Evaluation of a Blocked-Trials Procedure to Establish Complex Stimulus Control over Intraverbal Responses in Children with Autism

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Abstract We evaluated the use of a blocked-trials procedure to establish complex stimulus control over intraverbal responses. The participants were four young boys with a diagnosis of autism who had struggled to master intraverbals. The blocked-trials procedures involved presentation of stimuli in separate trial blocks. The trial blocks gradually reduced in size contingent upon correct responding, until the stimuli were presented in quasi-random order. All participants acquired multiple discriminations with the blocked-trials procedure, although additional procedures were needed to teach the first discrimination with two participants. Following acquisition of multiple discriminations, two participants acquired a novel discrimination with quasi-random presentation of stimuli, and a third participant demonstrated discriminated responding in intraverbal probes.

Keywords Autism · Blocked-trials procedure · Conditional discrimination · Intraverbal · Stimulus control · Verbal behavior

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In B.F. Skinner's taxonomy, the intraverbal describes verbal behavior that is evoked by verbal discriminative stimuli (SDs) and maintained by generalized reinforcement (Skinner, 1957). Intraverbal behavior is a broad category that can include such diverse responses as answering questions, conversational exchanges, reciting formulas and recipes, and completing somebody else's statements. Due to its characteristic antecedents and consequences, it is an important component of everyday social interactions and academic skills (Vargas, 1986).

Individuals with autism spectrum disorder (ASD) are characteristically delayed or deficient in their verbal development (Luyster & Lord, 2009). For those that acquire language, their verbal repertoires may be limited in functionality and complexity relative to same-age typically developing peers (Tager-Flusberg, Paul, & Lord, 2005). Consistent with this notion, Sundberg and Sundberg (2011) found that some children with ASD persist in making errors that are characteristic of an earlier stage of language development. As an example, a child might have learned to say "five" when asked "How old are you?" Subsequently, when someone asks "How are you?" she continues to answer "five" suggesting that all the relevant components of the verbal antecedent have not yet gained stimulus control over her responding.

Axe (2008) suggested that restricted stimulus control in intraverbal behavior could be conceptualized as a failure to establish conditional stimulus control. The characteristic errors would then be considered instances of simple stimulus control, where conditional stimulus control is needed. For example, a child might learn to answer the question "What is your name?" by stating their own name. When asked, "What is your mother's name?" or "What is your father's name?" the child might still respond with their own name. In order to establish correct responding, the words "mother" and "father" would have to become conditional stimuli that change the function of the phrase "What is your name?" (Axe, 2008; Mackay, 1991). Alternatively, one might view this as an issue of control by stimulus compounds. With this account, the issue is not whether individual components of the sentences change the stimulus functions of other components. Rather, errors occur because two or more components of the antecedent stimulus "What is your mother's name?" and "What is your father's name?" have not yet gained control as stimulus compounds (Eikeseth & Smith, 2013). This can also be viewed as an example of a failure to develop appropriate convergent stimulus control (Michael, Palmer, & Sundberg, 2011). A third possibility is to view incorrect responses to these questions as due to a failure to establish configural stimulus control, in which the response is under the control of the whole sentence, with no independent control by sentence components (Devine, Carp, Hiatt, & Petursdottir, 2016; Pearce, 2002). In any case, an intervention involving discrimination training to establish the desired stimulus control is indicated.

Several previous studies on intraverbal training have shown the effectiveness of transfer-of-stimulus control procedures to establish intraverbal responses in individuals with and without developmental disabilities (e.g., Coon & Miguel, 2012; Goldsmith, LeBlanc, & Sautter, 2007; Ingvarsson & Hollobaugh, 2011; Ingvarsson & Le, 2011; Miguel, Petursdottir, & Carr, 2005; Partington & Bailey, 1993; Vedora, Meunier, & Mackay, 2009; Watkins, Pack-Teixeira, & Howard, 1989). However, previous research on intraverbal training has typically not involved the arrangement of verbal antecedents

in the manner needed to ensure control by multiple stimulus components (Axe, 2008). An exception is a study by Braam and Poling (1983), who evaluated the use of picture prompts (i.e., tact-to-intraverbal transfer-of-stimulus control) to teach intraverbal responses to adolescents and adults with intellectual disabilities who communicated using signs. After exploring the use of error correction and delayed prompting, the authors arranged verbal antecedents in order to teach intraverbal responses under conditional stimulus control. They did this by alternating presentations of verbal stimuli that included two overlapping components, such as “school people,” “home people,” “school things,” and “home things.” Only by presenting overlapping components can appropriate conditional stimulus control be established and tested. To illustrate, if Braam and Poling had only taught “school people” and “home people,” the resulting discriminated responding might have been under the control of only the words “school” and “home”; “people” might exert no stimulus control.

Most of the research in the area of conditional discrimination training has focused on auditory-visual and visual-visual conditional discriminations. In auditory-visual conditional discriminations, auditory samples (e.g., spoken names of items) serve as conditional stimuli that modify the discriminative properties of visual comparison stimuli (e.g., pictures of corresponding items presented in an array). Visual-visual conditional discriminations are similar, except that the sample is a visual stimulus. Teaching conditional discriminations to individuals with intellectual and developmental disabilities often presents challenges (McIlvane, Dube, Kledaras, Iennaco, & Stoddard, 1990; McIlvane, Kledaras, Iennaco, McDonald, & Stoddard, 1995). When teaching conditional discriminations, instructors typically present auditory or visual samples in quasi-random order and implement prompting, error correction, and differential reinforcement as needed (e.g., Carp, Peterson, Arkel, Petursdottir, & Ingvarsson, 2012). To further facilitate acquisition and reduce the number of errors, several researchers have evaluated an approach referred to as the *blocked-trials procedure* (e.g., Gollin, 1965; Saunders & Spradlin, 1990; Slocum, Miller, & Tiger, 2012; Smeets & Striefel, 1994; Williams, Perez-Gonzales, & Queiroz, 2005). In its most common form, this procedure consists of presenting sample stimuli in alternating blocks of trials, with the blocks becoming gradually smaller contingent upon mastery criteria and ending with sample stimuli randomly interspersed.

Several studies have demonstrated that the blocked-trials procedure can help establish conditional discriminations when other methods have failed. A series of experiments by Saunders and Spradlin (1989, 1990, 1993) with adults with intellectual disabilities illustrates the potential utility of the blocked-trials approach. In the first study (1989), two participants did not acquire visual-visual conditional discriminations involving arbitrary symbols after they were taught to discriminate between the sample stimuli when presented successively (i.e., one at a time) and comparison stimuli when presented simultaneously (i.e., side by side). The blocked-trials procedure (Experiment 2B in Saunders & Spradlin, 1989) consisted of presenting alternating blocks of trials in which the sample stayed constant within each block. That is, the same sample stimulus was presented during each trial within the trial block, while the position of the comparison stimuli changed randomly. Contingent upon meeting accuracy criteria, the trial block ended and another trial block began, in which the other sample stimulus was presented on every trial, until the accuracy criteria were met. Initially, the trial

blocks were presented in separate sessions with breaks in between. When the participants responded with high accuracy in both types of trial blocks, the experimenters presented the blocks in greater temporal proximity (i.e., alternating blocks of 16 trials within the same session) and then gradually reduced the number of trials in each block until the participants responded accurately when the trial types were presented randomly. Saunders and Spradlin replicated and extended this finding in two subsequent studies (1990, 1993), demonstrating the benefits of differential sample naming (i.e., tacting). The sample names may have functioned as differential observing responses, which have been shown to facilitate discrimination learning (Cohen, Looney, Brady, & Aucella, 1976; Kisamore, Karsten, Mann, & Conde, 2013; Wyckoff, 1952). Additionally, the authors found that for most participants, discrimination learning under trial-and-error conditions occurred more readily after the participants had acquired several conditional discriminations.

Subsequently, several researchers have evaluated variations of the blocked-trials procedure with visual-visual conditional discriminations. Smeets and Striefel (1994) found success with a procedure in which the location of comparison stimuli was at first held constant while sample stimuli were randomly alternated, and then alternated contingent upon performance that met the mastery criteria. Perez-Gonzalez and Williams (2002) followed up on this study by evaluating a procedure in which comparison location was initially held constant (as in the Smeets & Striefel study) while the sample stimulus remained constant until a specific number of correct responses occurred. The other sample was then presented until the same criterion was reached. Contingent upon meeting the mastery criteria, the experimenters reduced the number of consecutive correct responses required in each block. Subsequently, the comparison location was reversed and sample presentation was randomized. Five children with ASD and intellectual disabilities successfully learned either visual-visual or auditory-visual conditional discriminations using this approach, which the authors referred to as the *combined blocking procedure*.

The main purpose of the current study was to evaluate the effectiveness and efficiency of a blocked-trials procedure, similar to the one described by Perez-Gonzalez and Williams (2002), in establishing conditional stimulus control over intraverbal responding with children with ASD. A secondary purpose was to evaluate whether participants would be more likely to acquire intraverbal discriminations using random interspersal (i.e., without blocked trials) following acquisition of several targets.

Method

Participants

The participants were four children with a diagnosis of ASD, conferred by an independent clinician, who were enrolled in a day program at a multidisciplinary center for children with developmental disabilities. Participants were recommended for the study by their supervising clinicians due to skill deficits in intraverbal behavior. All participants were able to answer some questions prior to the study but had specific deficits in terms of auditory discriminations.

All participants had good to excellent mand, tact, and echoic repertoires, as shown by their progress in the center's individualized curricula (additional information available from first author upon request). All participants spoke in three-to-six-word sentences and followed simple instructions. Andrew, Doug, and Ricky had participated in previous studies on intraverbal training (Ingvarsson & Le, 2011; Ingvarsson, Cammilleri & Macias, 2012). All participants attended the center 5 days per week, except Andrew, who attended 2 days per week. Praise typically functioned as a reinforcer for these participants' behavior during instructional tasks, and praise was used as the reinforcer through the study.

Doug was a 6-year-old Caucasian boy who had attended the center's school for children with developmental disabilities for 1 year and 3 months prior to this study and the center's autism intervention program for 1 year prior to that. Approximately 1 year and 6 months prior to this study, his IQ was measured at 58 using the Wechsler Preschool and Primary Scale of Intelligence III (WPPSI-III). At the same time, he received a standard score of 66 on the Peabody Picture Vocabulary Test, Fourth Edition (PPVT-IV), of receptive language and 63 on the Expressive One-Word Picture Vocabulary Test (EOWPVT) of expressive language. Three months prior to the study, Doug's reading age equivalence was measured at 5 years and 9 months using the Woodcock-Johnson III achievement test (WJ-III; Woodcock, McGrew, & Mather, 2001). Doug had mastered some intraverbal programs, including answering how, who, what, why, where, when, and personal information questions.

Ricky (Doug's twin brother) was a 6-year-old Caucasian boy who had attended the school and autism intervention program for the same length of time as Doug. Approximately 1 year and 6 months prior to this study, his IQ was measured at 59 using the WPPSI-III. At the same time, he received a standard score of 75 on the PPVT-IV test of receptive language and a standard score of 61 on the EOWPVT test of expressive language. Three months prior to the study, his reading age equivalence was measured at 6 years and 1 month using the WJ-III. Ricky had mastered some intraverbal programs, including answering how, who, what, why, where, and personal information questions.

Danny was a 6-year-old Caucasian boy who had attended the center's school for children with developmental disabilities for 2 years. Approximately 2 years prior to this study, his IQ was measured at 88 using the WPPSI-III. Danny's reading age equivalence was identified as 6 years and 4 months using the WJ-III, administered around the same time that he started the study. Danny had mastered some intraverbal programs, including answering how, who, what, why, when, where, and personal information questions.

Andrew was an 8-year-old African American boy who had been enrolled in the center's autism intervention program for 1 year and 10 months at the time of the study. Approximately 1 year prior to this study, his IQ was measured at 52 using the WISC-IV. Two months after the completion of this study, Andrew received a standard score of 62 on the PPVT-IV test of receptive language and 77 on the EOWPVT test of expressive language. Andrew had mastered multiple intraverbal programs. These included filling in words from a song, rote counting, naming opposites, naming class when given examples, giving multiple examples for categories, filling in functions, filling in features, filling in the name of the item, and filling in animal sounds. Andrew had mastered what, where, who, which, how, why, and personal information intraverbal question answering programs.

Setting

Sessions were conducted in a small library at the center. The library was approximately 5.5 m × 4.3 m and contained multiple bookshelves, child-sized tables and chairs, a computer, a printer, and various decorations. The experimenter and the child sat facing each other. The observer(s) sat approximately 2 m from the experimenter and the child. The only people in the library during sessions were the experimenter, the child, and one or two observers.

Stimulus Sets

All stimulus sets consisted of questions that the experimenters presented vocally. The table shows the question pairs and stimulus sets for each participant. The stimuli consisted of question pairs that took the form “What do you _____?” vs. “What do you _____ with?” Each stimulus set consisted of four such question pairs. Two question sets, or a total of eight question pairs, were included for each participant. The question pairs were grouped into sets for the purpose of interspersing the questions during intraverbal probes. We selected the targets based on the participants’ error patterns during pretests. For instance, if a participant answered the questions “What do you sweep with?” and “What do you sweep?” with the same answer (e.g., “floor”), that question pair was included. We also conducted probes to ensure that the participants could tact and/or respond as listeners to all the stimuli.

Measurement, Interobserver Agreement, and Procedural Fidelity

Observers used pencils and session-specific data sheets to collect data on correct, incorrect, and prompted answers. Correct answers were defined as those that matched the experimenter-defined target answers and had to occur without prompts and within 5 or 10 s of the question depending on the condition. Incorrect answers were defined as any answers that did not match the defined target answers, including giving no answer. Prompted answers were defined as answers that matched the experimenter’s vocal prompt and occurred within 5 s of the prompt.

The number of correct answers during intraverbal probes was the main dependent variable. Because multiple possible answers exist for many of the questions, the observers also narratively recorded any alternative answers that occurred. In some cases, the defined correct responses were determined by the participants’ answers during pretests. For Doug, two designated correct answers were changed based on his answers during the first probe session. Danny was the only participant that alternated between more than one correct answer for a given question. For him, two or three answers were defined as correct for some questions (see Table 1).

A second observer independently collected data during 51.1 % of sessions for Doug, 38.5 % of sessions for Ricky, 25.6 % of sessions for Danny, and 35.5 % of sessions for Andrew. Agreement between the two observers was noted if all scoring on a given trial was identical. A trial began when the experimenter presented a question and ended either with a prompted or independent answer by the participant. Interobserver agreement (IOA) was calculated by dividing the number of agreements by the total number of trials in each session. We obtained IOA data for at least 20 % of sessions in each

Table 1 Stimulus sets for all participants

Participant	Set 1	Set 2
Doug	1. Play (games; toys) ^a 2. Wash (hands; soap) ^a 3. Sweep (floor; broom) ^a 4. Color (paper; crayon) ^a	5. Kick (ball; leg) ^a 6. Hear (sound; ear) ^a 7. Taste (flavors; mouth) ^a 8. Paint (picture; paintbrush) ^a
Ricky	1. Wash (hands; soap) ^a 2. Sweep (floor; broom) ^a 3. Color (paper; crayon) ^a 4. Play (games; toys) ^a	5. Kick (ball; leg) ^a 6. Hear (music; ears) ^a 7. Taste (food; mouth) 8. Paint (picture; paintbrush)
Danny	1. Kick (soccer ball; legs/feet) ^a 2. Hear (sound/music; ear) ^a 3. Eat (food; fork) ^a 4. Write (letters/words; pencil) ^a	5. Color (paper/picture; crayon) ^a 6. Dig (dirt/ground; shovel) ^a 7. Paint (picture/paper/wall; paintbrush) ^b 8. Brush (hair; hairbrush) ^b
Andrew	1. Sweep (floor; broom) ^a 2. Wash (hands; soap) ^a 3. Color (paper; crayon) ^a 4. Play (games; toys)	5. Kick (ball; leg) 6. Hear (sound; ear) 7. Taste (flavors; mouth) 8. Paint (picture; paintbrush)

The number in front of the set name indicates the question pair number. The two words in parenthesis are the answers to the two questions (i.e., “what do you ___?” and “what do you ___ with?”) given by each participant

^a Denotes discriminations that were directly taught using the blocked-trials procedure

^b Denotes discriminations that were acquired in intraverbal probes

condition for all participants. IOA averaged 99.8 % (range, 93.3–100 %) for Doug, 99.7 % (range, 85.7–100 %) for Ricky, 100 % for Danny, and 99.8 % (range, 93.8–100 %) for Andrew.

A separate data sheet was used to collect data on procedural fidelity during 32.2 % of sessions for Doug, 25.2 % of sessions for Ricky, 21.8 % of sessions for Danny, and 29.1 % of sessions for Andrew. During intraverbal probes, the observers scored whether the experimenter presented the questions correctly, provided sufficient time to respond (10 s), delivered praise following correct answers only, and refrained from prompting. During intraverbal training, the observers scored whether the experimenter presented the questions correctly, switched between blocks following the correct number of correct answers, delivered reinforcement following correct answers, and implemented the prompting procedures correctly. Procedural fidelity was calculated by dividing the number of steps implemented correctly by the total number of steps in each session and converting the number to a percentage. Procedural fidelity averaged 99.6 % (range, 95.7–100 %) for Doug, 99.9 % (range, 96.9–100 %) for Ricky, 99.9 % (range, 97.8–100 %) for Danny, and 99.9 % (range, 96.7–100 %) for Andrew. In order to obtain IOA for the procedural fidelity data, a second observer collected data during a subset of the sessions in which procedural fidelity data were collected. IOA for fidelity data were collected for 37.5 % of sessions for Doug, 27.1 % of sessions for Ricky, 31.3 % of sessions for Danny, and 34.4 % of sessions for Andrew. IOA was calculated by determining agreements and disagreements by comparing observers’ scoring of each

procedural step within a session. The number of agreements was then divided by the total number of steps within the session, and the resulting number converted to a percentage. IOA for procedural fidelity averaged 100 % for Doug and Ricky, 99.6 % (range, 98.4–100 %) for Danny, and 99.8 % (range, 98.9–100 %) for Andrew.

Experimental Design

The effects of the blocked-trials procedure on discriminated intraverbal responding were evaluated using a concurrent multiple probe design across question pairs. Following mastery of each question pair, the experimenter conducted a comprehensive intraverbal probe (i.e., all targets). Intraverbal probes were usually conducted immediately after a question pair had been mastered or the following day. In addition, pretests and posttests were conducted with Ricky and Doug to evaluate whether experience with the training procedures produced accurate responding in the absence of the blocked-trials procedure.

Procedures

Overview Initial intraverbal pretests were conducted to identify question pairs that indicated possible restricted stimulus control. Next, a series of intraverbal probes were conducted with sets of question pairs presented in quasi-random order until stable responding occurred. Next, intraverbal training (i.e., the blocked-trials procedure) was conducted with one question pair at a time until the mastery criterion was reached, according to a multiple probe across question pair designs. For some participants, additional procedures were needed to achieve mastery of the first question pair. Following mastery of each question pair, intraverbal probes for all target questions were conducted. For two participants, intraverbal training using random presentation (i.e., without blocked trials) was probed prior to blocked-trials training for the first question pair and following the training of the last question pair. Throughout the study, session length varied, but each participant typically participated for 5–15 min per day.

Intraverbal Pretest This preliminary test was conducted to identify potential questions to include in baseline probes. The pretest consisted of questions that were designed to identify potential restricted stimulus control (e.g., “What do you taste with?” “What do you taste?”). The question pairs differed by only one word, yet had different correct answers. The questions were arranged in a quasi-random order. The paired questions were not presented in close temporal proximity (e.g., “What do you taste?” was not presented immediately or shortly after “What do you taste with?”).

During the pretest, the experimenter presented each question once. No prompts were delivered. Each pretest session consisted of 10–15 trials. Correct answers were followed by descriptive praise. Incorrect answers were followed by a brief pause, and then the next question was presented. Because all four participants answered nearly half of the pretest questions correctly, it was not necessary to intersperse maintenance tasks to ensure sufficient density of reinforcement. During the pretest, the protocol called for the experimenters to reinforce novel, but correct responses as they occurred. When this occurred, the definition of a correct answer was adjusted accordingly for that participant, as described above.

Intraverbal Probes Intraverbal probes were conducted both before intervention (i.e., baseline) and after intervention to evaluate the effects of the independent variable (i.e., the blocked-trials procedure). Two sets of four question pairs were selected based on two criteria. First, the participant had to give the same answer for each question during the pretest, provided that the answer was correct for one of the questions (e.g., answering “Floor” to both “What do you sweep with?” and “What do you sweep?”). Due to this selection criterion, it would be expected that the participants would typically answer correctly half of the time during baseline intraverbal probes (i.e., 50 % correct indicates lack of discriminated responding). Second, of the question pairs that met the first criterion, question pairs that had a smaller number of potential correct answers (i.e., relatively less “ambiguous”) were selected. Eight question pairs were selected for each participant, and they were grouped into two sets of four question pairs.

During probe sessions, the eight questions from each set were presented in quasi-random order (i.e., never two consecutive trials of the same question). Each question was presented twice for a total of 16 trials per set. The total number of trials during each probe session depended on whether one set was probed (16 trials) or both sets were probed (32 trials). When both sets were included, they were probed successively (i.e., questions from both sets were not interspersed). During both preintervention and postintervention probes, correct answers were differentially reinforced by delivering descriptive praise (e.g., “that’s right, you sweep with a broom”) following correct answers and moving to the next question after incorrect answers. Because the participants typically answered at least 50 % of the questions correctly, it was not necessary to intersperse maintenance tasks.

Intraverbal Training: General Procedures During intraverbal training, the experimenter delivered descriptive praise (i.e., a previously determined reinforcer for each child) contingent on correct answers. Following incorrect answers, the experimenter immediately delivered a vocal model of the correct answer (e.g., “Say floor”). The prompt was also delivered if the participant had not responded within 5 s of the question (i.e., constant prompt delay). The prompt was repeated as necessary until the child responded. Prompted responses were followed by descriptive praise, and the experimenter then moved to the next trial. Thus, the general training procedures consisted of constant prompt delay and error correction.

During training, no tangible reinforcers were delivered following correct responses, but the participants were given access to preferred items of their own choosing (e.g., books, toys) prior to and following sessions. A 1–2-min break was scheduled every 5 min, during which the participants had access to the preferred items. The training sessions varied in length, but typically lasted between 5 and 15 min.

Intraverbal Training: Blocked Trials The independent variable was a discrimination training procedure involving the presentation of blocked trials (Perez-Gonzalez & Williams, 2002; Saunders & Spradlin, 1989, 1990). The procedure included 5 steps. To maximize the efficiency of training and reduce unnecessary exposure to mass-trial procedures, each participant started with step 3 and progressed through steps 4 and 5 if successful with step 3. However, if the mastery criteria were not met in step 3 following 12 trial blocks and an increasing trend in the number of incorrect responses was observed, the participant was taught using step 1 and then progressed through the

remaining steps (2, 3, 4, and 5). The same would have occurred if a participant had been unable to meet the trial block mastery criterion (i.e., 10 consecutive correct answers) within two sessions. Andrew was the only participant who was taught using all 5 steps for the first question pair that was taught. The other participants progressed through steps 3–5 only.

The first step in the blocked-trials procedure was presentation of each question until 10 consecutive correct answers occurred (i.e., one *trial block*), at which point the experimenter presented the other question until 10 consecutive correct answers occurred (i.e., the next *trial block*), and so on. The criterion to move to the next step was 4 consecutive trial blocks with no more than 2 incorrect answers in each block. The second step in the blocked-trials procedure was presentation of each question until 8 consecutive correct answers occurred, at which point the experimenter presented the other question until 8 consecutive correct answers occurred, and so on. The criterion to move to the next step was 4 consecutive trial blocks with no more than 1 error in each block. In the third step, each question was presented until 5 consecutive questions occurred, and the criterion to move to the next step was 4 consecutive trial blocks with no incorrect or prompted answers. In the fourth step, the two questions were presented in alternating and counterbalanced blocks of 2 and 3 trials until 15 consecutive correct answers occurred. In the fifth step, the 2 questions were presented in a quasi-random order (i.e., random, but could not occur more than 3 times consecutively) until 15 consecutive correct answers occurred.

Intraverbal Training: Individualized Procedures Because it proved difficult to teach discrimination of the first question pair to Doug and Ricky, the experimenter implemented additional teaching procedures for that question pair. Both of these participants often answered the questions with multiword phrases, which were not always grammatically correct (e.g., “You sweep with a floor”). The words that the participants were adding could potentially result in unwanted intraverbal stimulus control that might interfere with the target discrimination. The experimenter added an error correction procedure in the form of vocally prompting the correct single word response whenever the participant answered with a multiword phrase. No other question pairs required this procedure.

One additional procedure was implemented for step 3 of Ricky’s first question pair for discrimination training. He repeatedly failed to change his response when the question changed; however, only one prompt was needed in almost every trial block. Therefore, Ricky’s responding seemed to be under the control of the last prompted or reinforced response rather than the verbal antecedent stimulus (i.e., the question). The experimenter inserted a series of three distracter trials (i.e., previously mastered fluent intraverbals) in rapid succession between each trial block during step 3 of the blocked-trials procedure. The experimenter praised correct responses and presented the next trial block immediately.

Remedial Training Remedial training involved repeating step 5 of the blocked-trials procedure. When only 1 question pair was included in remedial training, the procedure was implemented until 15 consecutive correct responses occurred. When more than 1 question pair was included, all questions were randomly interspersed and taught to the same mastery criterion.

For Doug and Ricky, remedial training was conducted at various points of the blocked-trials phase if more than 1 incorrect response occurred during a probe involving previously mastered questions. However, we almost always repeated the probe before conducting remedial training. If correct responding recovered in the repeated probe, we did not conduct remedial training. An exception was made with Doug following probe session 10, in which answers reverted to chance levels for all previously mastered questions. An additional exception was the remedial training following session 13 with Doug. There, he had only made 1 error in 2 consecutive probes. As stated above, the general rule was to conduct remedial training only if more than 1 incorrect response occurred per probe. However, we still decided to conduct remedial training in this case, because the same incorrect answer occurred during 2 consecutive probes for the most recently trained question pair (i.e., he had not yet demonstrated reliable responding to that question pair, indicating the need for additional training).

The experimenter generally conducted remedial training with all mastered questions in a given question set even if some had been answered correctly. However, with Ricky, the experimenter sometimes only trained the errant question pair to avoid excessively long participation in the study due to his greater number of training sessions than the other participants.

The experimenter conducted remedial training only once (i.e., following probe session 8) with Danny. Danny's errant responding typically improved in subsequent probes; therefore, no further remedial training was deemed necessary for him. Andrew never met the general criterion for remedial training.

Criterion-Level Intraverbal Probes The experimenter conducted these probes prior to the first intraverbal probe for Doug, Ricky, and Danny and immediately following the last intraverbal probe with Doug and Ricky to determine whether correct responding occurred without the blocked-trials procedure. The experimenter presented the 2 questions quasi-randomly, such that a single question could not appear more than 3 times consecutively (i.e., similar to step 5 of the blocked-trials procedure). The training was divided into 15-trial blocks, with the number of questions counterbalanced across trial blocks (e.g., if 1 question appeared 7 times in the first block, it appeared 8 times in the second block). The experimenter conducted a minimum of 6 trial blocks (i.e., 90 trials) with each participant. If acquisition was not evident after 90 trials, the pretest stopped and the blocked-trial training started. All 3 participants required the blocked-trials training.

For Doug and Ricky, this probe was repeated at the end of the experiment using a novel question pair, in order to evaluate whether novel discriminations could now be acquired without the blocked-trials procedure. For Doug, the question pair used in the pretest was "What do you play (with)?" and the question pair used in the posttest was "What do you drink (with)?" For Ricky, the question pair used in the pretest was "What do you hear (with)?" and the question pair used in the posttest was "What do you taste (with)?" It was not necessary to conduct this posttest with Danny, because he had begun to respond correctly to untrained question pairs in intraverbal probes toward the end of the experiment.

Fig. 2 The results of the intraverbal probes for Danny (*top panel*) and Andrew (*bottom panel*). The number inside each cell indicates the number of correct answers (out of four) for each question pair in a particular probe session. Dark grey shading indicates four out of four were correct, and light grey indicates three out of four were correct. Dashed lines indicate when remedial training was implemented

Danny's intraverbal probe results are shown in Fig. 2 (top panel). Danny answered two or fewer questions correct for each question pair in baseline sessions. For the first six question pairs, performance improvements occurred only after intraverbal training. In a few instances, accurate responding decreased, but responding typically improved when the probe session was repeated. Remedial training was implemented once. Unlike the other participants, Danny acquired responses to the last two question sets under baseline conditions so no blocked-trials intraverbal training was required.

Andrew's results are shown in Fig. 2 (bottom panel). In baseline, Andrew answered two or fewer questions for each question pair in every session. Following blocked-trials intraverbal training, Andrew answered 100 % correctly for almost all questions in all probes. Andrew's participation was discontinued after training of three question pairs, because he was discharged from the autism services program and transitioned to a public school.

We calculated trials to criterion during the blocked-trials procedure across consecutive question pairs for all four participants. A minimum of 50 trials was required to

meet the mastery criterion for each question pair. With Doug and Ricky, a “learning set” effect (Harlow, 1949) was evident following teaching of the first two question pairs, in that subsequent question pairs required fewer trials to reach mastery. A learning set effect was also suggested by Andrew’s data, although it was less clear due to the limited number of question pairs taught. However, Danny’s trials to criterion were variable. For Doug, the trials to criterion were as follows: set 1, 274; set 2, 77; set 3, 118; set 4, 106; set 5, 108; set 7, 72; and set 8, 59. For Ricky, the trials to criterion were set 1, 191; set 2, 231; set 3, 63; set 4, 72; set 5, 78; and set 6, 83. For Danny, the trials to criterion were set 1, 94; set 2, 72; set 3, 254; set 4, 96; set 5, 138; and set 6, 61. The trials to criterion for Andrew were set 1, 516; set 2, 84; and set 3, 269.

The size of the trial blocks was modified while teaching the first question pair to Andrew due to the difficulty acquiring the set (note that this was considered part of the standard procedure). During the initial step 3 for question pair 1, there was an increasing trend in the number of incorrect answers across 12 trial blocks. The experimenter, therefore, implemented training steps 1 and 2, which had a greater number of trials in each block (i.e., 10 and 8, respectively). Training step 1 resulted in a reduction in incorrect answers, but 14 trial blocks were still needed until the advancement criterion was met. Andrew then proceeded quickly through the remaining training steps (i.e., 2, 3, 4, and 5). Blocked-trials steps 1 and 2 were not required for the 2 remaining question pairs.

Some modifications to the standard blocked-trials procedure were required for Doug and Ricky, but only for the first question pair taught. For both of these participants, an additional error correction procedure was required for the first question pair only. For Ricky, distracter trials were inserted during step 3 with the first question pair only.

Figure 3 shows the number of prompted responses across consecutive 15-trial blocks in the criterion-level intraverbal pretest and posttest probes for the 2 participants for whom we had a full preset and postset, Doug and Ricky. In the pretest criterion-level probe, a stable pattern was present for both participants, suggesting that quasi-random presentation of the 2 questions using delayed prompting and error correction was not sufficient to teach the discrimination. The posttest criterion-level probes were conducted with a previously untaught question pair following mastery of 8 discriminations by Doug and 6 by Ricky. The posttest results show that both participants were able to learn with quasi-random presentation following experience with the blocked-trials procedure. Doug met the 15-consecutive-trials-correct mastery criterion in the second trial block, while Ricky did not meet the criterion until the seventh trial block. However, fewer prompts were needed with Ricky compared to the pretest criterion-level probe.

Discussion

We evaluated the effects of a blocked-trials procedure on the acquisition of complex intraverbal discriminations in four boys with diagnoses of ASD. All four participants learned multiple discriminations using the procedure, although procedural modifications were needed to teach the first discrimination with two participants. However, both of these participants subsequently learned multiple discriminations solely through the blocked-trials procedure. Two participants demonstrated a learning-to-learn effect, in that trials to criterion decreased across successive discriminations taught. One

Fig. 3 Precriterion- and postcriterion-level intraverbal probes for Doug (*top panel*) and Ricky (*bottom panel*). Number of prompted responses out of 15 is shown across consecutive 15-trial blocks. Because the mastery criterion was 15 consecutive correct answers, the last trial block for the posttest contained fewer than 15 trials (3 for Doug, and 8 for Ricky)

participant (Danny) acquired two discriminations in baseline probes after learning several discriminations via the blocked-trials procedure. Two additional participants (Doug and Ricky) were able to learn a novel discrimination without the use of the blocked-trials procedure at the end of the study.

The current study adds to the literature on intraverbal training by exploring the use of blocked-trials procedures (e.g., Perez-Gonzalez & Williams, 2002; Saunders & Spradlin, 1990) to establish conditional stimulus control over intraverbal behavior (Axe, 2008; Sundberg & Sundberg, 2011). Intraverbal probes were arranged to allow for evaluation of potential control exerted by multiple components of the verbal antecedent stimulus (i.e., question). To illustrate, the probes consisted of questions such as “What do you sweep with?” “What do you sweep?” “What do you eat with” and “What do you eat?” For responding to be sufficiently accurate, the intraverbal responses would have to come under the stimulus control of the words “sweep” vs. “eat,” as well as the presence vs. absence of “with.” Only one prior study on intraverbal behavior has arranged verbal stimuli with multiple overlapping components to establish complex discriminations (Braam & Poling, 1983).

Variations of blocked-trial procedures have been used in studies on discrimination training in the past (e.g., Gollin, 1965), and their clinical use has been recommended in Ivar Lovaas’ influential treatment manuals, although the term “blocked trials” has not always been used. Lovaas (1981, p. 136) recommended using a variation of a blocked-trials procedure when teaching receptive labels (see also Lovaas, 2003, p. 113).

However, to our knowledge, there is no previously published research on using the blocked-trials approach to teach intraverbal behavior.

There are several possible reasons why the blocked-trials procedure used in the current study facilitated discriminated performance. First, repeated presentations of the same antecedent stimulus in trial blocks may eliminate errors due to participants responding in accordance to a “win-shift” strategy (Lovaas, 2003, p. 114). The win-shift strategy consists of switching to the other response when one response is reinforced. In the current study, Andrew’s response pattern during early portions of the first discrimination training was frequently consistent with this pattern. Second, presenting stimuli in blocks of trials might serve to overcome blocking effects caused by previous learning. That is, if a child has learned to answer the question “What do you wash?” by saying “hands,” this history of learning may block the establishment of stimulus control by the sentence “What do you wash with?” Third, it is possible that the procedure resulted in the change in antecedent stimuli (i.e., changing from one question to the next) becoming more salient, therefore increasing the likelihood of learning. Fourth, by presenting blocks of trials, participants may initially be more likely to respond correctly, which would result in a higher density of reinforcement. The higher density of reinforcement may in turn increase participant motivation and attention to task, resulting in faster learning. Fifth, the blocked-trials procedure may be particularly well suited to intraverbal training because auditory stimuli are fleeting relative to visual stimuli, and repeated presentation of the same auditory stimulus complex might increase the likelihood of stimulus control being established. However, use of trial blocks essentially constitutes a massed-trial procedure, which may not be indicated in every case (cf. Grow, Carr, Kodak, Jostad, & Kisamore, 2011). Further research is needed to determine the conditions under which blocked trials are beneficial.

Because the current approach to discrimination training and testing for stimulus control was derived from research on conditional discriminations, this term has frequently been used to describe this particular form of complex stimulus control. However, convergent control by stimulus compounds is a plausible alternative conceptualization (Eikeseth & Smith, 2013; Michael et al., 2011). With the conditional account, one stimulus component changes the function of another component (e.g., “wash” evokes either “soap” or “hands” dependent on the presence or absence of “with”). With the compound account, discrimination training results in convergent stimulus control by two or more components of the antecedent verbal stimulus. The methods used in the current study do not allow us to determine which account is correct. However, future studies could further explore the nature of complex verbal stimulus control by presenting the stimulus components in isolation and in different combinations.

The blocked-trials procedure was effective in establishing complex stimulus control over intraverbal responses for these participants. However, there are several limitations that should be noted. First, it is unclear that the blocked-trials procedure was necessary in all cases. It is possible that following acquisition of one or two discriminations, simpler procedures might have been sufficient to teach the remaining question pairs. Future research should address this limitation by implementing more frequent criterion-level probes during the course of the study.

A second limitation is the lack of clarity about any potential stimulus control exerted by the sentence frame “what do you” over responding. The probes with overlapping

components ensure stimulus control by multiple components; however, the probes do not ensure control by all parts of the verbal antecedent. Additionally, it is not clear whether stimulus control was exerted by entire words, or just parts of words (e.g., the first syllable). Further, we cannot be certain that the specific verbal topography “with” exerted stimulus control over responding as any word (e.g., who) added to the end of the sentence could have altered responding similarly. Future research could evaluate the precise nature of stimulus control in more detail by systematically altering the topography of the stimulus components.

A third limitation is that the blocked trial procedure was not sufficient to teach the first discrimination with Doug and Ricky. An error correction procedure was needed to eliminate incorrect answers that appeared to be the result of a deficient sentence frame. For Ricky, during the teaching of the first question pair, we observed that he frequently showed a response pattern consistent with a “win-stay” strategy (Grow et al., 2011; Lovaas, 2003). That is, he usually repeated the response that had been correct on the previous trial. This resulted in frequent errors (i.e., incorrect answers) on the first trial in each trial block. A “distracter” strategy, in which high-probability intraverbal responses were targeted in between trial blocks, seemed to reduce the likelihood of incorrect answers and facilitate learning. However, we did not replicate the effects of the “distracter” responses, and further evaluation of their effectiveness awaits further study. The need for additional procedures for some participants may indicate that the blocked-trials procedure would not be sufficient to teach complex intraverbal discriminations in all cases. However, the current results suggest that it can be a useful tool in clinical practice.

A fourth limitation of the current study is that only auditory (i.e., echoic) prompts were used and differential reinforcement was not used. Textual or picture prompts might be more effective with some individuals. However, echoic prompts had been shown to be effective with three of these clients in previous studies in which they had participated. Additionally, both independent and prompted responses were reinforced (i.e., by delivering descriptive praise) during blocked-trials intraverbal training. The procedure might have been more effective if independent responses were differentially reinforced (Hausman, Ingvarsson, & Kahng, 2014; Karsten & Carr, 2009; Touchette & Howard, 1984).

A fifth potential limitation is that the discrimination targets might have been difficult for these participants given their age and verbal skills. The differences between the verbal stimuli were minimal and subtle, and the discrimination may have been made even more challenging by the fleeting nature of the auditory stimuli. The similarity may be why limited generalization across question pairs was seen in the current study, despite the fact that all participants acquired multiple discriminations. Future studies might evaluate stimulus sets in which the difference between the stimuli is more salient.

In conclusion, the current results suggest that the blocked-trials procedure might be useful in intraverbal training with children with autism and other developmental disabilities. Practitioners might consider implementing the blocked-trials procedure when teaching discriminations between verbal stimuli that differ in minimal ways if acquisition does not occur with quasi-random presentation of stimuli. Periodic probes of the discrimination under criterion conditions (i.e., quasi-random presentation of multiple targets) are recommended to evaluate whether stimulus control has improved as a result of the blocked-trials procedure. Further research is needed to elucidate the

conditions under which the blocked-trials procedure is most effective in intraverbal training.

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Compliance with Ethical Standards

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Conflict of Interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the Human Subjects Institutional Review Board at University of North Texas and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained for all individual participants included in the study. Participants could leave the study at any time, and assent was obtained during each session.

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