A COMPARISON OF OPERANT DISCRIMINATION TRAINING AND STIMULUS-STIMULUS PAIRING PROCEDURES TO INCREASE VOCALIZATIONS OF CHILDREN WITH AUTISM

by

TRACY LYNN LEPPER
Bachelor of Science, 2006
Western Michigan University
Kalamazoo, Michigan

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More positive trajectories for children with autism following early intensive behavioral intervention (EIBI) programs are correlated with early acquisition of functional verbal repertoires (Lovaas, 1987). Children with functional verbal behavior are typically more responsive to EIBI programs due to their deficits in the core areas (i.e., communication, social, and restricted or repetitive interests) being less severe. Amongst these children there is a subgroup for which deficits in language acquisition are more pronounced. These children cannot imitate auditory stimuli of others, have no functional vocal-verbal behavior, and often emit very few vocalizations which rarely vary in form. For these children identifying effective interventions that can lessen the pronounced deficits in language may have a dramatic effect on their long term prognosis.

The stimulus-stimulus pairing (SSP) procedure has been recommended to increase frequencies of vocalizations for children who engage in little to no vocal play so that the vocalizations may be captured and brought under the proper stimulus control (Greer & Ross, 2008; Sundberg & Partington, 1998). These passive pairing procedures generally involve contiguous presentations of auditory stimuli with previously conditioned reinforcers or primary reinforcers arranged such that the auditory stimuli reliably predict the presentation of the reinforcer. Conceptually, the procedure creates the proper conditions for the auditory stimuli to acquire conditioned reinforcing properties. Thus, when a child emits a vocalization that approximates the auditory stimulus it strengthens the stimulus-reinforcer relation presented in training, and that response should be emitted more frequently in the future due to the increase in response strength. The effects of matching of self-produced auditory stimuli to that of environmentally presented auditory stimuli have been well documented by researchers who have explored the acquisition of species typical birdsongs (e.g., Marler, Krieth, & Tamura, 1962). These studies have demonstrated that when some species of birds, including blackbirds and chaffinches, were raised from eggs or nestlings in acoustic isolation, their species typical songs did not match the songs emitted by the wild type of each species (Marler, Krieth, & Tamura, 1962; Poulsen 1951; Thorpe 1954). In addition, it has been shown that when canary fledglings were deafened following exposure to their species typical birdsong, but were never afforded the opportunity to practice the song, their song differed dramatically from the wild type song (Waser & Marler, 1977). These studies taken together provide some insight as to how important auditory feedback can be for the development of birdsong. There are definite parallels in human and avian vocalizations in that production of vocalizations. For example both use similar physical structures and the vocalizations have a functional role for both species (e.g., begging calls and operant cries of infants to attract parent, or subsongs and babbling), due to these similarities it is likely that auditory feedback is important in the acquisition of language for humans as well. This may suggest that for children with autism who do not vocalize at high rates, the auditory feedback of the self-produced vocalizations is not sufficient to maintain the efforts of vocalizing. The pairing procedure may correct for that by way of increasing the reinforcing effectiveness of the child hearing similar auditory stimuli after the auditory stimuli have been paired with an effective reinforcer.

Other parallels between the acquisition of birdsong and the acquisition of language have recently been cited by King, West and Goldstein (2005) who include the use of direct reinforcement by females through wing stroking and gapes to establish a foreign adult birdsong in juvenile males. The authors noted that directed birdsong was more frequent following periods where the female had wing flapped contingent on the occurrence of the male directed song.

Likewise, the vocalizations of typically developing children may be shaped into words through their resemblance with the adult vocalizations they are exposed to (Palmer, 1996) and into functional vocal-verbal repertoires through naturalistic contingencies presented by the child's verbal community (Skinner, 1957). However for the subgroup of children mentioned previously, these children do not emit a high rate of vocalizations which could preclude the development of functional verbal behavior.

Several applied studies have used passive pairing procedures to increase vocalizations of children with delayed speech. These studies provides support for the clinical utility of the procedures. For example, Sundberg, Michael, Partington, and Sundberg (1996) demonstrated that a passive pairing procedure was effective at increasing the vocalizations of four children with language delays and one typically developing child. The experimenters paired novel auditory stimuli (sounds, words or phrases) with socially mediated events (e.g., tickles, clapping, etc.) that had previously been observed to reinforce other responses. While all participants did emit more target vocalizations during the post-pairing observation compared to pre-pairing observation, the effect was transient. The authors did note that for 2 of the 5 participants the vocalizations appeared to have acquired a mand function (Skinner, 1957); that is, the participants appeared to be using them in an attempt to obtain the social reinforcers.

Smith, Michael, and Sundberg (1996) provided further support for the utility of SSP procedures by demonstrating that such procedures were effective at increasing non-novel vocalizations for two typically developing infants. The experiment included three conditions: a positive condition, during which target auditory stimuli (that were in the participants' repertoires) were paired with an established form of reinforcement, a neutral condition, during which target auditory stimuli were presented to the participants but were not followed by delivery of reinforcers, and a negative condition (for one participant), in which a target auditory stimulus was systematically paired with a mild punisher (i.e., disapproving statements). The neutral condition was conducted to assess the possibility that the responses were under echoic (Skinner, 1957) control; that is, that the participants were simply imitating immediately prior auditory stimuli (as opposed to delayed imitation, which is not considered echoic). The authors concluded that target responses were not under echoic control as there were no substantial increases in target vocalizations during this condition, whereas the expected effects (i.e., increased or decreased frequency of vocalizations) were demonstrated in the positive and negative conditions suggesting that the target vocalizations acquired conditioned reinforcing or punishing properties.

Yoon and Bennett (2000) demonstrated that the SSP procedure increased target vocalizations of four preschool-age participants, who did not exhibit functional vocal-verbal behavior and the effects were greater than the effects of standard echoic training. The experimenters paired target auditory stimuli with events that were identified as reinforcers (e.g., tickles) during the SSP condition approximately 36 times. During echoic training experimenters presented the target vocalization to the participant over 36 trials, thus providing the opportunity for the vocalization to be emitted and directly reinforced. Increases in target vocalizations were observed only during the SSP condition; however, the effects were transient.

Although there is substantial support for SSP procedures to create the proper conditions for increases in target vocalizations to be emitted by participants, several other studies have reported null or mixed effectiveness of these passive pairing procedures (e.g., Esch, Carr, & Michael, 2005; Miguel, Carr, & Michael, 2002; Normand & Knoll, 2006; Stock, Schulze, & Mirenda, 2008; Yoon & Feliciano, 2007). For example, Miguel et al. (2002) evaluated the effects of the SSP procedure on the vocal behavior of three boys between the ages of 3 and 5 years who met the criteria for an autism diagnosis. These authors corrected for some methodological issues evident in prior research through the inclusion of a control condition, omission contingencies for echoic responses, and a standard single-subject experimental design. The pairing procedure consisted of target auditory stimuli being paired with preferred food items. The control procedure consisted of the noncontiguous presentation of both the target auditory stimuli and the food items. An omission contingency was place for vocalizations that could be defined as echoic responses in order to rule out direct reinforcement as the behavioral mechanism responsible for any increases in target vocalizations. The omission contingency consisted of resetting the interval duration contingent on the emission of an echoic response. Post-pairing frequencies of target vocalizations were compared to pre-pairing frequencies using a combined reversal design and multiple-baseline design across response topographies. The post-pairing frequencies of target responses were higher than pre-session frequencies for 2 of the 3 participants. The third participant did not emit higher frequencies of the target vocalizations during the post-pairing observations (as compared to pre-session frequencies) for either form. These mixed (and null) effects reported in more recent literature suggest than when more rigorous methodological approaches have been adopted to evaluate the utility of these passive pairing procedures to establish auditory stimuli as conditioned reinforcers, its effects are more variable, which indicates the need for further investigation as to what conditions are necessary to produce robust effects.

There are numerous conditions described within the classical conditioning literature (e.g., base rate of unconditioned stimulus presentations are higher than neutral stimulus/unconditioned stimulus presentations) under which contiguity between presentations of a neutral stimulus and an unconditioned stimulus (or conditioned stimulus) may be insufficient for the neutral stimulus to acquire reinforcing properties (Rescorla, 1988). Some of these conditions may explain the mixed and null findings reported in the passive pairing literature on establishing vocalizations as conditioned reinforcers. Basic findings suggests that one way a stimulus may more readily acquire conditioned reinforcing properties under certain conditions is by increasing the salience of the neutral stimulus that reliably predicts the delivery of the reinforcer during pairing procedures (Rescorla, 1988). Esch, Carr and Grow (2009) reliably increased target vocalizations of 3 children with autism between the ages of 2 and 5 years through the use of an enhanced SSP procedure that was aimed at enhancing the salience of the target auditory stimuli. The enhanced procedure included using an observing prompt before every trial, inclusion of nontarget stimuli trials (i.e., auditory stimuli delivered by the experimenter that was not followed by a reinforcer) that were interspersed between pairing trials, pitch and tone changes to enhance discrimination between the target and any other verbal stimuli that may have been present in the environment (e.g., parental conversations in another room), and the incorporation of intertrial intervals (ITIs) of varying length to reduce temporal relations as a confounding variable. The authors also strayed from the conventional pre- and post-pairing data collection and opted to use within session data to assess the effects of the SSP procedure. While the enhanced procedure was effective for all participants, the specific variable(s) responsible for the effectiveness could not be identified.

While previous research has been aimed at increasing the frequency or rate of vocalizations, Petursdottir, Carp, Matthies and Esch (2011) sought to identify preference for the paired auditory stimulus over that of an unpaired control stimulus, as some reports have indicated that failures in the passive pairing procedures may be due to an inability of the participants' vocal-musculature to produce the target vocalizations. In addition, Petursdottir et al. also sought to minimize the potential for blocking and overshadowing to affect conditioning by using computer generated auditory stimuli. The researchers also incorporated variables into their procedures that were aimed at enhancing learning such as increasing the number of stimulus-stimulus presentations along with frequent stimulus preference assessments. These variables did not appear to increase preference for a target auditory stimulus over that of a control sound, as measured by button pressing during a concurrent operants procedure. The authors concluded that for the 3 boys with autism in their investigation, failures to observe an effect were not due to the inability of the participants to produce the target stimuli (because they could easily produce them by pressing buttons), but rather due to conditioning failures. These findings, in conjunction with the numerous other studies that have reported mixed and null effects of the SSP procedure, suggest that it is difficult to establish vocalizations as conditioned reinforcers through passive pairing procedures (Esch, Carr, & Michael, 2005; Miguel, Carr, & Michael, 2002; Normand & Knoll, 2006; Stock, Schulze, & Mirenda, 2008;Yoon & Feliciano, 2007).

Studies have demonstrated that once an effect has been achieved using the SSP procedure, the vocalizations emitted by the participant may be captured and brought under the proper stimulus control to function as mands for some participants (Yoon & Feliciano, 2007; Esch, Carr, & Grow, 2009). Mands are verbal operants that typically specify the specific type of reinforcement desired and are subject to changes in states of satiation and deprivation experienced by the speaker (Skinner, 1957 p. 35). These studies support the utility of the SSP procedure as an intervention for children with developmental disabilities who engage in little to no vocal play; however the experimental conditions under which a reliable effect can be produced or the potential for applied benefits, have yet to determine. To date, only one study (Normand & Knoll, 2006) has examined the effects of the SSP procedure on the vocalizations of children with delayed speech and attempted to assess the durability of the effect once demonstrated under experimental conditions. These follow-up data were collected 60 min after the pairing session was terminated. The SSP procedure itself did not increase the target vocalizations for the participant in this study, rendering the durability of the procedural effects undeterminable. It is noteworthy, however, that the follow-up data did indicate some increases in vocalizations. The authors suggest that this increase may have been due to the participant emitting the vocalization as a mand for a preferred item during the follow-up sessions. The participant was observed to reach for the item that was used during the pairing procedure and emit the target vocalization. This observation may lend credence to the possibility that the SSP procedure can inadvertently contrive conditions under which some aspect of the experimental procedure acquires stimulus control over the vocalization. It is worth noting that increases in vocalizations were seen in this study during the follow-up but not during the experimental sessions, which may suggest that some of the current methodologies of data collection may fail to detect conditioning effects. While most studies have employed post-pairing observation sessions to assess the effects of the passive pairing procedures on vocalizations, this is also the time during which satiation effects of the unconditioned reinforcer are most probable. For example, Esch et al. (2009) reported initially not seeing an effect during post-pairing sessions, but during the sessions observed several target vocalizations being emitted. This led the researchers to employ a within-session data collection methodology during which effects of the conditioning procedure were noted for all three participants.

If the SSP procedure exerts its effects through conditioned reinforcement, it is possible that alternative procedures for establishing conditioned reinforcers may produce a more reliable effect. One way to establish a conditioned reinforcer is through discrimination training, in which stimulus control is established over an operant response by reinforcing it only in the presence of a particular stimulus. The stimulus then not only acquires discriminative control over the operant response, but will also serve as a conditioned reinforcer for other operant responses that produce it (Catania, 1998). Holth, Vandbakk, Finstad, Gronnerud and Akselsen-Sorensen (2009) demonstrated that social stimuli could be established as conditioned reinforcers for both children with autism and typically developing children through an operant discrimination training (ODT) procedure. They also found that the effects of the ODT were greater than the effects of a SSP procedure when the stimuli established as conditioned reinforcers through the two procedures were presented contingently on an arbitrarily selected responses during post training tests. The operant discrimination was established through a series of steps that included prompting and prompt fading of the target response. Once the response was occurring reliably in Step 1, the response was then differentially reinforced in the presence of a neutral visual or auditory stimulus (i.e., stimulus to be established as a discriminative stimulus (S^D)) during Step 2. During SSP, a different neutral stimulus was presented in a manner that reliably predicted and overlapped with the delivery of the reinforcer. The numbers of pairing trials were yoked to the ODT procedure. During post-conditioning testing, one of the stimuli that was paired with the delivery of the reinforcer during SSP was delivered contingent upon an arbitrarily selected response, and the stimuli that functioned as a S^D during the ODT procedure was presented contingent on a second arbitrarily selected response. Higher rates of responding across the arbitrarily selected responses were emitted by 5 of the 7 participants in this study. These findings suggest that an ODT procedure may be a more advantageous procedure for establishing stimuli as conditioned reinforcers for humans. In addition, the ODT method has other advantages in that there is an inherent contingency on attending to the auditory stimulus. Studies that have evaluated blocking and overshadowing in conditioning procedures (e.g., Kamin, 1969) suggest that stimuli that are attended to more during conditioning trials acquire more stimulus control (i.e., produce more responding) than other stimuli that are redundant or do not provide additional information about the contingency arrangement to the subject. With the ODT procedure the auditory stimuli must be attended to in order for the participant to respond differentially in the presence of the S^D and S^Δ. Another benefit is that with the ODT procedure the experimenter or clinician may be able to more accurately identify whether the participant is attending to the S^D or some other irrelevant feature during the stimulus presentations. Identification of features that the control responding may be crucial, especially when designing intervention programs for children with autism, as they often exhibit what has been described as overselectivity (i.e., responding to irrelevant aspects of the stimulus; for a review *see* Ploog, 2010). With the passive pairing procedures that have been recommended to increase vocalizations of children with autism, there is no way of knowing what feature (or features) of the auditory stimulus the child is attending to, if any, before the reinforcer is delivered. Therefore, the purpose of the present study was to evaluate the effects of a SSP and an ODT procedure when utilized to increase target vocalizations of pre-school age children with autism who engage in little to no vocalization and assess the durability of the effects of both procedures by including follow-up sessions up to 1 month after experimental sessions had ended. Individual preferences for procedures were also assessed. This information allows future interventions for the participant to be tailored to his or her specific preference, which is consistent with the movement in mental health practice advocating for more person-centered interventions (Hanley, Piazza, Fisher, Contrucci, & Maglieri, 1997; Hanley, Piazza, Fisher, & Maglieri, 2005).

Method

Participants and Setting

All participants were recruited from a local center that provide early intervention services to children with developmental disabilities. This study was completed with three boys, Brad, Jonas and Colin. Brad was 4 years 2 months and had been receiving early intervention services from the center for 2 years. Jonas was 3 years 4 months when he began the experiment. He began receiving services from the center 3 months before participating in the present study. Colin, the youngest participant, was 2 years 10 months at the beginning of the experiment and had been receiving services at the center for approximately 1 year. None of the participants were receiving any type of speech therapy from the center or any other agency at the time of their participation. All participants had received a prior diagnosis of autism and presented with severely delayed speech as assessed by the Behavioral Language Assessment (BLA; Sundberg & Partington, 1998).

Sessions were conducted in a quiet room away from noise and other distractions of the center. Contents of the room varied depending on room availability but included a low table and chairs, a video camera positioned on a tripod, and various toys. Efforts were made to remove noise producing toys from the room before beginning experimental procedures each day. Visits were conducted 2-5 days per week and included 1-2 of the assessments or experimental conditions described below. Visits duration varied but never exceeded 50 minutes. Total duration of participation in this project ranged from 3 to 9 months for individual participants.

Dependent Variables and Data Collection

During each experimental condition frequency data on vocalizations that matched or approximated two auditory syllables or syllable combinations were recorded; one that was termed a target and one that was termed a nontarget. The target syllable within each condition had a programmed reinforcement contingency in place during trial delivery, whereas the nontarget syllables trials were never followed by the delivery of reinforcement. For example, Brad’s target vocalization was “mee-muh” during Set 1 of SSP and his nontarget vocalization was “too-tee.” During target trials, the experimenter delivered the auditory stimulus “mee-muh” 3 times and simultaneous with the third vocalization delivered the reinforcer. During nontarget trials, the experimenter delivered the auditory stimulus “too-tee” 3 times, but did not deliver a reinforcer. While the programmed contingency for the delivery of the reinforcer changed across conditions (e.g., a response requirement or longer ISI in place), targets trials were the only ones that resulted in reinforcer delivery. These data were recorded within the intertrial intervals of each experimental procedure across 40 trial sessions (20 target and 20 nontarget, conducted semi-randomly). For single-syllable auditory stimuli, only vocalizations that matched were recorded. For instance, if the participant’s target vocalization was “boo” and he emitted “moo” this would not be scored as an occurrence of the target vocalization. For complex or reduplicate syllable combinations, approximations were scored as targets or nontarget vocalizations. Approximations of auditory stimuli were operationally defined as vocalizations emitted by participant that contained both vowel sounds and at least one consonant sound in which the order of emission matched that of the auditory stimulus. For example, if the participant’s target vocalization was “mee-muh”, responses that would be scored as occurrences would include, “mee-muh”, “ee-muh” or “mee-uh.” Additionally, if extra consonants were included in the response the response would not be scored as an occurrence of the target or nontarget vocalization. For example, in the previously mentioned case, if the participant emitted “bee-muh” or “mee-kuh,” the response would not be scored as a target vocalization. Echoic responses were defined as the participant emitting a vocalization that matched or approximates the auditory stimulus that preceded the response within 5 s of the stimulus; these responses were not scored as vocalizations. The frequency of target and nontarget vocalizations within each session was divided by the duration of the session which yielded a rate of vocalization per minute measure. These data were collected across stimulus sets for each participant. The only difference across sets for the participants was the auditory stimuli used in the experimental procedures. For example, Brad's auditory stimuli during Set 1 of SSP were "mee-muh" and "too-tee," during Set 2 the auditory stimuli used as targets and nontargets were "goo" and "key." The auditory stimuli used in the other conditions were switched as well.

In addition, a manipulation check was conducted to ensure the integrity of the discrimination procedure and to help identify potential carry-over effects from procedure to procedure. The manipulation check consisted of scoring the number of times the participants made the operant response targeted in ODT (i.e., arm raising) in the presence of the target and nontarget stimuli during all procedures. Total frequencies of arm raises in the presence of the target stimulus were divided by the total number of times the opportunity to engage in arm raising was presented (i.e., the number of times the target stimulus was presented) across all sessions of the specific procedure, which yielded a conditional probability index of hand raising in the presence of the target auditory stimuli, for each participant during SSP, ODT, and the control procedure. The same analysis was conducted for arm raising in the presence of the nontarget stimuli, which yielded a conditional probability index for arm raising in the presence of the nontarget auditory stimulus for each participant across the procedures.

Interobserver Agreement

Two independent observers scored occurrence of target and nontarget vocalizations for at least 30% of all sessions across all experimental and control procedures and for each set of auditory stimuli during the session or from videotape. Interobserver agreement scores were calculated using the occurrence agreement method. With this method, only sessions for which at least one observer scored an occurrence of either the target or nontarget are included. For each of these sessions the lower frequency of target vocalizations (or nontarget responses) were divided by the larger frequency of target vocalizations (or nontarget vocalizations) and multiplied by 100. This was done to exclude inflation of the agreement score on the basis of nonoccurrences of target and nontarget vocalizations. Agreement on the occurrence of target vocalizations for Brad during Set 1was calculated for 63% of ODT sessions; mean interobserver agreement was 87% (range, 33% to 100%). Agreement on the occurrence of target vocalizations for Brad during Set 1 of SSP was calculated 38% of sessions. Average agreement was 67% (range, 0 to 100). For Brad agreement scores were not calculated for occurrences of target vocalizations during the control procedure, nontargets during SSP, and ODT, due to neither of the two observers scoring an occurrence during any of these sessions across Set 1. During Set 2 agreement on target vocalizations during ODT for Brad was calculated for 100% of sessions and yielded an average agreement score of 75% (range, 0% to 100%). During SSP agreement was calculated for 75% of sessions and yielded an average agreement score of 89% (range, 67% to 100%). Again, because neither observer scored occurrences of target vocalizations during the control procedure nor scored nontarget vocalizations across any of the procedures, agreement scores were not calculated.

Agreement on the occurrence of target vocalizations for Jonas during Set 1was calculated for 22% of ODT sessions; mean interobserver agreement was 88% (range, 75% to 100%). Agreement on nontarget occurrence during Set 1 of ODT was calculated for 11% of sessions; mean interobserver agreement was 100%. Agreement on the occurrence of target vocalizations for Jonas during Set 1 of SSP was calculated 22% of sessions. Average agreement was 100%. For Jonas agreement scores were not calculated for occurrence of target or nontarget vocalizations during the control procedure, nor nontargets during SSP, due to neither of the two observers scoring an occurrence during any of these sessions across Set 1. During Set 2 agreement on target vocalizations during ODT for Jonas was calculated for 56% of sessions and yielded an average agreement score of 90% (range, 50% to 100%). During SSP agreement was calculated for 44% of sessions and yielded an average agreement score of 75% (range, 50% to 100%). Nontarget occurrence agreement during Set 2 of SSP was calculated for 11% of sessions; mean agreement was 100%. Target occurrence agreement for the control procedure of Set 2 was calculated for 33% of sessions and yielded an average of 33% (range, 0% to 100%). Again, because neither observer scored occurrences of nontarget vocalizations during the control or ODT procedure, agreement scores were not calculated.

For Colin, agreement scores were not calculated for any of the conditions in Set 1, as only 1 observer indicated 1 occurrence of a nontarget during the control procedure (i.e., no other occurrences of targets or nontargets were recorded by either observer across the set). Agreement on the occurrence of target vocalizations during ODT Set 2 was calculated for 33% of sessions; mean agreement score was 100%. During SSP of Set 2 target occurrence agreement was calculated for 44% of sessions and yielded a mean agreement score of 79%. Agreement of nontarget vocalizations during SSP was also calculated for 44% of sessions and yielded a mean agreement score of 66% (range, 0 to 100). Agreement on target vocalization during the control procedure of Set 2 was calculated for 33% of sessions; mean agreement was 66% (range, 0 to 100%). Agreement scores on the occurrence of nontargets during ODT and the control procedure were not calculated as neither observer scored occurrences during Set 2.

Pre-experimental assessments

Behavioral language assessment. For this study only individuals for whom the Behavioral Language Assessment (BLA; Sundberg & Partington, 1998) indicated few to no echoic responses, and other verbal operants were selected to participate. The BLA is an informant assessment that was conducted with the potential participants' parents. The assessment consisted of 12 sections; each section assessed different language-related skills (e.g., motor imitation, labeling). Each section of the assessment was divided into five different levels. Each level had a different profile related to the specific language-related skill being assessed. Parents were asked to select the level that best represent their child's repertoire for each section. Results of this assessment were calculated by averaging scores across the 12 sections indicating a profile level for each participant. All participants were reported to be cooperative and able to complete match to sample tasks. Brad emitted some non-vocal mands, imitation of a few gross motor movements modeled by others, limited vocal play, limited echoic skills, and approached others for initiations. His profile level was 2 with a score of 2.0. Jonas emitted some nonvocal verbal mands (e.g., pointing), motor imitation skills, vocal play, and some receptive skills that included identifying actions nonverbally. His profile level was 2 with a score of 2.16. Colin emitted some non-vocal mands and frequently approached adults to gain access to reinforcers. His profile level was 2 with a score of 1.92. According to Sundberg and Partington, the level 2 profile indicates that the child is likely to have some behavior problems and probably require intensive language intervention.

Early Echoic Skills Assessment. The Early Echoic Skills Assessment (EESA; Esch, 2008) is a subtest of the Verbal Behavior Milestones Assessment and Placement Program

(VB-MAPP; Sundberg, 2008). This is a direct assessment of the participants' echoic skills conducted by the experimenter. The assessment consists of presenting the participant with up to 3 opportunities to emit an echoic response (i.e., emit a response that imitates the auditory stimulus delivered by the experimenter) to the auditory stimuli delivered by the experimenter. The best response of the 3 opportunities is scored as correct, which yields 1 point, or recognizable (response approximates the auditory stimulus but incorrect or missing consonants or extra syllables), which yields a score of .5. Failures to respond, incorrect vowels or missing syllables are scored as 0. The assessment evaluates the participant's ability to imitate simple and reduplicate syllables, syllable combinations, 3-syllable combinations, prosody of spoken phrases and prosody in other contexts. All participants in the current study failed to approximate any of the auditory stimuli presented under each category, yielding scores of 0.

Stimulus preference assessment. A brief multiple-stimulus without replacement preference assessment (MSWO; Carr, Nicolson, & Higbee, 2000) was conducted with each participant in order to identify preferred stimuli that were used during the experimental procedures. The stimulus pool consisted of items nominated by the participants' parents on the Reinforcer Assessment for Individuals with Severe Disabilities (RAISD; Fisher, Piazza, Bowman, & Amari, 1996) as preferred. Before conducting the preference assessment, participants were given the opportunity to sample the nominated items. This was done to assess the whether the participant could independently engage with the items in an appropriate manner (i.e., the item(s) do not evoke stereotypy) and had the ability to manipulate the item (e.g., turn the item on or off). The brief MSWO assessment was conducted by presenting 4-7 parent nominated items in an array equidistant from participant.

Experimenter gave a prompt to scan the array (e.g., "look" while pointing to each item in array). After experimenter had verified scanning has occurred, the verbal discriminative stimulus "pick one" was delivered. After participant selection all other non-selected items were removed. Participant was allowed 30 s access to selected item or allowed to consume edible. After the 30 s access the next presentation consisted of the remaining non-selected stimuli randomly rotated in terms of their position. This process continued until all items had been selected or the participant stopped selecting items. In order to identify highly preferred stimuli this process was conducted three times. Table 1 shows the selection percentage for each item included in the arrays for each participant. The highest ranked item was used during experimental procedures. These items included, tortilla chips for Brad, a spinning light-up toy for Jonas, and chocolate chips for Colin.

Table 1

Participants' Stimulus Preference Assessment

Participant	Highest Ranked Stimulus	Moderately Preferred Stimulus	Moderately/ Least Preferred Stimulus	Moderately/ Least Preferred Stimulus	Least Preferred Stimulus
Brad	Chips	Muffins	Gorilla Snack	Pretzels	Raisins
	(100%)	(50%)	(33%)	(0%)	(0%)
Jonas	Spinning	Ball	Bubbles	Rainstick	Toy
	(60%)	(50%)	(42.8%)	(25%)	
Colin	Chocolate	Chips	Cookies		
	(100%)	(14.3%)	(0%)		

Note. Selection percentages rounded to the nearest whole number are indicated below the stimulus within the parentheses. Highest ranked stimulus was used as a reinforcer during experimental and control procedures.

Color preference assessment. This assessment was conducted in order to ensure that the participants did not have substantial preexisting relative preferences for a color, as these stimuli were used in a concurrent operants selection procedure following termination of experimental procedures to identify individual relative preference for procedures. The same procedure as described above under the stimulus preference assessment section was used to identify relative preference of colored paper sheets with the exception that all stimuli in the array had a small edible item place on top of it. Selection of the edible item was taken as an indicator of preference for the color because all edible items were exactly the same and in the same spatial location on the stimuli. The three colors with the most similar selection percentages were selected as discrimination aids that were arbitrarily assigned to a procedure. Table 2 shows selection percentages for each color in the assessment for the 3 participants. Additional discriminations aids included colored t-shirts worn by the experimenter that matched the color sheet of papers placed in front of the participant during each of the experimental procedures.

Table 2

Participants' Color Preference Assessment

Participant	Highest Ranked Stimulus	Moderately Preferred Stimulus	Moderately Preferred Stimulus	Moderately Preferred Stimulus	Moderately Preferred Stimulus	Least Preferred Stimulus
Brad	Pink (43%)	Purple (38%)	Green* (27%)	Yellow* (27%)	Blue* (27%)	Orange (20%)
Jonas	Orange (67%)	Yellow* (29%)	Pink* (29%)	Green* (25%)	Blue (25%)	Purple (22%)
Colin	Yellow (50%)	Purple (43%)	Pink* (33%)	Green* (29%)	Blue* (27%)	Orange (0%)

Note. Selection percentages rounded to the nearest whole number are indicated below the stimulus within the parentheses. Asterisks indicate colors selected for discrimination aids for each participant.

Pre-experimental observation. These sessions were conducted to assess the frequency of vocalizations in the absence of experimental procedures and to identify potential target and nontarget auditory stimuli to use during experimental sessions. During these sessions, participants were able to engage in activities (e.g., play with toys) and interact with experimenter; however experimenter attempted to minimize interactions. For instance, if a participant emitted a mands for attention or help, the experimenter would deliver nonverbal reinforcement (e.g., turning on a toy, a smile or nod of the head). Vocalizations that occurred immediately before interactions or during the interactions were excluded as possible targets to be used during the experimental procedures. From these observations, 12 auditory stimuli (6 for each set) were selected for each participant. The auditory stimuli selected were phonemes or syllable combinations that the child never produced as a single unit, but were composed of sounds or single syllables that the child was observed to emit during the observation. For instance, if a participant emitted the syllables, "boo" and "mah" within the observation but not in immediate succession, both syllables would be excluded as potential single syllable auditory stimuli to use during the experimental sessions. However, "moo" and "bah", or the compound syllables "mah-boo" or "boo-mah" could be selected as target or nontarget auditory stimuli. These auditory stimuli were then arbitrarily assigned as either a target or nontarget for the SSP, ODT and control procedures for each participant. Table 1 provides a list of the auditory stimuli selected for each participant across the procedures and stimulus sets. The observation sessions were 5 min in duration. Between 6 and 10 sessions were conducted with each participant over 2 days.

Table 3

Participants' Auditory Stimuli

Participants	Procedure/ Target (T) or Nontarget (NT)	Set 1 Auditory Stimuli	Set 2 Auditory Stimuli
Brad	SSP T	Mee-muh	Goo
	SSP NT	Too-tee	Key
	ODT T	Bah-boo	Wee
	ODT NT	Dee-dah	Moo
	Control T	Day-doo	Kah
	Control NT	Nee-nah	Dih
Jonas	SSP T	Boo	Dah-dee
	SSP NT	Tah	Mee-muh
	ODT T	Bye	Bah-boo
	ODT NT	Tee	Too-tee
	Control T	Too	Nah-nee
	Control NT	Bah	Kah-kee
Colin	SSP T	Dah-bee	Koo
	SSP NT	Mee-mah	Tee
	ODT T	Mee-doo	Too
	ODT NT	Pah-pee	Kee
	Control T	Lah-dee	Poe
	Control NT	Bah-boo	Lee

Procedure

Experimental Design

Experimental control was assessed using an alternating treatments design and replication across auditory stimulus sets. This design controls for threats to internal validity by incorporating direct and repeated measures of the dependent variable coupled with the alternation of the treatment conditions and analysis is based on visual inspection of the data paths. An alternating treatments design consists of rapid alterations of the selected interventions and the control condition (Barlow & Hersen, 1984). For all conditions, data are typically collected on the same behavior. However, adapted versions of the alternating-treatments design for acquisition experiments permit randomly assigning different responses to conditions followed by a within-subject replication of the comparison with a different set of responses (Gast & Wolery, 1988). The order of presentation of experimental and control procedures were semi-randomized so that no more than 3 of the same procedure type was conducted consecutively to reduce ordering effects. For instance, during Set 1, the order of procedures conducted with Colin consisted of SSP, ODT, control, ODT, ODT, SSP, control, etc. While the order of procedures conducted with Brad during Set 1 were ODT, SSP, control, ODT, control, SSP, etc. This was done to ensure the participants were not consistently exposed to one series of procedures. A total of 12 auditory stimuli (6 Set 1, 6 Set 2) were selected from the pre-experimental observations and arbitrarily assigned as a target or nontarget for the experimental and control procedures. For example Brad's auditory stimuli during Set 1 consisted of target "day-doo" and nontarget "nee-nah" during the control, during ODT they consisted of target "bah-boo" and nontarget "dee-dah" and during SSP they consisted of target "mee-muh" and nontarget "too-tee."

All experimental and control sessions began by the experimenter putting on a t-shirt that was the color arbitrarily assigned to the specific condition. For example, blue was assigned as the control color for Brad, so the experimenter would put on a blue shirt before these sessions. Next the experimenter would place the discrimination aids (colored pieces of paper) that were assigned to each condition in an array in front of and equidistant from the participant. For Brad, this would mean that a blue, green and yellow piece of paper would be placed in the array. The experimenter would instruct the participant to select the color piece of paper that matched her shirt. After selection of the correct color for the type of session the experimenter began to deliver trials. During all experimental and control sessions, trials began by the experimenter delivering an observing prompt (e.g., "look") and the experimenter waiting for some behavior that indicated possible attending (e.g., eye contact). Sessions consisted of 40 trials made up of 20 target trials and 20 nontarget trials.

Once an effect was demonstrated in one or more procedures, new sets of auditory stimuli were used to replicate the effect. For instance, during the control procedure of Set 2, Brad's auditory stimuli consisted of the target "kah" and nontarget "dih." Intervention effectiveness was assessed based on individual participant data through visual inspection of the data paths. A procedure was deemed to be effective for an individual participant when clear differentiation between data paths of one or both of the interventions compared to that of the control was evident through visual inspection (i.e., 3 out of 5 consecutive data points for the specific intervention that were higher than those recorded during the control procedure) and when rates of target vocalizations for a specific procedure exceeded the rates of the nontarget vocalizations across 3 out of 5 consecutive sessions of that procedure type.

One potential drawback of the alternating-treatments design is the possibility of multiple-treatment interference, or the possibility that exposure to one condition may affect responding in a second condition. Multiple-treatment interference may be reduced by enhancing discrimination between conditions, for example, by correlating each condition or procedure with an extraneous stimulus that in itself is unlikely to affect responding (Barlow & Hersen, 1984). In the present study, efforts to enhance discrimination included the experimenter wearing a different colored t-shirt across different procedures, and placing a piece of colored paper of the same color within the participant's visual field. In efforts to promote participants' observing of the discrimination aids, before each session participants were asked to select the colored piece of paper from the array of colored papers that matched the experimenter's shirt. These colored papers were then used as initial links of a concurrent operant choice procedure (specific procedural details are described below under the procedure preference assessment section) to assess individual relative preference for the procedures following the termination of the experimental and control sessions.

In addition, a manipulation check was utilized to ensure that the S^D did gain control over arm raises and that this control was only established during the ODT procedure. The manipulation check consisted of recording the number of independent arm raises that occurred in the presence of the target and nontarget auditory stimuli auditory within each set and across procedures. These data are reported in terms of a conditional probability analysis where the probability of arm raising given the occurrence of target auditory stimuli presentations are compared to the probability arm raising given the occurrence of nontarget auditory stimuli presentations.

Control condition. The control condition was conducted in order to rule out the possibility that increases in vocalizations could be attributed to just the auditory stimulus and reinforcer being presented in the same sessions regardless of its temporal arrangement. This condition assessed the effects of noncontiguous presentation (i.e., at least 20 s between the delivery of the auditory stimulus and the reinforcer) of the auditory stimulus and reinforcer delivery on vocalizations. During target trials, the experimenter delivered the target auditory stimulus three times. A 20-s interstimulus interval (ISI) was initiated. After the ISI elapsed the experimenter delivered the reinforcer. Essentially, target trials consisted of a trace conditioning procedure with a 20-s ISI. Interspersed between target control trials nontarget (i.e., auditory stimuli that are never followed by delivery of the reinforcer) control trials were presented. All trials were separated by a 10-15-s intertrial interval (ITI). Nontarget control trials were conducted in the exact same manner as the target control trials with the exception that after the nontarget auditory stimulus was presented, the trial ended without reinforcer delivery and the ITI began. In order to control for the possibility that direct reinforcement of vocalizations might occur under these conditions, if during the 20-s ISI between presentations (i.e., auditory stimulus and reinforcer) the participant emitted the target vocalization, the 20-s interval was reset, prolonging the reinforcer delivery. In addition, if the participant emitted the target (or nontarget; depending on the trial type) vocalization within the first 5 s after that specific auditory stimulus was presented, the trial was terminated and represented after 20 s. The control procedure consisted of 20 target trials and 20 nontarget deliveries randomized with the restriction that no more than three of the same trial types were presented consecutively. The duration of these sessions varied but ranged from 30 to 45 minutes.

S**timulus-stimulus pairing.** This procedure was conducted to assess the effects of the contiguous presentation of the auditory stimuli and the reinforcer on vocalizations. During this condition trials were presented as in the control condition with the exception that the target auditory stimuli were arranged in a manner that reliably predicted the immediate delivery of the reinforcer. This procedure would be analogous to a delayed conditioning procedure, where as the control procedure would be analogous to a trace conditioning procedure. Again, target trials would consist of the experimenter delivering the auditory stimulus 3 times. Simultaneous with the third presentation the experimenter would also deliver the reinforcer. During this condition if an echoic response was emitted at any point during a trial between the first presentation of the auditory stimulus and the first 5 s following the last auditory stimulus presentation, the omission contingency would be in effect. Again, the omission contingency consisted of the immediate termination of the trial.

The trial would then be represented after 20 s. The duration of these sessions varied due to inclusion of the omission contingency placed on echoic responses but did not exceed 50 min.

Discrimination training. This procedure was conducted to assess the effects of the target auditory stimulus exerting control over a response on the rate of vocalizations. An operant discrimination procedure consists of presenting a stimulus that sets the occasion for a specific response to be reinforced (S^D trials). In addition the absence of the stimulus or during presentations of another stimulus regardless if the response is emitted reinforcement is not delivered (S^Δ trials). During this procedure, trials were presented as described in the SSP condition, with the exception that during the presentation of the target auditory stimulus a response requirement was in place before delivery of the reinforcer. For this study we arbitrarily selected arm raising as the response required in the presence of the target auditory stimulus because all children in this study had been observed to do this response independently. During initial target trials (i.e., S^D trials) if the response was not emitted independently by the 3rd presentation of the auditory stimulus within the trial than it was prompted using most-to-least prompting across physical and visual dimensions. With most-to-least prompting, prompts were delivered that began with the most intrusive, full physical guidance (i.e., grabbing arm at wrist and raising it above the participant's head) to ensure the response was emitted and contacted reinforcement. After a few successful trials, prompts were reduced in the level of intrusiveness to partial physical guidance (i.e., lifting elbow of participant). Again, after approximately 3 successful trials at this level of prompting, the degree of intrusiveness was reduced by providing a model prompt (i.e., experimenter raised her arm). After approximately 3 successful target trials with the model prompt, no prompts were delivered. If the prompt or auditory stimulus failed to occasion the response, prompting immediately returned to full physical guidance within the trial to ensure all target trials resulted in the delivery of the reinforcer.

Follow-up. This condition was conducted following the termination of the experimental and control procedures in order to assess the durability of each procedure on the rate of target and nontarget vocalizations. Follow-up sessions consisted of five reinstatement trials during which only the reinforcer was delivered for each procedure. At the beginning of the 10 min session the experimenter would put on the t-shirt that correlated with the specific procedure (e.g., blue for Brad during follow-up for the control procedure) and placed the other discrimination aid (i.e., colored piece of paper that corresponded the condition) in front of the participant. As soon as the session began, the experimenter would deliver the observing prompt, "look" to the participant. The experiment would wait for some indication that the child was attending (e.g., eye contact), then deliver the reinforcer. During this condition the experimenter never delivered the auditory stimuli used in any of the experimental or control procedures. Trials were presented at the start of the session and every 2 min after during the 10 min session. After a 10 min session ended for one procedure the next session would evaluate the durability of another procedure in the same manner. In order to control for ordering effects the order of the follow-up session for each procedure were randomized across days. Durability of each of the procedures was assessed at 1, 5, and 15 days following termination of the experimental and control procedures or until no vocalizations were recorded during a session. Rate of target and nontarget vocalizations were recorded.

Procedure preference assessment. This assessment was conducted after termination of experimental procedures. Preference for each procedure was evaluated in a concurrent-operant arrangement. The stimuli used during this assessment consisted of the discrimination aids (i.e., colored sheets of paper) and novel auditory stimuli. The participants had previous histories selecting these colored stimuli from an array at the beginning of the experimental and control sessions (with the exception of the blue paper for Jonas). This history had been previously established by the experimenter instructing the participant to select the color that matched her shirt at the beginning of the experimental and control sessions. Jonas did not have a history of selecting one of the colored stimuli in his array. This was due to Jonas' data initially indicating side-biased responding (i.e., he appeared to be selecting the discrimination aid only to the right). An additional stimulus (i.e., blue colored paper) was added to his array. Selection of the blue paper resulted in 3 min of play. This was done to evaluate whether the procedure would be sensitive to identify preference for Jonas. For all the participants, during each array selection of the color card during the procedure preference assessment indicated the upcoming procedure. Prior to the assessment there was a sampling demonstration conducted which consisted of 3 forced-choice trials (4 for Jonas as he had 4 colored stimuli in his array) to ensure expose to all the contingencies in effect for selection of each discrimination aid available in the array. During trials the experimenter placed the colored sheets of paper in an array in front and equidistant from the participant. The participant was instructed to "look" at each stimulus in the array. After participant's behavior indicated that he had glanced at all available stimuli, he was instructed to "pick one." The selected color would instruct the experimenter to how to proceed. For instance if the discrimination aid selected was pink, and pink corresponded to ODT for that participant, the experimenter would then put on the pink shirt and deliver 4 ODT trials (2 target and 2 nontarget) with novel auditory stimuli. Placement of stimuli was counterbalanced across trial presentations. During forced choice trials the colored sheet of paper selected during the trial, would not be made available on any subsequent trial, to ensure expose to all the contingencies for selection. During the assessment trials all stimuli were available for selection across trials. Preference for a procedure was defined as selection of the same colored piece of paper on three consecutive trials. Results of this assessment were given to parents so that they could inform the participants' therapists, if they wished.

Procedural Fidelity

Procedural fidelity was assessed for at least 25% of sessions across all experimental procedures. Each session used to calculate procedural fidelity was randomly selected. Procedural fidelity was calculated by dividing the total number of correctly implemented trials by the total number of correct and incorrect trials. The resulting quotient was multiplied by 100 in order to yield a percentage correct for each experimenter behavior. Trials were scored as correct or incorrect based on the following experimenter behaviors: (a) delivery of the target sound (b) delivery of the reinforcer (c) conducting trials according to the specified ITI (d) implementation of the correction procedure. For Brad and Jonas, procedural fidelity scores were calculated for at least 56% of sessions of Sets 1 and across the procedures (ODT, SSP and control) and yielded a mean fidelity score for correct implementation of trials of 100% for each procedure. During Set 2, procedural fidelity for Brad was calculated for at least 50% of sessions across ODT, SSP and the control procedure; mean fidelity scores were 100%, 99% (range, 97.5 to 100) and 100% respectively across the procedures. During Set 2 for Jonas procedural fidelity was calculated for at least 44% of sessions during ODT, SSP and for 22% of sessions during the control; mean fidelity scores were 100%, 99% (range, 95 to 100) and 100% respectively across the procedures. For Colin procedural fidelity was only calculated for 22% of sessions during Set 1 across SSP and ODT; mean fidelity scores were 99% (range, 97.5 to 100) for both procedures. During the control sessions of Set 1 procedural fidelity was scored for 44% of sessions and the mean fidelity was 100%. During Set 2, at least 33% of sessions were scored across ODT, SSP and control; mean procedural fidelity scores were 100% across the procedures.

Interobserver agreement on procedural fidelity was calculated using the total agreement method by having two independent observers score at least 30% of the session across all conditions for which procedural fidelity data were calculated. Total agreement scores were calculated by each observer summing the number of correctly implemented trials across the session. The smaller number was divided by the larger number and the quotient multiplied by 100. Mean agreement scores on procedural fidelity were 100% across participants and procedures with the exception that during Set 2 of SSP for Jonas mean agreement on procedure fidelity was 98% (range, 95 to 100).

Results

Higher rates of target vocalizations during ODT and SSP were evident in 5 out of 6 evaluations over that of the target vocalizations of the control procedures and nontarget control sounds within each procedure. In these five evaluations, effects were demonstrated by clear separation of the target data paths for the two interventions compared to the target data path of the control condition (i.e., rates of target vocalizations in at least 3 out of 5 consecutive sessions exceeded the rates of target vocalizations during the control condition). In addition, effects of SSP and ODT over that of the control sounds were demonstrated by the target data paths of the two procedures being consistently separated from the nontarget control sound data paths in at least 3 out of 5 consecutive sessions. This criterion could not be met in ODT until after discrimination began to occur.

Figure 1 shows rates per min of target and nontarget vocalizations for Brad across the control and experimental procedures for Set 1, Set 2 and follow-up. The data path depicted by the closed squares represents the ODT procedure. The criterion for determining an effect of the intervention was met after the 7th session (i.e., session 16) of ODT. Criterion was met in SSP after the 6th session (i.e., session 24). Visual inspection indicates that there were not consistent differences between rates of responding in ODT and SSP in that the data paths are not consistently separated. During Set 1, Brad's rate of target vocalizations during SSP (*M* = 0.01) and ODT (*M* = 0.05) were greater than during the control procedure (*M* = 0.00). In addition, his rates of target vocalizations exceeded the rates of nontarget vocalizations in SSP (*M* = 0.00), ODT (*M* = 0.00) and the control procedure (*M* = 0.00). Results of Set 2 show a similar pattern for Brad. The criterion was met in the ODT condition after 3 sessions (i.e., session 29). The criterion was met in SSP after 3 sessions (i.e., session 31). Because criterion was met in both conditions 5 consecutive sessions in each condition were not conducted. Visual inspection indicates that there were not consistent differences between the ODT procedure and the SSP procedure in that the data paths of the two procedures are not consistently separated. SSP rates of target vocalizations (*M* = 0.04) and ODT (*M* = 0.03) exceeded the rates of vocalizations during the control procedure (*M* = 0.00). Brad did not emit any nontarget vocalizations during Set 2 during any of the procedures (SSP: *M* = 0.00; ODT: *M* = 0.00; and control: *M* = 0.00). During follow-up Brad did not emit target or nontarget vocalizations during reinstatement trials for SSP during day 1, day 5, nor day 15 (*M* = 0.00). Brad emitted target vocalizations during ODT reinstatement trials on day 1 and day 5 of follow-up but not during day 15 (M = 0.07). For Brad, the control procedure did not produce increases in target vocalizations, which is in line with his follow-up results as he did not emit control target vocalizations during follow-up on day 1, 5 or 15 (M = 0.00). Brad did not emit nontargets during any of the follow-up sessions (SSP: M =0.00; ODT: M = 0.00; and control: M = 0.00). Brad's arm raising behavior did not come under control of the auditory stimulus until the 4th session (i.e., session 12 of ODT). During Set 2, the target auditory stimulus of ODT quickly acquired control over his responding during the 1st session (i.e., session 25). The manipulation check data depicted in Figure 2, on arm raises in the presence of the target auditory stimulus during Sets 1 and 2 shows that Brad's arm raising responses were more probable in the presence of the ODT target auditory stimulus in that they exceeded the probability of arm raises in the presence of any other auditory stimulus.

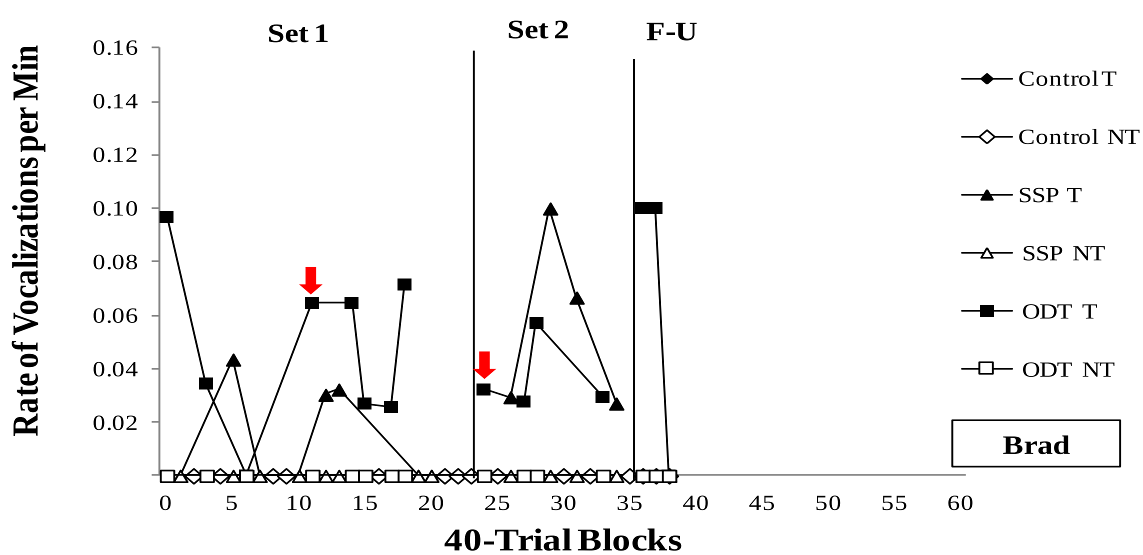

Figure 1. Depicts the rate of target and nontarget vocalizations across auditory stimulus sets and follow-up for Brad. Arrows indicate point at which conditional probability of arm raises in the presence of the target auditory stimulus exceeded that of the background probability of arm raises in the presence of the nontarget auditory stimulus.

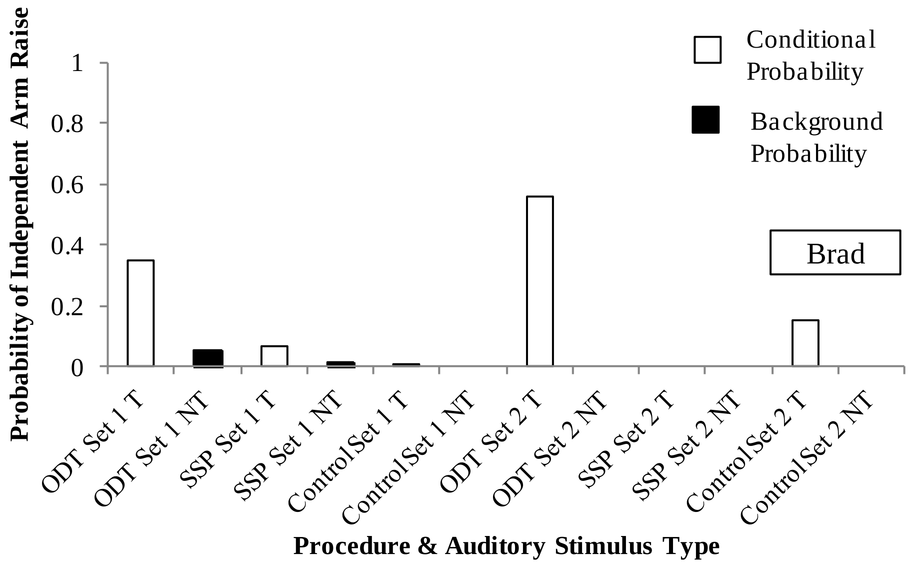

Figure 2. Shows the manipulation check data for Brad. This figure depicts the conditional probability of arm raises in the presence of the target auditory stimuli compared to the background probability of arm raises in the presence of the nontarget auditory stimuli for each procedure across stimulus Set 1 and Set 2.

Figure 3 shows similar rates of vocalizations for Jonas across procedures for Set 1, Set 2 and follow-up. Jonas met the criterion for an effective intervention for Set 1 with the ODT condition after the 5th session (i.e., session 13) and met criterion in the SSP condition after the 3rd session (i.e., session 6). No consistent difference between ODT and SSP are evident through visual inspection. During Set 2 Jonas' data indicate that criterion for an effective intervention was met in the ODT condition after the 5th session (i.e., session 40). During the next session (i.e., session 41) Jonas met the criterion in the SSP condition. This was the 5th session of SSP conducted during Set 2. Sessions with Jonas continued after criterion was met in both conditions to see if differential effects of the procedures would be demonstrated after extended training. However, visual inspection indicates that there were not consistent differences between the data paths of ODT and SSP. During Set 1 Jonas' rates of target vocalizations for SSP (*M* = 0.04) and ODT (*M* = 0.06) were greater than that of the control procedure (*M* = 0.00). Jonas emitted more nontarget vocalizations than Brad but his rates of target vocalizations still exceeded the rates of nontarget vocalizations in SSP (*M* = 0.00), and ODT (*M* = 0.0038). This was not true of the control procedure during which Jonas emitted more frequent nontarget vocalizations than target vocalizations (*M* = 0.01). Like Brad, during Set 2 Jonas' results indicated similar increases in rates of target vocalizations when new auditory stimuli were utilized during the experimental procedures. Jonas' rates of target vocalizations of SSP (*M* = 0.06 with outlier; *M* = 0.04 without outlier) and ODT (*M* = 0.05) during Set 2 exceeded the rates of vocalizations during the control procedure (*M* = 0.00). Jonas emitted infrequent nontarget vocalizations during SSP and the control procedure of Set 2 (SSP: *M* = 0.0074; ODT: *M* = 0.00; and control: *M* = 0.0028). During day 1 of follow-up Jonas did not emit target or nontarget vocalizations during the reinstatement trials for SSP, ODT or the control, so no further durability evaluations were conducted with him. Jonas' responding began to show evidence of coming under the control of the auditory stimulus during the 3rd ODT session (i.e., session 12). During Set 2, the target auditory stimulus of ODT began to acquire control over responding during the 3rd session of training (i.e., session 32). Figure 4 indicates that for Jonas, arm raising came under the control of the auditory stimulus during ODT across both Sets 1 and 2 in that the probability of an arm raise given a target vocalization in ODT exceeded arm raising given the presentation of any other auditory stimulus.

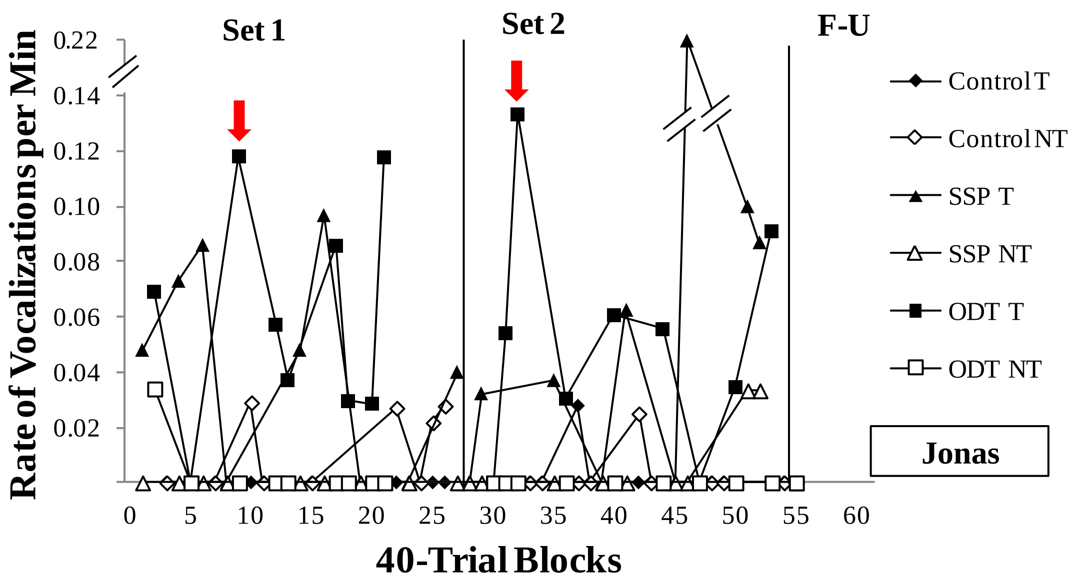

Figure 3. Depicts the rate of target and nontarget vocalizations across auditory stimulus sets and follow-up for Jonas. Arrows indicate point at which conditional probability of arm raises in the presence of the target auditory stimulus were exceeded that of the background probability of arm raises in the presence of the nontarget auditory stimulus. Note breaks in y-axis and data paths were inserted to accommodate an outlier during SSP, Session 46.

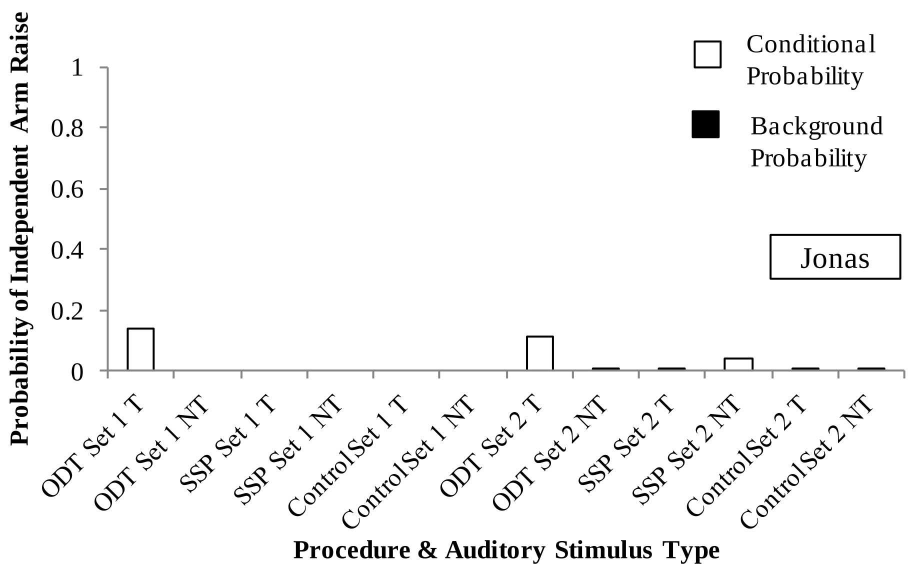

Figure 4. Shows the manipulation check data for Jonas. This figure depicts the conditional probability of arm raises in the presence of the target auditory stimuli compared to the background probability of arm raises in the presence of the nontarget auditory stimuli for

Figure 5 depicts rates of vocalizations for Colin across the procedures for Sets 1, 2 and follow-up. Visual inspection of the data paths show that neither procedure met the criterion for being deemed effective for Colin during Set 1 and there were no consistent difference between ODT and SSP. During Set 1 Colin's rate of target vocalizations for SSP (M = 0.00) and ODT (M = 0.00) did not exceed that of the control procedure (M = 0.00) nor that of the nontargets within each procedure (SSP: M = 0.00; ODT: M = 0.00; and control procedure: M = 0.004). When auditory stimuli were reduced from complex syllable combinations to simple syllables during Set 2, results indicated increases in rates of target vocalizations over that of the control procedure and nontargets within each procedure similar to Jonas and Brad. Visual inspection of the data paths show that criterion was reached on the 8th session of ODT (i.e., session 52). Criterion was met in the SSP condition after the 4th session (i.e., session 41) of Set 2. Although the ODT and SSP data paths were consistently elevated above the control condition data path, there were no consistent differences between the data paths of SSP and ODT. As with the previous participants during Set 2, SSP rates of target vocalizations (M = 0.07) and ODT (M = 0.03) both exceeded the rates of vocalizations during the control procedure (M = 0.00). Colin did not emit nontarget vocalizations during Set 2 during of the ODT (M = 0.00) or control (M = 0.00) but did emit a few during the SSP procedure (M = 0.01). During follow-up, Colin did not emit target or nontarget vocalizations during reinstatement trials for ODT or the control during day 1, or 5 (ODT: M = 0.00, control: M = 0.00). Colin did emit 1 target vocalizations during SSP reinstatement trials on day 1; however, this effect was not evident during day 5 of follow-up (M = 0.05). Colin did not emit nontargets during any of the follow-up sessions (SSP: M =0.00; ODT: M = 0.00; and control: M = 0.00). Durability evaluations ended after day 5 for Colin. Colin's arm raising behavior indicated only slight evidence of coming under control of the auditory stimulus during Set 1 of ODT as indicated by the manipulation check data on arm raises in the presence of the target auditory stimulus represented in figure 6. During Set 2, the target auditory stimulus during ODT began to show signs of acquiring control over his responding during the 5th session of ODT (i.e., session 40). Arm raising in the presence of the target auditory stimulus of ODT exceeded arm raising in the presence of any other auditory stimulus presentation.

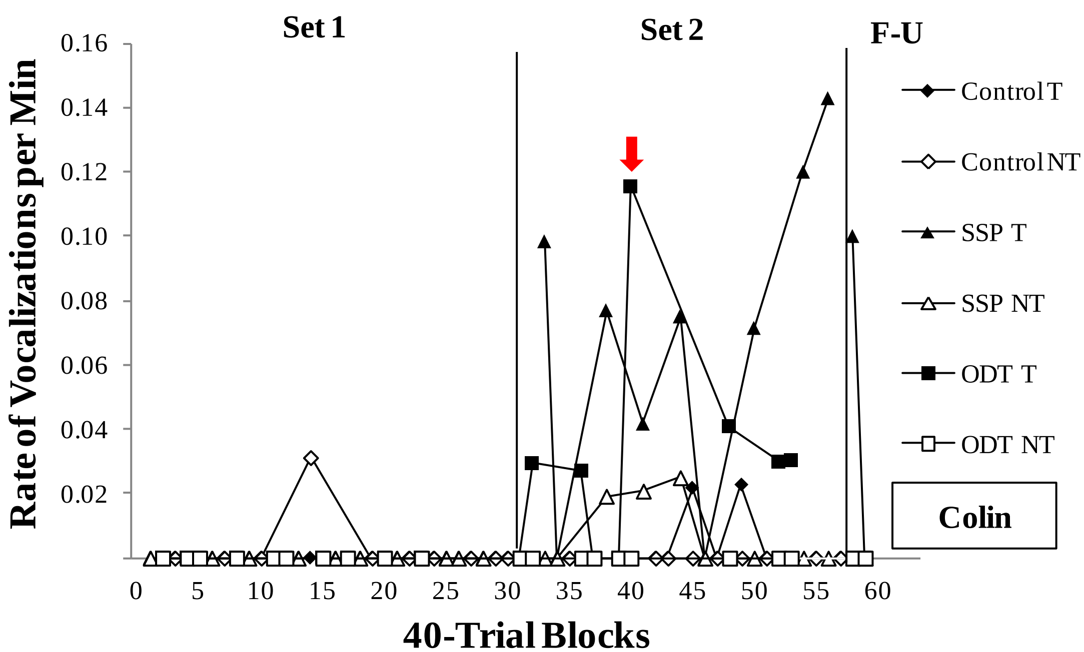

Figure 5. Depicts the rate of target and nontarget vocalizations across auditory stimulus sets and follow-up for Colin. Arrow indicates point at which conditional probability of arm raises in the presence of the target auditory stimulus were exceeded that of the background probability of arm raises in the presence of the nontarget auditory stimulus.

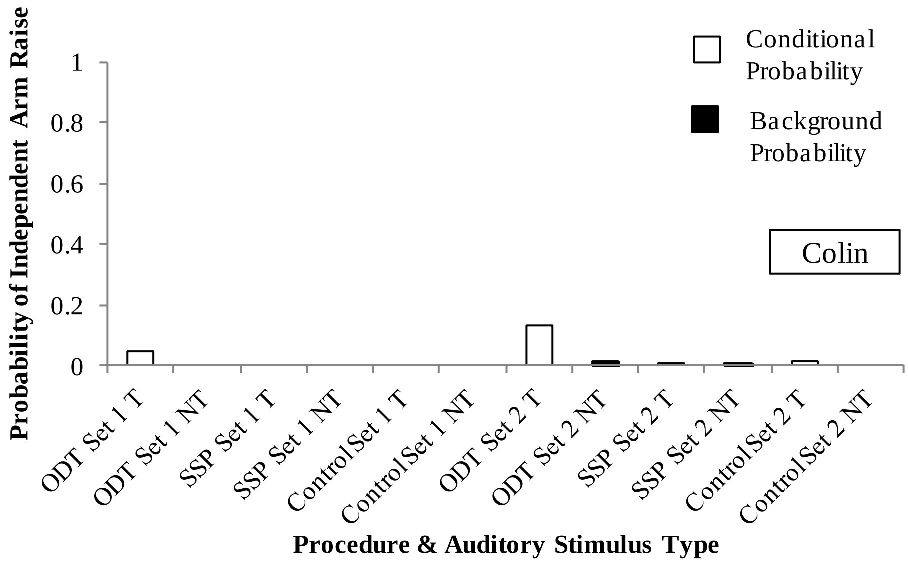

Figure 6. Shows the manipulation check data for Colin. This figure depicts the conditional probability of arm raises in the presence of the target auditory stimuli compared to the background probability of arm raises in the presence of the nontarget auditory stimuli for each procedure across stimulus Set 1 and Set 2.

Figure 7 shows that the mean rates of target vocalizations were very similar for SSP (*M* = .038) and ODT (*M* = 0.037) when collapsed across participants and sets of auditory stimuli and differed from the control condition (*M* = 0.002). These data reiterate the visual inspection data. The average rates of target vocalizations emitted by Brad across both sets were *M* = 0.0000 during the control procedure, *M* = 0.03 during the SSP procedure and M = 0.04 during the ODT procedure. The average rates of target vocalization emitted by Jonas across both sets were *M* = 0.015 during the control procedure, *M* = 0.05 during the SSP procedure and M = 0.06 during the ODT procedure. For Colin, average rates of target vocalization across both sets of stimuli during the control, SSP and ODT procedures were *M* = 0.0023, *M* = 0.03, and *M* = .01, respectively.

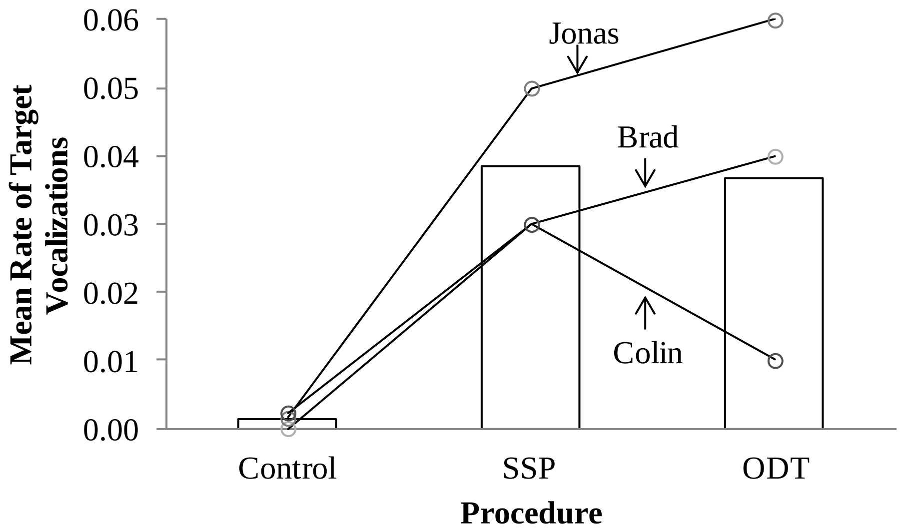

Figure 7. The bars depict the mean rates of target vocalizations collapsed across participants and sets of auditory stimuli for the 3 procedures. Circles indicate the overall mean for each participant across stimulus sets for the control, SSP and ODT procedures.

Results of the procedure preference assessments indicated that all participants preferred ODT to SSP and the control procedure. Figure 8 depicts the cumulative selection of the discrimination aids correlated with each procedure (SSP, ODT and control) for Brad. Brad met criterion indicating a preference for the ODT procedure during trial 19, which was 3 consecutive selections of the same discrimination aid. After the discrimination aid for ODT was removed, he selected the discrimination aid for SSP once, followed by 3 consecutive selections of the discrimination aid correlated with the control procedure. Total selection responses for Brad to the discrimination aids were 9 to ODT, 9 to the control and 6 to SSP.

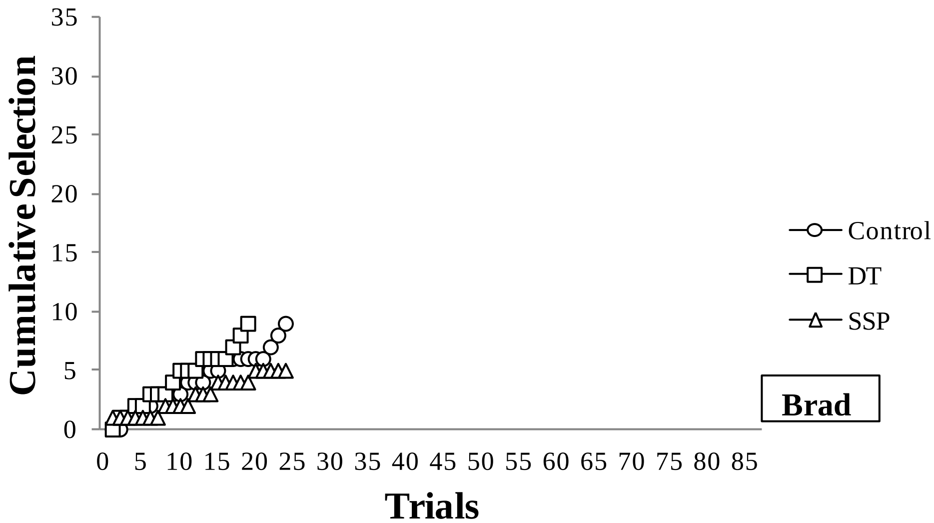

Figure 8. Depicts the cumulative selection responses allocated to the discriminative stimulus that corresponded to each procedure during experimental session during the concurrent operant procedure assessment for Brad.

Figure 9 shows the results of the procedure preference assessment for Jonas. For Jonas, a play procedure was included in the procedure preference assessment to ensure that the procedure was a sensitive measure of preference based on the consequences for selection, as his initial data (not reported here) indicated possible side-biased responding (selection appeared to be based on position rather than consequences). Jonas met selection criterion indicating a preference for the play condition over the other procedures at the conclusion of trial 35. After the play condition discrimination aid was removed from the array he continued to sample each condition until a preference for ODT was indicated by 3 cumulative selection to that discrimination aid which ended on trial 68. The ODT discrimination aid was removed from the array. Three selection responses were allocated to the control discrimination aid, which indicated a preference for the control at the conclusion of trial 74. Jonas allocated 14 responses to the control condition, 24 to ODT, 23 to the control procedure, and 12 to SSP, during the assessment.

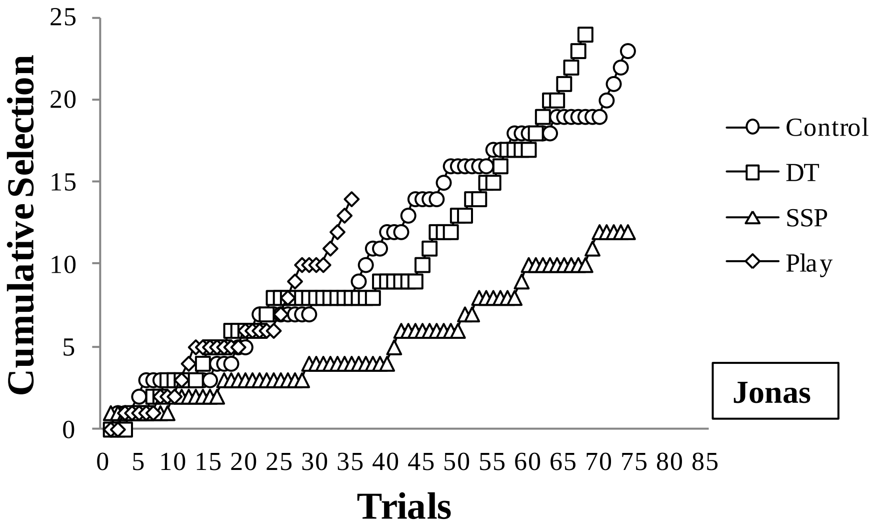

Figure 9. Depicts the cumulative selection responses allocated to the discriminative stimulus that corresponded to each procedure during experimental session during the concurrent operant procedure assessment for Jonas.

Colin's results for the procedure preference assessment are depicted in Figure 10 for the 3 procedures (SSP, ODT and control). Colin met criterion indicating a preference for ODT at the conclusion of trial 79. After the discrimination aid for ODT was removed from the array. He selected the discrimination aid for SSP once, and then allocated the next three responses to the control discrimination aid. Colin allocated 34 responses to the discrimination aid correlated with ODT, 29 to the discrimination aid correlated with the control procedure, and 20 to the discrimination aid correlated with the SSP procedure.

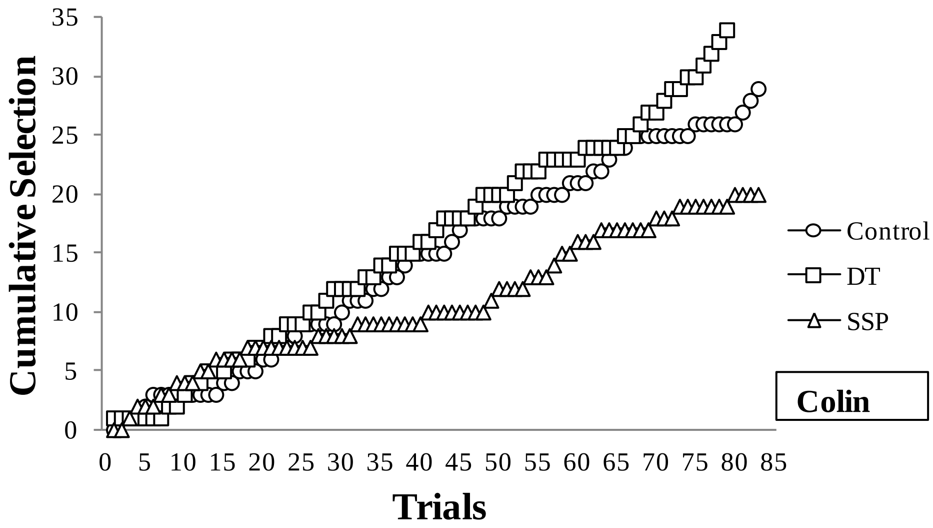

Figure 10. Depicts the cumulative selection responses allocated to the discriminative stimulus that corresponded to each procedure during experimental session during the concurrent operant procedure assessment for Colin.

The omission contingency data are depicted in figure 11. These data reflect the percentage of trials for each participant that had embedded omission contingencies due to echoic responses collapsed across stimulus sets for each procedure. During ODT, SSP and control sessions 0.42%, 3%, and 2% of trials respectively resulted in the use of the omission contingency for Brad. For Jonas 25% of ODT trials, 17% of SSP trials, and 21% of control trials resulted in the use of the omission contingency. For Colin 32% of ODT trials, 25% of SSP trials and 15% of control trials resulted in the use of the omission contingency.

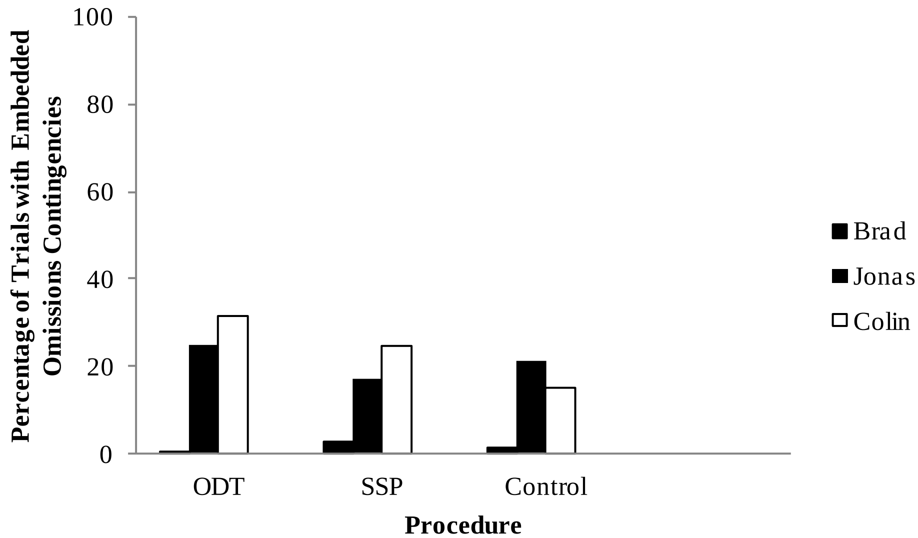

Figure 11. Depicts the percentage of embedded omission contingencies for each participant across both sets of auditory stimuli for each procedure.

Discussion

The ODT procedure was an effective intervention in that it increased the vocalizations of all participants in the current study, and all participants began to emit novel vocalizations. However, the effects of ODT were not greater than those observed during the SSP procedure. It is possible that the participants were already attending to the auditory stimuli being presented in all conditions, which would be expected to decrease the added benefits of conducting an intervention that places a contingency on attending, over a passive pairing procedure. Although efforts were taken to avoid potential carry-over effects across conditions, it is possible that once the contingency for attending to the auditory stimulus was established during ODT, it carried over into the SSP procedure. This could explain why the present data are inconsistent with Holth et al. (2008), who found that stimuli that acquired their conditioned reinforcing properties through an operant discrimination procedure produced higher rates of responding than those that acquired them through a passive-pairing procedure. However, in conjunction with Holth et al (2009), the results of the present study support the use of discrimination procedures to establish stimuli as conditioned reinforcers for children with autism.

These data are consistent with Esch, Carr and Grow (2009) in that the enhanced stimulus-stimulus pairing procedure did increase target vocalizations for all participants. It is possible that SSP produced a reliable effect for the participants in the present study due to the use of this enhanced procedure. However, it is also possible that the children in both studies simply had similar prerequisite skills that allowed them to benefit from passive pairing procedures, and that the reliable effect of SSP in both studies was not a product of the enhanced procedure. At this point, it is still unknown exactly what the prerequisite skills are for a child to benefit from SSP procedures. As a result, future research is needed in this area. In addition, future researchers should include as much information as possible on the current functioning levels and verbal repertoires of their participants.

Although both procedures produced an effect with all participants, the failure of both procedures to produce an effect with Colin in Set 1 is worth noting. The most plausible explanation for this failure is that the complex syllable combinations selected as targets and nontargets for Colin in Set 1 were too difficult for him to be able to produce vocal approximations. Support for this interpretation of the failure is that when the target and nontarget vocalizations were reduced to simple syllable combinations during Set 2, differentiation between the data paths of the target vocalizations and nontarget vocalizations within both procedures were evident within the first few sessions.

Overall, the participants in this study indicated a preference for ODT over that of the control and SSP procedures. This finding is consistent with Luczynski and Hanley (2009), who demonstrated that children preferred direct reinforcement of a specific behavior over that of noncontingent deliveries of social attention. However, it should be noted that all the children in the present study showed an increase in echoic skills throughout the course of the study. These increases in echoic responses were likely due to idiosyncratic variables unrelated to this study, although participation in this study cannot able to be ruled out as a causal variable. Increased echoic responding during the procedures may have impacted the results of the preference assessment, because increased echoic responses resulted in use of the omission contingency during procedures. When the omission contingency was used because an echoic response was emitted by the participant, the result was that an extinction trial was interspersed during the session. Several studies have reported response cost (e.g., omission contingencies) to decrease responding (e.g., Pietras, Brandt, & Searcy, 2010) suggesting that it is a punisher and that preferences for contingencies over noncontingent deliveries of reinforcers may change as schedules of contingent reinforcement are thinned (Luczynski & Hanley, 2010). With the exception of Brad, however, we did not see preference of procedure correlate with differences in the number of omissions contingencies embedded across the procedures (Figure 11 shows these data). It does not appear that preference for ODT over other conditions was influenced solely on ODT containing fewer omissions, as fewer omissions were not always present in ODT for the other participants. An interesting pattern in the preference assessment data was that all participants in the present study also preferred the control procedure to the SSP procedure. The only difference between these two procedures was the temporal continuity between the auditory stimulus and the delivery of the reinforcer. It is possible that during the control procedure, the participants were actually engaging in some response during the delay between the presentation of the auditory stimulus and the presentation of the reinforcer. These responses may have been adventitiously reinforced, creating a procedure that would be more analogous to the ODT procedure, which could explain why the control procedure was preferred over that of the SSP. Arm raising data for Brad support this possibility.

It is also worth noting that the current study only demonstrated slight increases in rates of target vocalizations over that of the control procedures and control sounds compared to other studies that have evaluated the effects of SSP on vocalizations (e.g., Miguel, et al). These low rates are most likely due to the operational definition of target and nontarget vocalizations that was employed. The strict definition was adopted to better ensure accuracy of observers when scoring vocalizations. The definition excluded echoic responses, self-echoic or repetitive target or nontarget responses that were emitted within 5 s of each other, and variations of approximations (e.g., the wrong consonant being emitted during either syllable in the complex syllable combinations target). However, a limitation of the current study is that it is unknown whether or not the increases in target vocalizations for all the participants would be clinically relevant because attempts were not made to capture these target vocalizations and bring them under any type of stimulus control.

The current study extends the literature on increasing target vocalizations in children with autism who engage in little to no echoic behavior, by providing support for the possible use of an alternative procedure to the passive pairing procedures. The ODT procedure was more preferred by all participants than SSP.   However, it would be premature to recommend the procedure in lieu of SSP, as the procedure did not produce greater effects than SSP. Additionally, the ODT procedure can be cumbersome to implement in that it requires use of prompting and prompt-fading strategies. These skills can be difficult to train parents to implement. The ease of implementation of the SSP procedure makes it more amenable for parents and caregivers to implement outside of the clinical setting. Tentatively, the ODT procedure should be reserved clinically as an intervention for instances when SSP does not produce an effect. However future research is necessary to evaluate whether the ODT can produce effects with SSP non-responders. Overall, both procedures provide furtive ground for experimental research on the identification of variables that increase the effectiveness and efficiency of the interventions aimed at increasing vocalizations of children with autism.

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VITA

Personal Background	Tracy Lynn Lepper Coldwater, Michigan Daughter of Gordon Lepper and Patricia McKinley One child
Education	Diploma, Coldwater High School, Coldwater Michigan, 1996 Associate of Arts, Kellogg Community College, Battle Creek, 2004 Bachelor of Science, Western Michigan University, Kalamazoo, 2006 Master of Science, Texas Christian University, Forth Worth, 2012
Experience	Behavior Intern, Timber Ridge Ranch NeuroRestorative Service, Benton, 2006 Behavior Specialist, WMU Center for Disability Services, 2008-2009 Teaching Assistantship, Western Michigan University, 2006-2009 Teaching Assistantship, Texas Christian University, 2009-2012 Volunteer Tutor, Child Study Center, Fort Worth, November 2011- present
Professional Memberships	Association for Behavior Analysis International Texas Association of Behavior Analysis

ABSTRACT

A COMPARISON OF OPERANT DISCRIMINATION TRAINING AND STIMULUS-STIMULUS PAIRING PROCEDURES TO INCREASE VOCALIZATIONS OF CHILDREN WITH AUTISM

by Tracy Lynn Lepper, M.S., 2012
Department of Psychology
Texas Christian University

Thesis Advisor: Dr. Anna I. Petursdottir, Assistant Professor of Psychology

This study sought to compare the effectiveness of a stimulus-stimulus pairing procedure (SSP) and an operant discrimination training (ODT) procedure on increasing target vocalizations of 3 boys with autism, and identify individual preference for each procedure. During SSP, auditory stimuli were presented in a manner that reliably predicted the delivery of a preferred stimulus. During ODT, auditory stimuli were presented in a manner that signaled the availability of reinforcement for engaging in an arbitrarily selected response. A control condition was also included that involved presenting auditory stimuli explicitly unpaired with the delivery of the preferred item. The procedure preference evaluation consisted of a concurrent operants selection procedure. Results indicate that both procedures were effective for increasing the target vocalizations in 5 out of 6 cases, and that all participants preferred ODT to SSP.