A Comparison of Most-to-Least and Least-to-Most Prompting on the Acquisition of Solitary Play Skills

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ABSTRACT

Two studies are presented in which common prompting procedures were evaluated while teaching children with autism to build Lego® play structures. In the first study, most-to-least (MTL) and least-to-most (LTM) prompting were compared. All participants learned to build the play structures when the teacher used MTL, which was associated with fewer errors than LTM. Nonetheless, three participants learned more quickly with LTM. This finding suggests that MTL may prevent errors, but it sometimes slows learning. The second study compared LTM to MTL without and with a delay (MTLD). MTLD provided an opportunity for the child to independently initiate responding but still minimized the likelihood of errors. Results showed that acquisition was nearly as rapid when the teacher used MTLD as LTM but it produced fewer errors than LTM. Best practice guidelines for choosing prompting procedures are proposed.
Descriptors: autism, behavior chains, play skills, prompting

Applied behavior analysts have a rich history of teaching socially important behavior to individuals with developmental disabilities and autism using behavior chaining. A behavior chain is a sequence of responses leading to a terminal behavioral objective. For example, brushing teeth involves responses such as picking up the toothbrush and toothpaste, squeezing the toothpaste onto the brush, bringing the brush into the mouth, brushing all of the teeth thoroughly, and rinsing the mouth. The order of this sequence is not fixed (e.g., the toothpaste can be picked up before the toothbrush), but some steps must come before others (e.g., toothpaste should be on the brush before the teeth are brushed). The units of responding within a chain are established by developing a task analysis, which is the delineation of a skill into its essential components (Cooper, Heron, & Heward, 2007; Foxx, 1982). Task analyses specify the response components and response sequences necessary to teach a complex skill. Task analyzed chaining has been used to teach a variety of skills, such as mending (Cronin & Cuvo, 1979), cooking (Schleien, Ash, Kiernan, & Wehman, 1981), completing vocational tasks (e.g., Maciag, Schuster, Collins, & Cooper, 2000), and following picture activity schedules (e.g., MacDuff, Krantz, & McClannahan, 1993).

A variety of response prompts, including vocal instruction, modeling, and physical guidance, have been used to teach chained responding (e.g., Cuvo, Leaf, & Borakove, 1978; Glendenning, Adams, & Sternberg, 1983). For example, Cuvo et al. used vocal instructions, along with modeling and physical guidance, to teach janitorial skills. Glendenning et al. found that vocal prompts were more effective when combined with physical prompts when teaching vocational tasks (i.e., tying strings around boxes). Systematic fading of prompts is also important to promote prompt-free or independent performance.

Effectiveness and efficiency of teaching are often cited as critical factors in evaluating chaining procedures. A procedure is considered effective if it leads to acquisition of the targeted skill. Efficiency is defined as the number of learning trials or time it takes to reach criterion performance, as well as the number of errors that occur during acquisition (Gast, Doyle, Wolery, & Ault, 1991). Response prompting procedures used to teach response chains likely have a crucial impact on the effectiveness and efficiency of teaching.

The focus of the current study was on the use of physical prompts to teach behavior chains. Generally, physical prompts are faded using either most-to-least or least-to-most techniques, both of which can be combined with a time delay. Most-to-least prompting consists of a teacher placing his or her hands over the learner's hands to guide the learner through the initial training trials. A less intrusive prompt, such as guiding the learner at the wrist, is used on subsequent training trials. The intrusiveness of the prompt continues to be faded as long as the learner is demonstrating success during training trials. With least-to-most fading, the teacher allows the learner a brief opportunity to respond independently on each training trial and then delivers the least intrusive prompt if needed. Increasingly more intrusive prompts are then delivered as necessary for the learner to complete each training trial. Time delay refers to the amount of time the learner is given to engage in the desired response prior to the teacher issuing a prompt. Inserting a delay to the prompt can be helpful when fading physical prompts.

One strength of behavior analytic techniques is that they can be tailored to the unique learning characteristics of each person. However, there have been far too few systematic comparisons of

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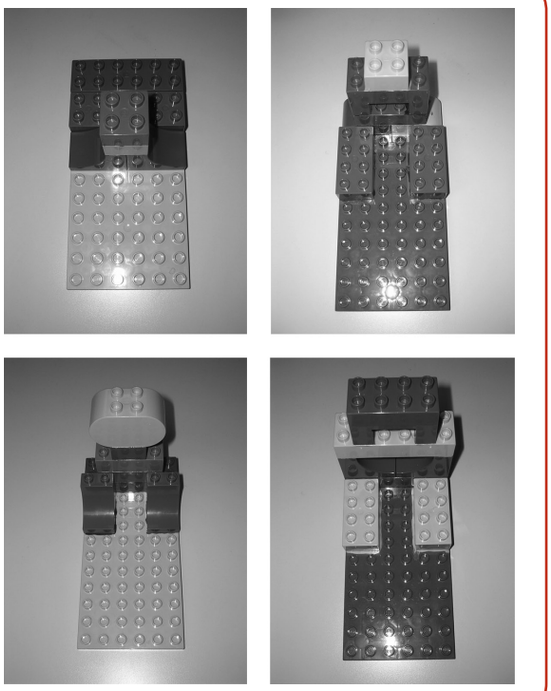

Figure 1. Pictures of the play structures that children were taught to build in Study 1.

prompting procedures to determine the relative efficacy of each. Demchak (1990), who reviewed the literature on response prompting procedures, made the following tentative conclusions for behaviors taught through chaining: (a) Most-to-least prompting is associated with fewer errors than least-to-most prompting; (b) constant time delay and least-to-most prompting are equally effective in teaching chains, but constant time delay is more efficient; and (c) more comparative research on prompt fading methods would be useful to guide practitioners. Many studies have examined specific prompting techniques or variants of effective strategies since Demchak was published. However, very few have systematically compared them and no definitive conclusions have been made.

The purpose of the current study was to conduct a comparative analysis of common prompting techniques for teaching behavior chains. The goal was to develop a strategy for identifying the most effective and efficient prompting procedure for learners who require systematic prompting to acquire new skills. When conducting this type of comparative analysis, special consideration must be given to other factors that might influence the relative outcomes of prompting techniques. One such variable is the size and complexity of the steps in the chain. It can be challenging to equate the difficulty or complexity of tasks associated with different prompting techniques. Previous comparison studies have examined chains with equal numbers of steps or with steps of equal difficulty (e.g., Kayser, Billingsley, & Neel, 1986; Spooner, 1984; Walls, Zane, & Ellis, 1981). However, these studies evaluated heterogeneous chains (steps with different response characteristics), so it is likely that task difficulty remained a relatively uncontrolled variable.

With this in mind, the children in this study were taught to manipulate Lego® blocks to assemble structures as they would during certain types of solitary play (e.g., building a house from blocks). Increasing appropriate solitary play skills was a goal for all of the participants. Each step of the chain consisted of locating and placing one piece in its designated place. The structures constructed were arbitrary in that they did not resemble real-life structures. This was done in an attempt to equate task difficulty and control for learning history. That is, while our participants may have had varied experience playing with Lego® blocks, none would have had any prior history with the actual structures they were taught to construct in the study.

We compared most-to-least and least-to-most prompting in the acquisition of these construction tasks. Based on the literature review, we assumed that the children would make fewer errors with most-to-least prompting than with least-to-most prompting. However, clinical experience led us to believe that the prompting procedure that would produce the most rapid acquisition (in terms of trials to criterion) would likely vary across the participants. In the first study, we compared most-to-least prompting to least-to-most prompting. In the second study, we compared least-to-most prompting to most-to-least prompting when it did and did not include a time delay.

Study I - Method

Participants

All five participants were children who resided in a private residential school for children with autism and related disabilities. Each child received educational and behavioral services at a centrally located school and in their various residences. All of the participants except Zach were diagnosed with autism. Zach was a 15-year-old boy with a primary diagnosis of pervasive developmental delay (PDD). He communicated through the use of a voice output device and a few manual signs. He also used a picture-based communication system with approximately 12 pictures. He produced vocal imitations and approximations but frequently emitted stereotypic vocal utterances. He could follow 2-step directions and was grouped in a 1:2 teacher-to-student ratio throughout his day. Ernie was an 11-year-old boy who had minimal expressive and receptive skills and communicated through vocalizations which approximated word sounds. He also used a picture-based communication system with approximately 30 pictures and had some limited signing. He could follow 2-step directions and was typically grouped in a 1:2 or 1:3 teacher-to-student ratio.

Tom, a 9-year-old boy, communicated vocally and could follow multi-step directions. He frequently received 1:1 staffing for problem behavior but was typically grouped 1:2 for academic instruction. Ricky was a 9-year-old boy who communicated vocally, often in complete sentences, and had good receptive skills. He could follow multiple-step directions and typically received 1:1 staffing due to behavior problems. Andy, a 9-year-old boy, communicated with the use of a picture-based communication system and manual signs. Andy had a receptive and expressive vocabulary of approximately 10 signs and was learning to make full sentence requests with picture cues using over 50 pictures. He followed 2-step directions and was typically grouped in a 1:2 teacher-to-student ratio.

All participants had received developmental testing in conjunction with the development of individual educational plans and all tested below 3 years of age. None were on behavior control medications

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during the study. Although all of the participants exhibited behavior problems, none of the target behaviors occurred during the study.

Setting

Training was conducted either in a classroom at the participants' school or in a leisure room at their residence. For a given participant, all training sessions occurred in the same setting. Materials in the training settings included a table, at least two chairs, data sheets, pencils, the task materials, preferred edibles, and a video camera. More than 60% of sessions were videotaped.

Materials and Task Analyses

Four play structures made from Lego® blocks were developed. The structures were randomly assigned to a teaching condition, and each structure was taught at least once with each response prompting technique. The four structures were evaluated by six independent raters (teachers and administrators) and judged to be of equivalent difficulty. Each structure consisted of a base upon which seven other Lego® pieces were placed. The bases for the four structures were the same shape and size, but varied in color. The completed play structures are shown in Figure 1. For each structure, the individual building pieces varied in color and shape but only one was used for each step in the chain. An 8-step task analysis that specified the order of placement of the pieces was developed for each structure. The first step of each chain was for the participant to pull the base out from a group of the blocks. The second and all following steps involved picking up and placing one block in the order determined by the task analysis. (To view the task analyses, visit www.abainternational.org/BAinPractice.asp). Each structure was taught to the participants using a different prompting technique so that the effectiveness and efficiency of the techniques could be compared.

Training Procedures

Prior to the study, a food preference assessment based on the methods described by Fisher et al. (1992) was conducted to identify highly preferred food items for each participant. At the beginning of each training session, the participant chose between two highly preferred foods, and the selected item was used as a reinforcer for correct responses in that session.

Forward chaining was used to teach all chains, regardless of the prompting technique. That is, each successive step in the chain was taught after the participant had mastered the previous step in the chain. At the beginning of each instructional trial, the trainer placed the materials in front of the participant in a random arrangement and said, "Let's play." Data were collected on the number of steps performed independently in sequence on the last trial of each session, the number of errors per session, and the number of sessions to acquisition. Correct order and placement were required to score a step as being correctly completed.

Each training session consisted of one "probe" trial followed by 10 training trials. The purpose of the probe trial was to allow the learner an opportunity to independently construct the Lego® structure in the absence of prompting and reinforcement. The probe trial continued until the participant made an error or went 15 s without responding. Probe data from the very first session served as baseline and indicated that none of the participants demonstrated any correct steps in the chain.

During training trials, the chain was taught using either most-to-least or least-to-most prompting. Each prompting technique was associated with a different but equally difficult response chain. The most-to-least prompting hierarchy (MTL) included five prompting levels: hand-over-hand, hand on the participant's forearm, hand on the participant's upper arm, light touch or shadow by the elbow, and no prompt. The prompting levels associated with MTL prompting are shown in Figure 2. The criterion for reducing the level of assistance on a step was two consecutive correct responses at the designated prompt level. Two consecutive errors led to an increase in the intrusiveness of the prompt used. After two consecutive correct independent responses, training moved to the next step in the chain. The least-to-most prompting hierarchy (LTM) was the same as that used for most-to-least but in the reverse order (see Figure 2). At the training step, the participant was given 2 s to respond independently. If there was no response, the trainer proceeded to give the next most intrusive prompt at 2 s intervals until the training step was completed. After 2 consecutive independent trials, the next step was taught. The training step at the start of each session was based on performance in the prior session.

With both prompting techniques, any errors made on the training step or on previously acquired steps of the chain were immediately corrected with hand-over-hand guidance. Two consecutive errors

Least-to-Most

Independent
Light touch/shadow
Manual guidance at upper arm
Manual guidance at forearm
Hand over hand

Most-to-Least

Hand over hand
Manual guidance at forearm
Manual guidance at upper arm
Light touch/shadow
Independent

Most-to-Least with 2-s Delay

Hand over hand
2-s delay, manual guidance at forearm
2-s delay, manual guidance at upper arm
2-s delay, light touch/shadow
Independent

Figure 2. This diagram shows the prompt levels associated with the three prompting techniques examined across the two studies (least-to-most and most-to-least with and without a 2-s delay); The most intrusive prompt in the sequence is shown in boldfaced type, and the opportunity for independent performance during training trials is italicized.

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on a previously acquired step resulted in retraining on that and all subsequent steps. Reinforcement consisting of the trainer saying, "Good Job," and delivering a preferred food item immediately followed correct completion of the trained step. After delivery of the reinforcer, the trainer completed the remaining (untaught) steps in the chain prior to starting the next training trial. Thus, a full model was displayed to each participant at the end of each trial. Each participant was taught by only one trainer, and there were different trainers across participants.

The mastery criterion was met when all steps of the chain were completed independently for two consecutive trials. If performance was 100% correct on a probe trial, another probe was run. If both probe trials were 100% correct, the solitary play structure was considered mastered. Thus, a structure could either be mastered at the start of a session, as indicated by performance during the probe, or mastery could emerge during the training trials. Following mastery, generalization probes were conducted by a novel trainer in a different room, typically on the same day as mastery was achieved. The skill was considered generalized if the participant completed the structure independently during the probe.

Performance associated with the two different prompting techniques was compared by rapidly alternating training sessions with each chain. This is called a multielement or alternating treatments design. Sessions were alternated such that no more than two sessions of either prompting procedure were run consecutively. Participants received training sessions one to three times per day, 2 to 5 days per week. Multiple sessions on one day were separated by a minimum of 10 min of unrelated activities.

Interobserver Agreement and Procedural Integrity

Most sessions were videotaped to allow interobserver agreement and procedural integrity to be measured. Agreement on each student's performance was examined on a trial-by-trial basis. Two trained observers independently recorded participant responses during at least 50% of sessions, and reliability was calculated by dividing the number of agreements by the total number of agreements and disagreements and multiplying by 100%. Mean agreement scores on training step performance exceeded 95% for each participant across conditions (range, 92% to 100%) Another critical aspect of teaching is procedural integrity or the accuracy with which the training procedures are implemented. The accuracy with which the trainers set up each training step, prompted correct responses, and delivered reinforcement was assessed by trained observers during a minimum of 50% of sessions across participants, conditions, and trainers. Mean accuracy scores were 95% (range, 93% to 100%).

Table 1: Total Number of Sessions and Average Number of Errors per Session in Study 1

Participant	Most-to-Least		Least-to-Most	
	Total Sessions	Avg. per session	Total Sessions	Avg. per session
Ernie	6	1.2	4	3.8
Ricky	4	0.5	3	1.3
Tom	11	0.8	7	2.7
Zach	22	2.2	23	4.6
Andy	26	1.6	22	2.2

Table 2: Number of Sessions and Average Number of Errors per Session in Study 2

Participant	Most-to-Least		Delayed Prompt		Least-to-Most	
	Total Sessions	Ave. per session	Total Sessions	Ave. per session	Total Sessions	Ave. per session
Ernie	15	2.33	6	2.17	5	3.4
Ricky	15	1.6	5	1.4	3	2.3
Ian	6	0	4	0.5	3	0

Results and Discussion

Acquisition graphs in Figures 3 and 4 show the number of consecutive independent steps performed by each participant on the last training trial of each session, as a function of the prompting procedure. Examining the last training trial reveals the learner's performance at the end of the training session. If all steps on the initial probe trial for a session were 100% correct, the data point for that session reflects performance on the probe. Three of the children (Ernie, Ricky, and Tom) acquired the chain in fewer sessions with LTM than with MTL. On the other hand, Zach had not yet progressed beyond Step 3 of the chain associated with LTM prompting when he acquired the chain associated with the MTL prompting. Therefore, after the 22nd LTM session, the prompting technique was changed to MTL. Zach then acquired the chain in 6 additional sessions. In a similar manner, Andy had made no progress on the structure being taught using LTM when he had acquired the chain taught through MTL. At that point, the LTM prompting procedure was changed to MTL. Andy then acquired that chain in 6 additional sessions. All participants immediately showed generalized responding to a novel therapist and setting.

Table 1 shows the total number of sessions and the average number of errors per session that were associated with the two prompting techniques. All participants made more errors with LTM prompting than with MTL prompting. The type of errors varied across individuals and did not cluster around a specific step of the task analysis for a structure.

To summarize briefly, for two of the five participants, MTL was more effective and efficient than LTM in teaching solitary play chains. However, both prompting techniques produced learning for the other three participants, although LTM was more efficient in all cases. Thus, although MTL may not be necessary for all learners, there

Video clips of simulated training sessions can be found on the BAP website
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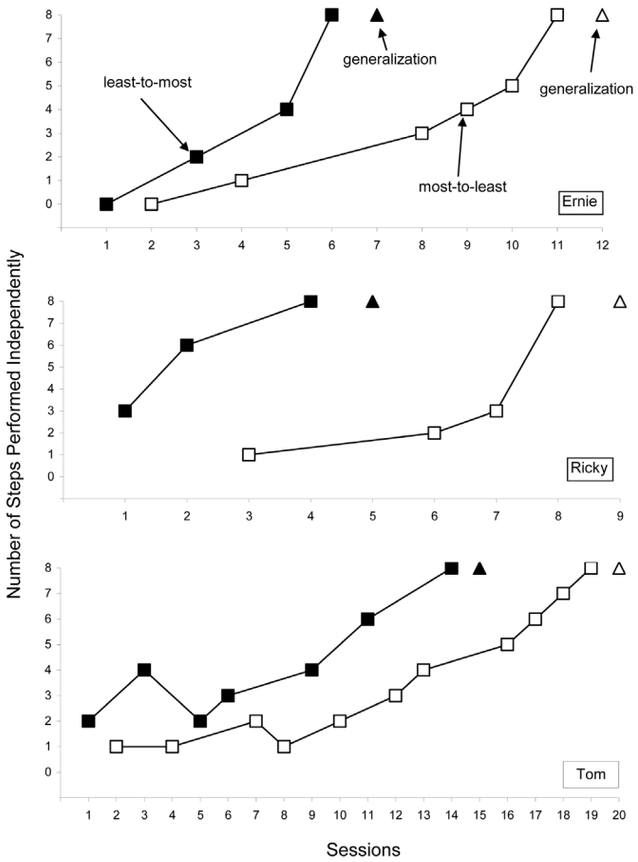

Figure 3. The number of steps of the task analysis performed independently during training with most-to-least and least-to-most prompting for three participants in Study 1. Each graph shows the results for one participant. The solid squares represent the acquisition of independent steps for the least-to-most condition. Open squares represent acquisition of independent steps for the most-to-least condition. The triangles represent the generalization trials.

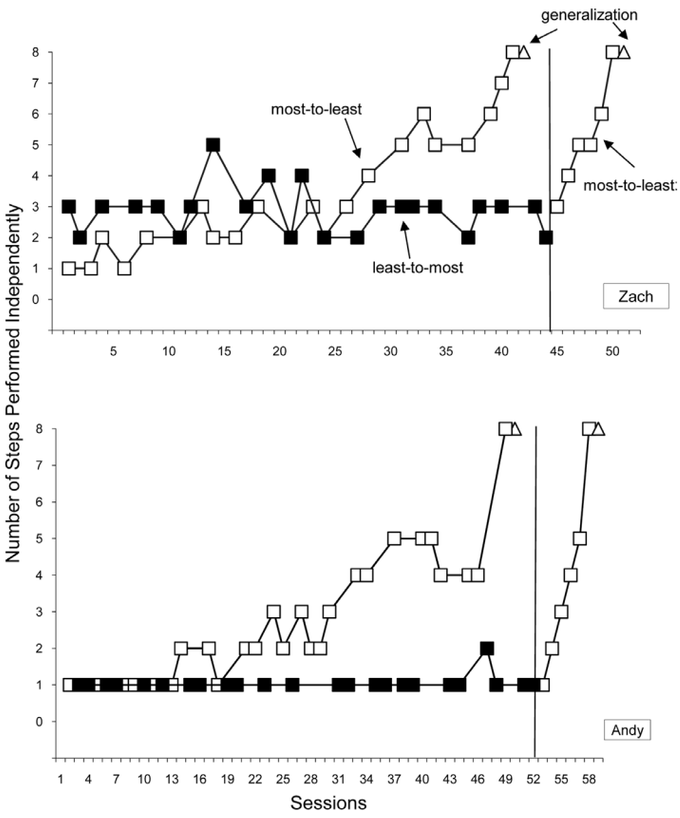

Figure 4. The number of steps of the task analysis performed independently during training with most-to-least and least-to-most prompting for two participants in Study 1. Each graph shows the results for one participant. The solid squares represent the acquisition of independent steps for the least-to-most condition. Open squares represent acquisition of independent steps for the most-to-least condition. The triangles represent the generalization trials.

were more errors per session with LTM prompting than with MTL prompting. This finding is consistent with those reported previously (Demchak, 1990). Overall, results support the use of MTL when errors are highly undesirable.

It is possible that the slower acquisition associated with MTL for the three participants was simply an artifact of the prompting procedure itself. As implemented, the prompt fading procedure required 8 trials of guided performance (2 trials of correct responding at each prompt level) before independent performance was possible, unless it occurred on the probe trial. Thus, the physical prompts provided to the participants at each step may have prevented them from engaging in independent responding. Prompt fading may have occurred more slowly than was necessary for the participants.

If so, this limitation of MTL could be remedied by combining MTL with a time-delay procedure. To examine this possibility, the trainers delayed the prompt for 2 s when using MTL in a second study. This allowed for independent performance to be demonstrated within the session as soon as the participant acquired the step. It could be very beneficial to develop a procedure that allows the learner to demonstrate a response as soon as it is acquired, as with LTM, but which also limits errors, as with MTL.

Study 2 - Method

Participants and Setting

Ernie and Ricky participated again, along with a third participant, Ian. Ian was a 9-year-old boy whose primary diagnosis was autism. Ian communicated vocally, followed 2- and 3-step directions, and could expressively label a variety of pictures, objects and people. Ian was typically grouped in a 1:2 teacher-to-student ratio. The setting was the same as that in Study 1.

Training Procedures

All procedures were the same as in Study 1 except that 10-step rather than 8-step solitary play chains were taught. In addition, three prompting techniques were compared for each participant: LTM, MTL, and MTL with a fixed time delay (MTLD). The MTLD procedure was identical to the MTL procedure except that, on all prompting steps except hand-over-hand, the experimenter waited 2 s before prompting

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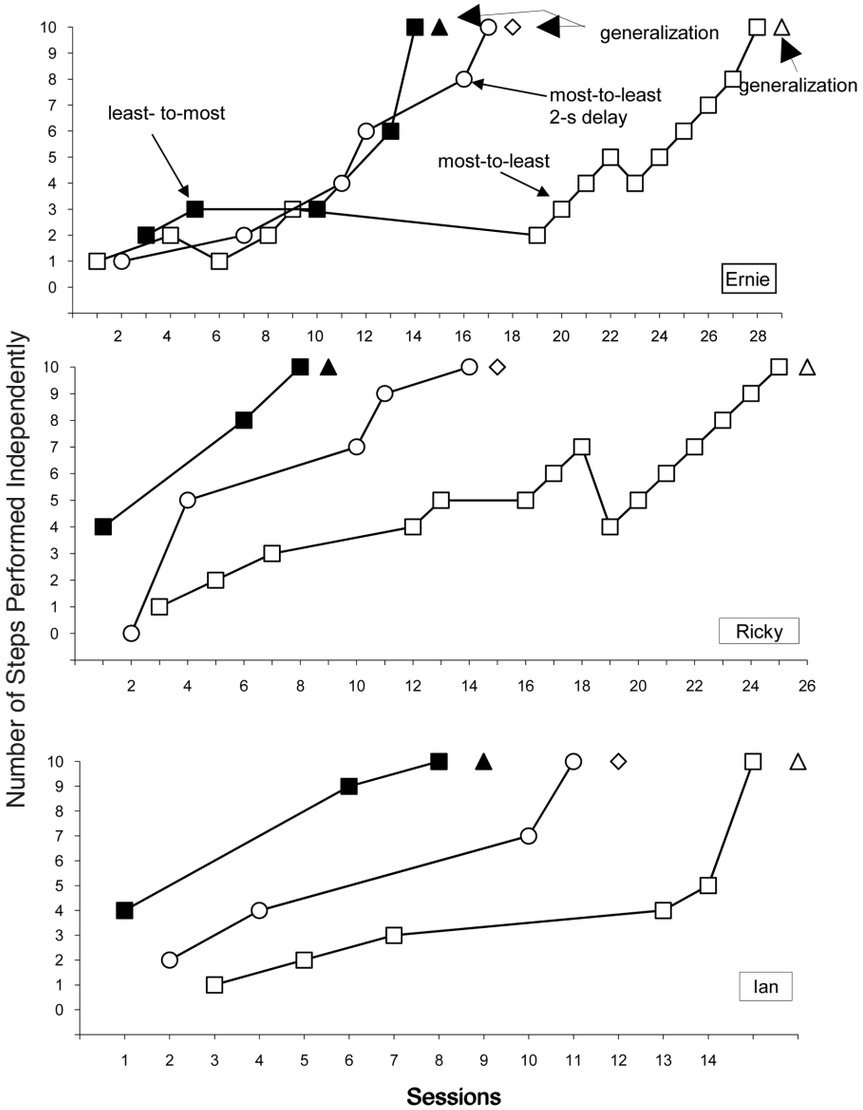

Figure 5. The number of steps of the task analysis performed independently during training with least-to-most prompting and most-to-least prompting with and without a delay for the three participants in Study 2. Each graph shows the results for one participant. The solid squares represent the acquisition of independent steps for the least-to-most condition. Open squares represent acquisition of independent steps for the most-to-least condition. The triangles and diamonds represent the generalization trials.

the participant unless an error was made; errors were corrected immediately with hand-over-hand guidance (see Figure 2 for prompt levels). Each participant was taught 3 different chains, each of which was associated with a different prompting technique. Sessions with each technique were rapidly alternated, as in Study 1. The assignment of chains to a prompting procedure was counterbalanced across the participants.

Results and Discussion

Acquisition graphs in Figure 5 show the number of consecutive independent steps performed by each participant on the last training trial of each session, as a function of the prompting procedure. All 3 participants acquired the chain trained with LTM first, followed by the chain trained with MTLD and then the chain trained with MTL. However, it should be noted that acquisition was nearly as rapid when the trainer used the MTLD procedure as the LTM procedure. Furthermore, both MTL and MTLD were associated with fewer errors per session than LTM, with the exception of Ian who had very few errors with any of the prompting techniques (see data in Table 2). These findings showed that MTLD was just as efficient as LTM in producing acquisition yet produced fewer errors.

Conclusions and Guidelines for Best Practice

Developing efficient and effective procedures for teaching students with autism and other developmental delays is fundamental to advancing applied behavior analysis as a field. Overall, results of these empirical analyses showed that MTL led to fewer errors per training session than LTM and produced fairly rapid acquisition when it was combined with a time delay. Furthermore, it was much more effective than LTM for two participants.

Practitioners may want to minimize errors because they have been shown to impair discrimination learning (e.g., Terrace, 1963). Errors provide no more, and perhaps less, feedback than correct reinforced attempts. They require additional training trials depending on the retraining criteria and make training more complex for teachers because decisions have to be made about resetting training steps and prompting levels. Errors also produce a lower rate of reinforcement per response, which may impair learning. Finally, minimizing errors may reduce the likelihood of problem behavior during instruction (Weeks & Gaylord-Ross, 1983).

Thus, MTLD may be the best choice as a default strategy. Nonetheless, some individual differences were found among the learners in this study. For example, although MTL prompting was the only technique that was effective for two participants in Study 1, LTM produced the most rapid acquisition for the remaining children. Based on these findings and those of previous studies, the following guidelines are recommended for best practice:

- MTLD is likely the best default response prompting technique when a child's learning history is unknown.
- MTL or MTLD is preferable if errors have been found to impede a child's learning or to increase problem behavior; however, MTL without a time delay may produce slower acquisition even though it minimizes errors.

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- LTM may be preferable for students who have already shown rapid acquisition with this prompting technique.
- Progress should be monitored frequently to insure that errors do not stall learning.

These recommendations indicate another important clinical implication of the findings: The prompting technique should be tailored to the individual learner. The procedures used in this study may be useful for determining the most effective prompting technique for individual learners. As demonstrated in this study, practitioners who would like to compare different prompting strategies for their learners should make certain that the tasks are of equal difficulty and that the learner does not have unequal exposure to the tasks prior to the comparison.

Practitioners should also consider the possibility that the most effective prompting technique for a learner may vary across the types of skills that are being taught. For example, a student may readily learn to answer questions with LTM prompting but require MTL prompting when learning to button a shirt. Further research is needed to address this issue. In the meantime, practitioners should probably conduct these comparisons for different skills areas with individual learners.

It should also be pointed out that the present data were obtained with participants diagnosed with autism, all boys between the ages of 9 and 15 who lived in the same residential facility. These findings may not generalize to other individuals, such as those who do not have the diagnosis of autism but do have profound intellectual disabilities. More research on chaining and prompting techniques is necessary to inform our practices so that we provide our students with the most effective and efficient training technology.

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