Evaluating the Effects of Similar and Distinct Discriminative Stimuli During Auditory Conditional Discrimination Training With Children With Autism

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Abstract

Children with autism are often taught auditory conditional discriminations in the form of personal information questions that might prove useful in conversation (e.g., “What is your favorite food?” “Pizza” and “What is your favorite color?” “Purple”). In these questions, the auditory stimuli presented as part of the compound discriminative stimulus (i.e., *what, favorite, color/food*) do not always simultaneously control responding. If all components of the auditory stimulus do not control responding, a child may master 1 target but have trouble acquiring subsequent targets that have a component of a previously learned auditory stimulus because the previously learned response is emitted. One way to avoid this problem is to teach many targets that have no overlapping component stimuli before introducing targets that include a previously learned component. Another way to avoid the problem is to systematically introduce overlapping stimulus components simultaneously to facilitate control by all relevant components. Three children with autism were taught auditory conditional discriminations. An adapted alternating-treatments design was used to compare the use of training sets with programmed overlap of component auditory stimuli to training sets with no overlap of stimulus components. The effects of these 2 arrangements were evaluated on trials to criterion and percentage accuracy during acquisition. All participants reached mastery faster with at least 1 target set in the nonoverlap condition compared to the overlapping condition; 2 out of the 3 participants met the mastery criteria for both overlapping and nonoverlapping targets at a similar rate by the 3rd training set.

Keywords Auditory conditional discrimination · Intraverbal · Personal questions · Stimulus control

In early intensive behavior interventions, it is typical to teach children with autism how to correctly respond to personal and social questions because many of our daily social interactions include these types of questions and their answers (Ingvarsson & Hollobaugh, 2011). Answering questions are characterized as intraverbal behavior, which is verbal

behavior controlled by a verbal stimulus with no point-to-point correspondence between the response and the stimulus (Skinner, 1957). There are a number of intraverbal behaviors ranging from simple to complex (Sundberg & Sundberg, 2011). By 2 years old, most typically developing children are able to make simple verbal discriminations, consisting of one verbal stimulus evoking the control of a response—for example, saying their first name when asked “What’s your name?” fill-in phrases (e.g., “Ready, set, go!”), and word associations such as “mommy and [daddy]” (Palmer, 2016; Sundberg, 2016; Sundberg & Sundberg, 2011). Most complex intraverbal behavior is under the control of multiple antecedent stimuli also known as *verbal conditional discriminations* (VCD; Axe, 2008; Sundberg & Sundberg, 2011)—for instance, saying “hairbrush” and “toothbrush” when asked “What do you brush your hair with?” versus “What do you brush your teeth with?” There has been a significant increase in the number of publications on the intraverbal in the past 10 years (see Aguirre, Valentino, & LeBlanc, 2016); however, there have only been a few studies that have specifically arranged antecedent stimuli to ensure participants were making VCDs (DeSouza, Fisher, & Rodriguez, 2018; Stauch, LaLonde, Plavnick, Bak, & Gatewood, 2017).

According to Skinner (1957), most intraverbal relations are multiply controlled when “the strength of a single response may be, and usually is, a function of more than one variable and a single variable usually affects more than one response” (p. 227). Divergent multiple control consists of emitting multiple responses contingent on the presence of one antecedent stimulus (Michael, Palmer, & Sundberg, 2011). For example, an individual may emit the responses “shapes, animals, and candy” following the verbal stimulus “Tell me some things you draw.” A response is under convergent multiple control when multiple stimuli influence the strength of one response. For example, if an individual responded “shapes” in the presence of the verbal stimulus “What is your favorite thing to draw?” the verbal stimuli *favorite* and *draw* converge to evoke the response *shapes*. Convergent multiple control is observed in most instances of verbal behavior due to the involvement of “any verbal or nonverbal stimulus affecting any sense mode, including private stimulation, and control can be shared with other antecedents such as conditioned and unconditioned stimuli, motivating operations, and audiences” (Sundberg & Sundberg, 2011, p. 25).

As described in Eikeseth and Smith (2013) and Schlinger and Blakely (1994), there are four types of verbal discriminations: simple, compound, verbal conditional, and verbal function-alternating. As mentioned earlier, a simple verbal discrimination involves a single verbal stimulus that evokes an intraverbal response. A compound verbal discrimination consists of two or more discriminative stimuli (S^D) that evoke different behavior, but when they occur in the same antecedent arrangement, a different function of the S^D is produced (e.g., saying “blue” after hearing “Red, white, . . .”). A VCD consists of a verbal stimulus that alters the effects of another verbal stimulus in the same question (e.g., saying “paper” and “canvas” when asked “What do you draw on?” and “What do you paint on?”). A verbal functioning-altering discrimination involves a verbal stimulus that alters the function of other stimuli at another time period (e.g., saying your name when you hear “Say your name when I say the color of your shirt.”). Sundberg and Sundberg (2011) found that typically developing 5-year-old children were able to make a number of VCDs but had continued difficulty answering questions related to negation, time concepts, and prepositions (e.g., “What day is today?” “Tell me something that is not a fruit”).

As mentioned previously, there are instances where antecedent stimuli involve multiple components that do not consistently occur together but may join together at a single instance. A correct response under this single instance is contingent on a conditional discrimination where one stimulus alters the evocative effect of another stimulus, but neither stimulus individually is sufficient to evoke the correct response. Conditional discriminations involving such compound stimuli are also described as VCDs (Sundberg & Sundberg, 2011). VCDs can become more difficult as verbal stimuli, such as different verbal modifiers (i.e., adjectives and prepositions), are added to the antecedent and as more complex concepts, vocabulary words, and topics are targeted.

Most children with autism have difficulty acquiring complex intraverbals, possibly due to the reasons described previously (e.g., need for convergent control). Sundberg and Sundberg (2011) found that typically developing children begin emitting complex intraverbals without direct instruction between 3 and 4 years old and are able to make VCDs (i.e., with compound stimuli) by 5 years of age. Children with autism and other developmental disabilities must learn how to respond correctly to compound verbal stimuli, such as social questions, as these skills are important in developing more advanced academic and social repertoires (Axe, 2008).

Prior to 2007, one study analyzed VCDs when teaching the intraverbal (Axe, 2008). Braam and Poling (1983) evaluated the use of transfer of stimulus-control procedures to teach intraverbals to young adults with intellectual disabilities. In Experiment 3 of that study, a delayed prompting procedure was used to teach intraverbal behavior that involved a conditional discrimination where multiple verbal stimuli overlapped (i.e., people at school, people at home, things at school, things at home). Using transfer of stimulus control from textual stimuli was effective in teaching intraverbal responses to compound verbal stimuli. In order to further examine the number of studies evaluating intraverbals under divergent and convergent control, Stauch et al. (2017) conducted a systematic search of intraverbal studies published from 2005 to 2016. According to Stauch et al. (2017), a total of 5 studies have taught intraverbal behavior under divergent control, and 21 studies have taught intraverbals under convergent control since 2005. Only two studies used procedures to ensure accurate VCDs were demonstrated (Ingvarsson, Kramer, Carp, Petursdottir, & Macias, 2016; Kisamore, Karsten, & Mann, 2016).

Ingvarsson et al. (2016) utilized a blocked-trial procedure to teach VCDs across trials to four children with autism throughout and took out ASD). Participants were to make discriminations across question pairs that included two forms, such as “What do you play?” and “What do you play with?” The blocked-trials procedure included five steps. The first, second, and third steps consisted of presenting each question until each participant responded correctly for 10, 8, and 5 consecutive trials, respectively, with no more than two incorrect responses per trial block. The fourth step consisted of alternating both questions until participants responded correctly for 15 consecutive trials. The final step included presenting both questions in a quasirandom order until they responded correctly for 15 consecutive trials. All participants acquired multiple VCDs with the blocked-trial procedure, although two participants required an error-correction procedure in order to teach the first target set by adding an echoic prompt for incorrect responses and interspersing distracter trials.

To further examine the use of conditional discrimination training to teach intraverbals to children with autism, Kisamore et al. (2016) examined the effect of a prompt delay with error correction, a differential observing response (DOR) that consisted of the participants repeating the target verbal stimuli, and a DOR plus blocked trials. All participants showed an increase in intraverbal responding for at least one stimulus set under the prompt-delay and error-correction procedure; however, four participants required the use of a DOR, modified DOR, or modified prompt delay with error correction. Further research is still required in order to effectively and sufficiently teach VCDs to children with autism and other related developmental disabilities.

Recently, DeSouza et al. (2018) evaluated the effects of training intraverbal prerequisite skills proposed by Sundberg and Sundberg (2011) on the emergence of convergent intraverbals with four children with autism. Two sets of four target stimuli were used in the study with each target overlapping with other targets in Class 1 (e.g., animal type) or Class 2 (e.g., biographical type). DeSouza implemented training of the following progression of prerequisite skills if participants did not emit 11 out of 12 correct responses during baseline sessions: multiple tacts, multiple listener, intraverbal categorization, and listener conditional discriminations. All participants demonstrated an emergence of convergent intraverbals once mastery of listener conditional discriminations was met. All participants used a type of DOR (i.e., vocal responses that matched the target stimuli before emitting the intraverbal response) during sessions without direct instruction during intraverbal probes.

In both studies described previously, multiple interventions were implemented in order to teach VCDs. If all components of the auditory stimulus do not control responding, a child may master one target (e.g., “What do you play?”) but have trouble acquiring subsequent targets (e.g., “What do you play with?”) that have a component of a previously learned auditory stimulus (i.e., *play*) because the previously learned response (i.e., *games*) is emitted. One possible way to avoid this problem is to teach many target questions that have no overlapping component stimuli before introducing target questions that include a previously learned component. Another way to possibly avoid the problem is to systematically program for common stimulus components that are introduced simultaneously to facilitate control by all relevant components. The purpose of the current study was to compare the use of training sets with programmed overlap of component auditory stimuli to training sets with no overlap of question components with three children with autism. The effects of training with two prior sets of stimuli in each of the two conditions were evaluated on a third set of stimuli.

Method

Participants, Setting, and Materials

The selected participants were one male and two female children diagnosed with ASD. Other children were screened; however, high levels of baseline responding were observed during the prebaseline probe (see the Procedures section). Cindy, Mary, and Sam were 8 years, 8 months old; 10 years, 6 months old; and 4 years, 11 months old, respectively, at the start of the study. Cindy received 9 hr of applied behavior analysis

(ABA) services per week in her home. According to Cindy's last Verbal Behavior Milestones Assessment and Placement Program (VB-MAPP) assessment, she had reached mastery criteria of Level 1 and demonstrated emerging skills of the following verbal operants from Level 2: mands; tacts; listener responding (LR); echoics; LR-feature, function, class (LRFFC); and intraverbals (see Sundberg, 2008). At the beginning of the study, Mary was receiving 23 hr per week of ABA in-home and center-based services. By the end of the study, she was receiving 10 hr per week of ABA in-home and center-based services. Her VB-MAPP assessment indicated she had mastered all of Level 1 and the tact, LR, echoics, and LRFFC operants from Level 2. Mary demonstrated emerging mands and intraverbals from Level 2 of the VB-MAPP. Sam received 15 hr per week of ABA center-based services at the start of the study, then received 9 hr per week by the end of the study. His VB-MAPP assessment illustrated he had mastered all of Level 1 verbal operants and mands, echoics, and LRFFC operants from Level 2. Sam showed emerging tact, LR, and intraverbal repertoires according to Level 2 of the VB-MAPP.

Baseline and treatment sessions were 5–10 min in duration and were conducted one to four times per week. Sessions were conducted in the bedroom, dining room, or living room of Cindy's home. Mary's sessions were conducted in a small office at her home or in a small therapy room at her center-based program as part of ongoing clinical services. For Sam, sessions were conducted in a large common area with dividers at his center-based program. All participants sat adjacent to the experimenter during all sessions. Besides a second observer collecting interobserver agreement (IOA) or procedural integrity (PI) data and the assigned behavioral therapist, no other individuals were present during sessions.

Materials and Stimuli

Materials included data sheets for all sessions, pens and paper, and preferred edible (Mary and Sam) and tangible items (Cindy) to be used as reinforcers. Two sets of overlapping target stimuli (OTS) and nonoverlapping target stimuli (non-OTS) were used (see Tables 1 and 2 for target stimuli for Cindy). Each target set consisted of four intraverbal questions that were presented three times for a total of 12 questions during all baseline and training sessions. For all OTS, each question included two target words that overlapped with the other intraverbal questions in the set. For example, the question "What vehicle is small?" and "What toy is small?" both have the word *small* within the question. For non-OTS 1 and 2, there was no overlap between the target questions (i.e., "What color is a basketball?" "What do you use to smell?"). A third target set was used to evaluate the effects of training with the two OTS and non-OTS set when overlapping stimuli were eventually introduced (as would happen in typical programming). The third target set consisted of eight intraverbal questions with at least one overlapping target word from the previous target sets. These questions were presented three times for a total of 24 questions during baseline and training sessions (see Tables 1 and 2).

Response Measurement

The primary dependent measure was the percentage of correct responses. A correct response was defined when a participant said an unprompted word or phrase that

Table 1 OTS Sets for Cindy and Sam

Set 1	1st Target Word				OTS Targets (Set 3)
	Vehicle			Toy	
2nd Target Word	What vehicle is small ? <i>Car</i>	Small		What toy is small ? <i>Legos</i>	What fruit is small ? <i>Blueberry</i>
	What vehicle flies ? <i>Airplane</i>	Flies		What toy flies ? <i>Frisbee</i>	What superhero flies ? <i>Superman</i>
OTS Targets (Set 3)	What vehicle is big? <i>Firetruck</i>			What toy spins ? <i>Top</i>	
Set 2	1st Target Word				OTS Targets (Set 3)
	Like			Time	
2nd Target Word	What do you like to play ? <i>Draw</i>	Play		What time do you play at school? <i>Recess</i>	What place do you play ? <i>Playground</i>
	What do you like to draw ? <i>Shapes</i>	Draw		What time do you draw ? <i>Break time</i>	What do you draw on? <i>Paper</i>
OTS Targets (Set 3)	What do you like to watch? <i>Barney</i>			What time do you sleep? <i>Nighttime</i>	

Note. The italicized words indicate examples of contextually appropriate responses, but other contextually appropriate responses would be considered a correct response. The boldface words indicate the overlap between each set.

Table 2 Non-OTS Sets for Cindy

Set 1	Target Questions What do you brush your teeth with? <i>Toothbrush</i> What grows on your head? <i>Hair</i> What do you brush your hair with? <i>Hairbrush</i>	OTS Targets (Set 3) What season is cold ? <i>Winter</i> What do you wear on your head ? <i>Hat</i>
Set 2	Target Questions What color is a basketball? <i>Orange</i> What is something you blow up? <i>Balloon</i> What color is the sun? <i>Yellow</i>	OTS Targets (Set 3) What food is cold? <i>Ice cream</i> What can you write with? <i>Pencil</i> What food is salty? <i>Pretzel</i> What do you use to smell? <i>Nose</i> What can you jump on? <i>Trampoline</i> What do you jump into? <i>Pool</i>
OTS Targets (Set 3)		OTS Targets (Set 3) What shape is a basketball ? <i>Circle</i> What is something you read? <i>Books</i>

Note. The italicized words indicate examples of contextually appropriate responses, but other contextually appropriate responses would be considered a correct response. The boldface words indicate the overlap in Set 3 from Set 1 and Set 2.

was contextually appropriate to the question within 3 s of the S^D (e.g., “What vehicle flies?” “airplane,” “helicopter”). An incorrect response consisted of a participant saying no response or a response that was contextually inappropriate to the question within 3 s of the S^D (e.g., “What vehicle flies?” “car,” “flies”). The number of correct responses was divided by the total number of trials to calculate the percentage of correct responses. The secondary dependent measure was the number of sessions to meet the mastery criterion of 100% correct responding across three consecutive sessions.

IOA was conducted for 78% of all baseline and 37% of all training sessions for Cindy, 93% of all baseline and 66% of all training sessions for Mary, and 50% of all baseline and training sessions for Sam by a second independent observer. IOA was calculated on a trial-by-trial basis by dividing agreements by agreements plus disagreements and multiplying by 100 to convert into a percentage. Baseline IOA scores were 98%, 100%, and 98% for Cindy, Mary, and Sam, respectively. Training IOA scores were 100%, 98%, and 98% for Cindy, Mary, and Sam, respectively. PI was conducted for 59% of all baseline sessions for Cindy and Mary and 51% of all baseline sessions for Sam. During training, PI checklists were conducted for 49%, 21%, and 51% of all sessions for Cindy, Mary, and Sam, respectively. Some of the steps on the PI checklist in treatment were (a) presenting the correct intraverbal, (b) prompting correctly, and (c) providing differential consequences for correct responses (i.e., tangible or edible item and praise). The full PI checklist is available upon request. Baseline PI scores were 100%, 94%, and 88% for Cindy, Mary, and Sam’s sessions, respectively. Training PI scores were 100% for Cindy and Mary’s sessions and 93% for Sam’s sessions.

Experimental Design

Two experimental designs were used in the study. A nonconcurrent adapted alternating-treatments design across two target sets was used with each participant. In order to evaluate the effects of training with the two OTS and non-OTS sets, a nonconcurrent adapted alternating-treatments design was used with a third target set. First, baseline data were collected for the third target set. Once a low, stable state of responding was established during baseline for Target Set 3, baseline data were gathered for Target Sets 1 and 2. When the levels of correct responding were low and stable, intraverbal training was implemented for OTS and non-OTS Sets 1 and 2. Intraverbal training for Target Set 3 began once the mastery criteria were met for both Set 1 and Set 2 for each participant.

Procedures

Preference assessment A multiple stimulus without replacement (MSWO; DeLeon & Iwata, 1996) preference assessment was conducted in order to identify a hierarchy of preferred items to use as potential reinforcers during subsequent prebaseline, baseline, and intervention sessions. An MSWO with edibles was used with Cindy, and an MSWO with tangible items was used with Mary and Sam.

Prebaseline probes Prebaseline probes were conducted for all OTS and non-OTS target sets in order to identify any potential targets that the participant already had in

his or her repertoire. During the pre-baseline probes, the therapist presented the target question and waited 3 s for the participant to respond. Following a correct response, an incorrect response, or after 3 s had elapsed, the therapist would say “Let’s try another,” or a similar neutral phrase. Maintenance trials of non-vocal response repertoires (e.g., matching, motor imitation, LR instructions) were interspersed every 3 to 10 trials (individualized based on the participants’ tolerance for lean schedules of reinforcement). A highly preferred item identified during the MSWO was delivered for 15–30 s contingent on a correct response on maintenance trials. If the participants responded correctly to any of the target questions during the probes, those questions were not included as part of their target sets.

Probes of echoic prompts were conducted in order to identify whether an echoic prompt was effective at producing a desired response. During the echoic probes, the therapist said a word and allowed 3 s for the participant to correctly echo the word. Consequences during the echoic probes were identical to those for the prebaseline probes for Sets 1, 2, and 3 described previously. An echoic prompt was successful at producing a correct response for all participants, and echoic prompts were used in other phases, as specified next.

Baseline Baseline probes were conducted for all target sets to assess pretreatment performance. Baseline for OTS and non-OTS Set 3 was conducted before the baseline for Sets 1 and 2 were initiated. Baseline procedures were identical for all sets. A baseline session for Set 3 consisted of presenting each target question three times for a total of 24 trials. A baseline session for Sets 1 and 2 consisted of presenting each target question three times for a total of 12 trials. Prior to each baseline session, the therapist randomly selected whether an OTS or non-OTS session would be conducted. Additionally, the order of the presentation of the intraverbal targets was randomized for each session. During baseline sessions, the therapist presented the target question and waited 3 s for the participant to respond. Following a correct response, an incorrect response, or after 3 s had elapsed, the therapist would say, for example, “Let’s try another,” or a similar neutral phrase. Maintenance trials of non-vocal response repertoires (e.g., matching, motor imitation, LR instructions) were interspersed every 3 to 10 trials, and a highly preferred item was delivered contingent on a correct response on maintenance trials. Once responding was low and stable for Sets 1 and 2, intervention was initiated for those sets.

Intraverbal training with echoic prompts Training for Sets 1 and 2 was conducted prior to training for Set 3. For Sets 1 and 2, one session consisted of presenting each question three times for a total of 12 trials. Targets were presented in random order, and prior to each session, the therapist randomly selected whether an OTS or non-OTS session for Set 1 or Set 2 would be conducted, for a total of four possibilities. During the first OTS and non-OTS session for Sets 1 and 2, the therapist implemented a 0-s prompt delay. The therapist presented the target question and immediately provided an echoic prompt. When the participant responded correctly, the therapist provided access to a highly preferred item for 15–30 s along with vocal praise. Following the first OTS and non-OTS session for each set, the delay was increased to 3 s. During the 3-s delay, the therapist presented the target question and waited 3 s for the participant to respond. Contingent on a correct response, the therapist provided access to a highly preferred

item for 15–30 s along with vocal praise. Contingent on no response or an incorrect response, the therapist repeated the target question followed by an immediate echoic prompt. Following a correct response after the echoic prompt, the therapist delivered vocal praise only. If the mastery criterion was met for one condition before the other (OTS or non-OTS), probes of those targets would be conducted approximately every third session while the intervention continued for the other condition. Following mastery (or discontinuation) of Sets 1 and 2, training was initiated for Set 3.

In Set 3, one session consisted of presenting each question three times for a total of 24 trials. During the first session of OTS and non-OTS targets in Set 3, a 0-s delay was implemented. Then, the delay was increased to 3 s. Intervention procedures for Set 3 were identical to the procedures for Sets 1 and 2.

Intraverbal training with tact prompt Intraverbal training with a tact prompt was introduced for Cindy for OTS Set 1 and Set 2 due to consistently low percentages of correct responding. For correct responses, the procedure was the same as during intraverbal training with an echoic prompt (i.e., vocal praise with 15–30 s of access to a highly preferred item). For an incorrect response, a tact prompt was implemented by showing a visual stimulus of a contextually appropriate response. For example, a visual stimulus of an airplane was shown during error correction for the question “What vehicle flies?” If Cindy responded correctly with the tact prompt, vocal praise was provided and the next question was presented.

Follow-up probes Follow-up probes of OTS and non-OTS Sets 1 and 2 were conducted after Set 3 training. Sessions were conducted in the same manner as during intraverbal training.

Results

Targets Sets 1 and 2

The results for Cindy for Targets Sets 1 and 2 are displayed in Fig. 1. During baseline, Cindy’s correct responding was at near-zero levels for both target sets. For non-OTS Set 1, Cindy’s percentage of correct responding reached the mastery criterion (i.e., 100% correct across three sessions) after 17 training sessions. Due to a low percentage of correct responding during training for OTS Set 1, a 0-s prompt delay was used during one training session. During Training Session 22, a tact prompt was implemented for Cindy. Cindy met the discharge criterion at 34 sessions for OTS Set 1 (i.e., 10 consecutive sessions of low, stable correct responding). An error analysis of the last five OTS Set 1 sessions indicated that Cindy’s incorrect responding was only under restricted stimulus control due to her saying “legos” (i.e., the response to the target question “What *toy* is *small*?”) when presented with the target questions “What *vehicle* is *small*?” and “What *toy* *flies*?” A 0-s prompt delay was implemented during training for both OTS Set 2 and non-OTS Set 2. For non-OTS Set 2, Cindy’s correct responding met mastery after 24 training sessions. A tact prompt was implemented at Session 25 for OTS Set 2. Cindy met the discharge criterion after 34 sessions for OTS Set 2. An error analysis of the last five OTS Set 2 sessions indicated that

Fig. 1. Percentage of correct responding for OTS and non-OTS Set 1 and Set 2 for Cindy. The black closed circles indicate correct responding with the OTS and the white closed circles indicate responding with the non-OTS. BL = Baseline; IVT + EP = intraverbal training with echoic prompt; IVT + TP = intraverbal training with tact prompt

Cindy's incorrect responding was under the restricted stimulus control of the target verbal stimulus *draw* due to her responding "break time" (i.e., the response to the target question "What time do you *draw*?" when presented with the target question "What do you *like* to *draw*?" Cindy maintained a high percentage of correct responding for non-OTS Set 1 at 16 weeks follow-up.

For Mary, new intraverbal questions were introduced during baseline due to an increasing trend in correct responding (see Fig. 2). Once Mary's responding was stable, training began for Set 1 for both targets. Mary met mastery after 8 sessions for non-OTS Set 1 and 18 sessions for OTS Set 1. For Training Target Set 2, Mary's correct responding reached the mastery criterion after 9 sessions for the non-OTS set and 20 sessions for the OTS set.

Fig. 2. Percentage of correct responding for OTS and non-OTS Set 1 and Set 2 for Mary. The black closed circles indicate correct responding with the OTS and the white closed circles indicate responding with the non-OTS. NS = new stimuli implemented; IVT + EP = intraverbal training with echoic prompt

Sam's results are displayed in Fig. 3. He emitted incorrect intraverbal responses during most baseline sessions. During training of Target Set 1, Sam met mastery of the non-OTS targets after five sessions. He met the discharge criterion after 22 sessions for OTS Set 1 (range 0%–83%). An error analysis of the last five OTS Set 1 sessions indicated that Sam's incorrect responding was under restricted stimulus control of the target questions "What *toy* is *small*?" and "What *toy* *flies*?" Sam was emitting the response "car" and "airplane" for the aforementioned target questions, which were the correct responses for the other questions in Target Set 1 (i.e., "What *vehicle* is *small*?" and "What *vehicle* *flies*?"). For Training Target Set 2, Sam met the mastery criteria for both targets after six sessions. Sam's percentage correct responding at follow-up maintained between 92% and 100% for up to 6 weeks for the non-OTS Set 1 and at 100% correct for 2 weeks for non-OTS Set 2. During

Fig. 3. Percentage of correct responding for OTS and non-OTS Set 1 and Set 2 for Sam. The black closed circles indicate correct responding with the OTS and the white closed circles indicate responding with the non-OTS. IVT + EP = intraverbal training with echoic prompt

follow-up probe sessions, Sam's correct responding was at 50% for both OTS and non-OTS Sets 1 and 2.

Target Set 3

Cindy emitted no correct responses during baseline (see Fig. 4). Cindy met the mastery criterion for Set 3 after 21 sessions for the non-OTS set and 31 sessions for the OTS set. For Mary, new intraverbal questions were introduced during baseline due to an increasing trend in correct responding. Mary met the mastery criterion for the target sets after 16 sessions (OTS) and 18 sessions (non-OTS). Sam engaged in a low percentage of correct responding during baseline (range 0%–20%) and met the mastery criterion for OTS and non-OTS sets at 9 and 10 sessions, respectively.

Fig. 4. Percentage of correct responding for OTS and non-OTS Set 3 for Cindy, Mary, and Sam. The black closed circles indicate correct responding with the OTS and the white closed circles indicate responding with the non-OTS. NS = new stimuli implemented; IVT + EP = intraverbal training with echoic prompt

Discussion

VC^Ds can be difficult for children with autism to acquire, particularly as verbal stimuli are added to the antecedent, and convergent control is required (Sundberg & Sundberg, 2011). Three prior studies used procedures to ensure accurate VC^Ds were demonstrated with appropriate convergent control (DeSouza et al., 2018; Ingvarsson et al., 2016;

Kisamore et al., 2016). In each study, these types of discriminations proved challenging but possible to acquire. Similar to DeSouza et al. (2018), the current investigation examined the role of the arrangement of the target S^D in a set to either require convergent control (i.e., OTS) or not (non-OTS). The differential effects of these arrangements were observed during initial training sets, with easier initial acquisition of sets with no overlap. The effects were also examined on acquisition of a third set with overlapping verbal stimuli requiring convergent control with no differential effects.

All three participants learned to make auditory conditional discriminations by the end of the study. Before the start of the study, it was hypothesized that participants' correct responding would initially take longer to meet the mastery criterion for questions with overlapping stimuli in comparison to questions with nonoverlapping stimuli. Subsequently, it was also hypothesized the number of sessions to meet mastery for questions with multiple component stimuli would decrease over time as preceding interferences are minimized (Braam & Poling, 1983; Ingvarsson et al., 2016). Although Cindy met the discontinuation criterion for OTS Sets 1 and 2, she met the mastery criterion for OTS Set 3 (DeSouza et al., 2018; Ingvarsson et al., 2016; Kisamore et al., 2016). Mary took longer to master OTS Sets 1 and 2 in comparison to non-OTS sets; however, the number of sessions to meet the mastery criterion for OTS Set 3 was approximately the same for non-OTS Set 3. Sam's correct percentage of responding met the discharge criterion for OTS Set 1, but the number of sessions to meet the mastery criterion for OTS Sets 2 and 3 were the same as for non-OTS Sets 2 and 3. Overall, there was no substantial difference in correct responding based on the arrangement of simple and complex verbal stimuli across participants by Set 3.

An additional procedure was implemented for Cindy by adding a tact prompt during intraverbal training for OTS Sets 1 and 2 due to her difficulty in discriminating between the questions "What vehicle is small?" "What toy flies?" and "What do you like to draw?" by emitting a previously correct response from one of the target intraverbal questions from the OTS set. Sam also did not meet mastery criterion for OTS Set 1 due to the same stimulus-control issue, but no additional procedures were implemented. A blocked-trial procedure similar to Ingvarsson et al. (2016) and Kisamore et al. (2016) may have been more successful for Cindy and Sam so that repeated presentation of the same auditory stimulus may increase the likelihood that convergent control would be established. A block of trials may also have been helpful for Cindy and Sam to respond more correctly, resulting in a higher density of reinforcement. Similar to the current study, supplementary procedures besides a blocked-trial procedure were required for some participants to emit auditory conditional discriminations with convergent control (Ingvarsson et al., 2016; Kisamore et al., 2016). In Ingvarsson et al. (2016), two of the four participants (Doug and Ricky) required extrastimulus prompting, distractor trials, and remedial instruction of the blocked-trial procedures to make auditory VC^D s. In addition, four out of the seven participants in Kisamore et al. (2016) required either the implementation of a DOR, a modified DOR, or a prompt-delay plus error-correction procedure in order to reach mastery with at least one intraverbal target set. However, the effectiveness of these procedures is unclear due to the fact the implementation was different for each of the four participants. Kisamore et al. suggest implementing a DOR procedure if a participant does not emit a response or emits a response that matches a part of the target question to increase the salience of each relevant verbal stimulus. If a participant is emitting responses based on previous learning, they recommended

introducing procedures to strengthen transfer of stimulus control. Furthermore, it may be useful to train the prerequisite skills, especially listener conditional discriminations, implemented in DeSouza et al. (2018), to facilitate correct convergent intraverbal responding. The additional procedures implemented in the previous literature and the current study emphasize the need for further assessment and research in corresponding teaching procedures depending on the controlling variables to establish auditory conditional discriminations that are multiply controlled (see Kisamore et al., 2016).

In general, there were no substantial differences in the effect of the target questions arranged into OTS and non-OTS sets in the current study. Results indicate that it may not be necessary to program for overlap in the antecedent auditory stimuli before teaching auditory conditional discriminations under convergent control with children with autism. However, the arrangement of OTS Sets 1 and 2 that required convergent control of responding may have improved subsequent convergent responding, as all participants met the mastery criterion for OTS Set 3. More specifically, participants were required to attend to the overlapping stimuli in the OTS sets, so they may have begun attending to all verbal stimulus components in all sets by the implementation of the third OTS and non-OTS sets. Practitioners may plan to have OTS when teaching convergent intraverbals initially, but it may not be necessary to have all overlap in all stimulus sets to produce a facilitative effect. Practitioners may consider using a blocked-trials or DOR procedure as implemented in Ingvarsson et al. (2016) and Kisamore et al. (2016) if convergent-control issues arise when children with autism encounter questions with overlapping stimulus components.

There are a number of limitations that need to be mentioned. First, the adapted alternating-treatments design may have produced some beneficial carryover effects with the acquisition of non-OTS sets. It may be more beneficial to evaluate acquisition of OTS and non-OTS separately and evaluate auditory conditional discriminations with convergent control with another OTS. Second, follow-up probes for OTS and non-OTS Sets 1 and 2 were completed after the mastery criterion was met for the third target set, which took 14 days to 3 months to complete depending on the participant. Sundberg (2016) summarized that Skinner (1957) determined the “intraverbal is the most susceptible to deterioration” in comparison to the other verbal operants, due to convergent and divergent control evoking the appropriate auditory conditional discriminations, as well as auditory verbal stimuli are being presented quickly and temporarily (p. 121). Future researchers may want to add continuous maintenance probes when examining acquisition with a third target set. Also, additional research is needed to examine how to more effectively maintain auditory conditional discriminations that are multiply controlled.

Third, OTS and non-OTS Set 3 only consisted of one verbal stimulus that was similar to the questions in Sets 1 and 2. In OTS Sets 1 and 2, two verbal stimuli were similar in each set. The similar verbal stimulus in Set 3 may have been easier to discriminate and acquire for participants in comparison to those in Sets 1 and 2. Future research may want to assess the accuracy of correct responding by having the number of antecedent verbal stimuli be constant across all stimulus sets.

Fourth, no data were collected on whether the participants ever emitted any of the acquired responses outside of sessions to promote generalization. Future researchers may examine convergent intraverbal responding with other people or monitor intraverbal responses in a play condition with a peer or adult.

Fifth, no testing occurred to identify if the non-OTS acquired responses were developing under convergent control until the teaching of the third target set. As mentioned previously, probing correct responding with an additional OTS may provide more data about this effect through teaching sessions.

The present study adds to the current literature in teaching intraverbals under the control of VCDs with children with autism (Ingvarsson et al., 2016; Kisamore et al., 2016). Although there were no substantial differences in the number of sessions to reach mastery between OTS and non-OTS by Set 3, programming VCDs may still be systematically arranged when teaching intraverbals with children with autism and other developmental disabilities. If stimulus-control issues occur during intraverbal programming, practitioners may use the blocked-trial procedure (Ingvarsson et al., 2016) or a DOR (Kisamore et al., 2016). Teaching intraverbals can be a highly complex skill, which Palmer (2016) suggested future researchers should differentiate between the intraverbal, intraverbal defined by Skinner (1957), and intraverbal control. Intraverbal control is what Palmer defined with a narrower definition: that is, “an intraverbal is a verbal response directly under control of a prior verbal stimulus *as the result of a history of reinforcement for emitting that response in the presence of that stimulus*” (p. 97). This narrower definition provides the opportunity to examine multiple controlling stimuli (i.e., verbal antecedents, overt or covert problem solving, etc.) when teaching more complex intraverbals and to find more effective ways to eliminate any future stimulus control issues.

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Compliance with Ethical Standards

Conflict of interest All authors declare that they have no conflicts of interest related to this project.

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