EMPIRICAL REPORT

A Comparison of the Effects of Two Prompt-Fading Strategies on Skill Acquisition in Children with Autism Spectrum Disorders

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Abstract Research has demonstrated that most-to-least (MTL) and least-to-most (LTM) prompting are effective in helping children with Autism Spectrum Disorders acquire a variety of new skills. However, when directly compared to one another, the efficiency and efficacy of the prompting procedures have been variable. The inconsistencies in the literature could be due to selecting prompt topographies that do not promote correct responding. To address this, the present study began by assessing different prompt topographies and then compared most-to-least (MTL) and least-to-most (LTM) prompt-fading with only prompt topographies that were potent enough to promote correct responding. The subsequent comparison of prompt-fading procedures revealed that MTL prompting was more effective and efficient than LTM prompting for all three participants. Further implications for practice and future research are discussed.

Keywords Least-to-most · Most-to-least · Prompt · Prompting · Prompt-fading

Children with autism spectrum disorders (ASDs) often require prompts to learn new behaviors and prompt-fading strategies to transfer stimulus control from the prompt to the naturally

occurring discriminative stimuli. Two of the most commonly used prompt-fading procedures are most-to-least (MTL) and least-to-most (LTM) prompting (Libby et al., 2008). These procedures employ the same prompt topographies, including verbal, gestural, and physical prompts; however, they differ in the order in which the prompts are presented. MTL fading sequences order prompt topographies from the most intrusive (e.g., physical prompts) to the least intrusive (e.g., verbal). In LTM fading, prompt sequences are arranged in the opposite order.

Both MTL and LTM prompting can effectively improve independent responding when compared to baseline levels of responding or control procedures (for a review, see Demchak 1990). A few studies have directly compared the effectiveness and efficiency of these two popular procedures (Libby et al. 2008; McConville et al. 1998; Walls 1981). In all of these studies with the exception of Libby et al. (2008), MTL and LTM procedures were similarly effective; however, efficiency outcomes were variable across participants and different measurements of efficiency.

Of the aforementioned studies, Libby et al. (2008) conducted the most systematic analysis and comparison of MTL and LTM procedures. In the first experiment, a direct comparison of the procedures revealed that three of five participants met a mastery criterion with both procedures, whereas the other two participants only met a mastery criterion with the MTL procedure. Therefore, overall, the MTL procedure was more effective than the LTM procedure in this experiment. Efficiency data, on the other hand, were variable across dependent variables. The LTM procedure was more efficient for the three participants who met a criterion with this procedure when considering trials to criterion; however, the MTL procedure was more efficient for all participants when considering errors to criterion. The authors concluded that the MTL procedure might have delayed learning, but it resulted in

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fewer errors. Green (2001) stated that minimizing the number of errors is crucial for avoiding the development of faulty stimulus control. Accordingly, to accelerate learning with MTL prompting while keeping the number of errors at minimum, the authors incorporated a 2-s time delay between the presentation of the natural discriminative stimulus and the prompt (Libby et al. 2008). During the 2-s delay, the participants had the opportunity to respond independently, which resulted in skipping prompt-fading steps when a participant made independent correct responses. In the second experiment, the interventionists compared MTL prompting with and without the 2-s time delay. The results confirmed that the MTL procedure with a 2-s time delay was more efficient in terms of trials to criterion while maintaining minimal errors to criterion. The authors concluded that the MTL procedure with a time delay should be the default procedure used for teaching skills to children with ASD whose instructional history is unknown.

Seaver and Bourret (2014) proposed a different conceptualization of the identification of effective and efficient prompt-fading procedures. To address the variability in efficiency outcomes across studies, the authors developed an assessment for the identification of optimal prompting strategies. The participants were all diagnosed with ASD, and their ages ranged from 7 to 20 years old. The interventionists used forward chaining to teach participants to construct Lego® patterns. First, the authors assessed response acquisition following four types of prompt topographies (verbal, gestural, model, and physical). Then, the prompt topography that was identified as being most efficient (i.e., task acquisition in the fewest training trials) for each participant was included in the assessment of prompt-fading procedures, which compared MTL, LTM, and progressive time delay procedures. The authors used these results to establish an efficiency ranking of the prompt-fading procedures for each participant. Next, the authors conducted a generality test to assess the comparative efficiency of prompt-fading procedures when used to teach functional domestic and vocational skills to the participants. The generality test confirmed that the prompt-fading procedure identified as most efficient in the prompt-fading assessments continued to promote the most efficient response acquisition across new skills.

The study by Seaver and Bourret (2014) is promising in that the authors controlled many instructional variables as a first step toward understanding the effectiveness and efficiency of prompt-fading procedures, when prompt topographies are potent enough to evoke correct responding. The next step is to investigate this conceptualization under more naturalistic conditions. For instance, Seaver and Bourret taught tasks that may not have been functional or age appropriate for all participants (i.e., the same task was targeted for individuals whose ages varied from 7 to 20) and the assessments were comprehensive. This area warrants additional studies to increase both social and external validity, such as

educationally relevant and functional tasks for children, briefer assessments to enhance the applications of such procedures to naturalistic settings, and research with additional populations.

The purpose of the present study was to systematically replicate the research conducted by Seaver and Bourret (2014) and evaluate a briefer series of assessments with other populations. This study extends the work of Seaver and Bourret in the following ways: (a) participants were preschool children (all were 5 years old), (b) the skills being taught were identified as deficient on each participant's individualized education plan, and (c) the prompt topography and prompt-fading assessments were briefer. For the purpose of this study, effectiveness is defined as the learner meeting a predetermined mastery criterion for a targeted skill (e.g., 90 % or greater accuracy for two consecutive sessions). Efficiency refers to teaching skills in the most optimal manner and can be measured by trials to criterion, sessions to criterion, number of errors, duration of training, and amount of educational resources.

Method

Participants

Three children diagnosed with ASD participated in the study. Informed consent was obtained for all participants. All participants were 5 years old and were enrolled full time in a preschool for children with ASD that based instruction on the principles of behavior analysis. The school's clinical director and teachers referred participants to the interventionist because the students exhibited difficulties acquiring skills. In particular, the staff reported that the participants demonstrated difficulty learning one-step directions. In 2 years prior to the study, James acquired only two one-step directions, Joseph did not acquire any one-step directions, and Sean acquired three one-step directions. These skills were chosen as the target responses because responding to one-step directions is one of the priority skills in the curriculum of preschoolers with ASD (e.g., in *Teaching language to children with autism or other developmental disabilities*, Sundberg and Partington 1998), and had been identified as targets for intervention in each participant's individualized educational plans. In addition, teaching participants to follow one-step directions may be conceived as a behavioral cusp (Rosales-Ruiz & Baer 1997), functioning as a prerequisite skill for more advanced behaviors.

Setting

The study was conducted in each participant's preschool classroom. Four or five other children, one teacher, and three teacher assistants were present in the room while the study was conducted. The classrooms were approximately 6 m by 6 m.

Each classroom was equipped with a computer, tables, chairs, and shelves to store materials. The sessions were conducted at the participant's desk in the classroom. It was typical for participants to receive this kind of individualized instruction in their classrooms throughout the day.

Materials

Materials included a video camera, data sheets, edibles, and a research randomizer software. A video camera was used to record part of the sessions. The interventionist used data sheets to collect data in vivo while conducting the study. Preferred edibles (identified through a preference assessment, described below) were used contingent on correct responding on a continuous schedule of reinforcement. One-step directions were assigned to two categories: one involving fine-motor movements (e.g., clapping) and one involving gross-motor movements (e.g., jumping). For each condition (i.e., MTL, LTM, and control), the one-step directions assigned consisted of one fine-motor movement and one gross-motor movement in order to equate the response effort. Within each category (i.e., fine- and gross-motor movements), a research randomizer (www.randomizer.org) software generated random numbers that were used to assign one-step directions to conditions and the order of implementation of treatments (described below).

Interventionist

The first author (referred to as the interventionist) conducted and collected data for the study. At the time of the study, the interventionist had 7 years of experience working with individuals with developmental disabilities using behavior analytic procedures and was a board-certified behavior analyst. A second observer collected data for interobserver agreement and treatment integrity purposes. At the time of the study, the second observer was an undergraduate student. The second observer had been trained to collect data by the interventionist prior to assisting with the current study.

Dependent Variable

The dependent variable was the percentage of correct independent responses to one-step directions. Specific operational definitions for each response targeted in the study are provided in Table 1. Responses were coded as correct, incorrect, and/or prompted. A correct independent response was defined as performing the specified response within 2 s of the presentation of the verbal discriminative stimulus (e.g., clapping when the interventionist said “Clap!”), in the absence of prompts. An incorrect response was defined as the failure to perform a response within 2 s of the presentation of the discriminative

stimulus or performing an action that was different from the one specified by the interventionist (e.g., shaking the head when the interventionist said “Clap!”). A prompted response was defined as engaging in the correct response following the prompt.

Procedure

Preference Assessment A paired-stimulus preference assessment (Fisher et al. 1992) was conducted to identify preferred edible items. During subsequent sessions, the three items identified as most preferred were provided by the interventionist contingent on correct prompted and independent responding. At the beginning of each experimental session, the participant was asked to choose one of the three preferred items and that item was used for the remainder of the session. The interventionist conducted a second preference assessment for activities (e.g., iPad) with Sean during the prompt hierarchy comparison phase, because Sean's teacher independently chose to restrict access to edibles throughout the day. The change in reinforcers was applied to all prompting conditions at the same point in time for this participant.

Prompt Topography Assessment A prompt topography assessment was conducted to identify prompt topographies that evoked correct responding. Ten one-step directions were selected from *Teaching language to children with autism or other developmental disorders* (Sundberg & Partington 1998). For each of these directions, responding to four different antecedent conditions (no prompt/vocal discriminative stimulus, model prompt, gestural prompt, partial physical prompts, and full physical prompt) was assessed under baseline conditions (i.e., no prompts or programmed consequences were provided for responding). As such, three variations of physical prompts (i.e., partial physical(s) and full physical) were included in this assessment. For Joseph, one partial prompt and the full physical prompts were assessed whereas two variations of partial physical prompts and the full physical prompts were assessed for the other two participants. In the first condition, the interventionist provided the verbal discriminative stimulus (e.g., the interventionist said “Clap!”) and waited 5 s for the participant to respond; this condition was conducted in order to assess whether participants can respond correctly to the natural discriminative stimulus, in the absence of prompts. In the second condition, the interventionist provided the verbal discriminative stimulus and immediately modeled the target response (e.g., the interventionist said “Clap!” and then clapped) and waited 5 s for the participant to respond. In the third condition, the interventionist provided a gestural prompt in addition to the verbal discriminative stimulus (e.g., the interventionist said “Clap!” and then pointed to the participant's hand) and waited 5 s for the participant to respond. In the fourth condition, the interventionist provided

Table 1 Operational definitions of one-step directions and correct responses

One-step directions	Operational definitions of correct responses
Blow kiss	Child takes open hand to the mouth and then moves the hand away from the mouth in the direction of the interventionist
Clap	Child strikes the open palms against one another once (at minimum) or more
Come	Child walks in the direction of the interventionist. At minimum, the child makes one step or come within 2 ft of the interventionist
Jump	Child pushes himself off the ground using the muscles of the legs and the feet, with both feet off the floor, one or more times
Point	Child directs the finger to an object
Roll (the ball)	Child places the hand over the ball and pushes the ball at minimum 1 in. in any direction
Sit down	Child sits on the chair placed behind him
Stomp feet	Child moves the feet up and down, at the same time or sequentially, one time or more
Turn around	Child turns his back to the interventionist
Wave	Child moves the palm to the right and to the left once (at minimum) or more

a partial or full physical prompt in addition to the verbal discriminative stimulus (e.g., the interventionist said “Clap!” and then used hand-over-hand guidance or touched the participant’s elbow, depending on the condition in place, to assist the participant to clap) and waited 5 s for the participant to respond. The percentage of correct responding for each of these conditions was calculated by dividing the number of correct responses by the number of total responses (10) and multiplying it by 100. The prompt topography that resulted in the highest level of responding was included in the development of prompt hierarchies for LTM and MTL prompting.

Target Identification In this phase, the interventionist identified target responses to be used in the subsequent phases of the study. Ten new one-step directions were selected from *Teaching language to children with autism or other developmental disorders* (Sundberg & Partington 1998). The interventionists chose targets that were not part of the participant’s current or past preschool intervention. Additionally, no one-step directions that specifically stated an object manipulation (e.g., “Touch ball!”) or explicit body part manipulation (e.g., “Touch nose!”) were tested. One session, consisting of 10 trials, was conducted for each prompt topography. During a trial, the interventionist provided one of the 10 one-step directions and waited 5 s for the participant to respond. After 5 s, regardless of the participant’s responses, the interventionist initiated a new trial.

The interventionists identified the six one-step directions that each participant responded to with the lowest accuracy, and within each category (i.e., fine-motor and gross-motor movements), randomly assigned them to experimental conditions (MTL, LTM, and control, see Table 2). There was one exception to this rule; in error, two gross-motor responses were assigned to the MTL condition and two fine-motor responses were assigned to the LTM condition for James. The fact that the response effort for the MTL condition was higher

did not affect its effectiveness and efficiency, as further described in the “Results” section.

Baseline Baseline was conducted after targets were identified. Two to four baseline sessions were conducted prior to the prompt hierarchy comparison (described below). Each session consisted of 10 trials. For each trial, the interventionist obtained attending behavior (i.e., by asking “Ready?”, or waiting for the participant to look at the interventionist), verbally stated the one-step direction (i.e., discriminative stimulus), and allowed 5 s for the participant to respond. No prompts or programmed consequences were provided. There were three conditions: control, MTL, and LTM. Two target responses were assigned to each of these conditions (described above). During each session, the discriminative stimuli for each of two target responses were presented five times in randomized order.

Prompt Hierarchy Comparison Training consisted of three experimental conditions: (a) control, (b) MTL prompting, and (c) LTM prompting. The control condition was conducted the same as baseline. In MTL prompting, trials were conducted similar to baseline, except that following the verbal

Table 2 One-step directions assigned to different prompt-fading procedures

Participant	MTL	LTM	Control
James	Jump	Blow kiss	Turn around
	Sit down	Point	Wave
Joseph	Jump	Come	Turn around
	Clap	Wave	Point
Sean	Roll (the ball)	Jump	Turn around
	Wave	Point	Stomp feet

Table 3 Operational definitions of prompt levels

Direction	Partial physical 1	Partial physical 2	Full physical
Blow kiss	The interventionist places her hands over the child's upper arm and pushes the arms up	The interventionist places her hands over the child's forearm and hands and pushes the arms and hands up	The interventionist provides hand-over-hand assistance to guide the child in performing the response as described in Table 1. The same topography of full physical prompt (i.e., hand-over-hand assistance) was used for all one-step directions
Clap	The interventionist places her hands over the child's upper arm and pushes the arms up	The interventionist places her hands over the child's forearm and hands and pushes the arms and hands up	
Come	The interventionist applies pressure behind the child's shoulders	The interventionist applies pressure on the child's back to move forward	
Jump	The interventionist applies pressure on the child's underarm	The interventionist places the hands on the child's underarm and pushes the child up	
Point	The interventionist places her hands over the child's upper arm and pushes the arms up	The interventionist places her hands over the child's forearm and hands and pushes the arms and hands up	
Roll (the ball)	The interventionist places her hands over the child's upper arm and pushes the arm toward the ball	The interventionist places her hands over the child's forearm and pushes the hands toward the ball	
Sit down	The interventionist applies pressure on the child's shoulders	The interventionist applies pressure on the child's shoulders to move back	
Stomp feet	The interventionist applies pressure to push up the child's upper legs	The interventionist places her hands over the child's lower legs and pushes up the child's legs off the ground	
Turn around	The interventionist applies pressure behind the child's shoulders	The interventionist applies pressure on the child's back to move to the side	
Wave	The interventionist places her hands over the child's upper arm and pushes the arms up	The interventionist places her hands over the child's forearm and hands and pushes the arms and hands up	

discriminative stimulus, the interventionist waited 2 s before prompting the participant, if needed. MTL prompting presented prompt topographies in succession from most assistance (i.e., full physical prompt) to least assistance (i.e., partial physical prompt). In LTM prompting, prompts were delivered 2 s after the verbal discriminative stimulus, if needed, and prompt topographies were presented in succession from the least assistance to most assistance. Operational definitions of prompt levels for each one-step directions are provided in Table 3.

The criterion for changing between prompt topographies was the same for MTL and LTM prompting. In the MTL condition, the criterion for fading assistance was as follows: following two consecutive trials with correct responding on a given prompt level, a less assistive prompt level was used. For example, after responding correctly for two consecutive trials to the full physical prompt, the participants received an instruction using partial physical prompt. The criterion for increasing assistance during the LTM condition was as follows: following two consecutive incorrect responses on a given prompt level, a more assistive prompt level was used. For example, after responding incorrectly to a partial physical prompt for two consecutive trials, the participants received instruction using a full physical prompt. For both procedures,

a differential reinforcement schedule was in place, where reinforcement was contingent on the lowest intrusive prompt that had evoked correct responding up to that trial, and responding that required more intrusive prompts was no longer reinforced.

The mastery criterion was 90 % or more correct independent responding for two consecutive sessions. After having met the mastery criterion with one prompt-fading procedure, additional sessions were conducted with the remaining two conditions. The number of additional sessions was set at 20 % of the total sessions needed to reach a criterion for the first prompt-fading procedure. For example, if the participant mastered the set of stimuli assigned to the MTL condition in 100 sessions, 20 additional sessions were conducted with the other two conditions (i.e., LTM procedure and control).

Target Reassignment After the 20 % additional sessions, any target responses that had not been mastered were reassigned to be taught using the prompt condition that had led to the quickest mastery criterion in the initial training phase (e.g., if a participant reached the mastery criterion first with the MTL condition, all other sets were assigned to the MTL condition). This follow-up intervention was conducted for a number of

sessions that represented 50 % of the sessions required to reach the mastery criterion with the most successful procedure during the prompt hierarchy comparison.

Maintenance Once the participant reached the mastery criterion in a condition, maintenance probes were conducted. One maintenance probe was conducted for every five training sessions in the other two conditions. Maintenance probes were conducted the same as baseline, with the exception that correct independent responses were reinforced.

Experimental Design

An adapted alternating treatment design (Sindelar et al. 1985) was used to evaluate the effects of three conditions (i.e., MTL, LTM, and control) on each participant's acquisition of one-step directions. The alternating treatment conditions were preceded by a phase of baseline. The order of presentation of the three levels of the independent variable during the alternating treatment analysis was randomized using a random number generator software.

Interobserver Agreement and Treatment Integrity

Interobserver agreement (IOA) data were collected for the comparison of prompting sequences. Data were collected in vivo by the first author, while a second observer analyzed the permanent product (i.e., video footage). The observers recorded each participant's number of independent correct responses for each experimental session. Interobserver agreement data were collected for 49 % of the sessions. Trial-by-trial IOA was used, where the number of trials with agreement was divided by the total number of trials and multiplied by 100. Overall IOA was 96 %, ranging from 70 to 100 %.

Task analyses of interventionist responses were developed for each condition of the prompt hierarchy comparison. An independent observer rated whether the interventionist correctly or incorrectly engaged in each response. The observer analyzed the permanent product (i.e., video footage). Treatment integrity was reported as the percentage of steps performed correctly. Treatment integrity data were collected for 53 % of the sessions. The overall treatment integrity score was 97 %, ranging from 80 to 100 %.

Results

Prompt Topography Assessment

The prompt topography assessment results are depicted in Fig. 1. All participants responded correctly following the presentation of a full physical prompt on 100 % of the trials. Physical prompts were used to develop MTL and LTM

Fig. 1 Prompt topography assessment results

prompt hierarchies based on these data. For all other prompt topographies, correct responding was lower across participants (range, 0 to 50 % correct).

Target Identification

Target responses were identified using the procedures described above. For James and Joseph, the procedure resulted in target responses that also produced low baseline levels. Their target responses are displayed in Table 2. For Sean, after completing the target identification phase and beginning baseline, the interventionist was informed that the classroom teacher independently chose to teach some of the selected responses. As such, the interventionist replicated the target identification phase with new target responses. Sean's target behaviors listed in Table 2 represent targets identified during the second target identification assessment.

Fig. 2 Comparison of correct independent responses with different prompting procedures for James

Prompt Hierarchy Comparison and Target Reassignment

Figure 2 depicts the data for the comparison of prompt-fading procedures with James. During baseline, James' responding ranged between 0 and 20 % correct for all target responses assigned to the various conditions. During baseline, reinforcement was provided for responding correctly and independently during the first session, which might have accounted for these results, but reinforcement was terminated for the remaining three baseline sessions. James met mastery criterion in the MTL condition after 24 training sessions. After reaching the mastery criterion, an additional training session was conducted and James responded with 90 % accuracy. During maintenance, James maintained responding between 0 and 90 % correct. He did not master targets assigned to the LTM training procedure in 29 training sessions, and his performance was between 30 and 50 % correct just prior to the termination of this prompt-fading procedure. During the prompt hierarchy comparison, he responded correctly to 0 or 10 % of the trials associated with the control condition.

After 29 unsuccessful sessions teaching with the LTM prompt-fading procedure, the targets initially assigned to the LTM condition were taught using the MTL prompt-fading strategy. The targets were taught using MTL prompting for 17 additional sessions, during which the trend was ascending and variable with scores ranging from 30 to 90 % correct; however, James did not reach mastery criterion with these targets. The last five sessions were conducted beyond the aforementioned 50 % sessions rule (see the “[Prompt Hierarchy Comparison and Target Reassignment](#)” section) because an ascending trend in correct responding was observed. During the additional sessions, responding returned to a lower

level and the intervention was then discontinued. The control condition targets were also reassigned to MTL prompting, and James mastered these targets with MTL prompting in 13 sessions.

Figure 3 depicts the data for the comparison of prompt-fading procedures with Joseph. During baseline, Joseph made no correct responses in any of the conditions. He met mastery criterion in the MTL condition after 29 training sessions. Maintenance data reflected a variable descending trend, ranging from 70 to 30 % correct. Joseph did not master the targets assigned to the LTM training procedure in 35 sessions, and his performance was between 10 and 50 % correct prior to terminating this prompt-fading procedure. During the initial prompt hierarchy comparison, Joseph responded correctly to 0 % of the trials associated with the control condition.

After 35 unsuccessful sessions of teaching with the LTM prompt-fading procedure, the targets associated with this condition were taught using MTL prompting. Fifteen additional sessions were conducted during which the trend was variable with scores ranging from 10 to 80 % correct. The control condition targets were also reassigned to MTL prompting, and Joseph's response during the 15 additional sessions was variable with a higher average level than baseline. Scores ranged from 0 to 40 % correct. Joseph did not reach mastery criterion with either condition once targets were reassigned to MTL prompting.

Figure 4 depicts the data for the comparison of prompt-fading procedures with Sean. During baseline, Sean's made no correct responses in any of the conditions. He met mastery criterion in the MTL condition after 34 training sessions. Maintenance sessions were conducted, with accuracy ranging from 70 to 100 % correct responding. Sean did not master targets assigned to the LTM training procedure in 42 sessions,

Fig. 3 Comparison of correct independent responses with different prompting procedures for Joseph

Fig. 4 Comparison of correct independent responses with different prompting procedures for Sean

and his performance was between 30 and 50 % correct prior to terminating this prompt-fading procedure. During the prompt hierarchy comparison, Sean's responding in the control condition was variable, with scores ranging from 0 to 50 % correct.

After 42 unsuccessful sessions of teaching with the LTM prompt-fading procedure, the targets associated with this condition were taught using MTL prompting. Seventeen additional sessions were conducted during which the data were relatively stable, with scores ranging from 30 to 60 % correct. Sean did not reach mastery criterion in this condition. The control condition targets were also reassigned to MTL prompting, and Sean reached mastery criterion with these targets using MTL prompting in seven sessions.

Discussion

This study identified effective prompt topographies during the prompt topography assessment and then compared prompt hierarchies using only effective prompt topographies. Under these conditions, all three preschool-aged children diagnosed with ASD mastered target responses with the MTL prompting hierarchy and did not master target responses with the LTM hierarchy, even with 20 % additional sessions. The general procedures replicated those reported by Seaver and Bourret (2014).

While Seaver and Bourret examined the use of extensive assessments on the same topography of a behavior chain (i.e., making Lego© patterns), the current study employed a briefer analysis of antecedent variables. Specifically, in the current study, the prompt topography assessment consisted of assessing responding to different antecedent stimuli (e.g., gestural, physical), without fading those prompts or conducting tests of generality. In clinical settings, the development and implementation of such assessments may help maximize the efficiency of training in the long run. For example, identifying effective and efficient prompt-fading procedure and using those procedures consistently across skills and domains might result in acquiring more skills as compared to making procedural decisions in the absence of such data.

In the present study, MTL prompting led to the quickest skill acquisition for all participants. This stands in contrast to previous studies (Glendenning et al. 1983; Libby et al. 2008; Seaver and Bourret 2014; Walls 1981), in which efficiency outcomes were inconsistent across participants. Since the participants in this study were all young learners (i.e., preschoolers), it is possible that the MTL procedure is generally more consistently effective and efficient with this population. As Green (2001) suggested, it is possible that young learners benefit more from more intrusive transfer-of-stimulus-control procedures, which might not necessarily be the case for older or more advanced learners. Similarly, it is possible that

temporal contiguity plays a more important role in conditioning for young learners, as compared to older ones. It is possible that the MTL procedure was more efficient because in this procedure the time interval between the natural discriminative stimulus and the programmed consequence was shorter, or more contiguous, than for LTM prompting. In MTL prompting, when the participant responded correctly to the most intrusive prompt level, the consequence was delivered immediately. This was not the case for LTM prompting. With LTM prompting, often the least intrusive prompt was ineffective and a few prompts were delivered before the child responded correctly, leading to more time between the discriminative stimulus and correct response and reinforcement. If trials were terminated upon the delivery of an incorrect response at a given prompt level and followed by a new trial where a more or less intrusive prompt was delivered with 0 time delay, both MTL and LTM prompting would be equated in terms of reinforcement immediacy. Future studies should compare the effectiveness of the two types of trials.

One interesting finding of this study was the outcomes of the reassignment phase. When target responses that were not mastered in control and LTM prompting were reassigned to be taught using MTL prompting, the targets previously assigned to the control condition were mastered for two of three participants. No participants mastered the targets that had been previously assigned to the LTM condition. These outcomes are surprising because correct responding was under extinction for the control condition and correct responses were reinforced during the LTM condition. One would expect that responses exposed to extinction would take longer to recondition as compared to previously reinforced responses (Bouton & Swartzentruber 1989). The literature on the effects of instructional history on response acquisition might help clarify these outcomes. Coon and Miguel (2012) found that the procedure that had been used before is likely to result in more efficient acquisition when compared to a never-before-experienced teaching procedure. In contrast, Finkel and Williams (2001) found that textual prompts were effective at teaching intraverbals to one child with ASD, but echoic prompts were not. The authors speculated that the participants may have attended more to the textual prompts because of a history of failure with echoic prompts. Thus, in one study, instructional history facilitated acquisition of new responses, while in another study, it appeared that instructional history may have interfered with acquisition of new responses. It is possible that in the current study, the LTM procedure may have interfered with acquisition of responses when the MTL procedure was then used. This has strong implications for clinical work with individuals with ASD. Traditionally, with behavior analytic instruction, children are taught using a specific prompting procedure, and if they do not demonstrate an increase in correct responding, the teaching procedure is changed. The results of the current study suggest that teaching with an ineffective

teaching procedure may hinder learning with a more effective teaching procedure, providing preliminary evidence for the need of prompt-topography and prompt-hierarchy assessments early in intervention. Nevertheless, this cannot be derived from this study alone and future research should be conducted to determine the extent to which history of exposure to prompting procedures affects future acquisition.

There are some limitations to this study. First, there were some treatment integrity failures that might have affected the results. During baseline, for most sessions, there were no programmed consequences for responding, whereas in one session, programmed consequences were provided (i.e., James' first baseline session). There were other deviations from the procedures, such as assigning two gross-motor movements to James' MTL condition and two fine-motor movements to his LTM condition; however, the reliability of the findings across participants suggests that these integrity issues had little or no effect. Second, Joseph demonstrated a decrease in accuracy of responding during maintenance probes. It is important to identify not only optimal teaching procedure but also procedures that lead to better maintenance of responding as well. Future studies should incorporate strategies to facilitate and program for better response maintenance, such as identifying the optimal maintenance schedule for each learner or modifying the consequences so that they match the natural contingencies (e.g., schedule of reinforcement, type of reinforcer) available in the participant's environment (Stokes & Baer 1977). Third, the measurement of efficiency employed in this study was sessions to criterion, while previous studies reported a broader set of measures, such as trials to criterion, sessions to criterion, and number of errors (e.g., Libby et al. 2008). Including a larger number of measurements can increase internal validity when the outcomes are congruent or can suggest new avenues of research when they are not, as was the case in Libby et al. (2008). Fourth, the prompt topography assessment identified stimuli that were potent enough to evoke correct responding. These stimuli were presented in isolation; it is possible that when presented in a hierarchy, such as from most intrusive to least intrusive (e.g., from full physical to gestural), transfer of stimulus control is achieved. Future studies should further investigate this hypothesis. Last, such a formal prompt topography assessment might not be needed in clinical settings, if program development is designed by a clinician who is familiar with the learner's skills and deficits. For example, if the clinician observes that the learner is typically not able to respond correctly to model prompts, she might use other stimulus topographies as prompts and set a separate goal for physical imitation, so that the learner ultimately can respond to imitative prompts as well.

This study replicated Seaver and Bourret (2014)'s approach to identifying effective prompt topographies prior to comparing prompt hierarchies and extended the work by providing additional support with younger populations and an alternative

procedure for conducting the prompt topography assessment. Such methodology can help identify optimal prompting procedures for learners with ASD. More research is needed to investigate whether these two types of prompting assessments are equally effective at identifying optimal procedures for participants; however, the outcomes of these two studies provide support for the development and use of such assessments in clinical practice with individuals with ASD.

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Compliance with Ethical Standards All the procedures performed in the study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the Institutional Review Board of the City University of New York (CUNY).

Conflict of Interest The first author received financial support from the Graduate Center, CUNY, to present the research data at the ABAI 41st Annual Convention in San Antonio. We believe that this funding does not create a potential conflict of interest.

Informed Consent Informed consent was obtained from the caretakers of all the participants included in the study.

References

- Bouton, M. E., & Swartzentruber, D. (1989). Slow reacquisition following extinction: context, encoding, and retrieval mechanisms. *Journal of Experimental Psychology: Animal Behavior Processes*, 15, 43.
- Coon, J. T., & Miguel, C. F. (2012). The role of increased exposure to transfer-of-stimulus-control procedures on the acquisition of intraverbal behavior. *Journal of Applied Behavior Analysis*, 45, 657–666.
- Demchak, M. (1990). A comparison of graduated guidance and increasing assistance in teaching adults with severe handicaps leisure skills. *Education & Training in Mental Retardation*, 1, 45–55.
- Finkel, A. S., & Williams, R. L. (2001). A comparison of textual and echoic prompts on the acquisition of intraverbal behavior in a six-year-old boy with autism. *The Analysis of Verbal Behavior*, 18, 61–70.
- Fisher, W., Piazza, C. C., Bowman, L. G., Hagopian, L. P., Owens, J. C., & Slevin, I. (1992). A comparison of two approaches for identifying reinforcers for persons with severe and profound disabilities. *Journal of Applied Behavior Analysis*, 25, 491–498.
- Glendenning, N. J., Adams, G. L., & Sternberg, L. (1983). Comparison of prompt sequences. *American Journal of Mental Deficiency*, 88, 321–325.
- Green, G. (2001). Behavior analytic instruction for learners with autism: advances in stimulus control technology. *Focus on Autism and Other Developmental Disabilities*, 16, 72–85.
- Libby, M. E., Weiss, J. S., Bancroft, S., & Ahearn, W. H. (2008). A comparison of most-to-least and least-to-most prompting on the acquisition of solitary play skills. *Behavior Analysis in Practice*, 1, 37–43.
- McConville, M. L., Hantula, D. A., & Axelrod, S. (1998). Matching training procedures to outcomes: a behavioral and quantitative analysis. *Behavior Modification*, 22, 391–414.

- Rosales-Ruiz, J., & Baer, D. M. (1997). Behavioral cusps: a developmental and pragmatic concept for behavior analysis. *Journal of Applied Behavior Analysis*, 30, 533–544.
- Seaver, J. L., & Bourret, J. C. (2014). An evaluation of response prompts for teaching behavior chains. *Journal of Applied Behavior Analysis*, 47, 777–792.
- Sindelar, P. T., Rosenberg, M. S., & Wilson, R. J. (1985). An adapted alternating treatments design for instructional research. *Education and Treatment of Children*, 8, 67–76.
- Stokes, T. F., & Baer, D. M. (1977). An implicit technology of generalization. *Journal of Applied Behavior Analysis*, 10, 349–367.
- Sundberg, M. L., & Partington, J. W. (1998). *Teaching language to children with autism and other developmental disabilities*. Pleasant Hill, CA: Behavior Analyst.
- Walls, R. T. (1981). Prompting sequences in teaching independent living skills. *Mental Retardation*, 19, 242–245.
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