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Validation of a skills assessment to match interventions to teach motor imitation to children with autism

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ABSTRACT

Motor imitation skills are usually targeted early in intervention with children with autism. Some children readily acquire motor imitation targets that involve objects (e.g., pushing a toy car) but do not acquire targets without objects (e.g., clapping hands). The disparity in acquisition could occur for various reasons, including differences in attending when an object is present as opposed to when no object is present. It also is possible that the delay in imitation that is required when no object is present could contribute to the discrepancy. The purpose of this study was to validate the use a brief assessment of delayed imitation and attending skills to predict the effectiveness of interventions specifically designed to address the identified deficits. The assessment showed one child with autism had deficits in attending, and an intervention that included a salient stimulus produced the quickest acquisition. The second participant's assessment did not show any deficits in attending, but showed deficits in delayed imitation. For this participant, the intervention designed to address deficits in delayed imitation (i.e., a secondary prompter) was most successful in establishing motor imitation responses.

Interventions derived from the principles of applied behavior analysis (ABA) have the strongest body of evidence supporting effectiveness for children with autism (e.g., Eikeseth, Smith, Jahr, & Eldevik, 2007; Flanagan, Perry, & Freeman, 2012; Lovaas, 1987; Sallows & Graupner, 2005). Practitioners of ABA often have multiple choices among effective procedures. For example, a practitioner designing a behavior intervention plan for escape-maintained problem behavior might select to implement functional communication training (Durand & Merges, 2001) or noncontingent escape (Carr & LeBlanc, 2006). When selecting between teaching procedures, assessments of prerequisite skills may provide useful guidance. For example, Gregory, DeLeon, and Richman (2009) evaluated motor imitation and matching skills to predict the effectiveness of mand training with different response modalities and found strong correspondence between accuracy during assessments and performance during mand training with both modalities.

Motor imitation is a critical repertoire that is often targeted early in intervention programming (e.g., Green & Luce, 1996; Leaf & McEachin, 1999; Lovaas 2002; Maurice, 1994) and is considered a behavioral cusp (Hixson, 2004). Imitation has been defined as the duplication of some properties of the behavior of a model (Catania, 1998). Cooper, Heron, and Heward (2007) specify that imitative behavior must immediately follow the model, have formal similarity (i.e., look or sound like it), and must be controlled by the model (i.e., if the model changes, so does the imitative behavior). Although typically developing children learn to imitate as infants, children with autism often present with deficits in imitation skills (Ritvo & Provence,

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1953; Rogers, Young, Cook, Giolzetti, & Ozonoff, 2010). Therefore, training procedures consisting of physical guidance to prompt responses similar to the model, prompt fading, shaping, and reinforcement (e.g., Baer, Peterson, & Sherman, 1967; Taylor & DeQuiznio, 2012) are used to teach imitation. The goal of all of these procedures is to teach the learner to readily imitate a model's behavior, regardless of form, so that he can quickly acquire new skills by observing novel events in his environment without explicit training (i.e., generalized imitation).

There are different forms of imitation including vocal imitation, imitation of actions with objects, imitation of large- or gross-motor movements, and imitation of small- or fine-motor movements (Garcia, Baer, & Firestone, 1971). Young, Krantz, McClannahan, and Poulson (1994) found generalized imitation can occur within these forms of responses; however, generalization across these forms does not often occur in children with autism. Additionally, children with autism may acquire some forms of imitation, such as toy play or movements that involve objects, more readily than other forms of imitation (Rogers et al., 2010; Williams, Whiten, & Singh, 2004). However, no empirical evidence exists to suggest why some of these forms of imitation are acquired more readily than others, but it is possible that certain prerequisite skills must be present for a learner to successfully acquire simple motor imitation responses during training with effective teaching procedures.

There are at least two possible explanations for why established teaching procedures may not be effective for teaching motor imitation without objects after successfully teaching motor imitation with objects; an individual may lack delayed imitation skills, or the individual may not consistently attend to the visual model. A precise look at a teaching trial demonstrates how the absence of one of both of these prerequisite skills could contribute to delayed acquisition of motor imitation with objects. A teaching trial for motor imitation typically involves an instructor presenting the motor movement, and quickly prompting the correct response using physical guidance which is faded on subsequent trials (Gena, Krantz, McClannahan, & Poulson, 1996; Striefel, 1974). This teaching arrangement requires the learner to orient directly toward the instructor and may result in lack of orientation toward the movement that is to be imitated (Miller, Rodriguez, & Rourke, 2015). Additionally, a delay occurs between presentation of the model and the prompt to respond (i.e., the teacher must stop modeling the target response in order to provide the prompt). Thus, the modeled response is transient, making delayed imitation a possible prerequisite to effectively establishing simple motor imitation responses via this teaching strategy. In contrast, with motor imitation with objects, the object itself remains visible as a discriminative stimulus for the action. A second possible explanation is that when motor movements contain objects, the objects may serve as discriminative stimuli for engaging with the object. Thus, the object likely results in increased attending to the action.

In analyzing a typical imitation teaching trial, both delayed imitation and attending skills may be prerequisites associated with the acquisition of simple motor imitation responses using established teaching methods. If the prerequisite skills are not present, slowed or no acquisition may occur. Identification of deficient prerequisite skills could lead practitioners to choose different interventions that do not require skills from the deficient repertoire. For example, if a learner does not readily attend to the visual model when no object is present, embedding a stimulus to which the child will attend may prove effective in facilitating imitation. Alternatively, if a learner does not engage in delayed imitation, removing the delay between the model and the prompt within the trial by using a second prompter may prove to be effective in increasing imitation. In each instance, those supplemental prompts could then be faded and eliminated. The purpose of this study was to validate the use of a brief assessment of delayed imitation and attending skills to identify deficits correlated with poor performance on motor imitation without objects and to subsequently test interventions designed to specifically address the deficit.

1. Method

1.1. Participants, materials, and setting

Two children with a diagnosis of autism spectrum disorder (ASD) participated in this study. Roxanne was a 2-year, 2-month-old female. She received ABA services in a center-based program for 3 h per day, 4 days per week. Roxanne emitted approximately 10–15 one- word vocal mands, identified some objects as a listener, and followed simple one-step instructions (e.g., sit down, high five). Prior to the start of the study, she acquired most targeted motor imitation responses with objects using least-to-most prompting; however, she had not acquired motor imitation targets without objects.

George was a 4-year, 6-month-old male. He received ABA services in a center-based program 6.5 h per day, 5 days per week. He independently emitted five, one-word vocal mands and required prompting for all other mands. George also consistently echoed (i.e., vocal imitation) as well as engaged listener responding by feature, function, or class. He quickly acquired motor imitation targets with objects, but failed to consistently acquire most motor imitation targets without objects despite similar teaching procedures (i.e., most-to-least prompting with prompt fading). For example, George typically mastered motor imitation targets with objects in less than 2 weeks, but required at least 3 months before motor imitation targets without objects were mastered or discontinued.

The centers for these participants contained child-sized chairs, tables, and preschool-aged toys. There were typically four to six other children and two to six instructors in the room during teaching sessions. Materials consisted of data sheets, pens, and preferred items. Stimuli used for Roxanne's assessments included a drum, ring stacker, pom poms, car, rattle, cymbals, blocks, ball and hoop, and two trains. George's assessment stimuli consisted of a car, ball, baby, two blocks, a stuffed animal, a container with a lid, a book, and a drum. The three objects used in the salient-stimulus intervention (see

Table 1
Objects and movements used for target identification.

Roxanne	*George*
Tapping a drum with one hand	Rolling a car
Placing one ring on a ring stacker	Rolling a ball
Waving a pom pom	Rocking a baby
Pushing a car	Patting a baby
Shaking a rattle	Stacking 2 blocks
Tapping two clappers together	Making a stuffed animal jump
Tapping two blocks together	Putting a lid on a container
Placing a small nerf basketball into a small play hoop	Opening a book
Pushing a train and a train whistle together	Banging on a drum

condition description below) for Roxanne included a set of pom poms, gloves with small felt balls attached, and a plastic mustache. The three objects used in the salient-stimulus intervention for George included a set of whale hand puppets, cow figurines, and an alien pointer-finger puppet.

1.2. Measurement and experimental design

The primary dependent variable was *correct imitation responses* defined as the participant emitting a motor movement that was topographically similar to the movement presented by the therapist within 3 s of the presentation of the model. *Incorrect responses* were defined as the participant emitting any other motor movement within 3 s of the model. *No response* was defined as the participant not emitting any response within 3 s of the model. *Attending* was defined as the participant orienting his or her eyes to the modeled motor movement for at least 1 s during its presentation.

In the prerequisite assessment, a *correct delayed imitation response* was defined as the participant emitting a motor movement that was topographically similar to the movement presented by the therapist within 6 s after the presentation of the model. *An incorrect delayed imitation response* was defined as the participant emitting any other motor movement within 6 s after the presentation of the model . *No response* was defined as the participant not responding within 6 s after the presentation of the model.

Interobserver agreement (IOA) was assessed by having a secondary observer collect data for an average of 37% (Roxanne) and 54% of sessions (George) across all conditions and dependent variables. An agreement was scored if the same responses were recorded by both the primary and secondary observer on the same trial. Agreement was calculated by dividing the number of trials with agreements by the total number of trials, and multiplying by 100. Mean IOA was 92% (range, 78%–100%) for Roxanne and 98% (range, 89%–100%) for George.

During all conditions, an observer scored implementation of the procedure using a procedural integrity checklist. Each trial was scored for presentation of the verbal instruction, correct modeled movement, and correct consequences. Complete procedural integrity checklists for each phase are available from the authors by request. To calculate the total percentage of correct procedural implementation, the number of steps completed correctly in the checklist were totaled and divided by the total number of steps. Data were summarized by percent correct implementation and averaged across sessions for each participant. For Roxanne, procedural integrity was recorded during 28% of all sessions and averaged 98% (range, 89%–100%). For George, procedural integrity was recorded during 54% of all sessions and averaged 99.5% (range, 89%–100%).

An adapted alternating treatments design (Sindelar, Rosenberg, & Wilson, 1985) with a best alone phase (Roxanne only) was used to assess the effects of three interventions on correct imitation responses. The adapted alternating treatments design was chosen because different targets were assigned to the three intervention conditions, and we sought to evaluate the intervention that produced the most rapid acquisition of imitation targets.

1.3. Preference assessment

A brief multiple stimulus without replacement preference assessment (Carr, Nicolson & Higbee, 2000) was conducted prior to each session to identify preferred items to use during the assessment and intervention phases. Items included in the assessment were gathered through therapist interview. The item ranked first was used in the session.

1.4. Target identification: imitation with objects

Nine motor movements were presented three times each for a total of 27 trials. During each trial, the therapist said, “do this,” and presented the motor movement with an object for 5 s. If the participant responded correctly (i.e., within 3-s of presentation), praise and a preferred item were delivered. If the participant did not emit a response or responded incorrectly, the therapist moved to the next trial. Refer to Table 1 for a description of the motor movements with objects included in the target identification for both participants.

The purpose of the target identification was to identify motor imitation targets with objects that the participants had already acquired to assess the difference in performance with and without objects (described below). To include the action

Table 2
Movements included in the attending assessment without objects, the delayed imitation assessment without objects, baseline, and the three intervention conditions for both participants.

Roxanne	George
Clap hands	Arms out to side
Arms up	#3 sign
Tap tummy	#4 sign
Cover mouth	Clap once
Wave	Pointer finger to thumb
Tap thighs	Pointer out
Raise hand	Thumbs up
Tap shoulders	Arms out front
Stomp feet	Hands on hips

as a target in subsequent assessments, the child had to emit a correct response three times (the total number of times the stimulus was presented. during all three trial presentations. If participants did not perform the actions correctly, the action was excluded from the study. See Tables 1 and 2 for a list of all motor movements selected for inclusion in the skills assessments.

1.5. Skill Assessments

Four assessments were conducted to determine each participant's attending and delayed imitation skills. Several procedural components were the same across each assessment. For example, each movement was presented once for a total of nine trials per assessment. Correct responses produced praise and a preferred item. Incorrect or no responses resulted in the presentation of the next trial. All motor movements were presented for a total of 5 s when the therapist said, "do this."

1.6. Attending without objects

The purpose of this assessment was to determine the percentage of trials with attending and correct responses to a set of motor movement targets (e.g., clap hands). The therapist did not provide differential reinforcement for attending although correct responses were reinforced. The therapist recorded data on correct responses and whether the participant attended to the motor movement.

1.7. Attending with objects

The purpose of this assessment was to determine the percentage of trials with attending and correct responses to a set of motor movement targets *with* objects (e.g., waving a pom pom). The therapist did not provide differential reinforcement for attending although correct responses were reinforced. The therapist recorded data on correct responses and whether the participant attended to the motor movement.

1.8. Delayed imitation without objects

The purpose of this assessment was to determine the percentage of trials with delayed imitation of motor movements *without* objects. After presenting the motor movement and saying, "do this," the therapist lightly placed her hands on the participant's hands and waited 3 s. After 3 s, she released the participant's hands to allow the opportunity to respond and provided consequences as described above. Data were collected on correct responses.

1.9. Delayed imitation with objects

The purpose of this assessment was to determine the percentage of trials with delayed imitation of motor movements *with* objects. After presenting the motor movement and saying, "do this," the therapist withheld the object and waited 3 s. Thereafter, the therapist handed the object to the participant, waited the allotted time for a response, and provided consequences as described above. Data were collected on correct responses.

1.10. Procedure

Between two and five sessions were conducted per day. Sessions were conducted at least 3 days per week during the participant's regularly scheduled ABA sessions. Session duration was 5–15 min depending on the phase of the study.

1.11. Baseline

The therapist presented the motor movement for 5 s and said, "do this." If the participant responded correctly, praise and a preferred item were delivered. If the participant did not emit a response or responded incorrectly, the therapist moved to the next trial. Nine motor movement targets were presented a total of three times for each participant (i.e., 27 trials total). These targets are the same as those described in the assessments without objects and are listed in Table 2.

1.12. Intervention

Three interventions for teaching motor imitation were simultaneously evaluated for each child. The purpose of comparing all three of the interventions was to determine if the deficit identified in the assessment accurately matched acquisition in the intervention intended to address that deficit. For example, a participant whose skill assessments showed the lowest scores in attending suggests that he/she will acquire motor imitation responses in the salient stimulus condition most quickly; this outcome shows that the intervention outcomes matched the identification of the deficit in the assessment.

Three of the motor movement targets assessed in baseline were assigned to each of the three intervention conditions. All sessions consisted of nine trials with three presentations of each of the three motor movement targets. There were several procedures that were consistent across interventions. A correct response on the first presentation of the motor movement target resulted in praise and a preferred edible item. Incorrect and no responses resulted in neutral praise and initiation of a prompt sequence specific to the intervention condition. The mastery criterion consisted of three consecutive sessions with at least 80% correct imitation responses.

1.13. Salient stimulus

This intervention was designed to address deficits in attending. First, the therapist modeled the motor movement without the object for 5 s to allow an independent opportunity to respond (e.g., "do this" plus a model of raising arms but without pom poms). If the participant responded incorrectly or with no response, the independent opportunity previously described was repeated a second time (this second independent response opportunity was provided to ensure each condition contained the same number of response opportunities). If the participant responded incorrectly or with no response, the movement was modeled again by the therapist, and a partial physical prompt was provided. The partial physical prompt consisted of the therapist placing her hands on the child's hands, forming the child's hands to complete half of the movement, and removing her hands for the rest of the movement. Finally, if the participant did not respond correctly after the partial physical prompt, the movement was modeled again by the therapist, and a full physical prompt was provided. The full physical prompt consisted of the therapist placing her hands on the child's hands and fully guiding the child's hands to complete the full movement. There was a 5-s response interval between prompts.

1.13.1. Secondary prompter

This intervention was designed to address deficits in delayed imitation. First, the therapist modeled the motor movement without the object for 5 s to allow an independent opportunity to respond. If the participant did not respond or responded incorrectly, the independent opportunity previously described was repeated a second time (this second independent response opportunity was provided to ensure each condition contained the same number of response opportunities). If the participant did not respond correctly, the movement was modeled again by the therapist, and a partial physical prompt was provided by a second prompter. The second prompter was positioned behind the child with her hands fully overlapping the participants' hands. The partial physical prompt consisted of the secondary therapist placing her hands over the child's hands, forming the child's hands to complete half of the movement, and removing her hands for the rest of the movement. Finally, if the participant did not respond correctly to the partial physical prompt, the movement was modeled again by the therapist and the secondary prompted provided a full physical prompt. The full physical prompt consisted of the secondary prompter placing her hands on the child's hands and fully guiding the child's hands to complete the full movement. There was a 5-s response interval between prompts.

1.13.1. Least-to-most prompts

This intervention was used as a control condition. That is, we made comparisons of correct imitative responses in a procedure implemented during the participant's regular ABA programming (i.e., least-to-most prompts) to the two interventions (described above) that were designed to address the outcomes in the skill assessments. First, the therapist modeled the movement without the object for 5 s to allow an independent opportunity to respond. The prompt sequence consisted of (1) another independent response opportunity for 5 s, (2) a partial physical prompt during which the therapist guided the participant's hands into the position to engage in the response but did not guide the entire motor movement, and (3) a full physical prompt during which the therapist guided the participant to engage in the motor movement modeled by the therapist. All prompts were provided by the therapist who was seated across from the child.

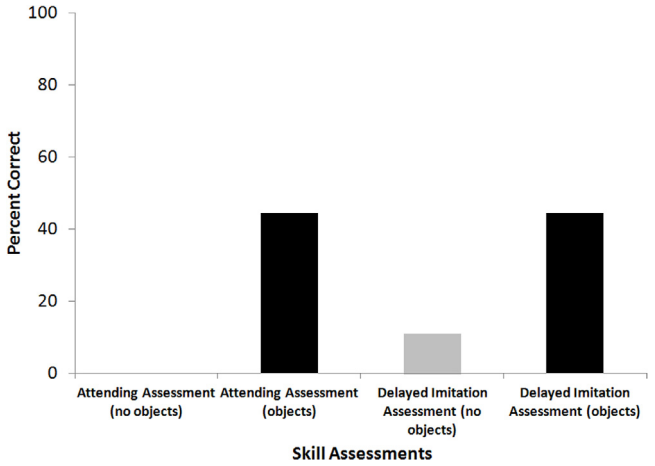

Fig. 1. Roxanne's percent correct responding for each of the four skill assessments. The x-axis indicates the type of assessment.

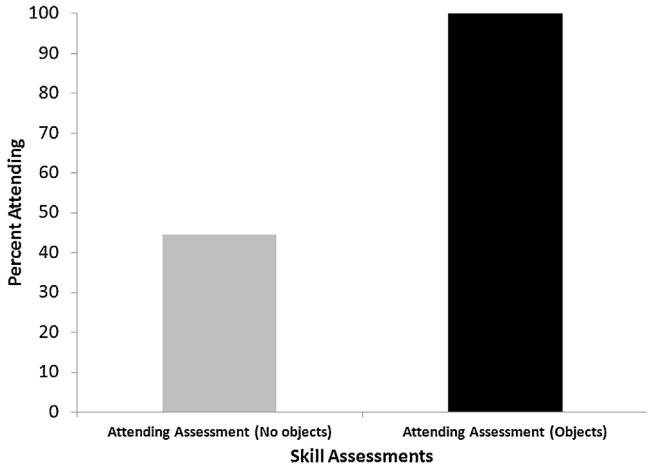

Fig. 2. Roxanne's percent attending during the two attending skill assessments with and without objects. The x-axis indicates the type of assessment.

1.13.2. Novel stimulus probes

Novel stimulus probes were conducted with Roxanne to determine whether the gains observed in intervention had produced a generalized imitation repertoire. The procedures were identical to baseline except that three sets of nine (i.e., 27) novel motor movements were assessed.

2. Results

Fig. 1 displays Roxanne's percentage of correct motor movement responses during the assessments of attending with and without objects and delayed imitation with and without objects. Roxanne did not emit any correct responses during the attending assessment without objects (0% correct). She emitted some correct responses during the attending assessment when objects were included (44% correct). During the delayed imitation assessment without objects included, Roxanne emitted some correct responses (11% correct). Finally, during the delayed imitation with objects included, she emitted 44% correct responses. Correct responding was higher when objects were included. The figure does not show attending (these responses will be described below), only whether she emitted the correct motor movement during the four assessments. These results suggest that Roxanne rarely emitted correct responses to motor imitation tasks without objects.

Fig. 2 displays the percentage of trials in which Roxanne attended to the therapist's movement during the two attending assessments that did and did not contain objects. When objects were not included, she attended to only 44% of trials. When objects were included, she attended to 100% of trials. However, she did not always emit correct responses to the trials to which she attended. These results suggest that a when an object was included, Roxanne's attending increased, suggesting that an intervention designed to include objects may be efficacious for her.

Fig. 3 depicts baseline and assessment of the salient stimulus, secondary prompter, and least-to-most prompting intervention conditions, as well as novel stimulus probes for Roxanne. Roxanne did not emit any correct responses in baseline.

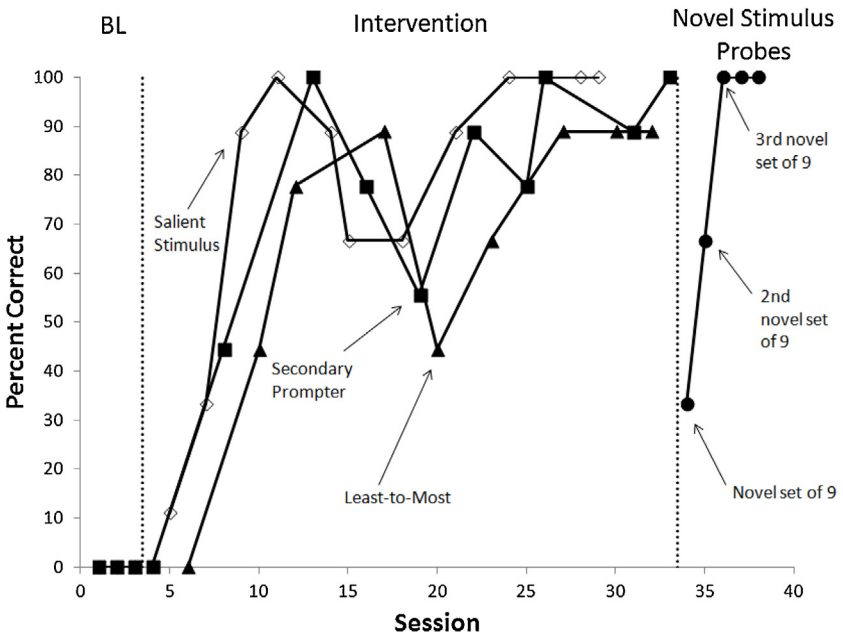

Fig. 3. Baseline, intervention and novel stimulus probes for Roxanne.

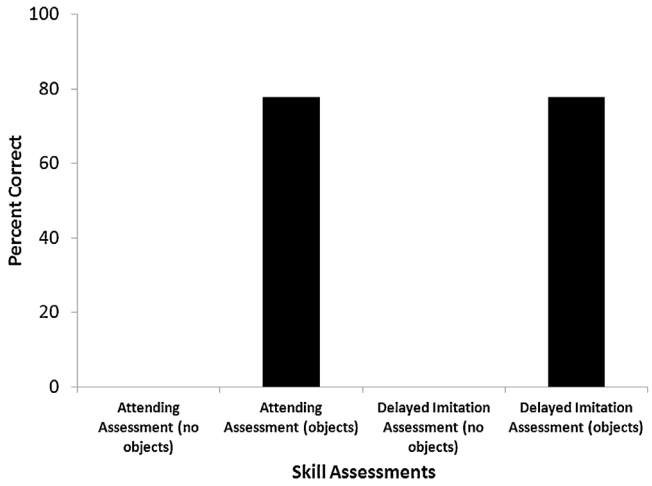

Fig. 4. George's percent correct responding for each of the four skill assessments. The x-axis indicates the type of assessment and the y-axis indicates percentage of correct responding.

During intervention, the salient stimulus condition initially produced the fastest acquisition (5 sessions to mastery), though the other two interventions followed the same pattern of acquisition with slightly more sessions (9 sessions to mastery for both secondary prompter and least-to-most prompting). During novel stimulus probes, she responded correctly to between 33% (first set of 9) and 100% (third set of 9) of motor movements without any intervention in place other than delivery of a tangible item and praise for correct responding. Although every intervention was efficacious, the salient stimulus condition required the fewest session to mastery.

Fig. 4 displays George's percentage of correct responding during the assessments of attending with and without objects and delayed imitation with and without objects. George did not emit any correct responses during the attending assessment without objects (0% correct). He emitted many more correct responses during the attending assessment when objects were included (78% correct). During the delayed imitation assessment without objects, George did not emit any correct responses (0% correct). Finally, during the delayed imitation with objects, he emitted 78% correct responses.

Fig. 5 displays the percentage of trials in which George attended to the therapist's movement during trials with and without objects. George attended to 100% of trials without objects. He attended to 89% of trials with objects. Thus, George's consistently attended to the therapist's movements across both types of trials, and attending did not appear to be a deficit.

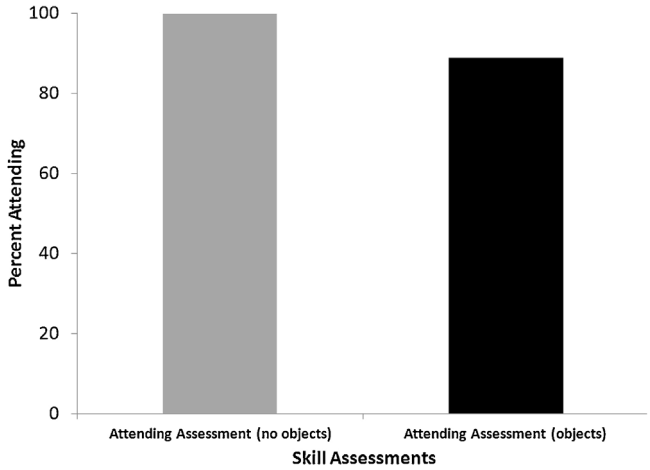

Fig. 5. George's percent attending during assessments with and without objects. The x-axis indicates the type of assessment and the y-axis indicates percentage of attending.

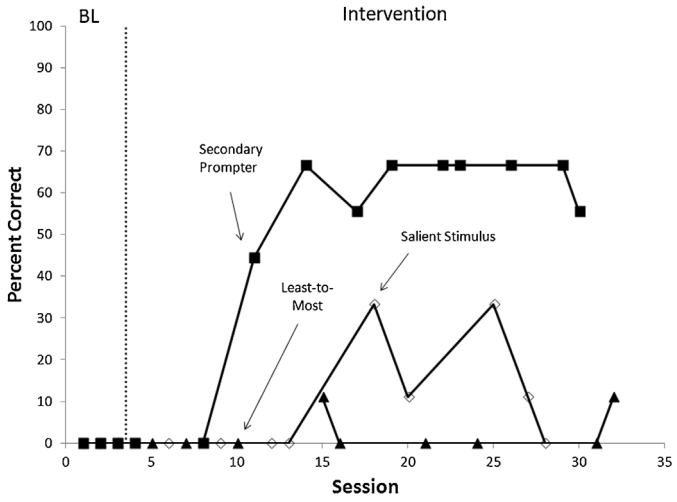

Fig. 6. Baseline and intervention for George. The x-axis represents sessions and the y-axis represents percent correct responses.

Overall, the results of the skill assessments suggest that attending was not a skill deficit but George still did not correctly imitate without objects. Thus, delayed imitation was George's main skill deficit.

Fig. 6 depicts baseline and assessment of the salient stimulus, secondary prompter, and least-to-most prompting intervention conditions for George. He did not emit any correct responses in baseline. During the intervention phase, the secondary prompter condition was effective in establishing motor imitation responses for two of the three targeted responses, showing an upward trend and maximum correct responding of 67%. George never met mastery criterion with this intervention, and we hypothesized that the third motor movement assigned to this condition was acquired at the same pace as the other two movements because it included fine-motor skills that were too difficult for him. Although he emitted some correct responses during the salient stimulus and least-to-most prompting conditions, correct responding was low and the mastery criterion was never met. Unfortunately, George withdrew from the study prior to reaching the mastery criterion or conducting novel stimulus probes.

These results partially validate the use of the assessment, demonstrating that the intervention designed to address delayed imitation (i.e., secondary prompter condition) produced the highest levels of correct responding. Further, the intervention that targeted deficits in attending (i.e., salient stimulus condition) resulted in low levels of correct responding.

3. Discussion

The treatment comparison and skill assessments produced similar results. These results are consistent with research that has briefly evaluated different interventions and chosen the one that produces the most independent and correct responding for ongoing instruction with the individual learner (e.g., Seaver & Bourret, 2009). Although in this study, all

three interventions were tested simultaneously, the results suggested that the intervention that was designed to address the primary deficit of each participant were effective.

Roxanne's results show a match between her assessment outcomes and the most efficacious and efficient intervention. She showed the greatest deficits in attending (particularly when objects were not involved) during the assessment phase. Although all three interventions were ultimately efficacious, the salient stimulus intervention produced the quickest acquisition. The reason she may have responded quickly to intervention with the salient stimulus is because the inclusion of a salient stimulus may have increased attending, which was a marked deficit noted in her assessments. Increased attending in initial trials of the salient stimulus intervention may have increased Roxanne's access to reinforcement for correct responses, and higher levels of attending may have generalized to the other interventions. Thus, the early success produced by the salient stimulus condition may have increased the efficacy of the other interventions over time. An increase in attending overall also could relate to her high percentages of responding during novel stimulus probes.

George only showed deficits in correct responding to delayed imitation tasks, and the intervention designed to address deficits in delayed imitation (i.e., secondary prompter) was most successful in establishing motor imitation responses. The secondary prompter condition reduced the delay between the therapist's model of the action and the opportunity to respond by having a second person provide the prompt while the therapist modeled the action. George did not show deficits in attending skills, and accordingly, the intervention designed to address this deficit (i.e., salient stimulus) was not effective in establishing motor imitation responses. Thus, an intervention that involves the addition of a stimulus to increase attending to the action is not likely to produce an increase in correct responding for participants who already consistently attend to the model. A traditional least-to-most prompting hierarchy also did not produce the same level of correct responding as the secondary prompter intervention, potentially due to George's deficits in delayed imitation, a hypothesized important skill for success with this traditional prompting procedure. George's data provide preliminary evidence that when a learner demonstrates a similar profile with primarily delayed imitation deficits, the secondary prompter intervention may be used to maximize skill acquisition. Though the results are preliminary and should be replicated, the procedure has promise for allowing practitioners to choose an intervention based on an early skills assessment. Had the assessment not been conducted, the standard least-to most-prompting strategy would not have produced acquisition of new motor imitation responses for George. These results are similar to assessment procedures used by other researchers to determine the intervention that will lead to the most independent and correct responding (Gregory et al., 2009; Kodak et al., 2015).

There were several limitations of the present investigation. First, the use of an adapted alternating treatment design may have limited our demonstration of experimental control due to similar outcomes across intervention conditions. The goal of these interventions was to establish motor imitation. It is possible that the efficacy of one intervention in establishing motor imitation may have carried over to other interventions that would not have been efficacious if conducted in isolation. Nevertheless, other single-subject designs would not permit an evaluation of the efficacy of each intervention without the potential for carryover effects. To demonstrate that the independent variables were responsible for the treatment effects, and not some extraneous variable, we could have used a multiple baseline across subjects design to show that correct responding increased only when the independent variables were introduced. Future studies on this topic should consider embedding the adapted alternating treatment design within another experimental design to enhance the evaluation of experimental control.

Second, it is unknown whether George would have acquired the motor movement responses via the secondary prompter intervention due to the discontinuation of his intervention. With repeated exposure to the secondary prompter intervention, he may have acquired the last target and achieved mastery criteria. It is also unknown whether the interventions resulted in the acquisition of putative prerequisite skills measured in the assessment. That is, it remains unclear whether (a) attending may have increased because of the salient stimulus intervention or some other variable, and (b) delayed imitation skills may have increased as a result of the secondary-prompter intervention. Researchers could re-conduct assessments of attending and delayed imitation after the intervention phase to assess any changes as a result of those interventions.

Finally, Roxanne acquired the novel stimulus probe targets as we conducted more probes, which suggests learning occurred across probes. Reinforcement was provided for correct responses during novel stimulus probes, which limits the conclusions that can be made about whether the results obtained during the probe sessions were a result of direct reinforcement or a result of training specific targets in the previous phase.

This study represents an extension of the literature focused on identifying the skill profiles or prerequisite skills of learners and matching interventions to those profiles or skills (e.g., Gregory et al., 2009). This topic of research is particularly important when well-established procedures prove ineffective for a specific skill set or for many skill sets for a particular learner. The assessment-based instruction framework could be useful for practitioners and could stimulate further research on identifying learner profiles that suggest a match to existing interventions or require the creation of new interventions to address specific deficits.

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