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Effect of Multiple Operant Training Across Similar and Different Response Topographies

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by

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Abstract

Title: Effect of Multiple Operant Training Across Similar and Different Response Topographies

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This study compared skill acquisition rates during multiple operants training across similar responses and different responses in children with Autism Spectrum Disorder (ASD). Secondary measures included functional independence of verbal operants and children's teaching condition preference. Discrete-trial instruction was used during both teaching conditions. An adapted alternating treatment design embedded in a nonconcurrent multiple baseline across participants was used to examine rates of skill acquisition. Results showed that two of the three participants acquired skills in fewer sessions during the multiple operants training across similar responses when compared to multiple operant training across different responses. Two of the three participants did not transfer targets to the untaught operant supporting research on the functional independence of the operants. Lastly, children showed idiosyncratic preferences during the condition preference assessment.

Keywords: multiple operant training, discrete-trial instruction, multiple exemplar instruction, referent-based instruction, autism spectrum disorder, skill acquisition

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Effect of Multiple Operant Training Across Similar and Different Response Topographies

Language deficits associated with autism spectrum disorder (ASD) have led researchers to develop interventions that focus on teaching verbal behavior. Interventions to improve language and communication have shown to enhance the lives of individuals with ASD (Virués-Ortega, 2010). The National Standards Project completed by the National Autism Center (2015) conducted an examination and quantification analysis of current research that supports interventions for ASD. Base on their findings, behavioral-based interventions were the largest category for established interventions for ASD. One behavior-based intervention described in their study was discrete-trial instruction combined with natural consequences and error correction.

Discrete Trial Instruction

Discrete trial instruction (DTI) is a teaching procedure that has been shown to be effective in teaching new skills to children with ASD (Koegel, Russo, & Rincover, 1977; National Autism Center, 2015). DTI has five components including delivery of instruction, delivery of a controlling prompt, the learner's response, a consequence following the learners response and an inter-trial interval (Koegel, Russo, & Rincover, 1977). Researchers have shown that different components of DTI can be altered to either improve or deteriorate the effectiveness

or efficiency of the intervention (Koegel, Russo, & Rincover, 1977). Within the basic structure of DTI, research has focused on analyzing various trial arrangement procedures (Dunlap & Koegel, 1980; Greer Stolfi, Chavez-Brown, & Rivera-Valdes, 2005; Carroll & Hesse, 1987). For example, varying types of tasks presented during a teaching session have shown to increase the efficiency of DTI (O'Neill,1987; Weiss, 2005). These trial arrangement studies have several names including task variation (Dunlap & Koegel, 1980; Dunlap, 1984), multiple exemplar training (Greer Stolfi, Chavez-Brown, & Rivera-Valdes, 2005; Greee, Stolfi, & Pistoljevic, 2007), and multiple operant training (Carroll & Hesse, 1987; Sidener, Carr, Karsten, Severtson, Cornelius, & Heinicke, 2010). Table 1 describes the different task variation procedures.

Task Variation

Task variation is an optimal component of DTI that improves the efficiency of teaching verbal behavior to children with ASD (O'Neill,1987; Weiss, 2005). Task variation is an instructional procedure that intersperses different targets within a single teaching session. The interspersed tasks may include previously mastered targets, different acquisition targets, or targets from a different verbal operant. Dunlap and Koegel (1980) examined the effect of DTI without task variation and DTI with task variation for two children with ASD. During DTI without task variation, the therapist used a constant task procedure in which a single target was

taught during the entire teaching session. During the task variation condition, the therapist taught one target interspersed with other acquisition targets. Dunlap and Koegel (1980) found that the task variation condition was more effective than the constant task condition.

Dunlap (1984) extended this study by examining DTI without task variation and DTI with task variation across different interspersed targets. The two conditions included task variation across mastered targets and task variation across other acquisition targets. During the constant task condition, the therapist taught one acquisition target during the entire session. During the task varied across acquisition targets condition, the therapist taught one acquisition target interspersed with other acquisition targets. During the task varied across mastered targets condition, the therapist taught one acquisition target interspersed with other mastered targets. They measured the children's rate of learning. Dunlap (1984) found that task variation across mastered targets condition was more efficient compared to the constant task condition and the task variation across acquisition targets condition.

Verbal Operants

Another form of task variation is the interspersal of mixed verbal operants within a single teaching session. In Skinner's (1957) analysis of verbal behavior, he organized an operant classification system based on the functions of verbal

behavior called verbal operants. Operants refer to a class of responses under the functional control of similar environmental factors. Therefore, verbal operants are classes of verbal responses under the control of similar antecedents and consequences in the natural environment. Verbal behavior adheres to the same laws as nonverbal behavior and can be studied as such (Skinner, 1957). In interventions for ASD, treatment for verbal behavior mainly focuses on four different verbal operants including mands, echoics, tacts, and intraverbals. Mands are verbal behavior under the functional control of a specific reinforcer. For example, if a child says "water" and their parent gives the child water, then the word water is a mand; the child's verbal behavior resulted in a specific reinforcer, the water. Echoics are spoken verbal behavior under the control of spoken verbal stimuli. For example, if a parent says "water" and the child mimic the parent by saying "water" then the word water is an echoic; the child vocally imitated the parent. Tacts are verbal behavior under the control of nonverbal stimuli. For example, if a child says "water" in the presence of water and their parent praises the child, then the word water is a tact; the child's verbal behavior was under the control of nonverbal stimuli, the sight of the water. Lastly, intraverbals or sequelic are verbal behavior under the control of verbal stimuli. For example, if a child's parents ask, "what do you swim in?" and the child responds "water" then the word water is an

intraverbal; the child's verbal behavior is under control of the parents' verbal behavior.

In addition to the verbal operants of the speaker, Skinner also describes the behavior of the listener. In contrast to speaker behavior, listener behavior is a response to the speaker. Listener responding is a nonverbal response under the control of verbal stimuli. For example, if a parent says, "find water" and the child points to a water bottle then the child's behavior would be listener responding. The behavior of the listener is in response to the speaker's actions.

Functional Independence of Verbal Operants

In Skinner's Verbal Behavior (1957) he describes the functional independence of the verbal operants; each operant is under the control of specific environmental contingencies. Therefore, the acquisition of one response as a single verbal operant does not mean that same response will generalize to a different verbal operates. For example, if an individual acquires the response "book" as a mand, the child may not acquire "book" as an intraverbal. Similar responses across different operants require training in each verbal operant. There have been a few studies demonstrating the functional independence of verbal operants (Lamarre, & Holland, 1985; Shillingburg, Kelley, Roane, Kisamore, & Brown, 2009; Gamba, Goyos, & Petursdottir, 2015).

Shillingburg, Kelley Roane Kisamore, and Brown (2009) examined the functional use of yes-no responses across tact, mand, and intraverbal operants and examined the functional independence and generalization of these operants. The experimenters taught yes-no responses as tact, mands, and intraverbals with three children with ASD. Training conditions included mand training, tact training, and intraverbal training. They taught one response for each condition and tested for the emergence of untaught responses in the same operant class and different operant class. Results show that the untaught targets emerged if they were in the same operant class as the taught targets. That is, when mand responses were taught, untaught mand responses emerged, but untaught tact and intraverbal responses did not emerge. These results show that mands, tacts, and intraverbals are functionally independent even when the responses are topographically similar, but generalization within an operant class can occur.

Understanding the functional independence of the verbal operants has aided in researchers developing alternate teaching procedures to promote generalization of responses across the operants (Greer, Stolfi, Chavez-Brown, & Rivera-Valdes, 2005; Arntzen, & Almas, 2002; Carroll, & Hess, 1987; Sidener, et. al., 2010; Sidener, 2006). Acquisition of skills not directly taught is optimal (Cooper, Heron, & Heward, 2007). There have been several studies examining several treatment

interventions to enable generalization across verbal operants including task variation with the interspersal of different verbal operants.

Verbal Operant Task Variation

Presenting tasks across different verbal operants is another form of task variation. In one study, Nicholson, et al. (in prep) examined the effect of task variation with the interspersal of different verbal operants on the rate of skill acquisition. They compared DTI without task variation to DTI with task variation across verbal operants with three children with autism. During the DTI without task variation, the children learned receptive identification, tacts, and intraverbals in three separate trial blocks, with a 2 min break in between. During the DTI with task variation across verbal operants, the children learned similar targets from each of the operant classes, but the operants were presented in random order across the trial blocks. All participants learned at the same rate in both conditions, suggesting that task variation across verbal operants may not yield any educational benefits. However, one participant indicated that he preferred the DTI with task variation across verbal operants in a post-experimental preference assessment. Nicholson et al. used different targets in each of the operant classes in both conditions. Task variation across different verbal operants might be more beneficial if one response topography was taught across different operant classes. For example, the target "dog" would be taught as a receptive, tact and intraverbal simultaneously.

Multiple Exemplar Instruction

Teaching one response topography across different verbal operants have been shown to be an effective approach in producing response generalization across verbal operants (Greer, Stolfi, Chavez-Brown, & Rivera-Valdes, 2005). When a learner hears a caregiver tact a stimulus and is then able to respond to that same stimuli as both a listener and speaker without direct training, the learner is said to have naming (Petursdottir, & Carr, 2011). Neurotypical individuals develop this naming skill incidentally at an early age and are essential for more efficient language learning. Nontypically developing individual may not acquire naming incidentally and protocols to induce naming may be required (Greee, Stolfi, & Pistoljevic, 2007).

Greer Stolfi, Chavez-Brown, & Rivera-Valdes (2005) showed that teaching similar response topographies as listener responses, pure tacts, impure tacts, and march-to-samples create a learning history that allows children to acquire naming capabilities. This training procedure is known as Multiple Exemplar Instruction (MEI).

In one study, Greer and colleges compared MEI to Single Exemplar Instruction (SEI) for the emergence of naming (2007). During MEI, therapists taught children similar response topographies across different verbal operants and interspersed the different verbal operant trails with each other. During SEI,

therapists taught similar response topographies across verbal operants, but mass trialed each operant before moving to the next operant (i.e., all responses were taught as pure tacts then as impure tact, then as listener responded then finally as match-to-sample). They found that interspersing the different verbal operant trials together was an essential component of MEI in producing naming. This study is not without limitations, mastery criterion was set at 80% instead of a more stringent 100%, naming with 3-dimensional objects was not tested, and only one laboratory has examined the effect of MEI on the induction of naming. More research is needed to examine the effects of this training procedure using a single case design and replication in different settings and situations to better determine best practice.

Referent-Based Instruction

Similar to multiple exemplar training, referent-based instruction (RBI) is a teaching procedure that teaches similar response topographies across different verbal operants. Referent refers to verbal behavior that has come under the control of relevant properties of a stimulus. RBI employs a naturalistic based teaching approach in which the learner initiates teaching trials. When the learner shows interest in an item the instructor will run mand, echoic, tact, and sequelic trials with that item (e.g. if the learner shows interest in a book the instructor will have the learner ask for the book, mimic the word “book”, label the book, and answer questions about the book). Initial training focuses on mand training, once mands

are in place other verbal operants are introduced. Instructors use errorless teaching and high-p sequences during training.

Mason and Andrews (2014) examined the effectiveness of RBI on 13 children diagnosed with ASD. The participants received RBI for 90 minutes a day, four days a week, for a total of 13 weeks. During RBI the instructors conduct errorless teaching and high-p teaching instructions for nine minutes then probed fluence of the taught verbal operants for one minute. Verbal Behavior Milestone Assessment Program Placement (VB-MAPP) scores were assessed before and after RBI. The results showed that after RBI children's score on the VB-MAPP increased. These results suggest that RBI is an effective approach to teaching verbal behavior and may be useful in producing generalization across verbal operants (Mason & Andrews, 2014).

Multiple Operant Training

Similar to the procedures used in MEI and RBI, other studies have examined the effects of teaching similar response topographies across different verbal operants known as multiple operant training. Such studies have examined the effects of teaching similar response topography as tacts and mands (Arntzen, & Almas, 2002; Carroll, & Hess, 1987; Sidener, et. al., 2010; Sidener, 2006) mands, tacts, and intraverbals (Shillingsburg, Kelley, Roane, Kisamore, & Brown, 2009), listener responses and tacts (Egan, & Barnes-Holmes, 2010). These studies have

found mixed results on the generalization of responses topographies across verbal operants and rate of skill acquisition.

Carroll and Hesse (1987) examined the efficiency of mand-tact training and tact only training on the acquisition of tacts with five typically developing preschool children. They examined the rate of skill acquisition during mand-tact training and tact only training. They interspersed mastered tasks in the tact only training to match the pace of the mand-tact training. The study was divided into two phases. In phase one, they conducted mand-tact and tact only training separately starting with mand-tact training. In phase two, they conducted mand-tact and tact only training simultaneously. They found that tacts were acquired in fewer trials during the mand-tact training then the tact only training. These results suggest mand-tact training was more effective then tact only training in the acquisition of tacts.

Sidener, Carr, Karsten, Severtson, Cornelius, and Heinicke (2010) replicated and extended Carroll and Hesse's (1987) study on multiple operant training. Sidener and colleagues examined the effects of mand-tact training, mand only training and tact only training on skill acquisition in typically developing preschoolers and one child with ASD. They conducted three experiments. In the first experiment, they examined the rate of skill acquisition during mand-tact, mand only and tact only training with six typically developing preschoolers. They found

that acquisition rates varied across targets but mands were acquired slightly quicker in the mand-tact training and tacts were acquired slightly quicker in the tact only training. These results show that there was an insufficient difference in acquisition rates between mixed verbal operant training and single verbal operant training. In the second experiment, Sidener and colleagues replicated the study done by Carroll and Hesse (1987). They examined the rate of skill acquisition during mand-tact training and tact only training with two typically developing preschoolers. They found that participants acquired tacts in fewer trials during the tact only training. These results show tact only training was more efficient then mand-tact training for the acquisition of tacts. Lastly, in experiment three Sidener and colleagues replicated experiment one with the inclusion of an establishing operation assessment to provide equal reinforcement across mand-tact, tact only, and mand only training. They found various acquisition rates across targets, but mands were acquired slightly faster during mand-tact training and tacts were acquired slightly faster during tact only training.

Purpose Statement

The purpose of the current study is to extend previous research examining the effect of teaching topographically similar responses across verbal operants and topographically different responses across verbal operants. Specifically, we will compare the effect of teaching similar responses as tacts, intraverbals, and listener

responses to teaching different responses as tacts, intraverbal, and listener responses.

Method

Participants, Setting, and Materials

The participants were three children diagnosed with autism spectrum disorder (ASD) by a licensed psychologist. The participants attended a school for children with ASD and received one-on-one ABA services. The Peak Relational Training System-Direct Training (PEAK-DT; Dixon et.al., 2014)) was used to assess the language skills of each of the participants.

Wain was a seven-year-old male that used an augmentative communication device. He scored 34 on Foundational Learning skills, 20 on Perceptual Learning skills, 92 on Verbal Comprehension skills, and 10 on Verbal Reasoning, Memory, and Mathematical skills on the PEAK-DT assessment (Dixon et.al., 2014). Wain used his augmentative communication device for the intraverbal and tact targets during the study.

Adam was a seven-year-old male with a speech deficit. He scored 31 on Foundational Learning skills, 21 on Perceptual Learning skills, 92 on Verbal Comprehension skills, and 16 on Verbal Reasoning, Memory, and Mathematical skills on the PEAK-DT assessment (Dixon et.al., 2014). Adam used vocal approximations for the intraverbal and tact targets during the study

Nathan was a seven-year-old male. He scored 33 on Foundational Learning skills, 22 on Perceptual Learning skills, 100 on Verbal Comprehension skills, and 24 on Verbal Reasoning, Memory, and Mathematical skills on the PEAK-DT assessment (Dixon et.al., 2014).

Sessions took place in an individual treatment room at an autism treatment center in central Florida and at the participants' houses. The room contained a table, two chairs, and session materials. Session materials included a computer, datasheets, session log, session checklist, pens, two timers, clipboards, and a video camera. The antecedent stimuli were pre-arranged in a Power Point presentation prior to the start of the study to ensure that trials were delivered in the manner specified by the condition in effect. For the listener selection trials, nine pictures of birds were presented in a grid. For the tact trials, a single picture of a bird appeared on the slide. For the intraverbal trials, the instruction was typed at the bottom of the slide (e.g., "Nevada state bird is").

Dependent Variables and Data Collection

The primary dependent measurement for this study was the percentage of correct responses. We scored responses as correct if the participant emitted a predetermined vocal or physical response corresponding to the instruction within 10 s for Adam and Nathan, and 30 s for Wain, who was typed tact and intraverbal responses on his augmentative communication device. We scored responses as

incorrect if the participant emitted a response that did not correspond with the instruction or failed to respond within 10 s for Adam and Nathan, or 30 s for Wain. We scored responses as prompted if the participant emitted a response following a therapist's prompt. To calculate the percentage of correct responses, we divided the number of correct responses by the total number of trials and multiplied it by 100. Secondary measures included (a) the number of trials until participants achieved the mastery criterion per target (trials-to-criterion), (b) the functional independence of tacts, intraverbals, and listener responses, measured by testing for response generalization across the three operants following teaching in the second teaching condition and (c) the participants' preference for teaching condition, measured by a concurrent operant preference assessment (Brower-Breitwieser, Miltenberger, Gross, Fuqua, & Breitwieser, 2008).

Experimental Design

We used an adapted alternating treatments design (Sindelar, Rosenberg & Wilson, 1985) embedded in a nonconcurrent multiple baseline across participants (Watson &Workman, 1981) to examine the effects of the experimental conditions. In the nonconcurrent multiple baseline design across participants, we implemented treatment with Wain first, then Adam, and lastly Nathan. The multiple baseline shows experimental control by demonstrating a treatment effect for different participants only when treatment has been implemented. This design controls for

carryover effects by showing that once we implement treatment for one participant, it does not affect the other participants' responding until we implement treatment for them (e.g., if we implement treatment for Wain, then Adam and Nathan will not acquire targets until we implement treatment for them).

In an adapted alternating treatments design (Sindelar, Rosenberg & Wilson, 1985), participants learn different targets that are balanced for difficulty across two or more different treatment procedures to compare their effectiveness and efficiency. This design shows experimental control by yielding differing data paths that show one treatment procedure is more efficient than another treatment procedure. If the different treatment procedures have similar effectiveness and efficiency, then there is no experimental control. For this reason, we embedded an adapted alternating treatment design into a nonconcurrent multiple baseline design; if the treatment procedures produce similar rates of responding, then experimental control will still be established by increases in responding when we introduce treatment.

General Procedures

Pre-assessments. Pre-assessment probes were conducted to determine appropriate target responses for each participant. If the participant responded correctly during a target probe trial, we removed that target. If the participant responded incorrectly, we selected that target for the study. Once all the targets

were selected, we counterbalanced the targets across the two teaching conditions based on the number of syllables in the target responses.

We conducted a color preference assessment for each participant before the start of the study. A Multiple Stimulus Without Replacement (MSWO; DeLeon & Iwata, 1996) was conducted to determine each participant's color preference. We used seven colors for the assessment (i.e., red, blue, yellow, green, orange, purple, and black). At the end of the color preference assessment, we assigned colors of moderate and equal preference to each of the teaching conditions. For Wain, blue was paired with the similar teaching condition and green was paired with the different teaching condition. For Adam, purple was paired with the similar teaching condition and green was paired with the different teaching condition. For Nathan, orange was paired with the similar teaching condition and green was paired with the different teaching condition.

Session structure. Each session included three blocks of 12 trials. During a trial block, each target was presented one time. A two-minute break occurred between each trial block and a 15-min break occurred between sessions. We ran each teaching condition together; if we ran condition one, then we ran condition two that same day and vice versa. The therapist started each session by presenting a color card and delivering a rule that corresponded with the condition in effect (i.e., "We are going to do some work; everything is going to be that same" or "We are

going to do some work; everything is going to be different"). The therapist started a timer at the onset of the first trial in the training block and stopped the timer after the completion of the last trial in the training block.

Baseline. During baseline, the therapist delivered instructions and allowed the participant 2 s to initiate a response. For the tact trials, the therapist showed a picture of a bird and said, “what’s this?” For the intraverbal trials, the therapist did not show any stimuli and asked the name of the state bird (Wain and Nathan) or state flower (Adam). For example, the therapist may have said, “The Nevada state bird is?” For the listener selection trials, the therapist showed an array of nine birds or flowers and gave an instruction to point to one (e.g., “Show me Nevada’s state bird). The therapist did not deliver any prompts in baseline. Following the participant's response, there were no planned consequences for correct or incorrect responses. The therapist delivered praise on a variable ratio three schedule (VR3) for appropriate behavior (e.g. sitting in the chair, looking at the stimuli, keeping hands still).

Teaching. During the teaching phase, the therapist delivered instructions and program-specific prompts on a time delay schedule (MacDuff, Krantz, & McClannahan, 2001). During the first two sessions, the therapist prompted the correct response on a 0-s time delay. For the following sessions, the therapist prompted the correct response after 2-s time delay. Upon initiating a response,

Adam and Nathan had 10 s to finish the response and Wain had 30 s to finish the response. Following a correct or prompted response, the therapist delivered praise. Following an incorrect response, the therapist conducted an error correction. The error correction procedure consisted of the therapist re-presenting the instruction, then delivering a prompt (e.g., echoic for intraverbal and tact targets, and gesture for listener selection targets) on a 1-s delay. No additional response was required after the error correction. The experimenters considered targets mastered once the participant responded correctly for 80% of trials in a session, across three consecutive sessions.

Modifications to teaching procedure. We added an observing response for Wain in session 18 to assure he attended to the stimuli in the array on listener selection trials. Wain's observing response consisted of touching all the pictures in the array before the therapist delivered the instruction.

An observing response (Fisher, Kodak, & Moore, 2007) and modified error correction procedure was implemented for Adam in session 20. The observing response required Adam to echo the name of the state (e.g., "Texas") before the instruction was given ("The Texas state bird is the?") for tact and intraverbal targets. The observing response for the listener selection targets was to touch all the pictures in the array before the instruction was given. The error correction procedure was modified for intraverbal and listener selection trials to add another

opportunity to respond following the prompted response. For example, following an error, the therapist would repeat the instruction and prompt the correct response (e.g., "Montana state flower is… Bitterroot"). Next, the therapist would repeat the initial instruction and allow Adam to respond independently. The independent opportunity was repeated until Adam responded correctly without a prompt.

Similar topographies. In the similar topographies condition, we taught four target topographies as tacts, intraverbals, and listener selection responses (e.g., "chickadee" was taught as a tact, intraverbal, and listener selection response) for a total of 12 targets.

Different topographies. In the different topographies condition, we taught four target topographies as tacts, four different target topographies as intraverbals, and four different target topographies as listener selection responses (e.g., Myosotis as a tact, Sego Lilly as an intraverbal, and Iris as a listener selection response) for a total of 12 targets. Table 1 shows all the targets for both conditions for each participant.

Post-Experimental Assessments

Functional independence. Once the participants reached the mastery criterion in the different topographies condition, the therapist conducted response generalization probes across operants to determine the functional independence of the intraverbals, tacts, and listener responding operants. We tested for

generalization of the taught response topographies to the untaught operants. For example, Adam was taught "Myosotis" as a tact and then tested to see if he was able to identify "Myosotis" on listener selection trials and say, "Myosotis" on tact trials. We did not conduct operant transfer probes for the similar topographies condition because all the targets were directly taught across all three operants. If the targets did not generalize to the untaught operants, we then implemented the direct teaching procedure as described above.

Teaching condition preference assessment. Once a participant reached the mastery criterion in both teaching conditions, the therapist conducted a concurrent operant preference assessment (Brower-Breitwieser, Miltenberger, Gross, Fuqua, & Breitwieser, 2008) to determine which teaching condition the participants preferred. The concurrent operant preference assessment consisted of a training phase and a preference assessment phase. During the training phase, the therapist prompted the participant to choose a color and then presented the corresponding teaching condition. The therapist conducted four forced choice trials for each condition. During the preference assessment phase, the therapist allowed the participant to select a color card followed by the corresponding teaching condition.

Maintenance. Once participants reached the mastery criterion in both teaching conditions, we conducted maintenance probes. Maintenance probes were conducted one to four weeks after mastery criterion was met for each condition.

Correct responses were praised and incorrect responses were ignored. The therapist did not deliver prompts or error correction during the maintenance probes.

Interobserver Agreement and Treatment Integrity

During the study, a second observer independently scored data on the participants' responses, either in vivo or from video recordings of the sessions. The data from the primary and secondary observers were compared on a trial-by-trial basis. For each trial, an agreement was noted if both observers scored a correct or incorrect response. A disagreement was noted if one observer scored a correct while the other scored an incorrect for the same trial. The number of agreements was then divided by the number of agreements plus disagreements and multiplied by 100 to yield an interobserver agreement (IOA) score. Interobserver agreement was scored for Wain in 34% of sessions, with a mean result of 97% (range = 88 – 100). Interobserver agreement was scored for Adam in 35% of sessions, with a mean result of 99% (range = 97 – 100). Interobserver agreement was scored for Nathan in 38% of sessions, with a mean result of 99% (range = 97 – 100).

The second observer also collected data on the fidelity with which the procedures were executed in 33% of sessions. Data were scored for each of the following items: (a) preparing for session accurately (b) implementing baseline procedures, (c) implementing teaching procedures, and (d) handling problem behavior. We calculated treatment integrity by dividing the number of correct

behaviors implemented by the primary therapist by the total number of items on the checklist. See Appendix A for the treatment integrity checklist. Treatment integrity data were collected for Wain in 34% of sessions, with a mean result of 98% (range = 94 – 100). Treatment integrity data were collected for Adam in 37%of sessions, with a mean result of 98% (range = 93 – 100). Treatment integrity data were collected for Nathan in 34% of sessions, with a mean result of 98% (range = 93 – 100).

Results

Figure 1 depicts the percentage of correct responses for Wain (top), Adam (middle), and Nathan (bottom). Figure 2 depicts the results of the condition preference assessment.

Wain

During baseline, Wain did not respond correctly to the tact or intraverbal targets for either teaching condition. He responded correctly to the listener response targets for 3% of opportunities in the similar teaching condition and 14% of opportunities in the different teaching condition, which was below chance levels (i.e., because there was an array size of nine stimuli, there was an 11% chance of getting a correct response). After implementation of the teaching package, Wain reached the mastery criteria for all targets in the similar teaching condition in eight sessions. Specifically, he mastered the tacts targets in seven sessions, intraverbal

targets in seven sessions, and listener selection response targets in eight sessions. Wain did not achieve the mastery criteria for the different teaching condition. He mastered the tacts targets in 10 sessions and the intraverbal targets in 10 sessions. However, he never met the mastery criteria for the listener selection response targets.

On the operant transfer probe, Wain responded correctly to 0% of tact opportunities, 0% to the intraverbal opportunities, and 9.38% of the listener response opportunities. He maintained correct responding for 97% of opportunities in the similar teaching condition and 100% of opportunities in the different teaching condition during the follow-up probe. During the condition preference assessment, Wain showed a preference for the Similar teaching condition; he selected the similar teaching condition for 65.38% of opportunities and the different teaching condition for 34.61% of opportunities.

Adam

During baseline, Adam did not respond correctly to any tact or intraverbal targets in either teaching condition. He responded correctly to the listener response targets for 9.7% of opportunities in the Similar condition and 12.45% of opportunities in the different teaching condition. After the implementation of the teaching package, Adam reached the mastery criterion in 20 sessions for both the Similar and different teaching conditions. In the Similar teaching condition, he

mastered tacts targets in seven sessions, intraverbal targets in 18 sessions, and listener selection response targets in 20 sessions. In the different teaching condition, Adam mastered tact targets in eight sessions, intraverbal targets in 18 sessions, and listener selection response targets in 20 sessions.

On the operant transfer probes, Adam responded correctly to 0% of tact opportunities, 0% of intraverbal opportunities, and 31.53% of listener response opportunities. During maintenance probes, Adam emitted correct responding on 100% of opportunities in both the Similar and different teaching conditions. During the condition preference assessment, Adam showed a preference for the different teaching condition; he selected the similar teaching condition for 18.18% of opportunities and the different teaching condition for 81.81% of opportunities.

Nathan

During baseline, Nathan did not respond correctly to the tact targets in either teaching condition. He scored correctly on 19.43% of the intraverbal opportunities in the different teaching condition but did not respond correctly in the similar condition. He responded correctly to the listener response targets for 3.69% of opportunities in the similar teaching condition and 0.92% of opportunities in the Different condition. After implementation of the teaching package, Nathan reached the mastery criteria in five sessions for the Similar teaching condition. Specifically, he mastered tact, intraverbal, and listener selection response targets in five sessions

each. Nathan reached the mastery criteria in seven sessions for the different teaching condition; he mastered tact and intraverbal targets in seven sessions and listener selection response targets in five sessions.

During the operant transfer probes, Nathan demonstrated transfer for 18 of the 24 targets to the untaught operants. He responded correctly to 69.64% of tact opportunities, 62.5% of intraverbal opportunities, and 83.92% to the listener response opportunities. Nathan reached the mastery criteria for six of the tact targets, five of the intraverbal targets, and seven of the listener response targets during the operant transfer probe. During maintenance probes, Nathan maintained correct responding for 97% of opportunities in the similar teaching condition and 100% of opportunities in the different teaching condition. For the condition preference assessment, Nathan appeared to have no preference for teaching conditions; he selected the similar teaching condition for 41.37% of opportunities and the different teaching condition for 58.62% of opportunities.

Discussion

The current study evaluated the efficiency of teaching similar response topographies as tacts, intraverbals, and listener selections responses and teaching different response topographies across the same operants in three children diagnosed with ASD. Overall, two of the three participants acquired targets in fewer sessions during the similar teaching condition compared to the different

teaching condition. During the operant transfer probe, two of the three participants did not transfer targets taught as one operant to untaught operants. These findings suggest that teaching similar, rather than different, response topographies across different operants (e.g., tacts, intraverbals, and listener selection response) is more efficient. These results support prior research that the operants are functionally independent (Gamba, Goyos, & Petursdottir, 2015; Lamarre, & Holland, 1985; Shillingburg, Kelley, Roane, Kisamore, & Brown, 2009). Lastly, during the condition preference assessment, one participant preferred the similar teaching condition; one participant preferred the different teaching condition, and one did not show any preference. These results suggest idiosyncratic results for the preferences assessment.

Efficiency of Instruction

The results for the teaching phase of the experiment are consistent with prior research on the efficiency of teaching similar responses across different operants (Carroll & Hesse, 1987; Arntzen & Almås, 2002; Sidener et al., 2010; Kodak & Clements, 2009), also known as Multiple Operant Training (Nicholson, et al., in prep). Multiple Operant Training consists of teaching similar response topographies across different operants. Carroll and Hesse (1987), Arntzen and Almås (2002), and Kodak and Clements (2009) compared Multiple Operant Training procedures to Single Operant Training procedures, generally finding that

participants acquired targets faster when taught similar response topographies across different operants. For example, Kodak and Clements (2009) compared mand-only training to mand-echoic training and tact-only training to tact-echoic training. Kodak and Clements found that mand-echoic and tact-echoic were more effective then mand-only and tact-only training. The results of this study and the current study show that teaching targets across operants is more effective than teaching targets as a single operant.

It is notable that Wain never mastered the listener selection response targets in the different condition until those targets were also taught as intraverbals and tacts during the operant transfer probe training phase, even after an observing response was added into the procedures. Wain's results suggest that if a child struggles to learn targets in a specific operant, then teaching those targets across different operants may facilitate acquisition in the operant that is causing difficulty. In one study, Miguel and Kobari-Wright (2013) examined the effect of tact training on the emergence of listener response and categorization skills in two children with ASD. They found that participants acquired listener response and categorization response following tact training for those targets. This study shows the benefit of tact training on the emergence of listener responses. Result found by Miguel and Kobari-Wright (2013) may explains Wain's results in the current study. Wain acquired the listener selection targets only after those targets were also taught as

tacts and intraverbals. The tact training may have facilitated his acquisition of the listener selection responses.

The current study expanded on the prior research by teaching similar targets as tact, intraverbals, and listener selection responses. This study also expanded prior research by including a comparison teaching condition that taught targets as tact-only, intraverbal-only, and listener selection-only in a mixed operant arrangement instead of a constant operant arrangement (Nicholson, et al., in prep). By comparing Multiple Operant Training to Single Operant Training using the same trial arrangement procedures for both teaching conditions, it is likely that the sequential arrangement in which trials are presented does not affect the efficiency of acquisition. However, teaching targets across different operants does appear to affect the efficiency of acquisition.

Transfer Across Operants

During the operant transfer probe, two of the three participants did not transfer targets taught as one operant to the untaught operants. Wain did not transfer any of the targets taught as one operant to the untaught operants, so we then directly trained those targets using procedures similar to the similar teaching condition. For example, the targets taught as listener selection response in the different teaching condition was then taught as tacts and intraverbals. Adam also did not transfer targets to the untaught operants. These results support prior

research on the functional independence of the operants (Gamba, Goyos, & Petursdottir, 2015; Lamarre, & Holland, 1985; Shillingburg, Kelley, Roane, Kisamore, & Brown, 2009).

In contrast, Nathan demonstrated a mean of 72% correct in the operant transfer probes. However, Nathan's parent reported that she caught him doing an internet search on the targets following the first operant transfer probe session, suggesting Nathan may have learned the targets outside of the study instead of transferring the targets to the untaught operants. It is also possible that children who demonstrate sophisticated skill sets in other areas (such as independently conducting internet searches) are more likely to be able to readily transfer targets learned in one operant to other operants.

Another possible explanation for why Nathan demonstrated transfer across operants, whereas Wain and Adam did not, could be related to the participants' preexisting naming repertoire. Naming refers to the ability of an individual to emit both speaker and listener behavior toward a stimulus after only being taught in one operant (Greer & Longano, 2010; Miguel & Petursdottir, 2009). Comparable to the similar teaching condition, Multiple Exemplar Instruction has been shown to be effective in establishing the name relation in children with ASD (Petursdottir & Carr, 2011). Multiple Exemplar Instruction teaches similar responses as pure and impure tacts, listener responses, and match to sample while our similar teaching

condition taught similar response topographies as tacts, intraverbals, and listener selection. In one study Greer and colleges compared a mixed trial arrangement procedure to a constant trial arrangement procedure using multiple operant training. He found that the mixed trial arrangement procedure was needed for the children to acquire the Naming capability. Our study expanded Greer and colleges research by comparing Multiple Operant Training to Single Operant Training using the mixed trial arrangement procedure. Our study found that the Multiple Operant Training aspect quickens skill acquisition, however we did not test before the study whether the children could demonstrate the naming relation.

It would be interesting to determine whether children who did not demonstrate the naming relation prior to the onset of the study would be able to acquire the capability following the similar teaching condition. Future researchers may want to evaluate participants' naming capability prior to the onset of similar studies and should test for the emergence of the naming relation following Multiple Operant Training across tacts, intraverbals, and listener selection responses.

Condition Preference

During the condition preference assessment, Wain preferred the different topographies teaching condition; Adam preferred the similar topographies teaching condition, and Nathan showed an equal preference for both teaching conditions. It is crucial to determine children's preference for the teaching conditions in question.

As stated in the Professional and Ethical Compliance Code for Behavior Analysis (2014), if more than one scientifically-supported intervention has been established, other factors such as client preference should be considered when selecting which intervention to use. Practitioners can create motivation for a child to complete a particular teaching session by first allowing them to make a decision on which teaching condition they prefer (Wehmeyer et al., 2007).

Wain learned targets more efficiently and preferred the similar topographies condition over the different topographies condition. Thus, it would be optimal for his intervention team to adopt a procedure in which similar targets are taught across operants. Nathan mastered targets relatively quickly in both conditions, and had high rates of responding to the operant transfer probes. He preferred the different target condition by a small margin, perhaps because it increased the variety of topics he learned about. Given that his acquisition data were not differentiated, it would be optimal to teach different targets across operants to him to enhance motivation to complete teaching sessions.

The decision as to which condition is most advantageous for Adam is not as clear. He acquired the targets at the same rate in both teaching conditions and seemed to prefer the different topographies targets condition. However, he did not readily transfer the mastered targets to new operants. Thus, the different topographies teaching arrangement may not be an optimal choice for him even

though he prefers it. In cases in which the most effective or efficient procedure is not the most preferred procedure, practitioners should further investigate the preference for condition to determine whether some other variable can account for the selections, such as the specific stimuli that were present in each condition. Once that can be ruled out, the practitioner should consider other variables such as problem behavior, latency to responding to instructions, and the client's individualized treatment plan, to help determine which procedure to use.

Limitations and Future Directions

The current study is not without limitations. One limitation is that we had to make modifications during our teaching process for two of the three participants. We had to add an observing response for Wain and Adam and modify the error correction procedures for Adam. For Wain, the observing response was added to the listener selection targets in the different teaching condition to ensure his lack of progress was not due to him not attending to the stimuli. Following the addition of the observing response, we did not see a change in his responding. Therefore, we can conclude that Wain's lack of progress was not due to poor attending. For Adam, the addition of the observing response and the modified error correction was added to the listener selection and intraverbal targets for both teaching conditions. Therefore, the difficulty of both conditions remained the same.

Additionally, the order in which each treatment conditions were presented was not counter-balanced, thus introducing a possible order effect confound into the study. The order effect refers to changes in the participants' responding due to the order in which the treatment conditions were presented (Kazdin, 2016). Therefore, the order in which the similar and different conditions were presented each session may have affected the participants responding. For example, if the similar condition was presented first every session, then there may have been a carryover from the similar condition to the different condition. The order effect may have resulted in the participants responding instead of the efficiency of the two interventions, thus introducing a threat to the internal validity of the study. However, there were variations in the order in which each condition was presented (e.g., neither condition was presented first for every session). Future research should randomize the order in which the two treatment conditions are presented to reduce the chance of the order effect occurring.

Each of the participants used the PEAK-DT assessment (Dixon et.al., 2014) to determine their functioning level instead of the Verbal Behavior Milestone Assessment Placement Program (VB-MAPP; Sundberg, 2008). Therefore, we were not able to test to see if the participants showed proportionate strength in the tact, intraverbal, and listener repertoire following training in the similar teaching condition, as seen in the research on Referent Based Instruction (Mason &

Andrews, 2014). Future research should assess VB-MAPP scores prior to and following interventions that teach similar response topographies across different operants.

Similar to Sidener and colleagues (2010), another limitation to the current study is the ceiling effect. Sidener and colleagues (2010) compared mand-tact training to tact-only training and mand-only training on the efficiency of skill acquisition in five typically developing children and found varying results across participants. The ceiling effect refers to children's ability to acquire targets quickly regardless of differing teaching procedures. This same limitation was seen with Nathan. Nathan acquired targets quicker in the similar teaching condition compared to the different teaching condition but only by one session. He also acquired all the targets in a total of seven sessions while it took the other participants to 21 sessions to acquire all of the targets. Nathan's quick acquisition may have been due to a ceiling effect; he may have acquired the target regardless of teaching similar or different targets across operants. Future research should conduct a parametric evaluation of varying difficulty levels on the efficiency of multiple operant training to eliminate the ceiling effect and better examine the efficiency of Multiple Operant Training.

Another limitation is related to Nathan's searching the internet about the targets taught in this study. This is a major threat to the internal validity of this

study because it presents an uncontrolled variable. It is unlikely that he conducted any searches prior to the operant probes due to his low baseline responding until the teaching package was introduced. However, we cannot draw any conclusions about his operant probe data. In retrospect, while unanticipated, it is unsurprising that this particular participant attempted to find out more about the targets, given his overall skill set and inquisitive nature. Future researchers can prevent such errors by teaching nonsense targets.

Additionally, the mode in which the stimuli was presented during the study is a limitation. During the study, the therapist used PowerPoint presentation to present the stimuli during the sessions. PowerPoint presentation was used to ensure ease of use throughout the study. However, during typical treatment sessions in a clinical setting, most therapists' do not use PowerPoint presentation and instead use picture cards to present learning trials during DTI. Therefore, we are not able to determine the efficiency of use of Multiple Operant Training for typical clinical use. In the case that more than one teaching procedure is scientifically establish other factors should be address such as practitioner experience and training (Behavior Analysis Certification Board, 2014). The effectiveness and efficiency of the teaching procedure is limited by the integrity in which practitioner are able to deliver the intervention. If therapists are not able to deliver the Multiple Operant Training procedure with high levels or treatment integrity and efficiency, then the

intervention losses effectiveness. Future research should test the efficiency of therapist delivery of both teaching procedures with picture cards to determine the overall benefit of the teaching procedures and therapists' preference for teaching procedures.

In conclusion, the data from the present study support prior research on the effectiveness and efficiency of teaching similar response topographies across different operants. This study replicated and expanded prior research on the efficiency of Multiple Operant Training by teaching tacts, intraverbals, and listener selection responses as well as employ a mixed operant arrangement for both teaching conditions. Future research should replicate the current study using varying difficulty of targets and different mode of stimuli presentation, assess the naming capability of the participants, assess the proportionate strength across the different operants following the intervention. The results from the present study suggest teaching topographically similar responses as different operants quicken the rate of acquisition and may be a beneficial teaching strategy to teach language to children diagnosed with ASD.

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Table 1

Types of task variations procedures

Procedure	Descriptions	Studies
Task interspersal	One acquisition target is interspersed with at least one other mastered target	Dunlap (1984)
Task variation	One acquisition target is interspersed with at least one other acquisition target	Dunlap and Koegel (1980) Dunlap (1984)
Multiple Exemplar Training	A single target topography is taught as listener responses, pure tacts, impure tacts, and march-to-sample	Greee, Stolfi, and Pistoljevic (2007)
Referent-Based Instruction	A single target topography is taught as mands, echoics, tacts, and sequelic	Mason and Andrews (2014) Nicholson, et al. (in prep)
Multiple Operant Training	A single target topography is taught as at least one other operant (e.g. mand and tact)	Carroll and Hesse (1987) Sidener, Carr, Karsten, Severtson, Cornelius, and Heinicke (2010)

Table 2

Targets for each participant, across conditions and operants

Wain's Targets

	Tact	**Intraverbal**	**Listener Selection**
Similar topographies	Mountain Bluebird Brown Thrasher Lark Bunting Chickadee	Mountain Bluebird Brown Thrasher Lark Bunting Chickadee	Mountain Bluebird Brown Thrasher Lark Bunting Chickadee
Different topographies	Purple Finch Oriole Blue Hen Chicken Common Loon	Pheasant Eastern Goldfinch Ruffed Grouse Yellow Hammer	Willow Ptarmigan Nene Western Meadowlark Road Runner

Adam's Targets

Similar topographies	Showy Lady Slipper Magnolia Goldenrod Bluebonnet	Showy Lady Slipper Magnolia Goldenrod Bluebonnet	Showy Lady Slipper Magnolia Goldenrod Bluebonnet
Different topographies	Flowering Dogwood Cherokee Rose Organ Grape Myosotis	Common blue violet Sego Lilly Red Clover Mountain Laurel	Mayflower Bitterroot Iris Black Eyed Susan

Nathan's Targets

Similar topographies	Blue Hen Chicken Yellow Hammer Road Runner Pheasant	Blue Chicken Hen Yellow Hammer Road Runner Pheasant	Blue Chicken Hen Yellow Hammer Road Runner Pheasant
Different topographies	Purple Finch Oriole Mountain Bluebird Common Loon	Chickadee Western Meadowlark Ruffed Grouse Brown Thrasher	Willow Ptarmigan Nene Eastern Goldfinch California quail

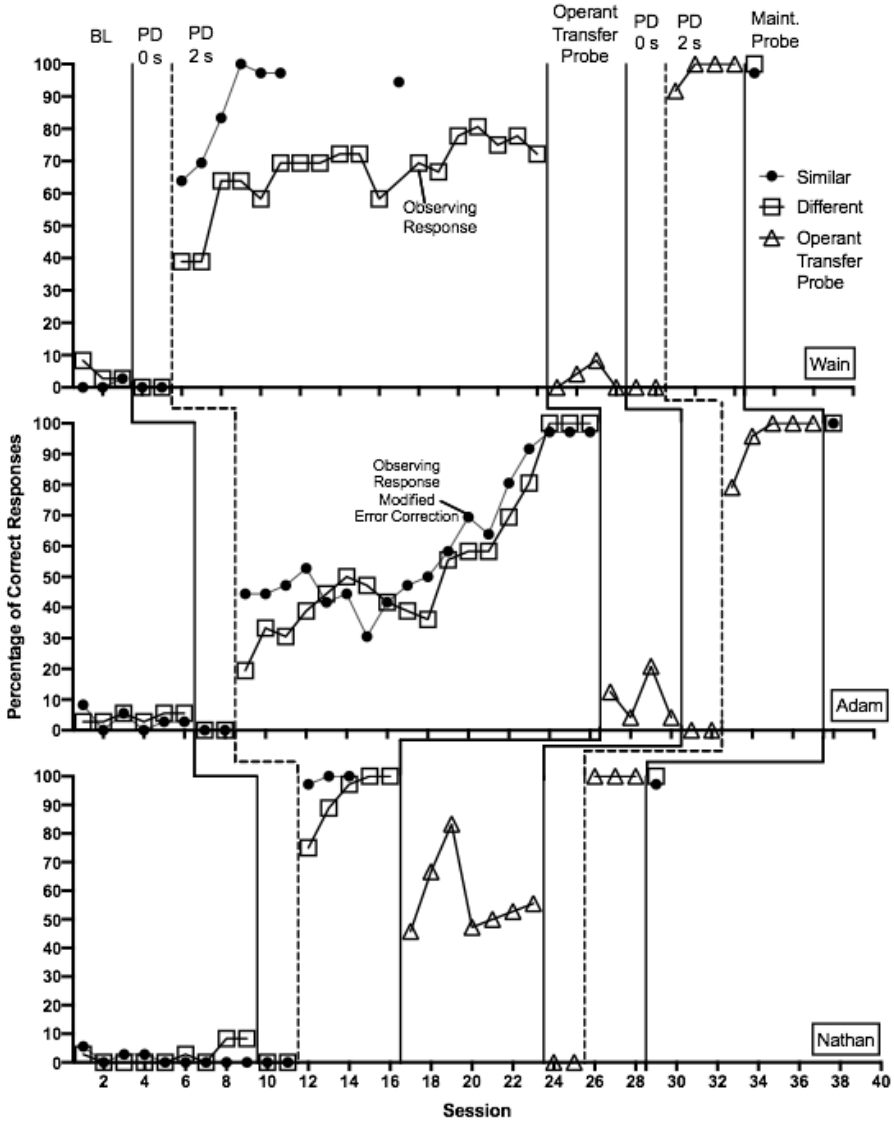

Figure 1. This figure depicts the percentage of correct responses for similar and different response conditions during baseline, treatment, generalization across operants and maintenance conditions for Wain, Adam, and Nathan.

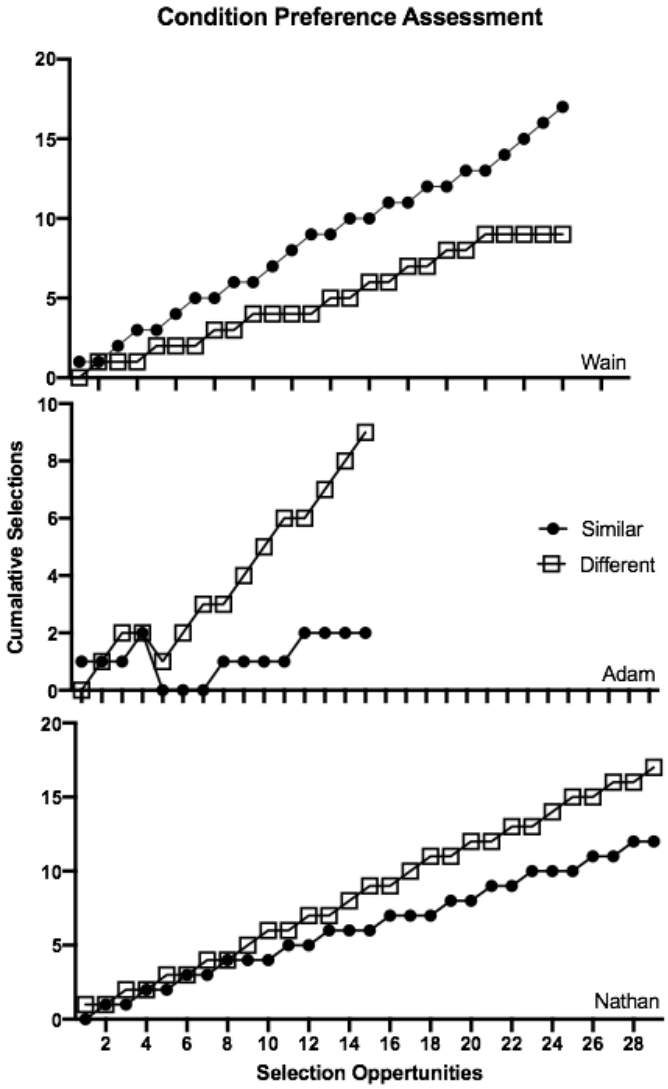

Figure 2. This figure depicts the total number of selections for the similar response and different response conditions during the condition preference assessments for Wain, Adam, and Nathan.

Appendix

Treatment Integrity Checklist

Treatment Integrity

Date: _____ Session #: _____ Condition: _____

Therapist: _____ Data Collector: _____

General Procedures						
Did the therapist have the correct materials ready for session? (Binders, datasheets, etc.)	Yes	No	Yes	No	Yes	No
Did the therapist indicate the condition (color card/statement) before bringing out the binder for each block and clean up the binder at the end of each block?	Yes	No	Yes	No	Yes	No
Did the therapist start the session timer when giving the first instruction and stop the session timer when delivering the reinforcer following the twelfth trial?	Yes	No	Yes	No	Yes	No
Did the therapist give the correct instructions, as stated on the datasheet?	Yes	No	Yes	No	Yes	No
Did the therapist collect data immediately after each trial?	Yes	No	Yes	No	Yes	No
Did the therapist turn the page after recording data, and then present the next instruction?	Yes	No	Yes	No	Yes	No
Did the therapist run an equal number of sessions from condition 1 and condition 2 throughout the day? (SCORE ONLY FOR SECOND SESSION OF DAY)	---	---	---	---	Yes	No
Did the therapist provide a 2-min break between each block and a 10-min break between sessions?	Yes	No	Yes	No	Yes	No
TOTAL per Block:						
Baseline Procedures						
Did the therapist wait 5s for response initiation, and 5s after initiation for response completion?	Yes	No	Yes	No	Yes	No
Did the therapist give behavior-specific praise about every 3-4 trials (i.e., 3 total deliveries) for appropriate sitting, eye contact, etc.?	Yes	No	Yes	No	Yes	No
Was praise provided at the end of each block? (i.e., 1 edible at the end of each block, 3 different edibles during each BL session)	Yes	No	Yes	No	Yes	No
Did the therapist refrain from prompting, error correction, and differential reinforcement?	Yes	No	Yes	No	Yes	No
TOTAL per Block:						
Teaching Procedures						
Did the therapist prompt and fade prompts as specified by the protocol?	Yes	No	Yes	No	Yes	No
Did the therapist provide the appropriate consequence as specified by the protocol, for correct/prompted/incorrect/no responses?	Yes	No	Yes	No	Yes	No
If the participant initiated a response within 2s of the instruction, did the therapist wait 5s for response completion?	Yes	No	Yes	No	Yes	No
TOTAL per Block:						
Problem Behavior						
Did the therapist block and redirect any problem behavior?	Yes	No	Yes	No	Yes	No
Did the therapist continue teaching?	Yes	No	Yes	No	Yes	No
Did the therapist record frequency of problem behavior throughout session?	Yes	No	Yes	No	Yes	No
TOTAL per Block:						