct responding occurred in all conditions when each positive comparison was presented consistently with the same three negative comparisons. However, levels of responding were similar in all three conditions across participants at the beginning of training, suggesting that the difficulty level of the discriminations did not differ across conditions.

The basic instructional procedure employed in the present study and that of Fisher et al. (2007) was a least-to-most prompting hierarchy with a constant prompt delay. The use of this procedure may warrant discussion, in that some authors strongly caution against the use of least-to-most prompting for beginning learners (e.g., Green, 2001; Greer & Ross, 2008; Sundberg & Partington, 1998) due to the large number of errors that may occur when each trial provides an opportunity to respond independently. Instead, they promote the use of "errorless" or most-to-least prompting procedures that involve gradually transferring stimulus control from a prompt that reliably evokes a response to the desired discriminative stimulus. A recent study that compared the use of least-to-most to most-to-least prompting in the context of teaching solitary play skills (Libby, Weiss, Bancroft, & Ahearn, 2008) found that although least-to-most prompting produced more errors than most-to-least prompting, acquisition was faster with the former method. However, acquisition rates with least-to-most or most-to-least strategies may depend on the nature of the task to be learned (McConville, Hantula, & Axelrod, 1998). In addition, the greater number of errors observed with least-to-most prompting may contribute to disruptive behavior (e.g., Heckamon, Alber, Hooper, & Heward, 1998). In the present study, Kelly, Seth, and Spencer did not engage in any disruptive behavior during training; however, Chris demonstrated noncompliance in several sessions before we reduced the session length from 16 to 8 trials. Thus, it is possible that an instructional strategy designed to minimize errors would have been more appropriate for Chris.

Future research should evaluate whether picture prompts enhance acquisition in the context of most-to-least prompting or other procedures to transfer stimulus control, such as progressive prompt delay (Walker, 2008). Picture prompts can be incorporated easily into most instructional programs that involve auditory-visual conditional discriminations, and may become recommended practice if their effects are found to hold across a variety of prompting and prompt-fading strategies.

REFERENCES

Augustson, K. G., & Dougher, M. J. (1991). Teaching conditional discrimination to young children: Some successes and failures. *Experimental Analysis of Human Behavior Bulletin*, *9*, 21–24.

Barnes-Holmes, D., Barnes-Holmes, Y., & Cullinan, V. (2000). Relational frame theory and Skinner's *Verbal Behavior*: A possible synthesis. *The Behavior Analyst*, *23*, 69–84.

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.

de Rose, J. C., de Souza, D. G., & Hanna, E. S. (1996). Teaching reading and spelling: Stimulus equivalence and generalization. *Journal of Applied Behavior Analysis, 29*, 451–469.

Doughty, A. H., & Saunders, K. J. (2009). Decreasing errors in reading-related matching to sample using a delayed-sample procedure. *Journal of Applied Behavior Analysis*, *42*, 717–721. doi:10.1901/jaba.2009.42-717

Dube, W. V., & McIlvane, W. J. (1999). Reduction of stimulus overselectivity with nonverbal differential observing responses. *Journal of Applied Behavior Analysis*, *32*, 25-33. doi:10.1901/jaba.1999.32-25

Fisher, W. W., Kodak, T., & Moore, J. W. (2007). Embedding an identity-matching task within a prompting hierarchy to facilitate acquisition of conditional discriminations in children with autism. *Journal of Applied Behavior Analysis*, *40*, 489–499. doi:10.1901/jaba.2007.40-489

Green, G. (2001). Behavior analytic instruction for learners with autism: Advances in stimulus control technology. *Focus on Autism and Other Developmental Disabilities*, *16*, 72–85. doi:10.1177/108835760101600203

Greer, R. D., & Ross, D. E. (2008). *Verbal behavior analysis: Inducing and expanding new verbal capabilities in children with language delays*. Boston, MA: Pearson.

Hart, B. M., & Risley, T. R. (1975). Incidental teaching of language in the preschool. *Journal of Applied Behavior Analysis*, *8*, 411–420. doi:10.1901/jaba.1975.8-411

Heckaman, K. A., Alber, S., Hooper, S., & Heward, W. L. (1998). A comparison of least-to-most prompts and progressive time delay on the disruptive behavior of students with autism. *Journal of Behavioral Education*, *8*, 171–201.

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

Ingvarsson, E. T., & Le, D. D. (2011). Further evaluation of prompting tactics for establishing intraverbal responding in children with autism. *The Analysis of Verbal Behavior*, *27*, 75–93.

Kodak, T., Fisher, W. W., Clements, A., Paden, A. R., & Dickes, N. R. (2011). Functional assessment of instructional variables: Linking assessment and treatment. *Research in Autism Spectrum Disorders*, *5*, 1059–1077. doi:10.1016/j.rasd.2010.11.012

LeBlanc, L. A., Miguel, C. F., Cummings, A. R., Goldsmith, T. R., & Carr, J. E. (2003). The effects of three stimulus-equivalence testing conditions on emergent US geography relations of children diagnosed with autism. *Behavioral Interventions*, *18*, 279–289. doi:10.1002/bin.144

Libby, M. E., Weiss, J. S., Bancroft, S., & Ahearn, W. H. (2008). A comparison of most-to-least and least-to-most prompting on the acquisition of solitary play skills. *Behavior Analysis in Practice*, *1*, 37–43.

Lovaas, O. I. (2003). *Teaching individuals with developmental delays: Basic intervention techniques*. Austin, TX: Pro-Ed.

Maurice, C., Green, G., & Luce, S. (Eds.). (1996). *Behavioral intervention for young children with autism: A manual for parents and professionals*. Austin, TX: Pro-Ed.

McConville, M. L., Hantula, D. A., & Axelrod, S. (1998). Matching training procedures to outcomes: A behavioral and quantitative analysis. *Behavior Modification*, *22*, 391–414. doi:10.1177/01454455980223011

McIlvane, W. J., Dube, W. V., Kledaras, J. B., Iennaco, F. M., & Stoddard, L. T. (1990). Teaching relational discrimination to individuals with mental retardation: Some problems and possible solutions. *American Journal on Mental Retardation*, *95*, 283–296.

McIlvane, W. J., Kledaras, J. B., Stoddard, J. T., & Dube, W. V. (1990). Delayed sample presentation in MTS: Some possible advantages for teaching individuals with developmental limitations. *Experimental Analysis of Human Behavior Bulletin*, *8*, 31–33.

Pérez-González, L. A., & Williams, G. (2002). Multicomponent procedure to teach conditional discriminations to children with autism. *American Journal on Mental Retardation*, *107*, 293–301. doi:10.1352/0895–8017(2002)107<0293:MPTTCD>2.0.CO;2

Pilgrim, C., Jackson, J., & Galizio, M. (2000). Acquisition of arbitrary conditional discriminations by young normally developing children. *Journal of the Experimental Analysis of Behavior*, *73*, 177–193. doi:10.1901/jeab.2000.73-177

Saunders, K. J., & Spradlin, J. E. (1989). Conditional discrimination in mentally retarded adults: The effect of training the component simple discriminations. *Journal of the Experimental Analysis of Behavior*, *52*, 1–12. doi:10.1901/jeab.1989.52-1

Saunders, K. J., & Spradlin, J. E. (1990). Conditional discrimination in mentally retarded adults: The development of generalized skills. *Journal of the Experimental Analysis of Behavior, 54*, 239–250. doi:10.1901/jeab.1990.54-239

Saunders, K. J., & Spradlin, J. E. (1993). Conditional discrimination in mentally retarded adults: Programming acquisition and learning set. *Journal of the Experimental Analysis of Behavior*, *60*, 571–585. doi:10.1901/jeab.1993.60-571

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

Skinner, B. F. (1957). *Verbal behavior*. Acton, MA: Copley.

Sundberg, M. L., & Partington, J. W. (1998). *Teaching language to children with autism or other developmental disabilities*. Pleasant Hill, CA: Behavior Analysts, Inc.

Valentino, A. L., & Shillingsburg, M. A. (2011). Acquisition of mands, tacts, and intraverbals through sign exposure in an individual with autism. *The Analysis of Verbal Behavior*, *27*, 95–101.

Walker, G. (2008). Constant and progressive time delay procedures for teaching children with autism: A literature review. *Journal of Autism and Developmental Disorders*, *38*, 261–275. doi:10.1007/s10803-007-0390-4

Walpole, C. W., Roscoe, E. M., & Dube, W. V. (2007). Use of a differential observing response to expand restricted stimulus control. *Journal of Applied Behavior Analysis*, *40*, 707–712. doi: 10.1901/jaba.2007.40-707

Williams, G., Pérez-González, L. A., & Queiroz, A. B. M. (2005). Using a combined blocking procedure to teach color discrimination to a child with autism. *Journal of Applied Behavior Analysis*, *38*, 555–558. doi:10.1901/jaba.2005.38-555

Zygmont, D. M., Lazar, R. M., Dube, W. V., & McIlvane, W. J. (1992). Teaching arbitrary matching via stimulus-control shaping to young children and mentally retarded individuals: A methodological note. *Journal of the Experimental Analysis of Behavior*, *57*, 109–117. doi:10.1901/jeab.1992.57-109

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