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Teaching receptive vocabulary to two autistic children: A replicated, clinic-based, single case experimental design

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Abstract

Background and aims: This study was conducted in a clinical setting with the aim of replicating previously used procedures for teaching receptive vocabulary. Researchers increased the number of vocabulary words and maintained use of match-to-sample (MtS), prompting, and reinforcement procedures. Researchers were also interested in the efficacy of the intervention from caregivers' perspectives.

Methods: Using a concurrent multiple baseline design, two autistic preschoolers with receptive language impairment were taught to identify 30 common objects. MtS, prompting, and reinforcement procedures were individualized to support each child. Maintenance checks and generalization probes were completed after a predetermined number of intervention sessions (i.e. three or four clinic sessions). A social validity questionnaire was completed by parents following the final maintenance check.

Results: Receptive object identification improved significantly for both participants. Despite exposure to vocabulary targets for only three or four sessions, they generalized the vocabulary targets to non-identical pictures and maintained words at maintenance checks. Participants were most successful when researchers individualized prompting and reinforcement.

Conclusion: MtS, prompting, and reinforcement were effective procedures for improving object identification, even with a limited number of intervention sessions. To support varying learner profiles, modifying prompting and reinforcement procedures was necessary. Caregivers of both participants reported positive improvements in areas such as communication, attention, and behaviors.

Implications: This replicated study provides support for MtS, prompting, and reinforcement as means of teaching receptive vocabulary to autistic preschoolers in a clinical setting. The materials used were simple and cost-effective. Overall, this study outlines and supports a flexible and effective evidence-based practice to teach receptive language to autistic children.

Keywords

Receptive language, autism spectrum disorder, intervention

Introduction

In the heterogeneous population of autistic children, there is variability in expressive and receptive language development, including consistent difficulty in nonverbal communication (American Psychiatric Association (APA), 2013; Broome et al., 2021; Thurm et al., 2007). Research regarding expressive language intervention in autistic children is plentiful (e.g. Lane et al., 2016; Sandbank et al., 2020) with researchers

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looking at a range of outcome measures from preverbal communication skills such as pointing, joint attention, and imitation (McDaniel et al., 2022) to syntax (Horvath et al., 2018). Receptive language is less well researched. Sandbank et al. (2020) found a significant lack of focus on receptive outcome measures: across 60 studies with autistic children measuring 221 outcomes, researchers found that only 36% ($n = 79$) focused on receptive language skills. Additionally, those outcomes that measured receptive language skills were found to show less growth from intervention (Sandbank et al., 2020). Likewise, Heidlage et al. (2020) found that studies focusing on expressive outcomes ($n = 13$) in autistic learners resulted in moderately significant outcomes, but receptive outcome measures ($n = 7$) did not show significant results. With smaller or nonsignificant effect sizes noted for receptive outcomes, the current evidence base for receptive language intervention is not sufficient for clinicians tasked with improving the receptive language of the autistic population (Heidlage et al., 2020; Sandbank et al., 2020). This is particularly true for children who have autism, lower cognitive scores, and co-occurring language difficulties as these children are often less well represented in research studies on autism spectrum disorder (Thurm et al., 2022).

In 2013, Grow and LeBlanc published evidence-based guidelines for teaching receptive language. They reported five key considerations for best practice: ensuring the child is attending prior to presenting the antecedent; reducing or eliminating inadvertent cues (e.g. tone of voice during presentation); ensuring stimulus control through selection of the stimuli and responses (simplification of auditory direction and simultaneous target introduction); monitoring and modifying prompting and reinforcement to reduce prompt dependence; and troubleshooting behaviors in responding and attending throughout intervention. LaMarca and LaMarca (2018) identified additional strategies that benefit autistic learners who are acquiring prerequisite skills needed to learn receptive language including: simplifying tasks by removing all but the target image/item for the child to select, reducing the stimulus field to two objects or pictures, having the child imitate the clinician's selection after the auditory stimuli, presenting the auditory stimuli prior to the visual choices, recognition through touch or pick up of the object, and time expansion. These authors stressed the importance of individualizing each child's needs (LaMarca & LaMarca, 2018; Grow & LeBlanc, 2013).

With the goal of contributing further to the evidence base in receptive language intervention, particularly with children who present with significant co-occurring language impairment, lower cognitive abilities, and autism, Muldoon and Gray (2023) outlined intervention procedures that demonstrated immediate effect on receptive vocabulary learning in autistic preschoolers. The researchers used matching to sample (MtS; matching objects to identical and non-identical pictures), reinforcement, and systematic prompting in a discrete trial training (DTT) format to teach receptive labels to nonspeaking autistic children in a preschool setting. DTT calls for clinicians to use procedures such as prompting and reinforcement to mark individual learning trials (Lerman et al., 2016). There is evidence supporting the use of DTT to teach skills such as social communication (e.g. Ali & Fazil, 2022), nonverbal communication (e.g. Hamdan, 2018), and presymbolic communication skills such as imitation (e.g. Bravo & Schwartz, 2022).

MtS is frequently used to teach relational responding in language (Barnes-Holmes et al., 2004; Tovar et al., 2023). MtS procedures are an effective means of teaching expressive language skills including divergent naming (Grannan & Rehfeldt, 2012) and metaphor generation (Lee et al., 2022). Bejno et al. (2018) used MtS to explore the effects of matching on identification of objects and emergent picture labeling with six autistic children in the only study found using matching for similar receptive language teaching as this study. MtS supports the child in making three-way associations between the object, its label, and a picture of the object (Plazas & Pena, 2015; Tovar et al., 2023). Stimulus equivalence, considered to be a type of relational responding, is the understanding that relations between words (spoken), pictures, and objects emerge (A is the same as B and B is the same as C, so A and C are the same) without direct training but rather through reinforcement of desired responses and ignoring or extinguishing incorrect responses (Plazas & Pena, 2015; Tovar et al., 2023). A key component of stimulus equivalence is the reinforcement of the target responses. It is this differential reinforcement that supports the indirectly created relationship that two or more stimuli are part of the same equivalence class while other stimuli are not (Silguero & Vaidya, 2023). Stimulus equivalence allows for the emergence of non-identical picture matching and direct object identification (both not directly taught but assessed herein during generalization and maintenance). Shillingsburg and Frampton (2019) used the interspersal of related language responses to test for untrained, novel responses in children who had previously only been taught more fundamental language related to labels and object function. They found that untrained responses do emerge if the language tasks are presented in "close temporal contiguity" (p. 185). Ming et al. (2019) explained that typically developing children learn these relationships through interactions with their environment and communication partners. Autistic children often do not draw the same conclusions through naturalistic interactions and can benefit from teaching strategies such as reinforcement of relationships (e.g. label and object), inherent in MtS, to facilitate their learning.

In a previous study, authors one and two taught autistic children to match identical pictures, match non-identical pictures, and subsequently investigated if an untaught relation emerged. For example, we taught participants to match the object "watch" to a picture of a watch. We then assessed

(a) their ability to match the watch to a nonidentical picture of a watch and (b) their ability to identify the object "watch" in the absence of a picture and only upon hearing the word (i.e. the receptive label). All the participants were successful in identifying the objects although the auditory stimulus had not been directly taught thus, supporting the hypothesis was that the participants arrived at the stimulus relationship, demonstrating stimulus equivalence (i.e. object, picture, and receptive label equivalence).

Social validity

Social validity refers to the extent to which the behaviors targeted, and procedures used in an intervention are acceptable and/or significant for the intended behavior change (Cooper et al., 2019). To assess social validity, we modified the goodness of fit (Albin et al., 1996) checklist to reflect the context (behaviors targeted and procedures used) for this intervention. When contextual fit is high, compatibility with caregivers' values is more likely and the intervention becomes more sustainable (Albin et al., 2001). In a review of social validity in social case research, Snodgrass et al. (2018) highlighted the importance of the caregivers' perceptions of the intervention from a buy-in and sustainability perspective. While they recommended measures are completed before, during or after the intervention, for this study we completed the measure following completion of the intervention.

Current study

For this study we employed the following strategies from the works of Grow and LeBlanc (2013) and LaMarca and LaMarca (2018): simplification of the auditory direction, monitoring and modifying prompting and reinforcement, troubleshooting behaviors of attending and responding, simplifying tasks by presenting only one object and two pictures (however, for this and the previous study three pictures were presented), time expansion and acknowledging recognition of the object through touch or pick up.

During this study, the child was presented with an object and the spoken label and expected to match the object to a corresponding picture presented in a field of three, all guidelines for teaching receptive language (Grow & LeBlanc, 2013; LaMarca & LaMarca, 2018; Ming et al., 2019).

The aims were to support the findings of Muldoon and Gray (2023) by significantly increasing the number of vocabulary targets while also outlining changes needed for individual children. This multiple baseline single case study served to answer three questions:

1. Does the MtS procedure assist clinicians in teaching receptive vocabulary to autistic preschoolers in a clinical setting (as opposed to a preschool setting)?
2. What individual, child-specific changes (e.g. prompting procedures and reinforcement schedules) must be made to allow for successful implementation in a clinical setting?
3. Do caregivers perceive the intervention as efficacious for language development and/or for behavior management?

Methods

Participants

Following institutional review board approval, participants were recruited from local preschools and daycares via flier distribution to community speech-language pathologists. Parents provided informed consent for the study. Participants Bella and Jason both received a diagnosis of autism from local community providers, confirmed by parent submissions of medical records. Both children presented with clear signs of autism; Bella engaged in self-stimulatory behavior and cried excessively, while Jason was rigid and repetitive in his behavior.

Cognitive and receptive language scores are summarized in Table 1. Bella was 3 years old at the start of the study, had minimal functional expressive language, and communicated primarily with vocalizations and gestures. Bella scripted songs throughout the study; for example, she sang "Itsy Bitsy Spider" each time she was shown a toy spider. Bella and her family traveled approximately an hour to the clinic to participate in the study. She typically slept during the car ride to the clinic, and was often fatigued and irritable upon arrival, requiring a period of play that was facilitated by the first author to help her become comfortable in the clinic environment. Bella had not attended daycare prior to this study but was enrolled in preschool for the upcoming school year.

Jason was 3 years and 8 months old at the start of the study. He communicated using one to two-word unintelligible utterances. Jason was very active during sessions and frequently walked around the room or tried to leave. He was easily distracted by the double-sided mirror and light switch and needed frequent reminders to attend to the language tasks. Jason had been in a preschool setting for the previous school year, but the school reported to his mother that his activity level was interfering with his ability to learn and make progress.

Jason had more expressive language than Bella at the start of the study. He was able to communicate using one to two words while Bella had no clear means of communication. He was also better able to engage in the activities presented to him as part of this research study as he had spent time in a preschool and was familiar with demands of the setting. Cognitive skills for both participants were established by community providers using the Bayley Scales of Infant and Toddler development with both children showing considerable delay in early cognitive

development (see Table 1). Receptively, both were assessed using different tools, but standard scores of 56 (Jason >2.5 standard deviation (SD) below the mean) and 54 (Bella >2.5 SD below the mean) established a similar, significant, and severe level of receptive language skill.

Setting

All sessions were conducted at a university speech-language-hearing center. Sessions were conducted in therapy rooms containing both child-size tables and chairs, and chairs for adults. The rooms contained cabinets to enclose materials, allowing for a minimally distracting environment. Therapy materials (i.e. objects and pictures) were organized in plastic boxes for ease of access and to avoid duplication when presenting objects.

Each therapy room had an observation room with a two-way mirror. Sessions were conducted by the authors and trained speech-language pathology graduate students. The majority of Bella's sessions were conducted by the first author, and the majority of Jason's were conducted by the second and third authors. A graduate student was in the room for each session to collect data. Additional trained graduate students recorded fidelity from the observation rooms. The children's caregivers watched sessions from the observation rooms.

Materials

One hundred common, functional nouns were available for use in the study, all chosen from a list of recommended verbal targets (Luckevich, 2018). Common nouns included the 14 nouns typically understood by 18–24 months (Fernald et al., 2013). Additional functional, frequently occurring words, typically understood at 18– 24 months, were chosen on the basis that they would increase the likelihood of success in teaching the vocabulary. Most of the nouns were items found in a preschooler's everyday environment (see Table 2). All the objects were small enough for the children to handle easily. Some were functional objects, such as a pen, a paper plate, and toilet paper. Other objects were toys, such as a plastic play phone, toy car, and dog figurine. Identical picture cards of each object were generated using iPhone cameras and were printed and laminated on 3×4-inch cards by the university print shop. Picture cards, similar in size and presentation, of non-identical objects were sourced from Google images.

Design

A concurrent, multiple baseline research design was used for this study. The participants attended different preschools and attended the clinic at different times, and their families did not know each other so a concurrent baseline was appropriate. Given the time constraints of the study, 60 vocabulary words/objects were randomly chosen for baseline (see Table 3).

Baseline. At baseline, participants were presented with objects in a field of three. The clinician verbally stated a single-word object label with the expectation that the participant would point to or touch the object. A verbal prompt was provided twice per object (see Table 4). A word was deemed known by the child and removed from the target list if the child accurately identified the object, using touch or pick up, more than three times. Reinforcement was not provided.

Following baseline, Jason consistently knew 14 of the 60 words, leaving 46 unknown. Bella consistently identified three, leaving 57 unknown (see Table 3). For each child, 30 unknown objects were randomly assigned for intervention (see Table 2). Throughout the course of intervention, the clinicians spent three—or four sessions, one time for Bella —on each set of 10 words. For this study, we made a decision to change the vocabulary set after three intervention sessions whether the child had mastered it or not. Continuing to mastery (e.g. 80% or higher over three consecutive sessions) would have had significant implications for Bella, who under strict mastery criteria might not have been exposed to more than 10 words in 15 weeks (i.e. the time available to the investigators for this study).

Measures

The initial measures for this study included a review of cognitive and language scores provided by parents (see Table 1). Second, measures of dosage are reported for length and number of sessions. Third, measures at baseline were established using the criteria to touch or pick up the object by the child and are reported as percentage independently correct. Similarly, during intervention, generalization, and maintenance, objects identified independently, and correctly were reported as a percentage of the total trials. No prompted responses were recorded for these percentages. Fourth, measures of interrater reliability and fidelity of implementation of the intervention are reported. Finally, an analysis of caregivers' perceptions of the intervention is outlined, though no quantitative measures were generated for this brief qualitative measure (see the Results section).

Prompt hierarchy. Initially, the clinician verbally stated a single-word object label with the expectation that the participant would point to or touch the object. A verbal prompt was provided twice per object (see Table 4). If the child did not respond, the prompting hierarchy was initiated. The same prompting procedure (Table 4) was used for each child, with modifications made to support Bella's independence following the fourth session (see Figure 1). In the least-to-most (LtM) prompting hierarchy, the gestural prompt consisted of the researcher pointing to the correct picture card. A partial prompt consisted of a

Table 1. Cognitive and receptive language test results for each participant.

Testing	Jason	Bella
Cognition	*Bayley scales of infant and toddler development: Fourth edition*	*Bayley scales of infant and toddler development: Fourth edition*
	Cognitive composite score 85	Cognitive composite score 75
	16th percentile	5th percentile
Receptive language	*Developmental assessment of young children: Second edition*	*Preschool language scales: Fifth edition*
	Receptive language	Auditory comprehension
	Standard score 56	Standard score 54
	0.2 percentile	First percentile

gentle physical touch without full hand-over-hand guidance; for example, the researchers often guided the child's elbow toward the correct picture card as a partial prompt. Hand-over-hand was used as a full physical prompt. The order of the prompts was reversed when using a most-to-least (MtL) prompting procedure. The order of prompts from MtL or LtM was individualized based on the child's needs. Both participants required MtL prompting in the initial phases of intervention as they learned the expectations of the task. In the presence of an incorrect response or no response, researchers restated the label and immediately used an MtL prompting procedure to decrease subsequent errors.

Reinforcement. Specific positive verbal feedback was provided consistently after a correct response (e.g. "you're right, that's the clock"). Additional reinforcement schedules were individualized for both children. Bella particularly enjoyed playing with a ball tower. She benefited from positive reinforcement on a variable ratio schedule; at times 1:1 reinforcement, otherwise a 1:2 or 1:3 schedule of reinforcement. The reinforcement periods lasted no more than 30 s. The reinforcer remained on the table throughout the session as a visual reminder of reinforcement. She was also verbally reminded of what she was working for as needed. If Bella was not interested in the ball tower, bubbles or a slinky were used for reinforcement.

Jason progressed through a full set of 10 trials before receiving reinforcement (i.e. 1:10 reinforcement schedule). Prior to beginning the session, he identified what he was working for that day, typically from a choice of two reinforcers. He enjoyed turning off the lights to reveal his mother in the observation room, seen through the double-sided mirror. Jason also enjoyed playing with toys such as rockets, bubbles, dinosaurs, and helicopters. After one minute of playing, the clinician set a 30 s visual timer to signal the end of the reinforcement period. Reinforcers remained on the table and visible to Jason throughout the session.

Table 2. List of 100 functional nouns selected for inclusion in the study.

1. Airplane	35. Duck	69. Puzzle
2. Baby	36. Egg	70. Raisins
3. Bag	37. Elephant	71. Ring
4. Ball	38. Flag	72. Rocking horse
5. Banana	39. Flowers	73. Ruler
6. Band Aid	40. Fork	74. Scissors
7. Bathtub	41. French fries	75. Screw
8. Bed	42. Fridge	76. Screwdriver
9. Bike	43. Giraffe	77. Shoes
10. Bird	44. Gloves	78. Shorts
11. Blocks	45. Glue	79. Shovel
12. Book	46. Hammer	80. Shower
13. Boots	47. Hat	81. Sink
14. Bow	48. Helicopter	82. Socks
15. Bowl	49. Hotdog	83. Spider
16. Box	50. Jacket	84. Spoon
17. Brush	51. Juice	85. Star
18. Bus	52. Ketchup	86. Stove
19. Candle	53. Keys	87. Straw
20. Car	54. Ladder	88. Sunglasses
21. Cat	55. Lamp	89. T-shirt
22. Chair	56. Lunchbox	90. Table
23. Cheetah	57. Mask	91. Tape
24. Clock	58. Mint	92. Teddy bear
25. Closet	59. Mustard	93. Toilet
26. Computer	60. Pan	94. Toilet paper
27. Couch	61. Pants	95. Toothbrush
28. Crayon	62. Paper	96. Train
29. Crib	63. Paperclip	97. Tree
30. Cup	64. Pen	98. Turtle
31. Dinosaur	65. Pencil	99. Watch
32. Dog	66. Phone	100. Water bottle
33. Doghouse	67. Plate	
34. Drum	68. Pumpkin	

Generalization. Generalization was assessed following three sessions. Each generalization probe was preceded by the MtS and prompting procedures for the previously targeted 10-word vocabulary list. During generalization, a field of three non-identical images was presented along with the corresponding object, and the child was expected to place the object on the corresponding non-identical image (see Appendix A). Immediate reinforcement was not provided during generalization. At the end of the generalization set, each child earned time to play with a desired toy.

Maintenance. Maintenance was assessed twice during the study and represents the child's ability to identify the objects in the absence of pictures. The first maintenance

Table 3. Lists of each participant's randomized vocabulary words.

	Bella	Jason	
Set 1	Bowl	Ball	
	Clock	Banana	
	Dog	Brush	
	Glue	Doghouse	
	Hammer	Gloves	
	Ladder	Pan	
	Pants	Shoes	
	Sink	Sink	
	Tree	Sunglasses	
	Table	Toilet paper	
Set 2	Hat	Bag	
	Lamp	Bird	
	Box	Car	
	Spider	Egg	
	Giraffe	Keys	
	Screwdriver	Ladder	
	Flowers	Mask	
	Socks	Pen	
	Bike	Tape	
	Phone	Watch	
Set 3	Bag	Spider	
	Airplane	Spoon	
	Puzzle	Pants	
	Bathtub	Flag	
	Toilet paper	Bed	
	Watch	Glue	
	Paperclip	Band-Aid	
	Helicopter	Hat	
	Blocks	Juice	
	Shorts	Giraffe	
Known at baseline	Crayon	Bird	
	Stove	Boots	
	Toothbrush	Car	
		Clock	
		Computer	Mask
		Dog	Phone
		French fries	Pumpkin
		Juice	Puzzle
		Keys	Toilet

check was cumulative of the first and second vocabulary sets. The second was cumulative of all three vocabulary sets. During maintenance checks, the child was presented with a field of three objects (i.e. no pictures were used during maintenance). Similar to the baseline, the participants were expected to touch or pick up the corresponding object. Verbal feedback was not provided during maintenance.

Interrater reliability and procedural fidelity. Interrater reliability data was collected for both participants for more than 35% of sessions. A minimum of two data collectors recorded responses during each session. The data collectors were trained graduate students and the authors. Interrater agreement was calculated to be 97.6% for Jason (range from 80% to 100%) and 94.75% for Bella (range from 80% to 100%) using point-by-point agreement on the occurrence of correct, independent responses over all responses for each child.

In addition, procedural fidelity was monitored in the intervention phase of the study. A fidelity checklist was used to track the correct presentation of the objects and pictures. Additionally, the checklist tracked the correct use of the prompting procedure and the use of reinforcement for each child. The checklist mirrored the prompting hierarchy as outlined in Table 4. In 45% of intervention sessions, researchers or trained graduate students tracked procedural fidelity for MtS, reinforcement, and the prompting hierarchy (see Table 4). Procedural fidelity ranged from 96% to 100% and averaged 99.3% across all intervention sessions.

To minimize the possibility of bias in collecting these data, several precautions were made: the one-way mirror was used consistently for data collection; this data was then rated against that collected by the student in the room with the child; and the graduate students met regularly with the investigators to minimize observer drift, particularly during the intervention phase. However, no student was blinded to the aims of the study for interrater reliability or procedural fidelity.

Results

Dosage

Each child was seen once weekly. Jason attended for 12 sessions (over 13 weeks) and Bella for 14 sessions (over 15 weeks). Bella attended two additional sessions to establish levels of generalization and maintenance, which could not be established at the end of the intervention sessions. Jason was able to complete intervention, generalization, and maintenance checks in one session. Jason's sessions were 30 min in length and Bella's were ~45 min. As mentioned, Bella required a period of adjustment at the beginning of each session, increasing her session length. During an intervention, the participants were presented with three picture cards and one object and were expected to place the object on the corresponding picture upon hearing the object label. Each set of vocabulary words was presented for three sessions (four on one occasion for Bella) and the 10-word vocabulary set was presented one to three times per session. For Jason, intervention sets were completed one time at the beginning of the session before generalization and maintenance were assessed; in other words, he completed three sets, one each of intervention, generalization, and maintenance. Bella's completion rate varied from one to three sets of trials per session depending on her fatigue and ensuing levels of attending and as mentioned, additional sessions were needed to complete probes for generalization and maintenance.

Table 4. Procedural fidelity and prompting procedures.

Procedural fidelity prior to prompt	
• Field of three pictures positioned on the table with the object to be matched positioned close to the child. • Verbal stimulus—one-word utterance identifying the target. May be repeated once. ◦ **Modification for Bella: repeat verbal stimulus up to three times.**	
Most-to-least (MtL) prompt procedure	Least-to-most (LtM) prompt procedure
• Physical prompt required? Using a MtL hierarchy, you prompted the child following up to five seconds of no response to the original request. **Modification for Bella: prompt following up to ten seconds of no response.** Follow the steps below. • **Full prompt**—place hand over the child's hand and match the object to the picture. • **Partial prompt**—touch the child to get him to match the object (e.g. nudge the child's elbow). Not as intrusive as the full prompt. • **Partial prompt—gesture**. Point to the picture and the child matches the object to it. • Reinforcer provided following correct matching, according to the reinforcer schedule.	• Physical prompt required? Using an LtM hierarchy, you prompted the child following up to five seconds of no response to the original request. **Modification for Bella: prompt following up to ten seconds of no response.** Follow the steps below. • **Partial prompt—gesture**. Point to the picture and the child matches the object to it. • **Partial prompt**—touch the child to get him to match the object (e.g. nudge the child's elbow). Not as intrusive as the full prompt. • **Full prompt**—place hand over the child's hand and match the object to the picture. • Reinforcer provided following correct matching and according to the reinforcer schedule.
Procedure for generalization probes	
• Present the non-identical picture and ask the child to match the object to it. No reinforcer provided ◦ **Modification for Bella: provide reinforcement every third to fifth trial** • Present the non-identical picture and ask the child to match the object to it. No prompt provided to either child	

Data analysis

Several different methods of data analysis were employed for this study including visual analysis of immediacy of effect, changes in level between baseline and intervention (see Figures 2 and 3, Bella and Jason, respectively), and percentage of data points exceeding the median (PEM; Ma, 2006).

The immediacy of effect illustrates behavior change that occurs once an intervention is introduced (Barton et al., 2018), thus assisting clinicians in seeing the efficacy of the procedures in the clinical setting. Both Jason and Bella had low levels of object identification during baseline. Jason's accuracy ranged from 20% to 30% with 14 known items removed, while Bella's ranged from 26% to 30% with three known items removed. At baseline, there were times when an object may have been identified during one session but not another resulting in the range of accuracy for the participants at baseline. Accuracy at baseline was measured using the criterion touch or pick up the object, and there were times when this was done inadvertently by the children if, for example, the object was preferred.

With the introduction of the intervention, Jason's performance improved immediately: the change in level between the last data point at baseline and the data points following intervention was immediate and provided a clear indication that the independent variable (MtS, prompting, and reinforcement) had an effect on the dependent variable (receptive identification of objects). Bella took longer to respond but she too responded with 53% accuracy during the third intervention session (see Figure 1) before prompt dependency was identified and rectified. The individual and child-specific changes in prompting resulted in the successful implementation and acquisition of the vocabulary for Bella. Subsequently, her independent performance improved (see Figure 4).

PEM was calculated for both participants by calculating the median at baseline and comparing this to treatment phase data points (see Figure 3). The median score at baseline for Jason was 22 with the first and subsequent data points of intervention, generalization, and maintenance all above that score. Thus, for Jason treatment phase data points exceeding the median score at baseline was 100%. The median score for Bella at baseline was 26, but not all the following data points were above this score so, for Bella PEM was 81%. The session when the first author was not available (i.e. session 16, Figure 1) appears to have skewed the results for Bella. Nonetheless, the intervention was rated as highly effective for Jason and moderately effective for Bella.

The improvement in accuracy when using LtM prompting (Jason) and following a prompting procedure modification for Bella (see Figure 4) suggests that the independent variable had an immediate and significant effect on the participants' ability to generalize the vocabulary and albeit to a lesser extent to maintain the vocabulary.

Participant outcomes

For each participant, correct, independent responses were recorded as a percentage of the total identified objects (during baseline) and MtS (during intervention). Prompted responses, at any level of the hierarchy, were not recorded in the total percentage reported for each child.

Jason. During baseline, Jason's accuracy in identifying the named items ranged from 20% to 30% correct (see Figure 1). Jason correctly identified 14 vocabulary words during baseline. These 14 words were removed from the pool of potential targets (see Table 3). When researchers introduced MtS, Jason quickly learned to match pictures and objects, with his independent responses starting at 53% and increasing to 70% by his third intervention session. Jason initially used a process of elimination to select the correct picture. He tapped each picture in the field and waited for the researchers' confirmation of a correct response. The researchers used MtL prompting to successfully eliminate this behavior. Following this brief initial use of MtL prompting, LtM prompting was used for intervention and Jason achieved 100% independence in his final intervention session. Jason participated in three intervention sessions for each set of vocabulary targets. On days when maintenance or generalization was completed (see Figure 1) the session started with intervention procedures to reintroduce the session expectation.

During generalization, Jason's accuracy increased from 80% to 100%. Jason's accuracy for the first maintenance check, encompassing the vocabulary targets from sets 1 and 2, was 63% and accuracy increased for the second maintenance probe to 87% (see Figure 1). During the second maintenance probe, Jason accurately identified eight objects from set one, eight from set two, and all 10 from set three. The MtS procedure was helpful in teaching receptive vocabulary to Jason in a clinical setting. Relatively few changes were needed to the procedures in Muldoon and Gray (2023) to assist Jason in acquisition of the vocabulary during intervention.

Bella. Bella's accuracy during baseline ranged from 19% to 28%. Bella lacked consistency in her responses and only three words (5%) were removed following baseline (see Table 3). During intervention, Bella required many learning trials to understand the teaching procedure with her entire first intervention session consisting of full physical prompts. Independent responses during intervention ranged from 0% to 87%. During her fourth intervention session, researchers saw clear evidence of prompt dependence when Bella refused to match objects to pictures independently; instead, she reached for the researcher's hands searching for a full physical prompt. Prompting modifications were immediately implemented, allowing Bella additional time and providing a third verbal prompt in lieu of a physical prompt. When these changes were made, Bella performed independently and continued to demonstrate growth during subsequent intervention sessions (see Figure 1). The MtS procedure was helpful in teaching receptive vocabulary to Bella in a clinical setting. The changes needed to the procedures in Muldoon and Gray (2023) were individualized for Bella and resulted in acquisition of the taught vocabulary.

To maintain attention and motivation, Bella required more frequent reinforcement than Jason. Bella's reinforcement schedule ranged from one to three teaching trials of the vocabulary targets. She received an equal number of intervention sessions as Jason, but vocabulary set one was targeted for a fourth session following detection of prompt dependence on day three. Bella's accuracy in generalization ranged from 67% to 90%. As mentioned, generalization probes were preceded by teaching procedures as a reminder of the expectations. For Bella, this resulted in 45% accuracy in session four of intervention for the first set of vocabulary and then 90% accuracy when presented with non-identical pictures during the generalization probe.

Bella achieved 35% accuracy on the first maintenance probe and 50% on the second (see Figure 1). During the first maintenance probe, Bella accurately identified three objects from the first set and four objects from the second set. During the second maintenance probe, Bella accurately identified three objects from the first set, six from the second, and four from the third.

Parent perceptions of intervention

Bella and Jason's caregivers completed a social validity (i.e. the modified goodness of fit) questionnaire following the study (see Appendix B). Both caregivers reported positive outcomes including that they believed their child made communicative, social, and behavioral improvements. Caregivers had observed all sessions through a double-sided mirror allowing them to comment on language teaching and behavior management strategies that they felt had benefited their child. At the conclusion of the intervention period of 12 weeks, caregivers were asked if the researchers had "used strategies that you feel will be useful in the future?" (see Appendix B). Both families reported that they picked up behavior management and language intervention techniques to use with their children in more natural environments. Bella's family reported on the impact of language teaching strategies (repetition and visuals), the fact that Bella started to pay more attention to words, and her mother reported that "her verbal communication increased drastically." In the survey, Bella's

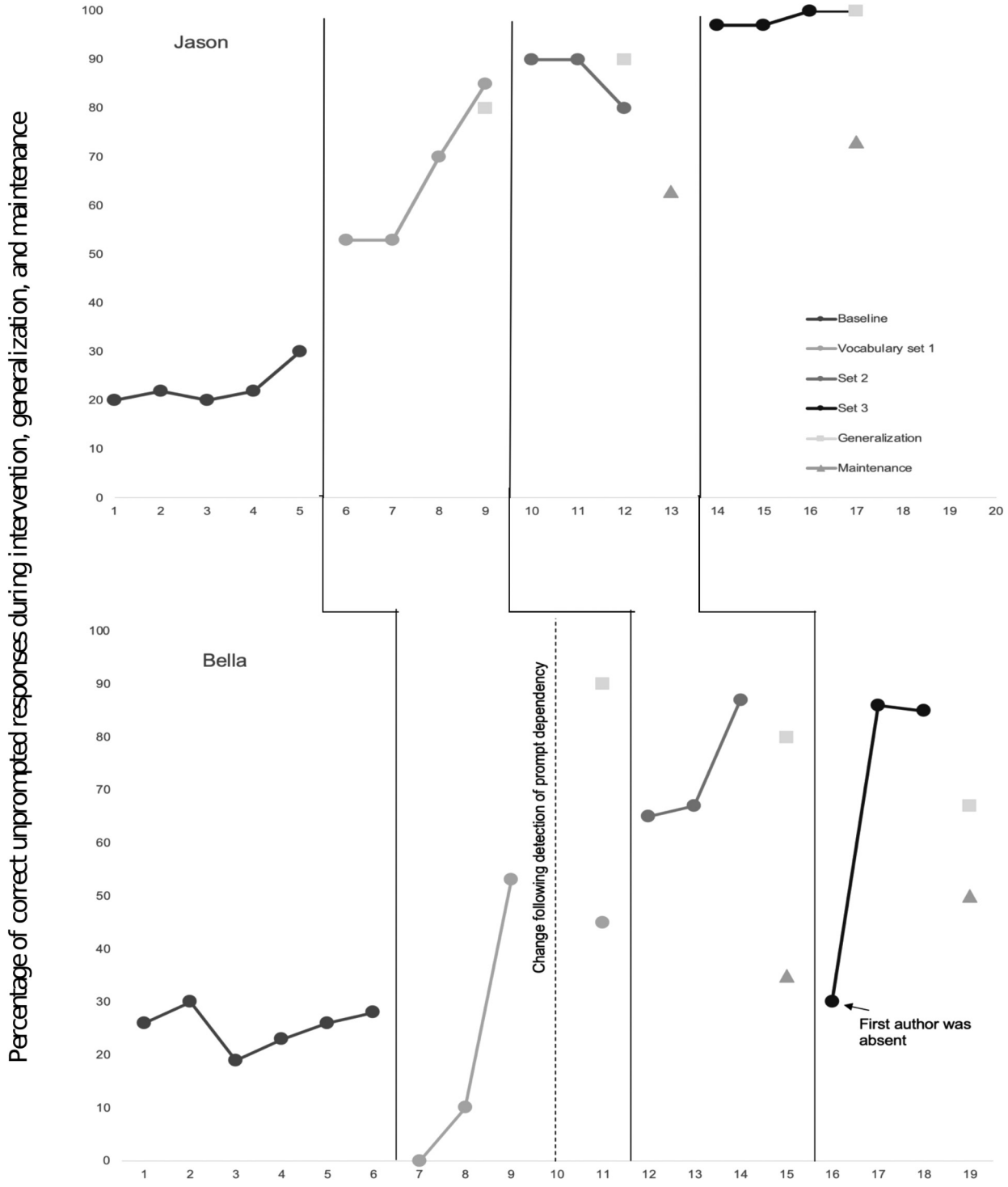

Figure 1. Baseline, learning trials, generalization, and maintenance for Bella and Jason.

caregivers reported that they clearly believed that the intervention had helped both them and Bella.

Jason's mother found the biggest benefit to be in learning to redirect him to or keep him engaged in an activity. She scored three items slightly lower, stating that she believed items 10, 11, and 12 (see Appendix B) helped "a little." She qualified the "a little" rating by saying "This experience was great" and "Jason's language exploded" over the time he was in intervention.

She reported that Jason's attention and utterance length were most impacted and that following the intervention she understood how to help him focus and be less impulsive.

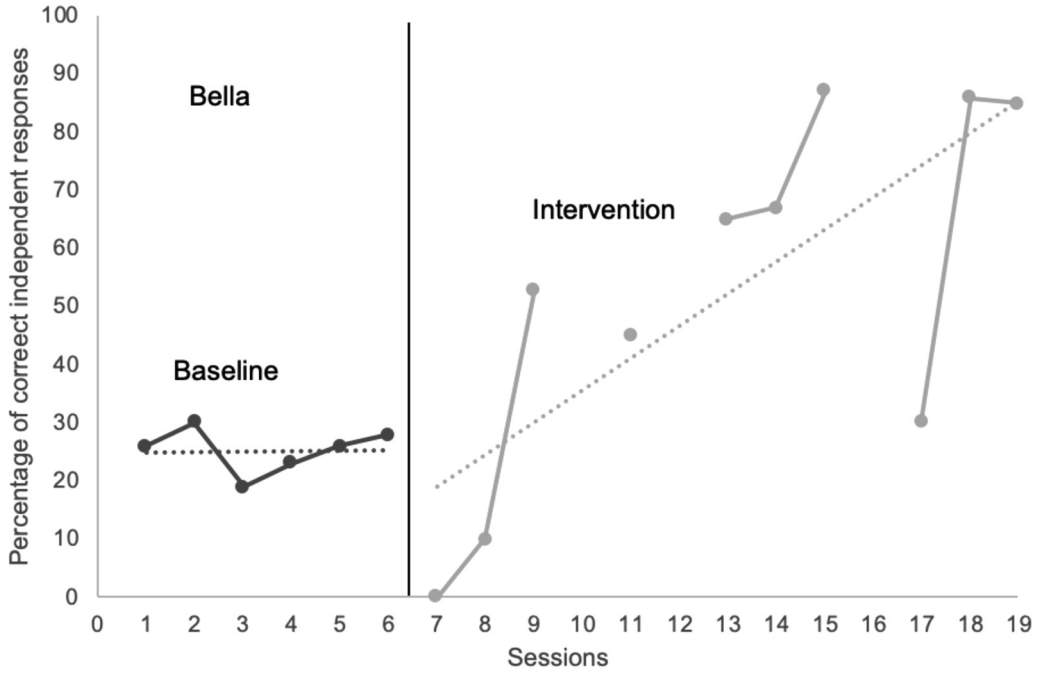

Figure 2. Trendlines during baseline and intervention for Bella.

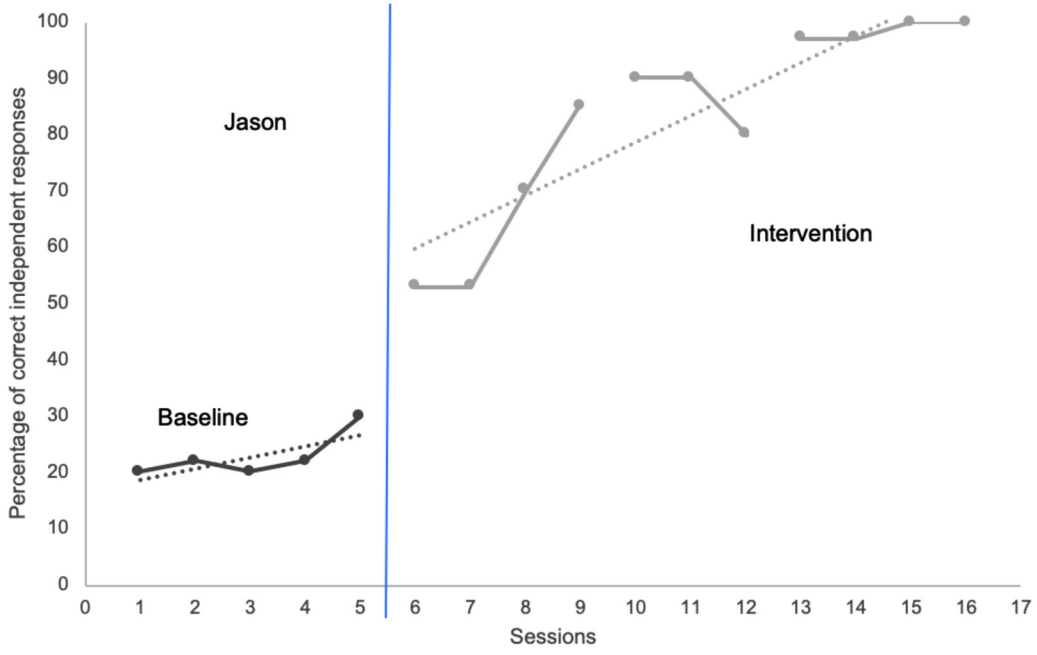

Figure 3. Trendlines during baseline and intervention for Jason.

Discussion

This replicated study has important clinical implications for practitioners working with autistic preschoolers. Receptive understanding of new vocabulary was successfully taught to two preschoolers with severe language receptive language impairment (RLI) in a short amount of time. The procedures used for this study were cost-effective. Toys and functional objects were easily found, and pictures were generated quickly and affordably. Even with the study time limitations, clear evidence of acquisition of vocabulary was documented and both children were able to generalize their learning to non-identical pictures. The progress made by participants in the previous study

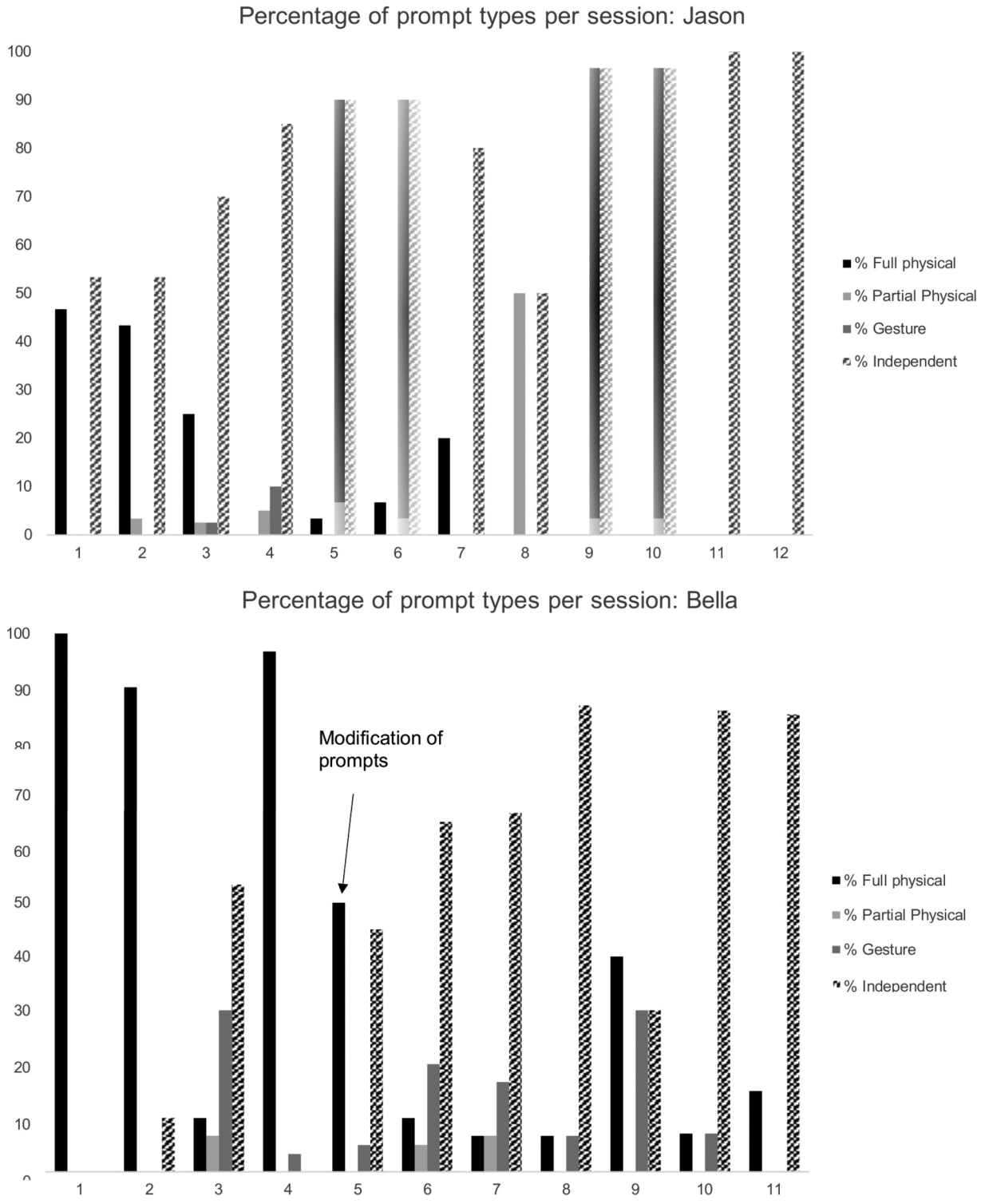

Figure 4. Bar graph illustrating the change in prompt levels by session for Bella and Jason.

completed in a preschool setting (Muldoon & Gray, 2023) was demonstrated in a university clinic, arguably a less natural setting.

There were several evidence-based practices used in the planning and design of this study. Of the strategies outlined by Grow and LeBlanc (2013), the authors of the current study employed the following: introduction of multiple targets simultaneously, simplification of auditory instruction (single word label), monitoring prompting (MtL, LtM, and prompt dependence) and troubleshooting

behaviors. Of LaMarca and LaMarca's (2018) guidelines, three were employed: touch or pick up the object, limiting the field of objects or pictures, and time expansion. This study appears to confirm the findings of the previous study that adding MtS to these established strategies, was an effective and efficient strategy for teaching and generalizing receptive vocabulary.

The children recruited for this study had significant language impairment, low cognitive abilities, and autism. Indeed, when recruiting the authors specifically looked for children with significant language difficulties as those with RLI are at greater risk for language difficulties (Tarvainen et al., 2020) and are less well represented in research (Thurm et al., 2022). Like the previous findings and important for professionals working with similar children, is the finding of significant variability in individual learning rates. As in the previous study, the learning rates were underscored by the different number of trials needed by the participants. Jason quickly learned the MtS procedure and reached 80% to 100% independence on sets one and two. He was supported by an LtM prompting hierarchy once expectations were established and did not require increases in reinforcement to maintain participation. In comparison, Bella's learning occurred at a much slower rate. Bella had not attended preschool and had not been exposed to DTT prior to the study. Once expectations were established and she became more comfortable with the first author, who conducted most of her sessions, Bella's participation increased. In order to support Bella's acquisition of the vocabulary, and given the time constraints of the study, researchers maintained the use of the MtL prompting procedure, only discontinuing when Bella showed clear prompt dependence. Prompt dependence was evident four sessions into intervention when Bella began reaching for the author's hand. Immediate modification of the prompting procedure, including adding additional wait time and using LtM prompting were crucial to Bella's independent success. Without altering the prompting procedure clinicians and researchers could have unwittingly increased the time needed for acquisition of vocabulary targets, or to unteach the prompt dependency. While modifications such as additional time or verbal prompts were not necessary for Jason, there was a need to monitor prompting procedures initially. Jason frequently used a process of elimination to find the correct picture by tapping the object on each card and waiting for clinician's denial or confirmation of a correct response. To eliminate this behavior, the clinicians used MtL prompting, providing a full physical prompt before he could tap each picture card. Following this prompting protocol, Jason no longer used the process of elimination, and a LtM hierarchy was consistently used. This troubleshooting of behaviors ultimately increased Jason's independence.

In stimulus equivalence, it is anticipated that a child will learn relationships between words without being directly taught. In classrooms, educators will teach the word "three" with three accompanying objects and the written number 3 and anticipate that a child will be able to relate all three to each other often without direct teaching. The untaught relationship emerges and becomes "critical" in language development of typically developing children (Ming et al., 2019). For this study, we relied on receptive labels, matching to non-identical pictures and identification of the objects in the absence of pictures, to illustrate stimulus equivalence. However, stimulus equivalence has applications beyond receptive language for children with language disorders. Theoretically, children would learn many other linguistic dimensions of the objects using stimulus equivalence—receptive labels for verbs, for example, that could be related to the action and the question "what is he doing?" and "show me … (target verb)."

In this study, with only receptive vocabulary as the goal the use of MtS resulted in both participants generalizing learning to non-identical pictures. Neither child came to the study with a history of responding appropriately to receptive vocabulary (as shown by poor receptive language scores and in baseline); yet, learning to understand object names is one of the important forms of early relational responding (Barnes-Holmes et al., 2004). Thus, they were taught to respond to spoken labels by matching objects to pictures, and then without further training were expected to match to a non-identical picture and later, identify objects without the pictures present. This procedure, coupled with reinforcement and prompting resulted in generalization probes showing steady development and understanding of receptive vocabulary.

The MtS procedure was successful in helping the children to learn the receptive label as evidenced by the scores during maintenance, which was similar to baseline, but with accumulating objects as the phases progressed (i.e. 20 words at the first maintenance check and 30 for the second). The improvement in scores for both generalization and maintenance indicates meaningful progress for both participants in acquiring the new vocabulary.

Additionally, Jason was successful in using new expressive vocabulary throughout the study, and afterward, as reported by his mother in the goodness of fit survey. Bella was less successful, however, her expressive communication also improved, with the emerging use of single vocabulary words and play-based verbal scripts. For example, in addition to singing the itsy-bitsy spider, Bella smelled the flowers, waved the flag, and pretended to blow her nose in the toilet paper each time these items appeared.

Maintenance checks were designed to show the previously unknown relational responding between the label and item (i.e. similar to the baseline). For this study, mastery of the vocabulary targets was not required before moving to the next set of vocabulary. This change from the original study appears to have decreased the scores for Bella during maintenance probes of the vocabulary. Additionally, Bella acquired the vocabulary at a slower rate than Jason and interfering behavior (fatigue after car

travel and irritability) reduced scores. Also of note was the fact that Bella appeared to be likely to complete tasks with accuracy when the first author was available to interact with her, and when she was not there (on one occasion) Bella's accuracy decreased significantly. She appeared to be most comfortable with the first author, as they had established a comfortable relationship from the outset of the study (e.g. at times Bella was comforted by sitting with the author and playing with a ball tower).

Caregivers' reports of positive outcomes were an important aspect of this study. Jason's mother reported she learned techniques to use at home simply through observation of intervention sessions. There was no parent training, but parent–professional conversations were ongoing and explanatory during the intervention sessions. Bella's caregivers reported increased responsiveness and they felt that they benefited from observing the use of consistent reinforcement and visuals.

Limitations and future directions

There are some acknowledged limitations in this study that may guide future research. While both children made gains in receptive vocabulary, generalizability is limited by the small sample size, clinical environment, and time constraints. Larger scale studies in a more natural environment (e.g. a school or a preschool setting), would further support the applicability of the approach. Additionally, because of the time constraint, participants did not learn a vocabulary set to mastery. It is likely that given more time and requiring mastery (e.g. 80% across three trials) would improve the generalization and maintenance for participants. Each participant was exposed to only 30 words. This small number of words further limits applicability.

An additional limitation of this study was that the caregivers were not asked about their child's prior knowledge of the chosen vocabulary. Additional research is needed that includes measures of prior knowledge of the targeted vocabulary and the authors are working on a follow-up study that will address this specific weakness in the context of a preschool setting.

Ming et al. (2019) explained that connections drawn through relational responding are precursors to generative language. Expanding receptive language using MtS therefore may lead to gains expressively; however, it was not formally tracked in this study. Future researchers could expand on the expressive outcomes using similar procedures.

Further research in RLI is needed as there remains limited evidence for clinicians. Investigating the use of MtS to teach other word types such as modifiers and verbs, further expanding receptive vocabulary, may be explored in the future. Additionally, a closer examination of the strategies outlined by Grow and LeBlanc (2013) and LaMarca and LaMarca (2018) such as the number of vocabulary words introduced at a time, auditory stimuli complexity, and the use or absence of blocked trials would be beneficial to determine a hierarchy of needed, individual supports.

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Appendix A. Examples of visual stimuli-pictures identical and non-identical to the object.

Noun	Identical	Non-identical
Watch		
Chair		

Appendix B. Appendix B. Modified social validity questions (adapted from Albin et al., 1996).

	Not at all	Not really	A little	Clearly
Do you believe that the intervention team understood the needs of your child around receptive language?				
Did the plan address areas of importance for you?				
Did you understand the intervention as completed by the team?				
Did you understand the researchers' roles in completing the intervention?				
Were you comfortable with what your child was expected to do?				
Do you believe that the intervention built on the strengths of your child?				
Were there strategies that you believed were successful for your child's learning style?				
How well did the plan fit with your expectations of the intervention?				
How well did the intervention fit with your parenting and behavior management styles?				
Did the plan include strategies that you believe will be useful in the future? If yes, what were they?				
Did you notice changes in your child's understanding of language in daily interactions? If yes, explain.				
Did you notice changes in your child's use of verbal language in daily interactions? If yes, explain.				
Did you notice other changes in your child during daily interactions (e.g. behaviors, social skills, eye contact, etc.)? If yes, what are they?				