Evaluating Three Methods of Stimulus Rotation when Teaching Receptive Labels

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Published online: 17 April 2018
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Abstract

The teaching of receptive labels (i.e., auditory-visual conditional discriminations) is common among early intervention programs for individuals diagnosed with autism spectrum disorder (ASD). Discrete trial teaching (DTT) is a common approach used to teach these receptive labels. Some have argued that the stimuli within the array, target and non-target, must be counterbalanced to prevent the development of undesired stimulus control. The purpose of the present study was to evaluate the effectiveness of three different approaches to stimulus rotation to teach receptive labels to five young children diagnosed with ASD. These approaches included counterbalanced, fixed, and clinician's choice. The results of an adapted alternating treatment design replicated across three stimulus sets and five participants indicated that all three methods of rotation were effective. Maintenance and generalization for targets taught in all three conditions was also assessed. The implications of the results with respect to current teaching practices in early intervention programs are discussed.

Keywords Autism · Conditional discrimination · Receptive label · DTT

Many professionals have expressed the potential benefits of teaching individuals diagnosed with autism spectrum disorder (ASD) receptive labels, which includes promoting expressive language, learning names associated with the object or picture, increasing attending, and following instructions (e.g., Leaf & McEachin, 1999; Lovaas, 2003). One common approach often used to teach individuals diagnosed with ASD receptive

labels is discrete trial teaching (DTT; Lovaas, 1981, 1987). DTT is commonly described as a three-step procedure that includes an instruction, the learner response, and a consequence based upon the learner's response. An optional fourth step is providing and fading prompts to facilitate correct responding (Wolery, & Gast, 1984). As applied to receptive language instruction, this approach typically consists of an instructor placing a stimulus array on the table, instructing the learner to identify the stimulus that corresponds with the instruction (e.g., the learner touching a picture of a ball following the instruction, "Find the ball"), and providing a consequence based on the learner's response. In addition to teaching receptive labels, researchers have found DTT to be effective for teaching expressive labeling (e.g., Conallen & Reed, 2016; Delfs & Frampton, 2014), play skills (e.g., Nuzzolo-Gomez, Leonard, Ortiz, Rivera, & Greer, 2002), question asking (e.g., Ingvarsson & Hollobaugh, 2010), and social skills (e.g., Shillingsburg, Bowen, & Shaprio, 2014). Researchers have also demonstrated the effectiveness of DTT when compared to other teaching approaches (e.g., Miranda-Linné & Melin, 1992).

Although researchers have found DTT to be an effective approach for teaching receptive labels for individuals with ASD, there are many variables that may alter the efficacy of DTT of receptive labels which warrant future research. Some

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of these variables include prompting and prompt fading procedures (Heckaman, Alber, Hooper, & Heward, 1998; Leaf et al., 2016b), introduction of new targets (e.g., Grow, Carr, Kodak, Jostad, & Kisamore, 2011; Gutierrez et al., 2009), instructional format (e.g., Taubman et al., 2001), topography of instructions and feedback (e.g., Leaf et al., 2017), staff training (e.g., following strict protocol or the use of clinical judgment; e.g., Grow & LeBlanc, 2013; Leaf et al., 2016a, 2016e), and rotation of stimuli while teaching receptive labels as it pertains to the position of each of the stimuli on the table.

One approach to help determine where to place stimuli when teaching receptive labels is a protocol outlining the counterbalancing of stimuli across all trials (Grow & LeBlanc, 2013). Counterbalancing consists of an instructor following a protocol with strict rules for how and when to rotate stimuli, where to place stimuli, and which stimulus to target on every trial. This protocol can consist of a table outlining where the stimuli should be placed, the target stimulus, the prompt used, and the participant's response on each trial. A protocol outlining counterbalancing helps ensure stimuli are evenly distributed across all possible positions (typically three: left, middle, and right). For example, if a clinician was teaching three different targets (e.g., ball, car, and dog), a protocol outlining counterbalanced trials ensures that each stimulus, targeted and non-targeted, will be placed in the left, middle, and right position on an equal number of trials. Rationales behind the use of a protocol utilizing counterbalanced trials include avoiding the development of faulty stimulus control, reducing responding to only one location (commonly referred to as a location bias), and increasing the rate of acquisition (Green, 2001; Grow & LeBlanc, 2013).

Counterbalancing of stimuli across all trials was first evaluated in the basic behavior research literature (e.g., Sidman et al., 1982; Sidman, 1992). Based upon the basic research, applied research, and, presumably, clinical practice, Green (2001) provided a seminal commentary on behavior analytic advances in stimulus control technology. In this commentary, Green provided recommendations for teaching match to sample tasks. These recommendations included rotating stimuli so the target stimulus is never placed in the same position across two consecutive trials, and that the placement of stimuli, both target and non-target stimuli, are balanced across trials. Green provided these recommendations for clinicians to avoid the development of undesired stimulus control and decrease potential learner errors during receptive instruction.

More recently, Grow and LeBlanc (2013) provided what the authors described as *best practice recommendations* for teaching receptive labels for individuals diagnosed with ASD. In this commentary, the authors recommended that clinicians counterbalance the trial order and placement of stimuli. Specifically, Grow and LeBlanc recommended that stimuli, target and non-target, be placed proportionately in the left, center, and right position across all conditions. The authors

provided Green's (2001) commentary to support their recommendation for the use of counterbalancing when teaching receptive labels. Finally, Grow and LeBlanc provided the readers with an example protocol of outlining counterbalanced trials when teaching receptive labels for individuals diagnosed with ASD.

Since the seminal basic studies on counterbalancing (i.e., Sidman et al., 1982; Sidman 1992) and the additional commentaries (i.e., Green, 2001; Grow & LeBlanc, 2013), professionals have promoted the use of counterbalancing (LeBlanc, 2014) and researchers have utilized counterbalancing when teaching individuals diagnosed with ASD. For example, Grow, Kodak, and Carr (2014) compared a conditional-only method to a simple-conditional method for teaching receptive labeling for two individuals diagnosed with ASD. The researchers used a counterbalancing procedure to rotate stimuli during the two teaching conditions. In another example, Grow and Hijde (2017) conducted a systematic replication of Grow et al. (2014). Specifically, Grow and Hijde compared a conditional-only to a modified simple-conditional method of teaching receptive labels of sight words for one student diagnosed with ASD. Although Grow and Hijde's purpose was to compare the most effective way to teach receptive labels of sight words, the authors used counterbalancing in the conditional-only, and the simple-conditional conditions.

Another approach that can be used to help determine the placement of stimuli, instead of a protocol with strict rules, is clinical judgment (Leaf et al., 2016e), or, when applied to teaching receptive labels, in-the-moment assessment of placement (IMAP). Similar to other approaches relying upon clinical judgment, such as in-the-moment reinforcer analysis (e.g., Leaf et al., 2016d) and flexible prompt fading (FPF; e.g., Leaf et al., 2016c; Lerman, Valentino, & Leblanc, 2016), the clinician determines, based on several variables, if and when to rotate target and non-target stimuli, rather than follow a predetermined counterbalanced order. These procedures fall within what has been described as a progressive approach to applied behavior analysis (ABA; for a detailed described, see Leaf et al., 2016e). Leaf et al. (2016e) suggested, while describing components of a progressive approach, that training the clinician to determine when to rotate stimuli may be a more preferred method when teaching individuals with ASD receptive labels. Leaf et al. (2016a) further expanded on a progressive approach when applied to DTT. The authors compared a progressive approach to DTT with a more conventional approach by outlining some guidelines of a progressive approach to DTT. Leaf et al. (2016a) argued that IMAP may be more beneficial to decrease location biases, ensuring that there is no stereotypic pattern of responding, and may be more efficacious when compared to counterbalancing for teaching receptive labels.

When clinicians use clinical judgment to determine the rotation of stimuli, they are responding based upon several variables. One of these variables involves identifying patterns

of responding such as location biases. If this is the case, the clinician may respond by never placing a target stimulus in the favored position. A second variable involves the rate of correct responses across trials. In this case, the clinician may respond by rotating stimuli more frequently to inform mastery. Another variable involves an incorrect response, which may result in the clinician determining to not move the stimuli or change the target to create an opportunity for the learner to acquire the target through exclusion. The opportunity to learn from mistakes is an important feature in a progressive approach to DTT (Leaf, 2012). Alternatively, the clinician may determine to change the target, but not move the stimuli, to prevent learning from exclusion, if the learner has adopted an automatic win-stay/lose-shift strategy. Win-stay/lose-shift is a strategy learners sometimes adopt of choosing the location or target that was reinforced on the previous trial. These variables are provided as examples and are not meant to be exhaustive. One key difference between a progressive and a counterbalanced protocol approach is the clinician's behavior (e.g., the arrangement of stimuli and selection of target response) is controlled by the learner's behavior instead of a set of rules outlined on a data sheet.

The progressive approach to DTT has a long clinical history of implementation dating back to some of the original work with DTT implemented in the UCLA Young Autism Project (Leaf et al., 2016a; Lovaas, 1987). Since then, this approach has been implemented clinically for individuals diagnosed with ASD receiving intervention based on the principles of applied behavior analysis (Leaf et al., 2011). This approach has also been explored experimentally. For instance, Soluaga, Leaf, Taubman, McEachin, and Leaf (2008) utilized IMAP when comparing FPF to a time delay procedure to teach various receptive labels (e.g., addition facts, pictures of objects, and sight words) to five individuals diagnosed with ASD. Within FPF, the clinician determined stimulus placement and rotation of stimuli prior to the initiation of every trial. The results of this study indicated that FPF was more effective than the time delay procedure.

Although counterbalancing of stimuli has been argued as best practice and is becoming more commonplace within the literature, the empirical literature demonstrating counterbalancing as more effective or efficient than other procedures for teaching receptive labels remains scant. Thus, the purpose of this study was to compare three approaches to stimulus rotation during receptive label instruction for five individuals diagnosed with ASD. More specifically, we compared (1) counterbalancing (as outlined by Grow and LeBlanc, 2013), (2) fixed (i.e., no rotation across trials), and (3) IMAP during DTT to teach receptive labels. To evaluate the relative effectiveness and efficiency of the three approaches, the researchers measured the number of sessions to reach the mastery criterion, maintenance, generalization, and responses during teaching trials across the three conditions.

Methods

Participants

Five children with independent diagnoses of ASD participated in this study. All participants were taught receptive labels as part of their comprehensive intervention and had a history with DTT. None of the participants had a history with a counterbalancing or a fixed placement approach to using DTT to teach receptive labels prior to the study. While the participants had a brief history with an IMAP approach, none had a history with the interventionist used across conditions.

Lily, a 5-year 3-month-old female, attended a general education preschool with an aid providing support based on the principles of ABA 2 days a week, and had been receiving an average of 37 h per week of behavioral intervention for 13 months prior to the study. Lily received an Adaptive Behavior Composite Score of 94 (Adequate) on the Vineland Adaptive Behavior Scales, 2nd Edition (VABS-II; Sparrow, Balla, & Cicchetti, 1984), a 110 standard score (75th percentile) on the Expressive One Word Picture Vocabulary Test-Fourth Edition (EOWPVT-4; Martin & Brownell, 2011), and a 104 standard score (61st percentile) on the Peabody Picture Vocabulary Test-Fourth Edition (PPVT-4; Dunn & Dunn, 2007). Lily could receptively label over 1000 pictures, engaged in limited spontaneous language, would often become dependent upon prompts to engage in correct responding throughout intervention, and was commonly inattentive during periods of instruction lasting longer than 2 min.

Barney, a 3-year 1-month-old male, had been receiving intensive behavioral intervention for 12 months at the time of this study. He had been receiving an average of 19 h per week of behavioral intervention for 15 months prior to the study. Barney received an Adaptive Behavior Composite Score of 79 (Moderately Low) on the VABS-II, a 100 standard score (50th percentile) on the EOWPVT-4, and a 65 standard score (1st percentile) on the PPVT-4. Barney could receptively label over 1000 pictures, engaged in spontaneous language, and was often uncooperative with learning tasks.

Robin, a 4-year 8-month-old female, attended a general education preschool with an aid providing support based on the principles of ABA, and been receiving an average 37 h of intensive behavioral intervention for 24 months prior to the study. She had an Adaptive Behavior Composite Score of 80 (Moderately Low) on the VABS-II, a 145 standard score (>99th percentile) on the EOWPVT-4, and a 132 standard score (98th percentile) on the PPVT-4. Robin could receptively label over 1000 words, engaged in spontaneous language, and displayed limited interfering behaviors (e.g., pouting).

Marshall, a 5-year 7-month-old male, received special education services in a general education Kindergarten classroom at the time of the study. In both settings, Marshall had a one-to-one paraprofessional. Additionally, Marshall was

receiving an average of 32 h of intensive behavioral intervention per week for 6 months prior to the study. Marshall had an Adaptive Behavior Composite Score of 71 (Moderately Low) on the VABS-II, a 114 standard score (83rd percentile) on the EOWPVT-4, and a 94 standard score (34th percentile) on the PPVT-4. Marshall could receptively label over 1000 words, engaged in spontaneous language, and was frequently uncooperative with learning tasks.

Ted, a 6-year 6-month-old male, had been receiving intensive behavioral intervention for the past 9 months at the time of the study. He had been receiving an average of 39 h per week of behavioral intervention for 13 months prior to the study. Ted had an Adaptive Behavior Composite Score of 69 (Low) on the VABS-II, a 94 standard score (39th percentile) on the EOWPVT-4, and a 77 standard score (6th percentile) on the PPVT-4. Ted could receptively label over 1000 words, exhibited spontaneous language, and engaged in gazing and inattentiveness during instructional periods.

The same clinician provided intervention across all participants, sets, and conditions. The clinician was a 25-year-old with a bachelor's degree in applied behavior analysis and a master's degree in behavior analysis. She had 5 years of experience with providing intervention for individuals diagnosed with ASD. However, she had no prior training or history with the protocols used in the counterbalanced or fixed conditions, and had never taught receptive labels using these protocols prior to the study.

Setting

All sessions were conducted in a room within a private clinic that provides intervention based on the principles of applied behavior analysis for individuals diagnosed with ASD. In the room, there was a table designed for a child, two chairs designed for a child, educational materials (e.g., books and toys), and adult furniture. However, only the two chairs and table designed for a child were used during the study.

Targets and Materials

The researchers met with each participant's clinical supervisor (i.e., the professional in charge of the participants' curriculum and training staff) to determine appropriate targets for each student. The targets were selected based on the participant's peers' interests that could be beneficial when interacting with her/his peers. A total of 27 different pictures were identified for each participant. The researchers randomly assigned three sets of three pictures to each condition. Pictures of cartoon characters were used for Lily, Barney, and Robin, while cartoon characters and sports teams were used for Marshall and Ted. None of the participants had any formal teaching history with the targets selected.

Datasheets were developed for all conditions within the study. The datasheets were based upon Grow and LeBlanc's (2013) example. For the counterbalanced condition, the data sheet consisted of a table outlining where the stimuli should be placed, the target stimulus, the prompt used, and the participant's response on each trial. The counterbalance remained the same across sessions and days. While this may have set the occasion for the learner to identify a pattern in responding, the researchers felt the number of trials made this unlikely and it was not observed for any of the participants. For the Fixed condition, the data sheet consisted of a table for listing where the stimuli remained across teaching trials, the target stimulus, the prompt used, and the participant's response on each trial. For the IMAP condition, the data sheet consisted of an empty table for listing where the stimuli were on each trial, the target stimulus, the prompt used, and the participant's response on each trial.

Trials and Behavior Coding

Trial Types There were two types of trials that were implemented in this study, probe trials and teaching trials. *Probe trials* were implemented during daily probe sessions (described below) and generalization probe sessions (described below). Probe trials consisted of the clinician: (a) placing the stimuli on the table; (b) providing an instruction to touch one of the cards (e.g., "Touch Gaston"); (c) waiting up to 10 s for the participant to respond; and (d) providing neutral feedback (e.g., "Thank You") regardless of accuracy. Stimuli were counterbalanced across all probe trials to ensure that the target stimuli were not adventitiously placed (e.g., during the IMAP condition, the interventionist could have placed the target stimuli in the right position on every trial, if this occurred during probe trials it could have provided a false measure of mastery).

Teaching trials were implemented during the three different teaching conditions (i.e., counterbalanced, fixed, and IMAP). Teaching trials consisted of the clinician: (a) placing the stimuli on the table (according to the rotation rules of the condition); (b) providing an instruction to touch one of the cards (e.g., "Touch Gaston," "Where is Gaston?," "Find Gaston,"); (c) providing a prompt when applicable (described below); (d) waiting up to 10 s for the participant to respond to the instruction; and (e) providing reinforcement for correct responding or corrective feedback for incorrect responding.

Coding A *correct response* was defined as the learner touching the stimulus that corresponded with the instruction in the absence of a prompt (e.g., touching the picture of a ball following the instruction "Where is the ball?"). An *incorrect response* was defined as the learner touching a stimulus that did not correspond to the instruction, touching multiple stimuli simultaneously, or not touching any stimulus within 10 s of

the instruction. A *prompted correct response* was defined as the learner touching the stimulus that corresponded with the instruction with prompting. A *prompted incorrect response* was defined as the learner touching a stimulus that did not correspond to the instruction, or touching multiple stimuli simultaneously following a prompt. It should be noted that no prompts were provided during probe trials; therefore, prompted correct and incorrect responses could only occur during teaching trials.

Dependent Measures

The primary dependent variable was the percentage of stimulus sets for which a participant reached the mastery criterion across the three teaching conditions (i.e., counterbalanced, fixed, and IMAP). The mastery criterion was defined as 100% correct responses on all targets within a set across three consecutive daily probe sessions. If a participant reached the mastery criterion on a condition, s/he was given 10 more sessions to reach the mastery criterion in the other condition(s). If the participant engaged in 100% correct responses on the 10th session with the other teaching condition(s), the researchers conducted additional sessions to provide the participant an opportunity to reach the mastery criterion. If the participant did not reach the mastery criterion by the 10th session, or 100% on the 10th session, for the other condition(s), the condition(s) was ended. If the participant reached the mastery criterion on a different set then the researchers allowed another 10 sessions for the participant to reach mastery criterion on the final condition.

Second, we evaluated the maintenance of correct responding once the mastery criterion was achieved. Maintenance was evaluated through participants' responding using methods similar to daily probe sessions. To assess responding in the maintenance condition, the researchers calculated the number of trials in which a participant responded correctly and divided by the total number of trials within a daily probe. Third, we measured generalization of responding from a field of three stimuli to a field of nine stimuli during generalization probes (described below). To assess responding in the generalization condition, the researchers calculated the number of trials in which a participant responded correctly and divided by the total number of trials within the generalization probe.

Fourth, we measured the number of sessions required for the participants to reach the mastery criterion for each set across all three teaching conditions. Fifth, we measured participant responding during teaching trials across the three conditions. Finally, we measured the percentage of trials the target stimulus was presented in the right, middle, or left location during the IMAP condition.

Daily Probe Sessions

The clinicians implemented daily probe sessions during baseline, intervention, and maintenance conditions. Daily probes were used to evaluate responding prior to intervention, during intervention, and once intervention had concluded. Daily probe sessions consisted of three trials for each stimulus in each set, per condition. Therefore, there were nine trials for the counterbalanced condition, nine trials for the fixed condition, and nine trials for the IMAP condition for a total of 27 trials within each probe. A brief break was provided after every nine trials. The set of stimuli for each condition were not combined with stimuli from other conditions. That is, each set of nine trials were specific to one condition. The order of the three conditions was randomly determined. During daily probe sessions, the order and position of stimuli were counterbalanced using Grow and Leblanc's (2013) sample data sheet. Thus, the correct response was evenly distributed across each location (i.e., on the right 33% of trials, the middle 33% of trials, and the left 33% of trials). It should be noted that with the exception of the first intervention session, daily probes were conducted prior to each intervention session (i.e., the first data point during intervention represents 1 day of intervention for all conditions).

The clinician started the daily probe session by placing the three stimuli on the table (i.e., one on the right, one on the middle, and one on the left). This was followed by an instruction to touch one of the stimuli (e.g., "Where is Jafar?"). The participant was then given 10 s to respond to the instruction. If the participant touched any of the stimuli in the array the clinician provided neutral feedback regardless of accuracy (e.g., "Thanks."). If the participant did not touch a stimulus in the array after the instruction was provided, the clinician provided feedback (e.g., "You need to try."). No reinforcement or prompting was provided during daily probe sessions.

Baseline

A single baseline session was conducted to determine if the participants responded correctly to the targets in the set prior to the intervention. Baseline sessions consisted of the same procedures as daily probe sessions (described previously).

Intervention

Intervention sessions began with the clinician implementing a daily probe session (described previously). This was followed by the clinician conducting the three teaching conditions. The order of the teaching conditions was determined in a semi-random format before each session using [Random.org](https://www.random.org) (i.e., we ensured the same condition would not begin the session across more than two consecutive sessions).

Teaching trials across all three conditions began with the clinician arranging the stimuli on the table as determined by the teaching condition. This was followed by the clinician providing an instruction to touch one of the stimuli (e.g., “Touch Jafar,” “Find Jafar,” “Point to Jafar”). If applicable, the clinician would provide a prompt (see below). After the instruction or prompt was provided, the participant was provided with 10 s to respond. If the participant engaged in a correct response, the clinician provided him or her with a token and simultaneously provided praise (e.g., “Way to go!”). If the participant responded incorrectly, prompted or otherwise, the clinician provided general corrective feedback (e.g., “That’s not it.”). No instructive feedback was provided during the delivery of reinforcement or corrective feedback. The trial order of the target stimuli was counterbalanced so that one stimulus was not targeted on two consecutive trials.

The clinicians utilized a most-to-least prompting procedure (MacDuff, Krantz, & McClannahan, 2001) during all teaching trials, across the three teaching conditions. The most-to-least prompting procedure consisted of a three-step prompting hierarchy with a full physical prompt (the most assistive prompt), gesturing or pointing to the correct targeted stimulus (least assistive prompt), and the instruction alone (no prompt). Each target stimulus was on its own prompting hierarchy. For example, with one target stimulus, the clinician may have provided a full physical prompt, while using a gestural prompt with another target stimulus in the same set and condition. The criterion to move to a less assistive prompt was two consecutive correct responses for a specific target on a given prompt level. The criterion to move to a more assistive prompt level was one incorrect response.

The clinicians used a token system (Ayllon & Azrin, 1968) in which the participants earned tokens for correct responding. The clinicians provided tokens across the three teaching conditions, and the participant could exchange those tokens for a preferred item. During each intervention session, the participants had the opportunity to earn a total of 27 tokens. Tokens, praise, and exchangeable items were provided differentially. The clinician provided a token and praise for every unprompted correct response. A token and verbal praise were also provided for prompted correct responses at the first introduction of each prompt level. If, however, the participant engaged in an incorrect response and the clinician moved back to a more assistive prompt, the clinician provided praise without a token for correct responding on that prompt level. For example, if the clinician moved from a full physical prompt to a gestural prompt and the participant responded incorrectly, s/he no longer earned tokens for correct responding during trials that the clinician implemented a full physical prompt. This occurred for each stimulus and across research sessions. If the participant reached the mastery criterion within one condition but not the other(s), the clinician started the teaching session by

giving the participant nine tokens for each condition in which the participant had reached the mastery criterion (i.e., teaching did not occur for the targets condition in which the participant reached mastery but only for those in which the participant had not yet reached mastery). At the end of each teaching session, if the participant earned 22–27 tokens, s/he could choose and keep an item from a treasure chest filled with various small toys. If the participant earned 6–21 tokens, s/he could play with an item from the treasure chest for up to 5 min, but was not allowed to keep the item. If the participant earned 0–6 tokens, s/he was not able to go to the treasure chest that day.

Counterbalanced Condition There were nine teaching trials during the counterbalanced condition. In this condition, the clinicians followed Grow and LeBlanc’s (2013) guidelines. As such, the clinician ensured that the target stimuli and non-target stimuli were equally distributed between the left, middle, and right positions.

Fixed Condition There were nine teaching trials during the fixed condition. In this condition, the clinician positioned the three stimuli on the table so that one stimulus was on the right, one was in the middle, and one was on the left. The clinician did not move the placement of the cards throughout the nine teaching trials. It should be noted that while the stimuli were not moved within session, the location of each did vary across sessions.

IMAP Condition There were nine teaching trials during the IMAP condition. In this condition, the clinician used clinical judgment to determine if and when to rotate the placement of the stimuli. The clinician used in-the-moment assessment and clinical judgment regarding when and how to rotate the stimuli based upon several factors. First, the clinician analyzed if the participant was responding to only one location (i.e., location bias). If this occurred, the clinician would ensure not to place the stimulus in that position on subsequent trials. Second, if the participant was responding at a high rate of correct responses, she would move the stimuli sufficiently to ensure that responding would occur across all positions. Third, the clinician ensured that the participant was not developing a pattern of responding (e.g., responding to the middle, then right, then left; choosing the item the clinician touched last; or following a win-stay pattern) and would rotate stimuli to ensure that the clinician was not reinforcing this pattern.

Maintenance

Maintenance data were assessed using methods similar to daily probe sessions (described previously), 7 days after the participant reached the mastery criterion for each set.

Generalization

After the participant had completed intervention and maintenance for all sets across each condition, the clinician implemented a generalization probe. The generalization probes were similar to the daily probe sessions with a few exceptions. First, all targets across the three conditions were presented together (i.e. nine stimuli presented in the same array). Second, each target received two probe trials as opposed to three for a total of 18 trials in the generalization session. Third, instead of three positions (right, middle, and left) for the stimuli, there were now nine different positions. There were three rows each with three different positions (e.g., right, middle, and left). This meant that the clinicians were evaluating generalization of responding from a field of three to a field of nine. Assessing generalization in a larger field was selected based on the assumption that some conditions may lead to better generalization with respect to larger fields (e.g., the Fixed condition in which the stimuli were not moved may lead to less generalization whereas the Counterbalanced condition may lead to better generalization). Finally, generalization was only assessed following mastery of each set; therefore, it could be argued it is not a true measure of generalization. However, it can be assumed that if the participant was not successful within a field of three (i.e., baseline), s/he would also not be successful in a field of nine.

Design

The researchers implemented an adapted alternating treatment design replicated across three sets and five participants. Although not required with an adapted alternating treatment design, a baseline condition was implemented to ensure that there was no noticeable difference in responding across the conditions prior to intervention. The goal of this design is to reveal noticeable differences between the different conditions. Since DTT was used in all three conditions and has a history of demonstrated effectiveness to teach receptive labeling, we hypothesized that the difference would be minimal. The adapted alternating treatment design allows demonstration of functional control even with minimal differences between the treatment conditions.

Interobserver Reliability

The primary clinician recorded every participant response during every probe trial and every teaching trial across all three conditions. A second researcher independently recorded participant responses via video recording during 34.4% of daily probe sessions (range, 31.5 to 49.3% across participants), 53.3% of generalization probe sessions (range, 33 to 100% across participants), 39.2% of teaching trials for the counterbalancing condition (range, 31.5 to 80% across

participants), 38.1% of teaching trials for the fixed condition (range, 33 to 72.2% across participants), and 39.7% of teaching trials for the IMAP condition (range, 31.5 to 80% across participants). Interobserver reliability was determined by taking the number of trials with agreement divided by the total number of trials on which reliability was taken.

IOA for daily probe sessions was 99.5% (range, 77.7 to 100% across sessions), for generalization probe sessions was 100%, for teaching trials during the counterbalancing condition was 99.7% (range, 88.8 to 100% across sessions), for teaching trials for the fixed condition was 99.8% (range, 88.8 to 100% across sessions), and for teaching trials for the IMAP condition was 100%.

Treatment Fidelity

Treatment fidelity data were taken via video recording during 33% of all daily probe sessions across all sets and participants and 34.7% of all generalization probe sessions. Correct implementation of daily probe trials consisted of the clinician: (a) rotating the stimuli on every trial, (b) providing the correct instruction, (c) allowing up to 10 s for the participant to respond, and (d) delivering neutral feedback regardless of accuracy. Treatment fidelity was calculated by dividing the number of total trials scored by the number of trials in which the clinician engaged in all four steps on a given trial. Treatment fidelity for daily probe sessions was 99.4% across all participants (range, 99.7 to 100%). Treatment fidelity for generalization probe sessions was 100% across all participants.

Treatment fidelity was taken during 34.4% of all counterbalancing teaching sessions across all sets and participants. Correct implementation consisted of: (a) placing the stimuli in the correct prescribed location on every trial, (b) providing the correct instruction, (c) providing the correct prompt, (d) allowing up to 10 s for the participant to respond, and (e) delivering the correct consequence. Treatment fidelity was calculated by dividing the number of total trials scored by the number of trials where the clinician engaged in all five steps on a given trial. Treatment fidelity for counterbalanced sessions was 99.7% across all participants (range, 98.9 to 100%).

Treatment fidelity was taken during 34.9% of all fixed teaching sessions across all sets and participants. Correct implementation consisted of: (a) not rotating the stimuli across trials, (b) providing the correct instruction, (c) providing the correct prompt, (d) allowing up to 10 s for the participant to respond, and (e) delivering the correct consequence. Treatment fidelity was calculated by dividing the number of total trials scored by the number of trials where the clinician engaged in all five steps. Treatment fidelity for fixed sessions was 99.3% across all participants (range, 98.1 to 100%).

Treatment fidelity data were taken during 34.7% of all IMAP sessions across all sets and participants. Correct

implementation consisted of: (a) providing the correct instruction, (b) providing the correct prompt level, (c) allowing up to 10 s for the participant to respond, and (d) delivering the correct consequence. Treatment fidelity was calculated by dividing the number of total trials scored by the number of trials where the clinician engaged in all four steps on a given trial. Treatment fidelity for IMAP sessions was 99.7% across all participants (range, 99.1 to 100%).

Results

Mastery Criterion, Sessions to Mastery, Maintenance, and Generalization

Lily Figure 1 displays the results for Lily across the three sets of stimuli and three conditions. Lily reached the mastery criterion with all three sets of stimuli in the counterbalanced condition and with two sets in the fixed and IMAP conditions (i.e., first and third). She reached the mastery criterion in fewer sessions in the fixed condition for the first set, in the counterbalanced condition for the second set, and in the counterbalanced and fixed conditions for the third set (see Table 1 for a detailed summary of sessions to mastery for each set and condition). During the assessment of maintenance, Lily responded correctly on 92.5, 87.6, and 70.4% of probe trials for the counterbalanced condition, fixed condition, and IMAP condition across the three sets, respectively. When analyzing the fixed and IMAP sets for which Lily reached the mastery criterion (i.e., set 1 and set 3), her maintenance data were 96.2 and 94.4% for the fixed and IMAP condition, respectively. During the assessment of generalization, Lily responded correctly on 94.4, 83.3, and, 83.3% of probe trials for the counterbalanced condition, fixed condition, and IMAP condition across the three sets, respectively. When analyzing the fixed and IMAP sets for which Lily reached the mastery criterion (i.e., set 1 and set 3), her generalization data were 91.2 and 100% for the fixed and IMAP condition respectively.

Barney Figure 2 displays the results for Barney across the three sets of stimuli and three conditions. Barney reached the mastery criterion on all three sets across all three teaching conditions. He reached the mastery criterion in a fewer number of sessions in the counterbalanced condition for sets 1 and 3 and a fewer number of sessions in the IMAP condition for set 2 (see Table 1). During the assessment of maintenance, across the three sets, Barney responded correctly on 97.5, 92.5, and 92.5% of probe trials for the counterbalanced condition, fixed condition, and IMAP condition, respectively. During the assessment of generalization, across the three sets, Barney responded correctly on 100% of opportunities across all three teaching conditions.

Robin Figure 3 displays the results for Robin across the three sets of stimuli and three conditions. It should be noted that the first data point within the intervention condition shows the first daily probe following one intervention session. Therefore, it is possible for the participant to engage in 100% correct responses during this daily probe given an intervention session had already occurred. This is precisely the case with Robin. Furthermore, Robin reached the mastery criterion on all three sets across all three teaching conditions. She reached the mastery criterion in a fewer number of sessions in the counterbalanced and IMAP conditions for set 1, in the same number of sessions across all three conditions for set 2, and in a fewer number of sessions in the fixed condition for set 3. During the assessment of maintenance, across the three sets, Robin responded correctly on 100, 100, and 98.7% of probe trials in the counterbalanced condition, fixed condition, and IMAP condition, respectively. For the assessment of generalization, across the three sets, she responded correctly on 100, 94.4, and, 100% of probe trials during the counterbalanced condition, fixed condition, and IMAP condition, respectively.

Marshall Figure 4 displays the results for Marshall across the three sets of stimuli and three conditions. Marshall reached mastery criterion on all three sets with the counterbalanced and IMAP condition and on two of the sets (i.e., set 1 and set 2) for the fixed condition. Marshall reached the mastery criterion in a fewer number of sessions in the IMAP condition for sets 1 and 3, and in the counterbalanced condition for set 2. During the assessment of maintenance, across the three sets, Marshall responded correctly on 97.5, 91.3, and 96.2% of probe trials for the counterbalanced condition, fixed condition, and IMAP condition, respectively. When analyzing the fixed sets for which Marshall reached the mastery criterion (i.e., set 1 and set 3), his maintenance data were 87%. During the assessment of generalization, across the three sets, he responded correctly on 94.4, 83.3, and, 83.3% of probe trials for the counterbalanced condition, fixed condition, and IMAP condition, respectively. When analyzing the fixed sets for which Marshall reached the mastery criterion (i.e., set 1 and set 3), his generalization data were 83%.

Ted Figure 5 displays the results for Ted across the three sets of stimuli and three conditions. Ted reached the mastery criterion for all three sets in the IMAP condition and for two sets in the counterbalanced and fixed condition (i.e., sets 1 and 3). He reached the mastery criterion in fewer sessions in the counterbalanced condition with sets 1 and 3. He only reached the mastery criterion with set 2 in the IMAP condition. During the assessment of maintenance, across the three sets, Ted responded correctly on 81.5, 76.5, and 100% of probe trials for the counterbalanced condition, fixed condition, and IMAP condition, respectively. When analyzing the data from the

Fig. 1 Skill acquisition, maintenance, and generalization during probe sessions for Lily

counterbalanced and fixed sets for which Ted reached the mastery criterion (i.e., sets 1 and 3), he responded correctly on 98.1 and 90.7% of probe trials for the counterbalanced and

Table 1 Number of sessions to mastery

Participant	Set	Counterbalanced	Fixed	IMAP
Lily	1	5	4	5
	2	15	25*	25*
	3	6	6	8
Barney	1	5	7	13
	2	23	27	18
	3	4	18	11
Robin	1	3	5	3
	2	3	3	3
	3	4	3	4
Marshall	1	7	10	3
	2	5	18*	7
	3	9	11	5
Ted	1	7	14	14
	2	21*	21*	11
	3	5	12	7

*Did not reach the mastery criterion

fixed condition, respectively. During the generalization assessments across the three sets, Ted responded correctly on 83.3, 72.2, and 100% of probe trials for the counterbalanced condition, fixed condition, and IMAP conditions, respectively. When analyzing the data from the counterbalanced and fixed sets for which Ted reached the mastery criterion (i.e., sets 1 and 3), he responded correctly on 100 and 91.7% of probe trials for the counterbalanced and fixed condition respectively.

Responses During Teaching Sessions

Table 2 provides information on the percentage of correct trials, incorrect trials, prompted correct trials, prompted incorrect trials, the total percentage of correct trials (i.e., independent and prompted), and the total percentage of incorrect trials (i.e., independent and prompted) for each participant across all sets of stimuli and conditions. Across all sets, the five participants on average displayed independent correct responses on a higher percentage of trials (65.5%) in the IMAP condition than the other conditions. The five participants on average displayed prompted correct responses on a higher percentage of trials (32.2%) and an overall higher percentage of total correct responses (92.4%) in the counterbalanced condition.

Fig. 2 Skill acquisition, maintenance, and generalization during probe sessions for Barney

It should be noted that, overall, participants responded correctly (independent plus prompted) on average more than 90% (range 85.4 to 100%) of teaching trials regardless of the condition.

Rotation of Stimuli During IMAP Condition

Table 3 displays the overall percentage of trials the targeted stimulus was placed on the left, middle, and right position of the table per participant and across all participants in the IMAP condition. The results showed that the three possible locations were evenly distributed (range 32 to 36.5%) and very close to the 33.3% that would have occurred through counterbalancing.

Discussion

The purpose of this study was to compare the effectiveness and efficiency of three methods of stimulus rotation during receptive label instruction for individuals diagnosed with ASD. The researchers evaluated five different dependent variables (i.e., sessions to mastery, efficiency, maintenance, generalization, and responses during teaching) to compare

the three different methods. The results of the study were idiosyncratic across participants, and, sometimes, across sets within participant. Two of the participants (i.e., Barney and Robin) reached the mastery criterion in all three teaching conditions for all three sets, one participant (i.e., Marshall) reached the mastery criterion for all three sets in the counterbalanced and IMAP condition, one participant (i.e., Lily) reached the mastery criterion for all three sets only for the counterbalanced condition, and one participant (i.e., Ted) reached mastery criterion for all three sets only in the IMAP condition.

With respect to sessions to reach the mastery criterion, none of the conditions were consistently more efficient across the three sets. In terms of maintenance, for two of the participants (i.e., Lily and Robin), the counterbalanced and fixed condition were equivalent, for two participants (i.e. Barney and Marshall) the counterbalanced condition resulted in better maintenance, and for one participant (i.e., Ted) the IMAP condition resulted in better maintenance. It should be noted that we did not systematically plan for maintenance or generalization, which may differ from clinical implementation of the teaching conditions evaluated within this study. In terms of generalization, for one of the participants (i.e., Barney) all three conditions resulted in equal levels of generalization,

Fig. 3 Skill acquisition, maintenance, and generalization during probe sessions for Robin

for three participants (i.e., Lily, Robin, and Ted) the counterbalanced and IMAP condition resulted in equal levels of generalization, and for one participant (i.e., Marshall) the counterbalanced condition resulted in higher levels of generalization. Finally, in terms of correct responses during teaching trials, two of the participants (i.e., Lily and Ted) responded correctly on a higher percentage of trials during the counterbalanced condition, one of the participants (i.e., Robin) responded correctly on a higher percentage of trials during the counterbalanced and IMAP condition, one of the participants (i.e., Marshall) responded correctly on a higher percentage of trials during the IMAP condition, and one participant (i.e., Barney) responded correctly on a higher percentage of trials during the fixed condition.

Taken together, the results across all three conditions are idiosyncratic. That is, none of the methods of rotating stimuli during receptive language instruction evaluated within this study were more efficacious than the others. Therefore, at this point, to consider any as *best practice* when teaching receptive labels for individuals diagnosed with ASD may be premature. Instead, researchers and clinicians should continue to evaluate the conditions under which each method may be the most desired for each individual learner. There are several variables for clinicians to consider and researchers to evaluate when

determining which of the three methods for stimulus rotation evaluated within the present study may be desired.

One variable to consider is whether a learner is selecting one location most of the time, commonly referred to as a location bias. While some have argued that using methods from the counterbalanced condition could prevent location bias (e.g., Grow & LeBlanc, 2013), if location bias exists, counterbalancing the location of the stimuli still allows the learner to access reinforcement on 33% of trials and constitutes an intermittent schedule of reinforcement that may not effectively extinguish the incorrect learning strategy. The same is true with the methods employed in the fixed condition, in which the correct item would appear in the favored location one-third of the time. Therefore, when faced with this problem, a clinician may opt to select the methods used in the IMAP condition rather than the counterbalanced or fixed condition. IMAP provides the clinician with the flexibility to move the stimuli based on learner responding, as opposed to following a predetermined sequence. As such, the clinician can ensure the target stimulus is never placed in the location which the learner favors, essentially placing biased responding on extinction and preventing an intermittent schedule of reinforcement that may be maintaining the location bias.

Fig. 4 Skill acquisition, maintenance, and generalization during probe sessions for Marshall

A second variable to consider is in regard to staff training. Although not empirically evaluated, if brief training is desired, one may select to train a clinician on the methods used in the fixed condition as there would be no need to train on how, when, or the rationales to rotate stimuli. If, however, training in what has been described as a *Progressive approach to ABA* (Leaf et al., 2016e; e.g., the clinician using in-the-moment assessment to analyze functions of behavior, analyze past performance, and analyze prompt level needed) is desired, one may elect to train a clinician on how to implement the methods used in the IMAP condition.

The findings of this study expand the literature in at least three ways. First, it is the only study, to our knowledge, that has compared three different methods of rotating stimuli within a DTT approach for teaching receptive labels to individuals diagnosed with ASD. Thus, it provides empirical evidence that all three rotation methods can be used to help teach receptive labels for individuals diagnosed with ASD. Second, it provides some preliminary evidence that clinicians who are not guided by a strict protocol dictating when to rotate stimuli can still ensure a successful level of rotation during teaching sessions. Finally, this study provides further demonstration that one component of a progressive approach to ABA (e.g.,

moving stimuli location based upon clinical judgment) can be an effective way to help teach individuals diagnosed with ASD.

Despite the positive findings, there are considerations and limitations which future researchers should address. First, all participants in this study had a history of at least 8 months of intervention utilizing DTT. Thus, it is unknown if the results would be replicated for participants who had less of a history with DTT. Second, all participants in this study had a previous history of DTT intervention in which the clinician used IMAP in rotating stimuli. Thus, it is not known what the results would have been for participants that did not have a previous learning history with the IMAP condition. Therefore, future researchers should evaluate the three rotation methods with participants who have no previous history with any of the rotation procedures and who have less of a history with DTT. Third, in addition to a previous history with DTT, the participants included in this study engaged in many receptive discriminations and scored high on the standard assessments. Future researchers should evaluate if the results of this study can be replicated with participants with fewer receptive discriminations and lower scores on the standardized tests employed in this study.

Fig. 5 Skill acquisition, maintenance, and generalization during probe sessions for Ted

Another limitation of this study was that the same clinician conducted the intervention across the three rotation conditions. Therefore, it is unknown what carry over effects, if any, may have occurred across three conditions. On the other hand, an advantage of using the same clinician across the three conditions is consistency across all other variables (e.g., topography of praise and instructions). Nonetheless, future researchers may wish to replicate the study, but ensure that the same clinician is not used across all three conditions to reduce any potential carry over effects. Also, the clinician in this study had 5 years of experience implementing DTT with individuals diagnosed with ASD. Therefore, it remains unknown if the results would have been the same with a novice clinician. It is possible that this more highly experienced clinician was able to achieve better results for the IMAP condition as she could make highly accurate in-the-moment decisions. Future researchers may also wish to evaluate the three conditions with clinicians of differing experience levels.

In addition to these limitations, there are several areas of future research which should be evaluated. First, future researchers may wish to evaluate the teaching procedures with a different set of skills (e.g., matching) which also requires decisions about the placement of stimuli. Second, future

researchers may wish to evaluate the teaching procedures with a wider range of individuals diagnosed with ASD with different demographic characteristics (e.g., age), preexisting verbal repertoires, and patterns of responding (e.g., previous demonstration of a side bias). Third, future researchers may wish to evaluate the three rotation procedures using a different prompting system than the most-to-least prompting system that was implemented in this study. It could be that utilizing a different prompting system such as constant time delay (e.g., Walker, 2008), least-to-most prompting (e.g., Libby, Weiss, Bancroft, & Ahearn, 2008), or flexible prompt fading (e.g., Soluaga et al., 2008) may result in different effects than observed in this study. While most-to-least has been shown to be an effective prompting procedure, research has shown it may not be as effective as a progressive approach to prompting (e.g., Leaf et al., 2016c). Anecdotally, the researchers felt that each participant might have met the mastery criterion more rapidly if the prompting system required less steps to fade. Fourth, this study evaluated the clinician's rotation of the stimulus array. However, trial order was also counterbalanced (i.e., what the target stimulus was on each trial) based on Grow and Leblanc's (2013) recommendations. Therefore, use of trial sequence as a way of improving acquisition and maintenance

Table 2 Responses during teaching conditions

Participant	Condition	Percentage correct	Percentage prompted correct	Total percentage of correct	Percentage incorrect	Percentage prompted incorrect	Total percentage of incorrect
Lily	Counterbalance	66.6	27.5	94.1	5.9	0	5.9
	Fixed	47.9	38.8	86.7	13.3	0	13.3
	IMAP	50.9	36.7	87.6	12.4	0	12.4
Barney	Counterbalance	59.5	31.5	91	9	0	9
	Fixed	75.4	18.7	94.1	4.9	1	5.9
	IMAP	63.9	27.7	91.6	8.4	0	8.4
Robin	Counterbalance	60	40	100	0	0	0
	Fixed	60.6	38.4	99	1	0	1
	IMAP	60	40	100	0	0	0
Marshall	Counterbalance	66.1	29.7	95.8	4.2	0	4.2
	Fixed	67.9	24.9	92.8	7.2	0	7.2
	IMAP	65.9	31.2	97.1	2.9	0	2.9
Ted	Counterbalance	52.1	35.7	87.8	12.2	0	12.2
	Fixed	47.6	37.8	85.4	14.6	0	14.6
	IMAP	61.9	29.5	91.4	8.6	0	8.6
Total	Counterbalance	60.2	32.2	92.4	7.6	0	7.6
	Fixed	60.4	29.8	90.2	9.3	0.5	9.8
	IMAP	65.5	26.3	91.8	8.2	0	8.2

Table 3 Distribution of placement during IMAP condition

Participant	Percentage of trials on the left position	Percentage of trials on the middle position	Percentage of trials on the right position
Lily	33.1	33.1	33.8
Barney	32	36.5	31.5
Robin	33.3	32.2	34.5
Marshall	33.3	34.1	32.6
Ted	32.6	34.8	32.6
Total	32.7	34.6	32.7

which is used regularly in our clinic work was precluded in this study. Future researchers may wish to evaluate counterbalancing the stimulus array with and without counterbalanced trial order as well as comparing deliberate repetition of a target against prohibition of repeated presentation.

Finally, the methods employed in the counterbalanced and fixed condition represent a conventional protocol-based approach to DTT, whereas the methods in the IMAP condition represent a progressive approach to DTT (Leaf et al., 2016e). However, this study only evaluated one component of the two models of DTT (i.e., the placement of stimuli). It could be argued that the rotation of the stimuli may be the least important difference between a protocol-based approach and a progressive approach; as compared to differences in prompting, the type of discriminative stimulus provided, or how data were being collected. Therefore, future researchers may wish to do a comparison of the conventional approach to DTT (i.e., counterbalancing across stimuli and trial order, fixed prompting protocol, and simplified instructions) vs. a full implementation of a progressive approach in which the clinicians have discretion of how to rotate the stimuli, trial order, and use a flexible prompt fading system to teach individuals diagnosed with ASD. Doing so may lead to a better understanding of the most effective and efficient practices for teaching receptive labels to individuals diagnosed with ASD.

Compliance with Ethical Standards

Ethical Approval All procedures performed in studies involving human participants were in accordance with ethical standards of the institutional research committee and with 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from the parents of all individual participants included in the study.

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