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Assessment to identify learner-specific prompt and prompt-fading procedures for children with autism spectrum disorder

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Few studies have evaluated the use of assessment to identify the most efficient instructional practices for individuals with autism spectrum disorder. This is problematic as these individuals often have difficulty acquiring skills, and the procedures that may be efficient with one individual may not be for others. The experimenters conducted instructional assessments to identify the most efficient prompt type (model, partial physical, full physical) and prompt-fading procedure (progressive delay, most-to-least, least-to-most) for teaching auditory–visual conditional discriminations for individuals with autism spectrum disorder. Each assessment was conducted at least twice, and a final generality test combined the most and the least efficient prompt type and prompt-fading procedure for teaching novel auditory–visual conditional discriminations. The results demonstrated learner-specific outcomes for the prompt type assessment, whereas the least-to-most prompt fading procedure was most efficient for all participants.

Key words: assessment, auditory–visual conditional discrimination, instructional efficiency, prompt fading, prompt type

Assessment plays a vital role in the programming and education of students with autism spectrum disorder (ASD). Assessment procedures typically involve the systematic collection and interpretation of data on which to base instructional decisions (Pierangelo & Giuliani, 2012). Behavior analysts could use assessment outcomes to identify educational goals for students, provide input on how a teacher should arrange instruction to achieve these goals, and evaluate the extent to which students make progress toward and meet these goals.

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Recently, a handful of studies have begun to examine the use of assessment procedures to identify the most efficient learner-specific instructional procedures for individuals with ASD (e.g., Bourret, Vollmer, & Rapp, 2004; Carroll, Owsiany, & Cheatham, 2018; Cengher et al., 2015; Johnson, Vladescu, Kodak, & Sidener, 2017; McGhan & Lerman, 2013; Seaver & Bourret, 2014). Broadly speaking, the purpose of these studies is to identify learner-specific instructional components that would lead to the most efficient learning outcomes. The hope is that by identifying the most efficient instructional components, individuals with ASD will acquire skills quicker, maximizing instructional time and resources.

For example, Seaver and Bourret (2014) conducted separate assessment phases to identify the most efficient prompt type (verbal plus gestural, model, or physical) and prompt-fading procedure (least-to-most, most-to-least, or progressive prompt delay) for teaching building block structures for 10 participants with ASD. The experimenters demonstrated that the most efficient prompt type and prompt-fading procedure was learner specific. Efficiency was determined by analyzing the number of training trials required to mastery. In addition, Seaver and Bourret demonstrated generality of the assessment outcomes by comparing the most and least efficient prompt type and prompt-fading procedure on the acquisition of various domestic and vocational skills with the same participants.

Cengher et al. (2015) replicated and extended Seaver and Bourret (2014) by using an assessment procedure to identify the prompt type that resulted in the most efficient acquisition of responses to one-step directions for three preschool-age participants with ASD. Once the most efficient prompt type was identified, the experimenters compared the most-to-least (MTL) and least-to-most (LTM) prompt fading procedures. The results of Cengher et al. demonstrated that MTL fading was more efficient than LTM prompt fading for all three participants.

These previous studies on the use of instructional assessment have primarily evaluated efficiency of instruction by comparing relative training trials to mastery (Cengher et al., 2015; Seaver & Bourret, 2014). One potential question is whether this measurement scale is the most accurate way to determine efficiency, especially if there are differences in the amount of total training time across conditions. For example, for one participant in Black et al. (2016), one condition was judged more efficient when relative training sessions were considered, whereas another condition was more efficient when training time was evaluated.

Although the use of assessment holds promise to identify learner-specific instructional components for individuals with ASD, generality across tasks remains a concern. While previous studies have examined the effects of instructional assessment to identify prompt type and prompt-fading procedures as they relate to block building (Seaver & Bourret, 2014) and one-step direction following (Cengher et al., 2015), no studies to date have examined the usefulness of such assessment to identify prompt type and prompt-fading procedures on acquisition of auditory–visual conditional discriminations (AVCDs) during discrete-trial teaching for individuals with ASD.

Early intensive behavioral intervention programs commonly target AVCDs (Cubicciotti, Vladescu, Reeve, Carroll, & Schnell, 2018; Schneider, Devine, Aguilar, & Petursdottir, 2018). This is not surprising considering many skills require individuals to differentially respond to the verbal behavior of others. Additionally, it is not uncommon for teachers to observe responding during conditional discrimination tasks that is indicative of faulty stimulus control (e.g., stimulus overselectivity, stimulus biases, position biases; Pilgrim, 2015). Future research is needed as differences in the prompt type or prompt-fading procedure may ultimately influence the development of stimulus control.

Therefore, the purpose of this study was to replicate and extend Seaver and Bourret (2014). We replicated the procedures of Seaver and Bourret by conducting prompt type and prompt-fading assessments designed to determine the most efficient instructional components for learners with ASD. We extended the procedures of Seaver and Bourret by evaluating these assessments on the acquisition of AVCDs as measured by total training sessions and total training time required prior to mastery. Additionally, data were collected on the occurrence of problem behavior across prompt-type and prompt-fading procedures to evaluate whether participants would differentially respond with elevated levels of problem behavior across conditions, potentially leading to increases in training time and resulting in less efficient outcomes. The most efficient and least efficient instructional components were combined into treatment packages applied to teaching a novel set of AVCDs with participants.

METHOD

Participants

Ethan was a 3 year, 11-month-old boy who received services based on the principles of applied behavior analysis beginning at 29 months of age. He had an approximate one-year history with AVCD instruction. Ethan obtained standard scores of 79 (Moderately Low) and 70 (Moderately Low) on the Expressive Vocabulary Test-Second Edition (EVT-2; Williams, 2007) and the Peabody Picture Vocabulary Test-Fourth Edition (PPVT-4; Dunn & Dunn, 2007), respectively. Ethan scored in Level 1 on the imitation domain and into Level 2 on the listener and visual perceptual/match-to-sample domains of the Verbal Behavior-Milestones Assessment and Placement Program (VB-MAPP; Sundberg, 2008). He scored a 32 on the Barriers Assessment of the VB-MAPP.

Alex was a 4 year, 3-month-old boy who received services based on the principles of applied behavior analysis beginning at 24 months of age. He had an approximate one-and-a-half-year history with AVCD instruction. Alex obtained standard scores of 88 (Low Average) and 69 (Extremely Low) on the EVT-2 and the PPVT-4, respectively. Alex scored into Level 2 on the imitation domain and into Level 3 on the listener and visual perceptual/match-to-sample domains of the VB-MAPP. He scored a 22 on the Barriers Assessment of the VB-MAPP.

Zelda was a 5 year, 7-month-old boy who received services based on the principles of applied behavior analysis beginning at 20 months of age. He had an approximate two-year history with AVCD instruction. Zelda obtained standard scores of 62 (Extremely Low) and 45 (Extremely Low) on the EVT-2 and the PPVT-4, respectively. Zelda scored into Level 2 on the imitation domain and into Level 3 of the listener and visual perceptual/match to-sample domains of the VB-MAPP. He scored a 32 on the Barriers Assessment of the VB-MAPP.

All participants had educational histories (as reported by their teachers) that included all of the prompt types and prompt-fading procedures included in the current study.

Setting and Materials

The study was conducted in an empty classroom at the suburban public school attended by all participants. The classroom contained a table, chairs, paper data sheets, pencils, stimuli binders, a digital timer, a choice board, edibles, and a video camera. The experimenter sat across from the participants and recorded sessions using the video camera.

Stimulus binders were created for each condition to present trials for each session. The experimenter created each stimulus binder by affixing a blank piece of colored paper (based on a color preference assessment) to the cover of a three-ring binder. Inside each binder were six trial sheets. Each trial sheet consisted of a piece of colored (specific to the condition) paper containing three pictures (comparison stimuli). Comparison stimuli were each approximately 8.89 cm by 10.16 cm, spaced 1.27 cm apart and aligned horizontally in the middle of the page. Additionally, a blank piece of colored paper (specific to the condition) was placed on top of each trial sheet to provide an opportunity for an observing response.

Dependent Variables, Interobserver Agreement, and Procedural Integrity

The experimenter scored unprompted correct, unprompted incorrect, prompted correct, and prompted incorrect responses on data sheets prepared for each session. The percentage of trials with problem behavior and unprompted correct responses are depicted in the figures. Unprompted correct responses were defined as the participant emitting the predefined target response prior to the delivery of a prompt. Unprompted and prompted incorrect responses were defined as the participant selecting an incorrect comparison stimulus (i.e., error of commission) or not emitting a response within 5 s (i.e., error of omission) that occurred prior to or following the delivery of a prompt, respectively. Prompted correct responses were defined as the participant emitting the target response following the delivery of a prompt. The experimenter recorded the occurrence of problem behavior during each trial. Problem behavior was scored if any of the following topographies were observed: aggression, self-injurious behavior, property destruction, disruptions, tantrum, elopement, and stereotypy (definitions available from the first author) and summarized as the percentage of trials in which problem behavior occurred per session, calculated by dividing the number of trials where problem behavior occurred by the total number of trials and multiplied the resulting ratio by 100. The experimenter recorded session duration in minutes using a digital timer. The experimenter started the timer immediately prior to the presentation of the antecedent stimuli on the first trial of the session and stopped the timer immediately following the completion of the last trial of the session.

Total training time was calculated by adding the session durations in minutes for each training session per condition. The total number of incorrect responses was also calculated by adding all unprompted and prompted incorrect responses during each training session per condition.

A second observer independently scored participants' unprompted correct, unprompted incorrect, prompted correct, and prompted incorrect responses, as well as session duration and problem behavior during a minimum of 33% of sessions across conditions and phases in vivo or from video for interobserver agreement (IOA) purposes. IOA was calculated on a trial-by-trial basis by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100. Mean IOA scores for Ethan, Alex and Zelda were 95%, 98%, and 98% for the prompt-type assessments, respectively (range across participants, 90% to 100%); 96%, 93%, and 97% for the prompt-fading assessments, respectively (range across participants, 69% to 100%); and 95%, 95%, and 93% for the most versus least efficient comparisons, respectively (range across participants, 86% to 100%).

Total duration IOA for session duration was calculated by dividing the shorter duration by the longer duration and multiplying by 100. Mean duration IOA scores for Ethan, Alex and Zelda were 90%, 94%, and 90% for the prompt-type assessments, respectively (range across participants, 83% to 100%); 94%, 94%, and 90% for the prompt-fading assessments, respectively (range across participants, 83% to 100%); and 94%, 94%, and 94% for the most versus least efficient comparisons, respectively (range across participants, 83% to 100%).

An independent observer collected procedural integrity data during a minimum of 25% of sessions for each participant in vivo or from video (a list of steps for which PI was collected is available from the first or second author). Procedural integrity was calculated by dividing the number of correctly implemented steps by the number of correctly implemented steps plus the number of incorrectly implemented steps and multiplying by 100. Mean procedural integrity scores for Ethan for the prompt-type assessment, prompt-fading assessment, and the most versus least efficient comparison were 93%, 93%, and 95%, respectively (range across assessments, 86% to 100%). Mean procedural integrity scores for Alex for the prompt-type assessment, prompt-fading assessment, and the most versus least efficient comparison were 93%, 97%, and 95%, respectively (range across assessments, 86% to 100%). Mean procedural integrity scores for Zelda for the prompt-type assessment, prompt-fading assessment, and the most versus least efficient comparison were 93%, 91%, and 93%, respectively (range across assessments, 72% to 100%).

A secondary observer measured procedural integrity during a minimum of 25% of all sessions across participants for IOA purposes. An agreement was scored if both observers recorded the same responses during a step of the procedure. Procedural integrity IOA was calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100. Mean procedural integrity IOA scores for Ethan for the prompt-type assessment, prompt-fading assessment, and the most versus least comparison were all 100%. Mean procedural integrity IOA scores for Alex for the prompt-type assessment, prompt-fading assessment, and the most versus least efficient comparison were 100%, 100%, and 95% (range, 86% to 100%), respectively. Mean procedural integrity IOA scores for Zelda for the prompt-type assessment, prompt-fading assessment, and the most versus least efficient comparison were 100%, 100%, and 95% (range, 86% to 100%), respectively.

Preference Assessments

The experimenter conducted a color preference assessment (Heal, Hanley, & Layer, 2009) using colored pieces of paper and items to determine participant preference for 10 colors. Five colors that were approached during an equal percentage of trials were assigned as condition-correlated stimuli in an attempt to increase the discriminability of the conditions. Additionally, the experimenter conducted a paired-stimulus preference assessment (Fisher et al., 1992) using 10 edibles selected through interviews with the participants' teacher and parents. The experimenter then conducted a brief edible multiple stimulus without replacement (MSWO; Carr, Nicolson, & Higbee, 2000) preference assessment using the top five edibles identified from the paired-stimulus preference assessment with each participant prior to each session in an attempt to control for shifts in preference. The first three edibles selected from the MSWO were used as the putative reinforcers for the subsequent session.

Target Identification and Assignment

The experimenter identified a large pool of potential AVCD targets based on the participants' individual education goals. The experimenter presented the sample stimulus and allowed 5 s for a response. No differential consequences were provided for unprompted correct or incorrect responses. The experimenter presented the next trial after a 3- to 5-s intertrial interval. Each potential target was tested three times. If a participant engaged in an unprompted correct response to a potential target at least twice, it was discarded. Following the target identification, the experimenter assigned three targets to each condition based on a logical analysis (Wolery, Gast, & Ledford, 2014). One additional group of targets was assigned to each condition of each assessment and validation comparison for replication purposes. The logical analysis considered the following dimensions: number of syllables in each target name, physical similarity (e.g., orientation, color, size), and redundancy of phonemes across target names across the comparison stimuli. A list of targets is available as online supporting information.

Design and General Procedure

The experimenter used an adapted alternating treatments design (Sindelar, Rosenberg, & Wilson, 1985) with a no-treatment control condition. We conducted all comparisons twice (an initial comparison and one replication), each with a novel set of targets, for each participant to establish the reliability and generality of the results. Had the results of the initial comparison for an assessment or most versus least efficient comparison not been replicated, we would have conducted additional comparisons until similar results were achieved for two consecutive comparisons (this was not necessary for any participant). We conducted up to 15 sessions per day, in a random without replacement order, at least 10 min apart, and up to 5 days per week based on the experimenter and participant's availability. The experimenter presented the sample and comparison stimuli using a comparison-first arrangement (Cubicciotti et al., 2018). The experimenter required the participant to touch the condition-specific stimulus binder and tact the condition-correlated color before each session. The experimenter then removed a blank piece of paper, white for baseline and colored for training, to reveal the trial sheet. The experimenter waited 3 s in the absence of responding and delivered the prompt as outlined in the condition.

Prompt-type assessment. The purpose of the prompt-type assessment was to identify the participant-specific prompt type that resulted in the most efficient acquisition of AVCDs. We conducted each comparison at least twice to establish the reliability and generality of the assessment outcomes. Flow charts detailing procedural steps for each condition are available as online supporting information.

We compared model, partial physical, and full physical prompt types during the prompt-type assessment. The experimenters presented and faded the prompt using a progressive prompt delay (0 s, 2 s; Seaver & Bourret, 2014). The experimenters initially implemented all prompts using a 0-s prompt delay and increased the prompt delay one level (2-s prompt delay) after the participant demonstrated prompted correct responses for 100% of trials for two sessions. The experimenters decreased the prompt delay one level (2 s, 0 s) if the participant responded with unprompted incorrect responses for 50% or more of trials. Training continued in a condition until the participant engaged in two consecutive sessions with 100% unprompted correct responses. Training continued in the additional conditions until the mastery criterion was achieved or the total training time was 25% longer than the initial mastered condition overall training time.

Baseline and control. The experimenter presented the sample stimulus and allowed 5 s for a response. No differential consequences were provided for unprompted correct or incorrect responses. The experimenter presented the next trial after a 3- to 5-s intertrial interval.

Model prompt. During sessions with trials conducted at a 0-s prompt delay, the experimenter presented the sample stimulus after the 3-s wait time and immediately presented the model prompt by touching the correct comparison stimulus with her pointer finger for 3 s. The participant had 5 s to respond. The experimenter delivered an edible and praise for prompted correct responses. If the participant engaged in a prompted incorrect response, the experimenter removed the materials and presented the next trial.

During sessions with trials conducted with a 2-s delay, the experimenter waited 3 s in the absence of responding, then presented the sample stimulus and allowed 2 s for a response. The experimenter delivered an edible and praise for unprompted correct responses. If the participant engaged in an unprompted incorrect response, the experimenter removed the materials and presented the next trial. If the 2-s delay passed with no response, the experimenter simultaneously re-presented the sample stimulus and the model prompt and allowed 5 s for a response. The experimenters delivered an edible and praise contingent upon the prompted correct response. If the participant engaged in a prompted incorrect response, the experimenter removed the materials and presented the next trial.

Partial physical prompt. During sessions with trials conducted at a 0-s prompt delay, the experimenter presented the sample stimulus after the 3-s wait time and immediately presented the partial physical prompt by placing her hand on the participant's right hand and guiding it so that it hovered approximately 15.24 cm over the correct comparison stimulus for 3 s. The participant had 5 s to respond. The experimenter delivered an edible and praise for prompted correct responses. If the participant engaged in a prompted incorrect response, the experimenter removed the materials and presented the next trial.

During sessions with trials conducted with a 2-s delay, the experimenter presented the sample stimulus after the 3-s wait time and delivered an edible and praise for unprompted correct responses. If the participant engaged in an unprompted incorrect response, the experimenter removed the materials and presented the next trial. If the 2-s delay passed with no response, the experimenter simultaneously re-presented the sample stimulus and the partial physical prompt and allowed 5 s for a response. The experimenters delivered an edible and praise contingent upon the prompted correct response. If the participant engaged in a prompted incorrect response, the experimenter removed the materials and presented the next trial.

Full physical prompt. During sessions with trials conducted at a 0-s prompt delay, the experimenter presented the sample stimulus after the 3-s wait time and immediately presented the full physical prompt by placing her hand completely on top of the participant's right hand and guiding it so that the palm of the participant's hand touched the correct comparison stimulus for 3 s. The 5-s response interval was not implemented during the full physical prompt as the nature of this prompt (a full hand over hand prompt to select the correct comparison) required the participant select the correct comparison immediately using full hand over hand guidance. The experimenter delivered an edible and praise for prompted correct responses. If the participant engaged in a prompted incorrect response, the experimenter removed the materials and presented the next trial.

During sessions with trials conducted with a 2-s delay, the experimenter presented the sample stimulus after the 3-s wait time and delivered an edible and praise for unprompted correct responses. If the participant engaged in an unprompted incorrect response, the experimenter removed the materials and presented the next trial. If the 2-s delay passed with no response, the experimenter simultaneously re-presented the sample stimulus and the full physical prompt. The experimenters delivered an edible and praise contingent upon the prompted correct response. If the participant engaged in a prompted incorrect response, the experimenter removed the materials and presented the next trial.

Prompt-fading assessment. During the prompt-fading assessment three different prompt fading procedures (i.e., least-to-most, most-to-least, progressive prompt delay) were compared. For each participant, the prompt type identified as most efficient during the prompt type assessment was used during the prompt-fading assessment (Seaver & Bourret, 2014).

The experimenters developed prompt hierarchies for the model, partial physical, and full physical prompts (Seaver & Bourret, 2014). For the model prompt, in least-to-most intrusive order the hierarchy included: (a) no prompt, (b) partial model (the experimenter pointing to the correct response by hovering her pointer finger approximately 15.24 cm over the stimulus card for 5 s), (c) brief model (the experimenter touching the correct stimulus card with her pointer finger for 1 s), and (d) full model (the experimenter touching the correct stimulus card with her pointer finger for 3 s). For the partial physical prompt, in least-to-most intrusive order, the hierarchy included: (a) no prompt, (b) upper arm (guiding the participant's arm by lightly holding between the elbow and shoulder area with the experimenter's index and thumb, hovering approximately 15.24 cm over the correct comparison stimulus for 3 s, (c) forearm (guiding the participant's arm by lightly holding between the wrist and elbow area with the experimenter's index and thumb, hovering approximately 15.24 cm over the correct comparison stimulus for 3 s, and (d) partial hand-over-hand physical guidance (guiding the participant by placing the experimenter's hand on top of the participant's right hand so that it hovers approximately 15.24 cm over the correct comparison stimulus for 3 s). For the full physical prompt, in least-to-most intrusive order, the hierarchy included: (a) no prompt, (b) upper arm (guiding the participant's arm by lightly holding between the elbow and shoulder area with the experimenter's index and thumb until the participant's hand makes physical contact with the correct comparison stimulus for 3 s), (c) forearm (guiding the participant's arm by lightly holding between the wrist and elbow area with the experimenter's index and thumb until the participant's hand makes physical contact with the correct comparison stimulus for 3 s), (d) partial hand over hand physical guidance (guiding the participant by placing the experimenter's hand on top of the participant's right hand until the participant's hand makes physical contact with the correct comparison stimulus for 3 s), and (e) full physical guidance (the experimenter places her hand on the participant's right hand and guides it so that the palm of the participant's hand touches the correct comparison stimulus for 3 s). Training continued in a condition until the participant engaged in two consecutive sessions with 100% unprompted correct responses. Training continued in the additional conditions until the mastery criterion was achieved or the total training time was 25% longer than the initial mastered condition overall training time.

Baseline and control. Procedures were identical to those in the prompt-type assessment.

Least-to-most. During all trials, the experimenter presented the sample stimulus after the 3-s wait time, initially provided the least intrusive prompt (i.e., no prompt), and allowed the participant 5 s to respond. The experimenter delivered an edible and praise if the participant engaged in an unprompted correct response. If the participant engaged in an unprompted incorrect response, the experimenter moved up the relevant prompt hierarchy (i.e., re-presented the sample stimulus and provided a more intrusive prompt topography). If the participant engaged in a prompted correct response the experimenter delivered praise and an edible. If the participant engaged in a prompted incorrect response the experimenter moved up the relevant prompt hierarchy again.

The experimenters continued to move up the prompt hierarchy until the participant engaged in a prompted correct response or until the most intrusive prompt was provided. The experimenters moved to the next trial if the participant engaged in a prompted incorrect response following the most intrusive prompt. No other consequences were provided.

Most-to-least. Initially, the experimenter presented the sample stimulus after the 3-s wait time and provided the most intrusive prompt. The experimenter provided an edible and praise contingent upon a prompted correct response. The experimenters moved to the next trial if the participant engaged in a prompted incorrect response following the most intrusive prompt. The experimenters moved down the relevant prompt hierarchy (i.e., provided a less intrusive prompt) following two consecutive sessions with 100% prompted correct responding. The experimenter delivered an edible and praise following all unprompted (during sessions with no prompt provided) or prompted correct responses. If the participant engaged in a prompted incorrect response at any other prompt level (other than the most intrusive), the experimenter re-presented the sample stimulus and provided the most intrusive prompt of the hierarchy that allowed for a prompted correct response. The experimenter removed the materials and re-presented the next trial if the participant engaged in a second prompted incorrect response following the most intrusive prompt. The experimenter moved up the relevant prompt hierarchy (i.e., provided a more intrusive prompt) if the participant responded with unprompted (during sessions with no prompt provided) or prompted incorrect responses for 50% or more of trials.

Progressive prompt delay. The prompt determined to be most efficient in the prompt assessment was implemented and faded using a progressive prompt delay (0 s, 2 s; Seaver & Bourret, 2014). The progressive prompt delay used during the prompt fading assessment was identical to the procedures from the prompt type assessment previously described.

Most efficient versus least efficient comparison. The purpose of this comparison was to evaluate whether the results of the prompt type and prompt-fading assessments could collectively inform learner-specific instructional components that would lead to efficient acquisition of AVCDs. To evaluate this, we compared a condition that involved a combination of the *most* efficient instructional components from the two assessments to a condition that involved a combination of the *least* efficient instructional components. For example, if the model prompt and the LTM prompt-fading procedure resulted in the most efficient acquisition of AVCDs, they were combined into one treatment package. Similarly, if the partial physical prompt and the MTL prompt-fading procedure resulted in the least efficient acquisition, they were combined into one treatment package. These packages were then implemented to teach novel sets of AVCDs. We conducted this comparison at least twice to determine the generality of the assessment outcomes.

Baseline and control. Procedures were identical to those used in the prompt-type and prompt-fading assessments.

Training with most efficient arrangement. The experimenters arranged an instructional condition consisting of the prompt type and prompt fading procedure associated with the *most* efficient instruction for each participant. The most efficient combination for Ethan was the full physical prompt plus least-to-most prompt fading procedure. The most efficient combination was the model prompt plus least-to-most prompt fading procedure for both Alex and Zelda.

Training with least efficient arrangement. The experimenters arranged an instructional condition consisting of the prompt type and prompt fading procedure associated with the *least* efficient instruction for each participant. The least efficient combination for Ethan was the model prompt plus the most-to-least prompt fading procedure, the full physical prompt and progressive prompt delay for Alex, and the partial physical prompt and progressive prompt delay for Zelda.

RESULTS

Figures 1–3 illustrate the percentage of trials with problem behavior and unprompted correct responses for all comparisons during the prompt type assessment, prompt-fading assessment, and most versus least efficient comparisons. The comparative analysis of efficiency measures— training sessions to mastery, total training time, and total incorrect responses— for all initial and replication assessments is provided in Table 1. Across all comparisons, participants emitted unprompted correct responses during a low to moderate percentage of trials during baseline sessions across conditions. Increases in unprompted correct responses were observed only after the introduction of intervention.

The results of the prompt-type assessment indicate that the prompt type associated with the most efficient training differed across participants. That is, the full-physical prompt was most effective for Ethan and the model prompt was most effective for Alex and Zelda. Additionally, all participants failed to demonstrate mastery with one of the prompt types and Zelda engaged in problem behavior across all conditions. More specifically, Ethan demonstrated mastery in the full-physical prompt and partial-physical prompt conditions in 9 and 10 training sessions, respectively. Similarly, he demonstrated mastery in the full-physical prompt and partial-physical prompt conditions in four and seven training sessions, respectively, during his prompt-type assessment replication. Ethan failed to demonstrate mastery in the model-prompt condition during both comparisons.

Alex demonstrated mastery in the model prompt and partial physical-prompt conditions in 11 and 12 training sessions, respectively. Similarly, he demonstrated mastery in the model prompt and partial-physical prompt conditions in four and five training sessions, respectively, during his prompt-type assessment replication. Alex failed to demonstrate mastery in the full-physical prompt condition during both comparisons.

Zelda demonstrated mastery in the model prompt and full-physical prompt conditions in six and seven training sessions, respectively. Similarly, he demonstrated mastery in the model prompt and the full-physical prompt conditions in five and seven training sessions, respectively, during his prompt-type assessment replication. Zelda failed to demonstrate mastery in the partial-physical prompt condition during both comparisons.

We used the results of the prompt-type assessment to inform the prompt type to be included in each participant's prompt-fading assessment. That is, we arranged the full-physical prompt to be in place for Ethan and the model prompt to be in place for Alex and Zelda. The results of the prompt-fading assessment indicate that the least-to-most prompt-fading procedure was most effective for all three participants.

During his initial prompt-fading assessment comparison, Ethan demonstrated mastery in the least-to-most, progressive-prompt delay, and most-to-least prompt-fading conditions in 4, 5, and 10 training sessions, respectively. Similarly, he demonstrated mastery in the least-to-most, progressive-prompt delay, and most-to-least in 3, 8, and 10 training sessions, respectively during the replication comparison.

Alex demonstrated mastery in the least-to-most and most-to-least prompt-fading conditions in seven and eight training sessions, respectively. Similarly, he demonstrated mastery in the least-to-most and most-to-least prompt-fading conditions in 6 and 11 training sessions, respectively during the replication comparison.

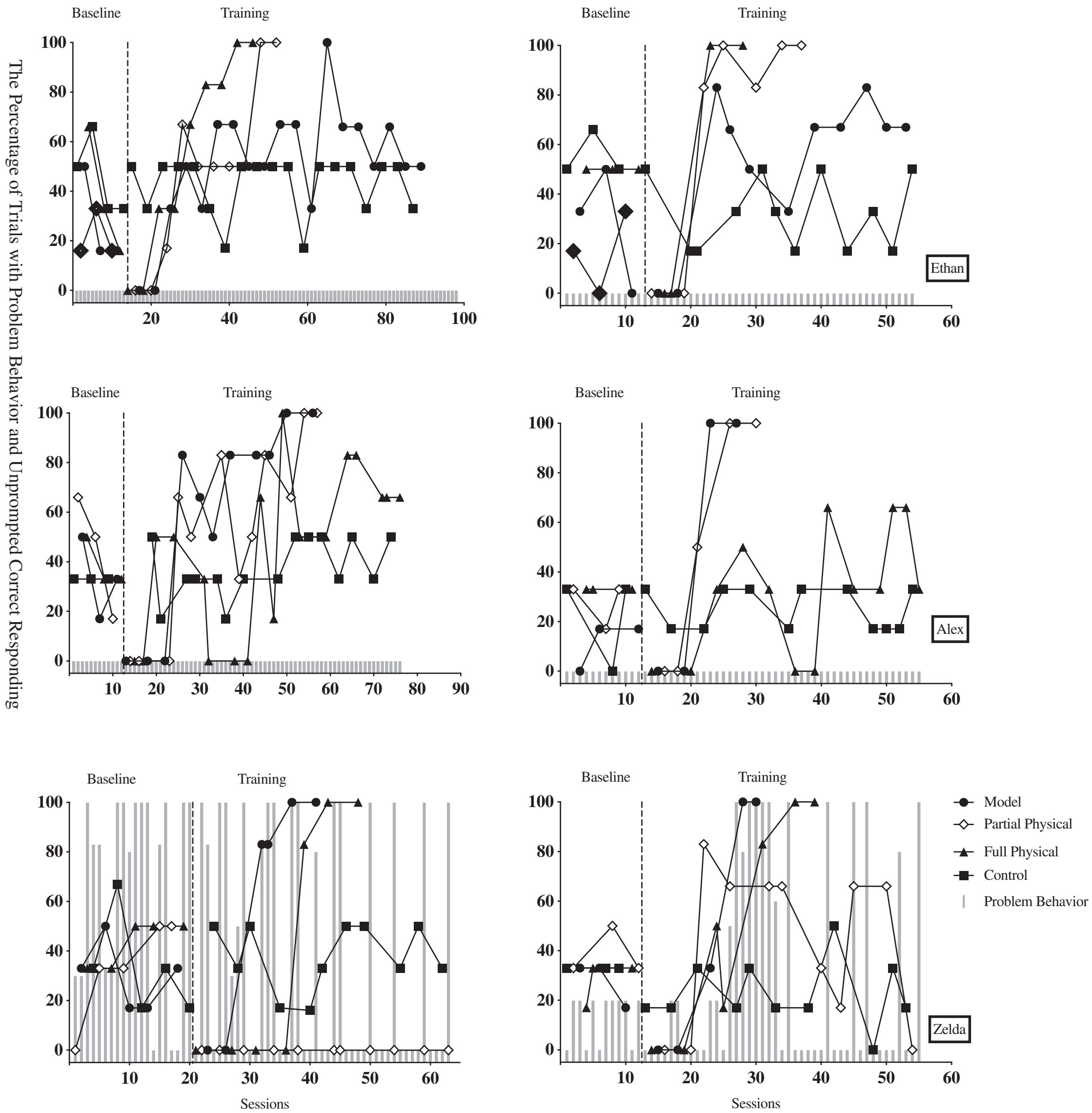

Figure 1. Percentage of trials with problem behavior and unprompted correct responses for all participants during the prompt-type assessment.

Alex failed to demonstrate mastery in the progressive-prompt delay condition during both comparisons.

Zelda demonstrated mastery in the least-to-most, most-to-least, and progressive-prompt delay prompt fading conditions in five, eight, and seven training sessions, respectively. Similarly, he demonstrated mastery in the least-to-most, most-to-least, and progressive-prompt delay prompt-fading conditions in four, eight, and five training sessions, respectively, during the replication comparison.

Overall, the results of the most versus least efficient comparison indicate that the most

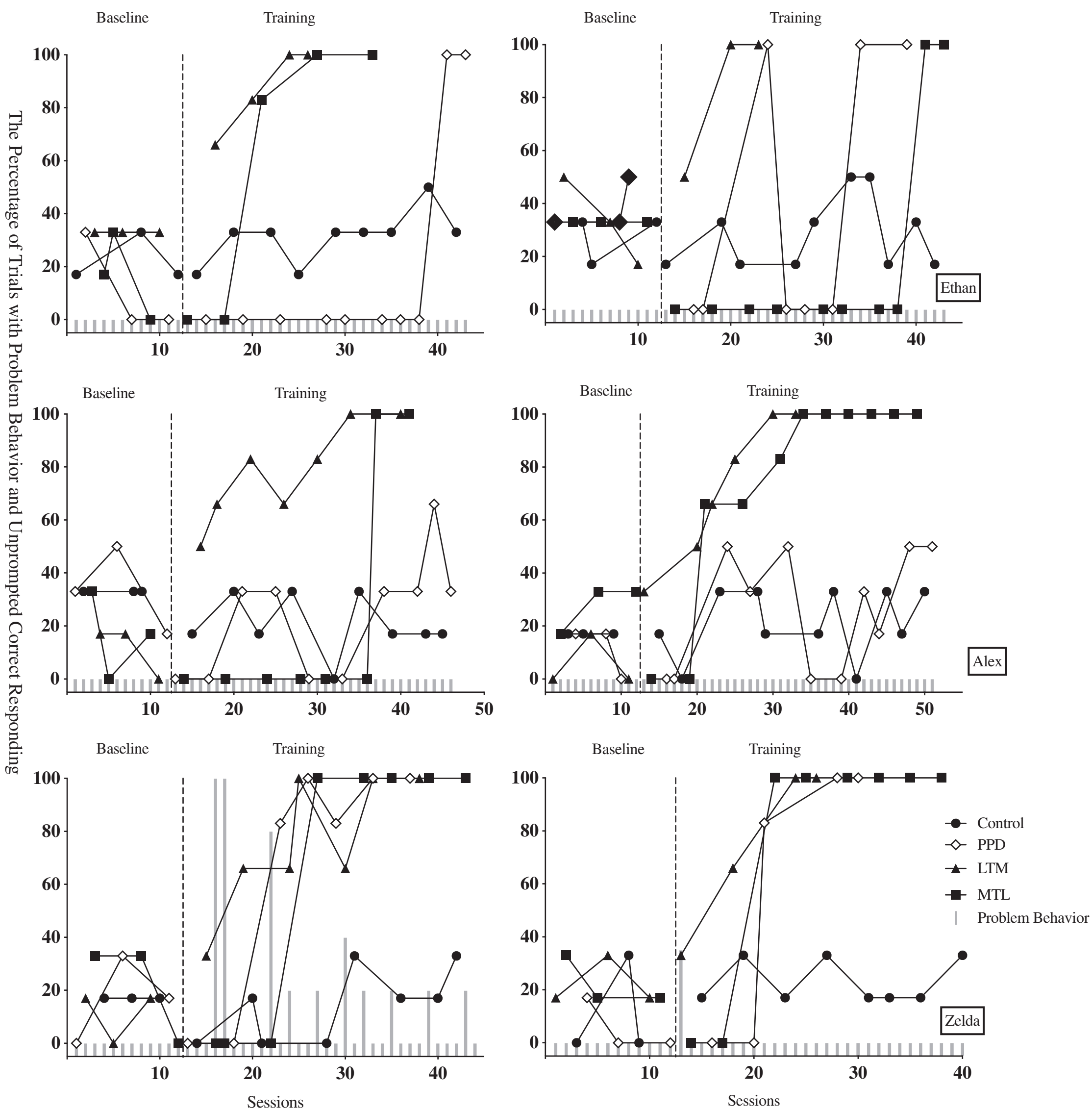

Figure 2. Percentage of trials with problem behavior and unprompted correct responses for all participants during the Progressive prompt delay (PPD), Least-to-most.(LTM), Most-to-least (MTL) conditions of the prompt-fading assessment.

efficient training condition was associated with best outcomes for all participants. During his initial comparison, Ethan demonstrated mastery in the most efficient and least efficient conditions in 3 and 11 training sessions, respectively. Similarly, he demonstrated mastery in the most efficient and least efficient conditions in 8 and 13 training sessions, respectively, during his replication.

During his initial most versus least efficient comparison, Alex demonstrated mastery in the most efficient condition in six training sessions. Similarly, he demonstrated mastery in the most efficient condition in six training sessions

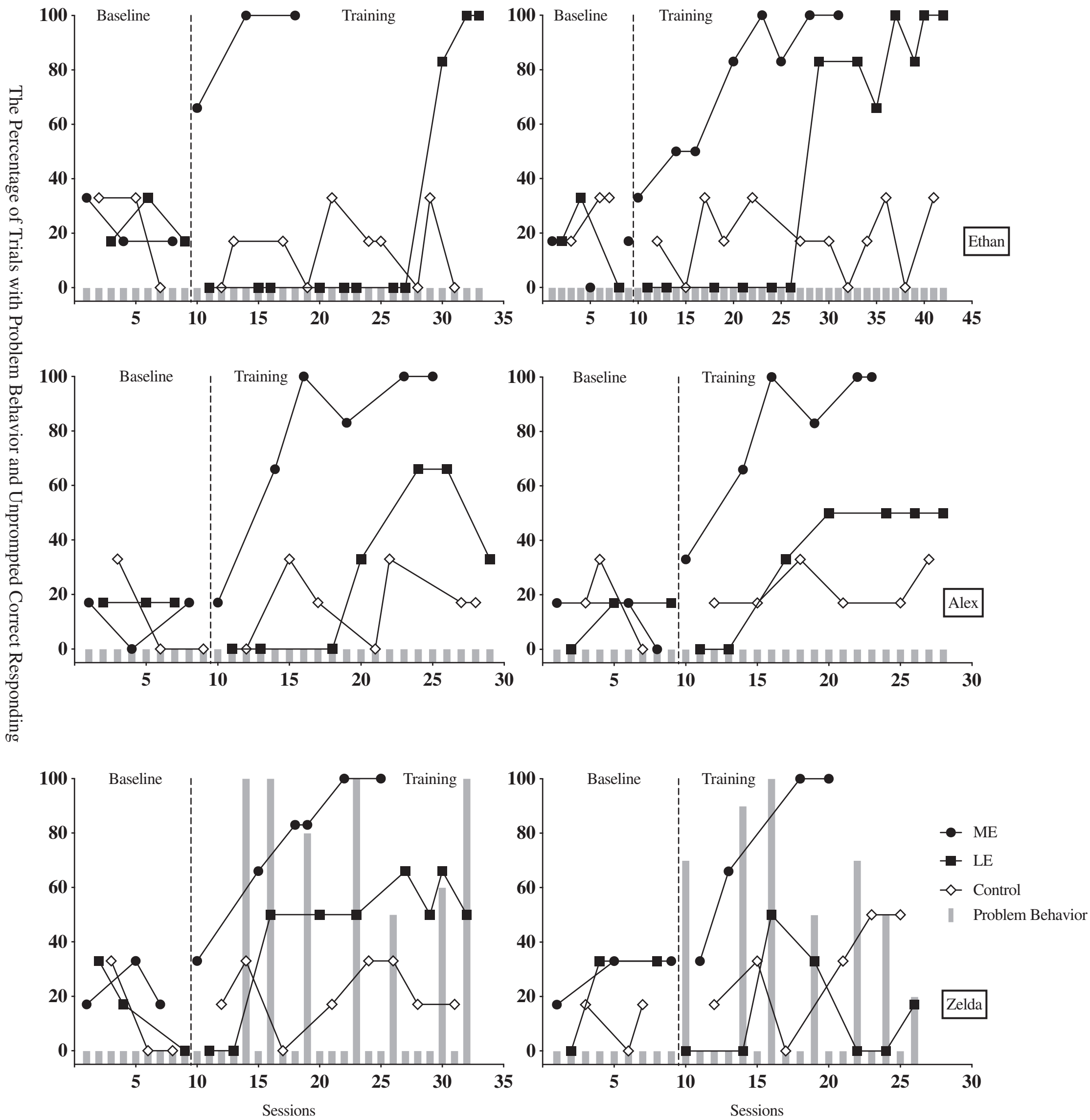

Figure 3. Percentage of trials with problem behavior and unprompted correct responses for all participants during the most efficient (ME) versus least efficient (LE) comparison.

during his replication. Alex failed to demonstrate mastery in the least efficient condition during both comparisons. Zelda demonstrated mastery in his initial most versus least efficient comparison in six training sessions. Similarly, he demonstrated mastery in the most efficient condition in four training sessions, during his most versus least efficient comparison replication. Zelda failed to demonstrate mastery in the least efficient combination during both comparisons.

Ethan and Alex did not engage in problem behavior during the prompt-type assessment, prompt-fading assessment, or most versus least

Table 1
Training Sessions to Mastery, Training Time, and Incorrect Responses for all Participants Across Assessments

Condition	Phase	Training sessions to mastery			Total training time			Incorrect responses		
		Ethan	Alex	Zelda	Ethan	Alex	Zelda	Ethan	Alex	Zelda
Prompt Type	Model	*	11	6	*	12	16	14	10	2
	PP	10	12	*	24	12	*	6	10	27
	FP	9	*	7	22	*	19	6	28	2
	Model	*	4	5	*	8	10	9	0	2
	PP	7	5	8	23	10	*	0	2	12
	FP	4	*	7	16	*	17	0	15	1
Prompt Fading	PPD	5	*	7	10	*	17	0	19	0
	MTL	10	8	8	17	9	13	0	0	0
	LTM	4	7	5	8	9	9	1	0	5
	PPD	8	*	5	11	*	8	0	22	1
	MTL	10	11	8	17	23	10	0	0	0
	LTM	3	6	4	5	10	5	1	0	0
Comparison	LE	11	*	*	16	*	*	6	12	11
	ME	3	6	6	5	8	7	2	2	1
	LE	13	*	*	22	*	*	3	16	12
	ME	8	6	4	12	7	6	3	0	0

Note. The specific phases of each assessment have been abbreviated into the following, Model, Partial physical (PP), Full physical (FP), Progressive prompt delay (PPD), Most-to-least (MTL), Least-to-most (LTM), Least efficient (LE), and Most efficient (ME). Total training time is rounded to the nearest whole number.
* Signifies the mastery criterion was not met

efficient comparisons. During the prompt-type assessment, Zelda engaged in problem behavior during 91%, 15%, and 100% of the model prompt, full-physical prompt, and partial-physical prompt sessions, respectively, during the initial comparison. He engaged in problem behavior for 55%, 60%, and 78% of the model prompt, full physical prompt, and partial physical prompt sessions, respectively, during the replication comparison.

During the prompt-fading assessment, Zelda engaged in problem behavior for 48% and 30% of the most-to-least and least-to-most prompt fading sessions during the initial comparison. Zelda engaged in problem behavior for 35% of least-to-most sessions during the replication comparison but did not engage in problem behavior during most-to-least or progressive prompt delay conditions.

Zelda engaged in problem behavior for 80% and 90% of most efficient and least efficient sessions respectively, during the initial comparison. Zelda engaged in problem behavior for 0% and 63% of most efficient and least efficient sessions respectively, during the replication comparison.

DISCUSSION

The identification of individualized instructional procedures for individuals with ASD is an important endeavor as understanding the optional instructional components that precede and follow student responding may result in more efficient acquisition of academic responses over time (Cengher et al., 2015; Seaver & Bourret, 2014). As students with ASD may not demonstrate adequate learning using traditional instructional approaches (e.g., Howard, Stanislaw, Green, Sparkman & Cohen, 2014), it is necessary to maximize individual instructional opportunities. One potential way to do this is by providing clinicians a technology to assist in the selection of efficient, learner-specific instructional procedures.

One way to identify the most efficient instructional procedures is by conducting individualized instructional assessments (Cengher et al., 2015; Johnson et al., 2017; McGhan & Lerman, 2013; Seaver & Bourret, 2014). Along this line, Seaver and Bourret (2014) evaluated an instructional assessment to identify the most efficient response prompt and prompt-fading procedure when teaching block building to individuals with ASD. In a replication, Cengher et al. (2015) evaluated a similar assessment to determine the most efficient prompts and prompt-fading procedures when teaching responses to one-step directions. Although Seaver and Bourret demonstrated learner-specific results, in that the most efficient prompts and prompt-fading procedures varied across participants, Cengher et al. found that all three of their participants learned most efficiently with full-physical prompts and most-to-least prompt fading. Our prompt-type assessment results are somewhat similar to Seaver and Bourret as the outcomes indicated the model prompt was most efficient for two participants and the full-physical prompt was most efficient for one. However, similar to Cengher et al., we found that the same prompt-fading procedure (least-to-most) was most efficient for all three participants.

Similar to Seaver and Bourret (2014) and Cenghar et al. (2015) we replicated the outcomes of each initial assessment across an additional set of targets for all participants and then validated these outcomes by comparing a combination of the most versus least efficient prompt type and prompt-fading procedures. Across participants, results replicated during both assessments and the most versus least comparisons. Unlike Seaver and Bourret and Johnson et al. (2017), our evaluation did not test for generality across skill types. For example, Seaver and Bourret conducted an assessment to determine the efficiency of different prompt types and prompt-fading procedures on block building, then assessed the generality of the outcomes on domestic vocational tasks. Johnson et al. compared four reinforcement arrangements during training of arbitrary AVCDs and tested for generality across functional AVCDs, tacts, and intraverbals. Across participants, generality of assessment results was observed during subsequent AVCD training, but not for the other task types (tacts, intraverbals). Future researchers would be wise to conduct replications to establish the generality of outcomes to other tasks that require motor responses (e.g., visual–visual conditional discriminations, vocational tasks, play skills).

Although our findings that outcomes are primarily learner-specific are not surprising, they do beg the question, why might the efficiency of certain instructional components be learner-specific? One explanation may be related to the specific learner characteristics of each participant. Perhaps there may be skills or barriers in the participants' repertoires that influence their responding under certain instructional components. For example, in Zelda's case, the experimenters observed higher levels of problem behavior during the partial-physical prompt condition, which may be related to potentially aversive properties of the physical prompt in this condition (see problem behavior data depicted in Figure 3). These occurrences of problem behavior led to an overall increase in the session times during both the partial-physical and full-physical prompt conditions and ultimately prevented Zelda from meeting the mastery criterion in the partial-physical prompt condition. We suspect that Zelda likely met mastery criterion in the full-physical prompt condition because instances of his problem behavior were placed on extinction in this condition. During the full-physical prompt condition, regardless of problem behavior occurrence, hand-over-hand prompting was implemented to ensure Zelda selected the correct comparison stimulus. Ultimately, this may have led to an overall decrease in problem behavior and the eventual mastery in the full-physical prompt condition. However, this was not the case for the partial-physical prompt condition. During this condition, hand-over-hand prompting was implemented but only until Zelda's hand was 15.24 cm over the correct comparison stimulus. Therefore, Zelda could continue to engage in problem behavior and not engage in a prompted correct response. Ethan, on the other hand did not meet the mastery criterion in the model prompt condition during the prompt-type assessment. This could perhaps be due to his imitation repertoire, as he was the only participant to score into Level 1 on the imitation domain of the VB-MAPP, suggesting he may not be able to spontaneously imitate the novel behavior of others. This suggests future research is needed to identify what learner characteristics are correlated with improved performance under the context of specific instructional components or what role assessments can play in assessing these learner-specific skills.

Another possible explanation is learning history. The participants' teachers reported mixed histories with the prompt types and prompt-fading procedures used in the current evaluation. This history may be relevant as previous research (e.g., Coon & Miguel, 2012; Kay et al., 2019; Roncati, Souza, & Miguel, 2019) has demonstrated the role that proximal history plays on subsequent responding. Future research could examine the degree to which a history with a prompt type and prompt-fading procedure influences the relative efficiency of such instructional components when teaching AVCDs.

It should be noted that the full physical hierarchy in the prompt-type assessment included an additional step relative to the model and partial physical hierarchies. This may have served as a potential confound as this additional step may have resulted in a longer duration to mastery. Although the experimenters arranged these hierarchies in this manner to distinguish the differences between the full physical (e.g., an additional hand over hand step in the hierarchy) and partial physical prompt, future evaluations could modify the conditions to allow participants to meet the mastery criteria within a similar number of steps across all prompt types.

One variable which has not been consistently reported in the literature on instructional assessment is the duration of time it took researchers to complete the assessments. The exceptions to this are Seaver and Bourret (2014) and Johnson et al. (2017) who reported mean assessment durations of 8 hr and 3 hr 45 min, respectively. Our assessment procedures, including the initial and replication prompt type and prompt-fading comparisons without and with the most versus least efficient comparisons took an average of 3 hr 12 min (range, 2 hr 50 min to 3 hr 40 min) and 3 hr 45 min (range, 3 hr 34 min to 4 hr 30 min) per participant, respectively. This duration includes the cumulative duration of training sessions across the conditions of all comparisons but did not include the time required to complete other procedural components (e.g., the color and stimulus preference assessments). The duration of the assessment could be considered a mitigating factor as it may make it unlikely that practitioners would utilize such procedures in their clinical work. Future research is needed to identify ways to reduce assessment duration. In this vein, Carroll et al. (2018) evaluated the validity of an abbreviated assessment to identify the most efficient error-correction procedure for participants with ASD and developmental delays. During the initial assessment, the experimenters identified an error-correction procedure following 60 training trials, then evaluated the degree to which this outcome was valid across two validation comparisons. The results indicated high correspondence between the abbreviated and validation assessments for a subset of participants, and partial correspondence for the remaining participants. Additional research is needed to evaluate the usefulness of abbreviated assessments for identifying learner-specific instructional components.

To make decisions regarding the relative efficiency of prompt types and prompt-fading procedures we examined training sessions to mastery and total training time to mastery. Different measurement scales may result in varying interpretations of efficiency and lead to the inadvertent promotion of one instructional procedure over another (e.g., Black et al., 2016). This issue seems directly relevant as previous studies have drawn conclusions regarding instructional efficiency by comparing training trials (e.g., McGhan & Lerman, 2013; Seaver & Bourret, 2014), training sessions (e.g., Cengher et al., 2015), or training time (e.g., Johnson et al., 2017). This is problematic because it is possible that the conclusions drawn from using one measurement scale (training trials or sessions) may be different when compared to another (training time). These changes in measurement scale may result in varying interpretations of efficiency and lead to the inadvertent promotion of one instructional procedure variation as efficient when results would vary if a different measurement scale were used (Skinner, 2010). As such, future studies should evaluate different measurement scales and the effect that they have on determining both effectiveness and efficiency of instruction.

For all participants, the differences in training sessions to mastery (between one to three sessions) and training times (between 1 to 12 min) between the most and least efficient conditions across comparisons were small. In fact, the results of both Ethan and Alex's prompt-type assessments may appear to have produced equivalent outcomes, as the differences across the most and least efficient prompt types varied by only one session. These differences may seem insignificant at first, however, it is easy to imagine how such differences can compound over the long periods of time that consumers with ASD may receive intervention based on the principles of applied behavior analysis. Given the costly (Jacobson, Mulick, & Green, 1998) and comprehensive (Lovaas, 1987) nature of intensive behavioral intervention, it seems important to maximize instructional time.

The findings from the current study raise questions regarding how clinicians should arrange instructional components for individuals with ASD during teaching. Future research should continue to develop and modify instructional assessments to examine additional components of teaching (e.g., error-correction procedures) and to focus on combining results from assessment procedures to identify the most efficient interventions for clinical practice.

In this vein, McGhan and Lerman (2013) evaluated the use of an assessment to identify the least intrusive and most efficient error-correction procedures when teaching AVCDs to individuals with ASD. Similar to the current study the authors found that results were idiosyncratic across learners. A combination of the most efficient prompt type, prompt-fading procedure, and error correction procedures should be compared with a combination of the least efficient component variations to evaluate the potential usefulness of this assessment methodology in maximizing skill acquisition.

Lastly, in the current study we did not conduct all conditions to mastery. That is, once mastery was achieved in a condition, training was only continued in all other conditions for a limited number of sessions (equal to 25% of the number of sessions required in the condition that produced mastery) as long as there was no increasing trend in performance. Training termination was necessary for all three participants. We implemented this criterion to prevent possible establishment of the presentation of stimuli as aversive (McGhan & Lerman, 2013) and to ensure that we maximized the time that participants spent receiving effective intervention. Because of this termination we are unaware of how much additional training time would have been necessary to produce mastery in all conditions.

There has been very little research on assessment of the components of discrete trial training to identify which would be most effective. The results of these assessments have potential utility in informing future teaching and instructional components arranged across individual students to increase teaching efficiency. Similar to Seaver and Bourret (2014), our results demonstrate the usefulness of applying assessments to identify instructional components prior to teaching. Outcomes of these studies may help in guiding clinicians to arrange instructional components that lead to the most efficient outcomes for individuals with ASD during teaching.

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