Generalization across Modalities of Expressive and Receptive Language Acquisition through the Use of Multiple Exemplar Training and Errorless Teaching

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Abstract

Title: Generalization across Modalities of Expressive and Receptive Language Acquisition Through the Use of Multiple Exemplar Training and Errorless Teaching

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Children with Autism Spectrum Disorder (ASD) tend to display deficits with language acquisition and generalization of language skills after acquisition. Discrete trial teaching (DTT) includes general procedures used to teach language acquisition skills (such as receptive and expressive language) to children with ASD. Multiple exemplar teaching (MET) is a specialized type of DTT that includes multiple discriminative stimuli used during teaching trials, as opposed to only one target during the initial teaching. This present study assessed the efficacy of a general DTT procedure and MET for acquisition and generalization of two modalities of language skills: receptive and expressive. Goals of the study included determining (1) whether DTT or MET produced more efficient teaching of language acquisition skills, (2) which order the modalities should be taught, and (3) the modality for the greater propensity for generalization. In general, therapists taught individuals a target in one modality and then tested for...
generalization in the untrained modality, across all individuals with both teaching procedures. Results suggested that both teaching procedures readily produced acquisition of targets, and that generalization across modalities was idiosyncratic across participants. For all three participants, expressive targets generalized to receptive targets. Receptive targets generalized to expressive targets for two of the participants. For the one participant for whom generalization was not evident in the expressive modality, the target was taught until mastery criteria were met.
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Dedication

I dedicate this thesis to my grandfather David Carter. Thank you for your support throughout this journey.

Generalization across Modalities of Expressive and Receptive Language Acquisition through the Use of Multiple Exemplar Training and Errorless Teaching

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**Introduction**

Autism Spectrum Disorder (ASD) is associated with deficits in language and social communication/interaction and excesses in stereotypical behavior (American Psychiatric Association, 2013). Voluminous research suggests that there is a high probability that skill and language deficits in individuals with ASD will persist in the absence of appropriate treatment (e.g., Dawson et al., 2010; Lovaas, 1987; McEachin Smith, & Lovaas, 1993; Rogers et al., 2014). ASD affects 1 out of 68 children across the United States (CDC, 2016). The prevalence of ASD reflects the importance of investigating potentially effective approaches to intervene for the deficits associated with ASD.

Numerous interventions and medical therapies lacking empirical support are available for attempting to treat ASD (Smith, 2012). As a natural science, Applied Behavior Analysis (ABA) focuses on implementing empirically supported interventions, and is committed to researching new, effective, and efficient treatments for symptoms of ASD. Previous research suggests that Early Intensive Behavioral Interventions (EIBI) is the most effective general intervention strategy in treating children with ASD (Lovaas, 1987). EIBI involves many components that are customized to the individual receiving the intervention. Specifically, EIBI programs target problem behavior and skill deficits that are unique to individuals, and include procedural variations that have come about via related research over the years. However, EIBI programs share consistencies despite the numerous
procedural variations, such as a link to conceptual systems in behavior analysis. As such, EIBI programs are often used for individuals with ASD and adhere to the principles of applied behavior analysis.

Lovaas’ (1987) seminal study demonstrated EIBI as an effective behavior intervention in treating young children with ASD. Thirty-eight children under the age of 4 served as participants. Children were assigned to the experimental or control group, and pre-treatment measures revealed there to be no significant difference between the groups. The experimental group (n = 19) received more than 40 hours of one-on-one treatment per week. The control group (n = 19) received the same treatment as the experimental group, but at a lower dosage (10 hours or less of one-on-one treatment per week). At the conclusion of the study, the experimental group performed significantly better than the control group across all measures. For example, 47% of the individuals in the experimental group achieved normal intellectual and educational functioning by first grade, in contrast to only 2% of the control group. Similarly, following treatment, the experimental group exhibited a greater IQ test score than the control group. The results of Lovaas also showed that out of the experimental group 9 of the 19 children who received early intensive behavior analytic treatment for at least 2 years achieved cognitive and language test scores in the normal range by the age of 6-7 years and completed first grade without special instruction (Howard et al.,
These results suggested that a minimal behavior therapy intervention was not nearly as effective as the intensive behavior intervention.

Lovaas’ (1987) study represented the first attempt to systematically assess the efficacy of EIBI for young children with ASD. Several studies have been conducted since Lovaas’ study to address limitations that compromised the generality of the findings. McEachin, Smith, and Lovaas (1993) conducted a follow up to Lovaas to assess the extent to which participants retained skills that were learned in the initial study. This follow-up included the same participants from both Lovaas’ experimental group and a control group. The follow-up measures of these participants consisted of an assessment of school placement, administration of three standardized tests, and the results from an assessment battery. Results showed that the experimental group maintained the previous gains better than the control group, which included IQ test scores and higher levels of functioning on measures of adaptive behavior and personality. These results supported the initial findings that an EIBI program was superior to the less intensive intervention and suggested that the intensive EIBI programming included significant generality (due to the long-lasting effects of the initial intervention).

Extending the research from Lovaas (1987) and McEachin et al. (1993), Howard, Sparkman, Cohen, Green, and Stanislaw (2005) compared three treatment procedures for pre-school aged children with ASD: EIBI and 2
“eclectic” treatment modalities. Eclectic interventions consisted of a combination of different methods generally used with children diagnosed with ASD in the school setting. Specifically, the EIBI group (n = 29) included 25-40 hours per week of therapy delivered on a one-to-one adult-to-child ratio. The “AP group” (n = 16) consisted of “business as usual” intensive eclectic intervention in a public special education setting that was specifically designed for children with ASD. The AP group therapy consisted of a combination of methods of 1:1 or 1:2 adult child ratio for 30 hours per week. Finally, the “GP group” (n = 16) included non-intensive public early intervention programs in a general educational programming classroom including individuals of various diagnoses and a combination of methods with small groups of a 1:6 adult child ratio for 15 hours per week. The dependent measures included cognitive skills, non-verbal skills, receptive and expressive language, and adaptive skills. Results showed participants in the IBT group surpassed the other two eclectic groups in every measure at follow up, except motor skills. These findings are consistent with the findings of Lovaas, and provide evidence showing EIBI programs may support more skill acquisition relative to special education classrooms and eclectic interventions.

Howard, Stanislaw, Green, Sparkman, and Cohen (2014) conducted a follow-up study two years following Howard et al. (2005). This study was a replication of Howard et al. (2005) and aimed at reporting on the progress of the exact same
participants from all three groups. Results for the participants who received eclectic interventions in special education classrooms showed no consistent differences in outcomes at years 2 or 3 (i.e., these participants showed little to no gains in the measured skill domains). Those participants who received intensive behavior interventions in the original study were more than two times as likely to score in the normal range of their peers on various academic measures such as language and adaptive functioning compared to the other two comparison groups. This finding not only strengthens the previous evidence of the efficacy of EIBI, but also suggests that this type of intervention delivered at an early age is more likely to produce substantial improvements in young children with ASD than common interventions (Howard et al., 2005).

In summary, previous literature has shown the success of EIBI programs compared to eclectic treatment strategies. That success is defined by a significant difference in language acquisition, pre-academic skills acquisition, and IQ score gains (e.g., Lovaas, 1978; 1993). A hallmark of EIBI programs involves the inclusion of various components tailored to the individual needs of the client who is receiving the treatment. That is, while there are recommended guidelines for implementing EIBI, EIBI services include a multitude of teaching strategies and techniques.
Discrete Trial Teaching (DTT)

Discrete trial teaching (DTT) is a common procedure used for instructional teaching. The DTT procedure involves several components in which skills are taught individually through systematic discrete trials until the untaught skill has been acquired (Schreibman et al., 2015). Discrete trial training includes four components: a motivating operation, a discriminative stimulus, a learner response, and reinforcement or error correction.

Communication deficits are a hallmark of ASD. Thus, individuals with ASD typically emit few, if any, vocalizations, and have generally limited verbal repertoires. A primary strength of DTT is its effective teaching of language skills in individuals with ASD. For example, Hicks, Rivera, and Patterson (2016) enhanced language development by teaching children with ASD the proper use of prepositions. Risley, Hart, & Doke, (1972) focused on general syntax skills while teaching individuals with ASD to speak in sentences, an improvement from baseline in which participants spoke in simple words. DTT has also been shown to be effective in behavior management. For example, Carr and Durand (1985) used DTT to teach participants to request for desired activities or tangible objects in replacement of disruptive behaviors (e.g., engaging in tantrum behavior).

Smith (2001) noted the main uses of DTT include teaching new forms of behavior, new discriminations, imitation, receptive language, expressive language, conversation, sentences, grammar and syntax, and alternative forms of
communication systems. These skills are representative of important areas in the language acquisition of children, especially those with ASD and developmental disabilities who display fewer skills than their same-aged peers. Though effective in teaching new skills, DTT might sometimes lead to failures to generalize newly learned skills across multiple environments and circumstances, the presence of escape/avoidance challenging behaviors, lack of spontaneity, and overdependence on prompts (Schreibman et al., 2015). Thus, despite the efficacy of DTT for producing skills, criticism includes that it may not be “natural” and skills taught may not be able to generalize to other settings (Geiger et al., 2012).

Sarokoff and Sturmey (2004) provide an example of both the efficacy of DTT for training skills and the potential for generalization deficits. Sarokoff and Sturmey evaluated a treatment package to train adults to correctly implement DTT to children with ASD. Results concluded that the teachers were able to improve their accuracy of implementing DTT. However generalization across programs, children, nor maintenance of performance was not examined in regards to the children. Even though DTT was successful for this specific task in the study, evidence of the teaching transferred to other teachers, stimuli, or maintained across different environments was lacking.

Because research suggests that DTT might be associated with relatively low levels of generalization, additional research for improving its efficacy is warranted. Some authors (e.g., Wynn & Smith, 2003) suggest that Multiple
Exemplar Training (MET) may retain the efficacy of DTT for teaching new skills, but lay the foundation for enhanced generalization.

**Multiple Exemplar Training (MET)**

Multiple Exemplar Training (MET) is a specialized type of DTT. Multiple Exemplar Training is an approach in which there are multiple discriminative stimuli used during the teaching trials. For example, when teaching ‘cat’ in an MET approach, the therapist might include a photo of a cat, a stuffed animal cat, 3 different pictures of different cats, or a combination of such stimuli. In a DTT arrangement, there is one only stimulus that is used in the teaching array whereas in an MET arrangement there is more than one stimulus used in the array size to teach the desired target.

Multiple Exemplar Training has been used to teach children with autism a variety of skills that have resulted in generalization. Some examples include teaching children with autism to use vending machines appropriately (Sprague & Horner, 1984), setting and clearing tables in restaurant settings (Horner, Eberhard, & Sheehan, 1986), and to teach sharing. Marzullo-Kerth et al. (2011) used MET to three teach children with ASD to share. Categories of stimuli such as toys and art materials were used throughout the study. Participants were taught through the use of a treatment package that aimed at prompting and generalizing sharing of the chosen stimuli. The treatment package consisted of video modeling, prompting, and reinforcement. This treatment package was used across all three
of the conditions. In addition to the treatment package, teaching was also conducted in different settings to promote generalization of the skills. The results from Marzullo-Kerth et al. (2011) produced an increase in and maintenance of sharing across all three participants.

The use of multiple exemplars has also been useful in teaching children with autism to acquire a naming repertoire (Carol & Greer, 2007). Four participants who did not engage in speaker to listener or listener to speaker naming behaviors and tacting of two and three dimensional stimuli participated. In Experiment, 1, tact training was not effective for any of the participants. Next, the authors used MET to teach across speaker and listener repertoires, which resulted in the participants acquiring naming for the untaught sets of stimuli after successfully being taught the first teaching set. After training, all participants successfully acquired a naming repertoire. The participants also all acquired tact instruction when tested after they completed the training. Carol and Greer demonstrated the potential for MET to both produce acquisition of new targets and to promote generalization of taught skills to a variety of untaught skills. Such generalization makes teaching more efficient, and allows for increased learning opportunities in general.
**General Teaching Strategies for Language Acquisition**

Language can be categorized as *receptive* or *expressive*. Receptive language involves the presentation of a verbal cue and responding with the appropriate action. For example, one might instruct an individual to touch his or her head, and he or she touching his or her head is the correct response. Expressive language involves giving a verbal/vocal response to a visual cue (Smith, 2001). For example, when an individual is touching his or her head and asks ‘what am I doing’, responding with “*touching head*” is an example of a correct expressive language. There are several recommendations for sequencing receptive and expressive learning acquisition procedures in early and intensive behavioral intervention programs. These recommendations typically include the receptive before expressive sequence, expressive before receptive sequence, simultaneously teaching expressive and receptive skills, and teaching the skills without direct instruction which will ultimately build up to the acquisition.

The receptive before expressive sequence recommendation reflects the sequence that is observed in typically developing children for acquisition of receptive and expressive repertoires (Lovaas, 1987). Since this is the way that typical developing children learn, it would make sense that all children would learn this way. There are many intuitive reasons for why this sequence may be essential, such as (1) the difficulty of completing programs that require a vocal response before a child has acquired a vocal imitation repertoire and (2) the
interference presented by noncompliance with instructions (receptive may be
easier to train and complete, due to the possibility of physical prompting and
errorless training procedures that enhance acquisition; Petursdottir & Carr, 2011).
Though the expressive before receptive sequence does not reflect how typically
developing children acquire receptive and expressive repertoires, it has been
effective in teaching children language acquisition. Simultaneously teaching
expressive and receptive skills is a third recommendation which consists of both
modalities being taught at the same time. Sundberg and Partington (1998) assume
that each repertoire should be acquired independently, essentially simultaneously.
More specifically when teaching tacting of objects teaching with both receptive
trials and expressive trials (Petursdottir & Carr, 2011). The fourth
recommendation of teaching skills to children as is, without direct instruction and
then acquisition will automatically be built up and acquired as teaching and
learning persist. Greer and Ross (2008) support the idea that learning histories
will permit a child to acquire new skills without direct reinforcement. Greer and
Ross also highlight the use of MET to overcome functional independence of
receptive and expressive repertoires (Petursdottir & Carr).

Despite the recommendations, there is little empirical support for teaching
receptive targets before expressive (Petursdottir & Carr, 2011). Petursdotttir and
Carr reviewed receptive and expressive language instruction in EIBI programs,
specifically focusing on evidence supporting recommendations for teaching
receptive before expressive, expressive before receptive, and other ways to introduce receptive and expressive targets rather than sequencing one way before the other. Results of the review were inconclusive, and did not support any particular teaching sequence. That is, there was little empirical support for the sequencing for receptive and expressive language acquisition, particularly for children with ASD. Petursdottir and Carr noted that the potential benefits of MET should be further evaluated when looking at the sequencing of receptive and expressive acquisition procedures. Multiple exemplars may influence the efficiency and generalization of receptive and expressive instruction.

Petursdottir and Carr (2011) also noted that one specific limitation to this literature includes the lack of research on the population of children with ASD in particular. They found that much of the literature that has focused on evaluating teaching receptive before expressive or the reverse sequence has focused on individuals that were not diagnosed with ASD (Cuvo & Riva, 1980; Hupp et al., 1986; Keller & Bucher, 1979; Keller & Bucher, 1980; Miller et al., 1977; Smeets & Striefel, 1976; Watter et al., 1981; Wynn & Smith, 2003). There have been two studies that have specified that the participants were diagnosed with ASD (Watters et al.; Wynn & Smith). However, of the studies that have evaluated the sequence of training, several studies have evaluated teaching the receptive before expressive sequence and have found that the receptive-before-expressive sequence took more time and trials than when expressive training came first.
(Keller & Bucher, 1980; Miller et al., 1977; Watters et al.). When teaching the receptive before expressive sequence, research has shown that prior receptive training did not facilitate subsequent expressive training (Keller & Bucher; Miller et al.; Watters et al.). However, Cuvo and Riva found that prior receptive training facilitated subsequent expressive training but prior expressive training rendered subsequent receptive training unnecessary.

Some research suggests that teaching receptive before expressive produces greater accuracy on receptive tests following expressive training than on expressive tests following receptive training (Keller & Bucher, 1979; Smeets & Striefel, 1976; Watters et al., 1981). Even though this sequence is recommended in the literature it was found that in some cases expressive training was completed in fewer trials than receptive training but this only holds true to the first few stimulus sets of the study (Smeets, 1978). Wynn & Smith (2003) evaluated generalization between expressive and receptive language across modalities with 6 boys diagnosed with autism. The procedure consisted of a baseline, followed by a discrete trial teaching conditions of word pairs in a counterbalanced receptive and expressive order. Following this, a generalization test was conducted to determine generalization across modalities. Results indicated that across participants, the ‘expressive first’ condition led to cross-modal generalization more often than the ‘receptive first’ condition; however, one child displayed the opposite pattern and three other children’s patterns varied across training stimuli.
(Wynn & Smith, 2003). The results did not conclude that one modality is necessarily better than the other consistently across participants.

The current study examined (1) the extent to which training was more effective for teaching receptive and expressive language by comparing DTT with and without MET and (2) the extent to which generalization of mastered targets might occur within DTT and MET training modalities. After targets were taught and learned in the teaching conditions, a generalization test was conducted to determine whether there was generalization across modalities. If one target was taught expressively in either of the teaching procedures, the generalization test was conducted receptively for the corresponding word in the pair. If one target was taught receptively in either of the teaching procedures, the generalization test was conducted expressively for the corresponding word in the pair.

The generalization test was conducted in a similar manner as Wynn and Smith (2003) test for generalization. Specifically, each test was comprised of 30 trials: 20 target trials (10 trials for each target of the pair) and 10 filler trials interspersed. The filler trials involved tasks such as following simple instructions, answering conversational questions and imitating adult actions which were all mastered prior to the study. The results of this generalization test determined which teaching procedure was more efficient and which modality produced generalized acquisition.
Unlike previous studies focusing on receptive and expressive generalization across modalities, this study included only children diagnosed with ASD. Determining which modality generalizes more efficiently across individuals will enhance programming and learning for children diagnosed with ASD. Finding a more efficient procedure will aid in not only teaching children more efficiently but will lead to the possibility of learning at a rate that is more similar to their typically developing peers. The purpose of this study was to determine whether DTT or MET produced more efficient teaching of language acquisition skills, which order modalities should be taught, and which of the two modalities was greater for propensity for generalization.

Method

Participants

Participants were recruited from a clinic for children with developmental disabilities on a university campus. The participants met the following criteria: (a) have a diagnosis of autism spectrum disorder, (b) able to emit target responses, and (c) not engage in problem behaviors that were dangerous or that might interfere with the implementation of the study. The current study included three boys diagnosed with autism. Issac was a 3-year old who received 30 h per week of early intervention services. He scored as a level 2 learner on the Verbal
Behavior Milestones Assessment and Placement Program (VB-MAPP; Sundberg, 2008). Aaron was a 5-year old who received 30 h per week of early intervention services. He scored as a level 3 learner on the VB-MAPP. Julian was a 4-year old boy who received 30 h per week of early intervention services. He scored as a level 3 learner on the VB-MAPP.

Materials and Setting

Therapists conducted sessions at a clinic for children with developmental disabilities. All teaching procedures in the study met individual client programming goals for all three participants. Due to this, sessions were conducted during their regular service hours at the desk in the designated classroom where they received services during the day. Sessions were conducted 3 to 4 times per week. The area where sessions were conducted contained the participants’ desk, two to three chairs, a video camera for data collection purposes, and session materials. Session materials included a data sheet, timer, pen, preferred stimuli and or edibles, and target stimuli.

Experimental Procedures

Experimental design. A combined pre-test/post-test and multiple probe design was used to evaluate which teaching procedure (DTT or MET) was most efficient for teaching target skills and which was more effective for producing generalization in children diagnosed with ASD. One of two modalities,
counterbalanced, and alternated across participants, were used to conduct training. Acquisition in the trained modality and generalization to the untrained modality was probed in the testing condition, following training in baseline.

**Response measures and data collection.** The dependent variable was the percentage of teaching trials per target of the modality to reaching mastery criteria in each of the teaching conditions. Mastery criteria of a target was defined as correct responding independently at 80% or above in the trained modality across 3 teaching sessions in each teaching condition. A receptive response was correct if the participant accurately pointed to the target that corresponded to the verbal instruction from the therapist. An expressive response was considered correct if the participant accurately verbally emitted the target that corresponds to the verbal instruction previously given by the therapist.

The secondary dependent variable included the percentage of correct target responses of generalization probes in the testing condition of both teaching procedures. Generalization probes assessed the extent in which targets mastered in the teaching conditions generalized to the untrained modality. For example, when a participant was taught a word in the receptive modality, the target was then tested in the expressive modality, and vice versa.

**General Procedures.** The sessions were conducted at a table with the therapist seated across or next to the participant. First, a multiple stimulus without replacement (MSWO) preference assessment (DeLeon & Iwata, 1996) was
conducted before each session to determine a preferred item to be used in that session as a consequence for correct responding. The preferred item was delivered contingent on correct independent responses, while praise was provided for correct prompted responses. Baseline sessions were conducted, following the initial preference assessment, to ensure that the target stimuli were not in the participant’s repertoire. A target was not used for the purposes of this study if the participant had it in either one of the modalities.

Next, we compared a general DTT teaching procedure to MET for both acquisition and generalization. Discrete Trial Training includes four components. These four components include a motivating operation, discriminative stimuli, learner response, and reinforcement or error correction. The MET approach is similar to the DTT approach, with the exception of the presence of multiple exemplars of the target stimulus. For both of these teaching conditions, stimuli were evenly distributed for all targets across the different comparisons. For example, if colors or prepositions were used in the DTT condition, colors or prepositions were used in the corresponding MET condition. Distractors (additional stimuli such as pictures or objects) were presented in the array with the target stimulus during receptive baseline, teaching, and generalization testing. Each of these trials included two distractors in addition to the target stimulus. Thus, the therapist presented an array of 3 total items to the individual: the target and two distractors.
The therapist prompted by using a most to least prompting procedure with a gesture. This included prompting immediately with a 0-s time delay and fading prompts accordingly (0-s, 3-s, and 5-s). Five trials were conducted with a 0-s delay, and after the final trial, prompts were faded every three trials contingent on correct responding. The therapist moved the target back one prompt level contingent on two errors within a prompt level. This prompt level will continue for two consecutive trials of correct responding. Correct responses produced reinforcement.

If the participant failed to learn the target in either teaching condition, we introduced error correction (this was only necessary one time, for Julian) after 23 sessions. The error correction procedure consisted of four components. These four components consisted of, blocking the incorrect response, prompting and re-presenting the initial instruction with the most intrusive prompt level, testing the initial instruction by re-presenting it using the original prompt, and lastly, re-testing, by removing and rearranging materials and re-presenting the originally.

Lastly, a generalization test was conducted to determine whether there was generalization across the two modalities. The generalization test was administered to each participant up to 3 times as long as responding was above 10%. The therapist placed the target back into teaching for two trials and then tested again if responding was less than 10%. This was repeated until a maximum of 3
generalization tests were completed in addition to the three teaching trials. If there was still not generalization evident, then the therapist initiated teaching for that target in the modality in which generalization had failed.

**Pre-baseline Procedures.** Participants were exposed to all targets in both receptive and expressive modalities to ensure that responses were not currently in their repertoires at mastery levels prior to the formal baseline condition. The therapist presented the instruction and waited for the participant to engage in the target responses during these probe sessions. Correct responses produced praise. There were not any programmed consequences for incorrect responses. During the receptive condition, the therapist provided instructions such as “touch orange” or “give me the one that is dirty”. The target was presented in an array of 3 as described above: the target stimulus and two distractors. There were not any programmed consequences if the individual touched either of the two distractors presented in the array. The therapist asked statements such as “what is this?” or “what color” while holding up or pointing to one corresponding stimulus in the expressive condition. Correct responses were defined as vocal behavior that was (1) consistent with the statement provided by the therapist and (2) occurred within 3 s of the instructions. Responses that were inconsistent with the statement or occurred more than 3-s after the therapist’s statement were marked as incorrect. Non-responses were defined as failure to answer within 3-s of the therapist’s instruction (Wynn & Smith, 2003). Sessions were conducted until responding was
stable and low across three consecutive sessions. Targets were rotated throughout this condition to ensure that mastered targets were not included in the study. The target was not used if the individual responded correctly on three consecutive trials at 20% or above. This method was used to rotate out items that the individual already had in their repertoire and produced at least 10 unknown targets for use in the study.

**Baseline.** Procedures during baseline were identical to those in the Pre-baseline condition. The purpose of the Baseline condition was to provide a comparison for upcoming teaching conditions.

**Discrete trial teaching (DTT receptive condition).** The therapist presented the participant with varied academic tasks consisting of word pairs (e.g., big and small, in front or behind), color identification (e.g., red or orange), etc. The therapist gave the instruction “touch target” while presenting one word in the pair (Wynn & Smith, 2003). For each target, there was one word which was the target stimulus in isolation. This single target was presented with multiple trials and was the only one used in the teaching. As described in the general procedure, the array consisted of three stimuli: the target and two distractors. The target stimuli were the same throughout all the teaching trials while the distractors were rotated. For example, if the target was dog, there was one dog stimulus used throughout all the trials with different distractors being rotated. The purpose of including the distractors was to ensure that the participants discriminated the target in an array
of various other stimuli. The participant was given 5-s to respond to the target. These were presented in a mass trial format until the child responded correctly in 8 out of 10 trials. Trials were conducted one after the other without any other acquisition tasks interspersed. The target was tested for generalization once the individual correctly responded across 3 sessions at 80% or above.

**Multiple exemplar teaching (MET receptive condition).** Procedures in this condition were identical to those in the DTT receptive condition with one exception. For each target, the therapist included multiple stimuli, such as three different red objects, cards, or mix of both presented throughout the trials. For example, if the target was cat, there were three different cat stimuli rotated throughout the trials (such as a black cat, a clipart photo of a cat, and a white cat). These different stimuli were rotated so that there were not consecutive trials of the same target. The distractors were also rotated so that no identical array of 3 was presented consecutively, as described in the DTT receptive condition. All targets were equivalent in meaning for the specific target.

**Discrete trial teaching (DTT expressive condition).** The therapist presented the participant with varied academic tasks, of word pairs such as big and small, preposition identification such as above or under, color identification such as green or blue, etc. The therapist said “what is it?” or “what color is it” or “where is the animal” etc. while holding up a card or object with the corresponding target. This corresponding target was one word from the word pair. The participant was
given 5 s to respond to the target. These were presented in a massed trial instruction format until the child responded correctly to 3 consecutive sessions at 80% or above independently. Massed trial instruction involves teaching one exemplar at a time with no other trials or programs interspersed. The therapist prompted by using a most to least prompting procedure with an echoic. This, like the receptive conditions, included prompting immediately with a 0-s time delay and fading prompts according (0-s, 3-s, and 5-s). Three five trial blocks were conducted with a 0-s delay, and after the final trial, prompts were faded every three trials contingent on correct responding. The target was moved back one prompt level if there were two errors within a prompt level. Reinforcement was given contingent upon every correct response

**Multiple exemplar teaching (MET expressive condition).** Procedures in this condition were identical to those in the DTT (expressive condition) with one exception. For each target, the therapist included multiple objects, such as three different red objects, cards, or mix of both presented throughout the trials. Like the MET (receptive condition) all targets were equivalent in meaning for the specific target, ensuring that one picture or object was not any more difficult to identify or articulate than the other. The way in which trials are conducted, reinforcement, and prompting were identical to the DTT (expressive condition).

**Generalization test for DTT and MET.** Generalization tests were conducted for the untaught targets within each condition after each target within each
teaching procedure reached mastery (responding correctly at 80% or better across 3 consecutive sessions). Generalization tests were conducted identically to procedures described baseline. There were 5-s allowed for the child’s response in each target trial. All responses received a neutral feedback statement such as “OK” regardless if the responses were correct or incorrect (Wynn & Smith, 2003). Generalization was determined if the individual emitted the correct answer at least 80% or more across the generalization test.

**Interobserver Agreement and Treatment Integrity**

Interobserver agreement (IOA) and treatment integrity was collected individually by at least two trained observers. Each observer was trained on all procedures and data collection. IOA was collected for 50% of all sessions across each condition for each participant. Exact interval IOA was calculated by dividing the total number of intervals in which each observer scored the exact same behaviors by the total number of intervals and multiplying by 100 to yield a percentage score.

**Results**

Figures 1 & 2 depict data for Aaron. Figure 1 shows the first set of MET and DTT conditions. For MET, this included ‘full’ and ‘empty’ as the receptive (left panel) and expressive (right panel) target responses, respectively. ‘Full’ (an array of three different photos were presented, the three targets rotated throughout trials included, a full glass of water, full box of cans, and a full basket of fruit, followed
by the instruction “touch the one that is full”) was acquired after 13 sessions (65 trials). ‘Empty’ (three different stimuli were rotated throughout trials and were presented individually, targets included an empty glass of water, empty box of cans, and an empty basket, with the instruction, “what is it?”) was acquired after 6 sessions (30 trials). ‘Generalization tests were conducted for ‘empty’ receptively (untrained) and ‘full’ expressively (untrained). Results suggested that both topographies generalized to the other modality after the first generalization test. ‘Full’ resulted in an 80% generalization, while ‘empty’ resulted in a 90% generalization across modalities.

For DTT, targets included ‘clean’ and ‘dirty’ as the expressive (left panel) and receptive (right panel) target responses, respectively. ‘Clean’ (the one target stimulus was presented, a photo of clean dishes, followed by the instruction, “what are they?”) was acquired after 6 sessions (30 trials). ‘Dirty’ (an array of three was presented, the target stimulus was a photo of dirty dishes, followed by the instruction “touch the one that is dirty”) was acquired after 6 sessions (30 trials). Generalization tests were conducted for ‘clean’ receptively (untrained) and ‘dirty’ expressively (untrained). Results suggested that both topographies generalized to the other modality after the first generalization test. ‘Clean’ resulted in a 90% of correct responding for generalization while ‘dirty’ resulted in a 100% of correct responding for generalization. Overall, results suggested that for Aaron, both teaching procedures resulted in acquisition. They also suggest that
the receptive to expressive modality generalized and so did the expressive to receptive.

Figure 2 shows the second data set of data for the DTT and MET conditions for Aaron. For DTT, this included ‘dry’ and ‘wet’ as the expressive (left panel) and receptive (right panel) target responses, respectively. ‘Dry’ (the one target stimulus was presented, a dry towel, followed by the instruction, “what is it?”) was acquired after 9 sessions (50 trials). ‘Wet’ (an array of three was presented, the target stimulus was a wet towel, followed by the instruction “give me the one that is wet”) was acquired after 6 sessions (30 trials). Generalization tests were conducted for ‘dry’ receptively (untrained) and ‘wet’ expressively (untrained). ‘Dry’ resulted in 90% of correct responding in the first generalization test. ‘Wet’ resulted in 100% of correct responding in the third generalization test, the previous two tests resulted in 10% and 40% of correct responding. Results suggested that both topographies generalized to the other modality. Overall, both data sets reflect successfully teaching of the targets for both DTT and MET.

For MET, targets included ‘big’ and ‘small’ as the expressive (left panel) and receptive (right panel) target responses, respectively. ‘Big’ (three different stimuli were rotated and presented individually, target stimuli included a basketball, a soccer ball, and a kickball, with the instruction, “what size is it?”) was acquired after 11 sessions (60 trials). ‘Small’ (an array of three different objects was presented, the three target stimuli rotated throughout trials included, a small blue
ball, a bouncy ball, and a ping pong ball, followed by the instruction “give me the one that is small”) was acquired after 6 sessions (30 trials). Generalization tests were conducted for ‘big’ receptively (untrained) and ‘small’ expressively (untrained). Results suggested that both topographies generalized to the other modality. ‘Big’ resulted in an 80% of correct responding after the generalization test, while small resulted in a 100% of correct responding in the generalization test. Results suggested that for Aaron, the receptive to expressive modality generalized and so did the expressive to receptive for both teaching procedures. It is also suggested that both teaching procedures produced acquisition for all targets.

Figures 3 & 4 depict the data for Issac. Figure 3 shows the first set of DTT and MET conditions. For DTT, this included ‘red’ and ‘pink’ as the expressive (left panel) and receptive (right panel) target responses, respectively. ‘Red’ (the target stimulus was presented, a photo of an apple, followed by the instruction, “what color is it?”) was acquired after 6 sessions (30 trials). ‘Pink’ (an array of three different photos was presented, the target stimulus was a photo of a grapefruit, followed with the instruction “touch the one that is pink”) was acquired after 6 sessions (30 trials). Generalization tests were conducted for ‘red’ receptively (untrained) and ‘pink’ expressively (untrained). Results suggested that both topographies generalized to the other modality.
For MET, targets included ‘yellow’ and ‘green’ as the receptive (left panel) and expressive (right panel) target responses, respectively. ‘Yellow’ (an array of three different photos was presented, the three target stimuli rotated throughout trials included, photos of a pineapple, a lemon, and bananas, followed with the instruction “touch the one that is “yellow””) was acquired after 13 sessions (50 trials). ‘Green’ (three different stimuli were rotated and presented individually, target stimuli included photos of a kiwi, lime, and green grapes, with the instruction “what color is it”) was acquired after 9 sessions (45 trials).

Generalization tests were conducted for ‘yellow’ expressively (untrained) and ‘green’ receptively (untrained). ‘Yellow’ resulted in 100% of correct responding during the second generalization test, while the first resulted in a 10% of correct responding, showing some generalization was evident. ‘Green’ resulted in 90% of correct responding after the generalization test. Results suggested that both topographies generalized to the other modality. Furthermore, results suggested that for Isaac, both teaching procedures resulted in acquisition. They also suggest that the receptive to expressive modality generalized and so did the expressive to receptive.

Figure 4 shows the second data set of data for the DTT and MET conditions for Issac. For MET, targets included ‘purple’ and ‘tan’ as the receptive (left panel) and expressive (right panel) target responses, respectively. ‘Purple’ (an array of three different photos was presented, the three target stimuli rotated
throughout trials included, a purple index card, a photo of a purple block, and a photo of a purple t-shirt, followed with the instruction, “touch the one that is purple”) was acquired after 6 sessions (30 trials). ‘Tan’ (three stimuli were rotated, one presented at a time, target stimuli included a photo of a tan index card, a tan block, and a photo of a tan t-shirt, with the instruction “what color is it?”) was acquired after 6 sessions (30 trials). Generalization tests were conducted for ‘purple’ receptively (untrained) and ‘tan’ expressively (untrained). ‘Purple’ resulted in 90% of correct responding after the third generalization test, while the first two resulted in 20% and 60% of correct responding, with clear results that generalization was evident. ‘Tan’ resulted in 80% of correct responding after the first generalization test. Results suggested that both topographies generalized to the other modality.

For DTT, targets included ‘teal’ and ‘gray’ as the receptive (left panel) and expressive (right panel) target responses, respectively. ‘Teal’ (an array of three different photos was presented, the target stimulus was a teal index card, followed by the instruction “touch the one that is teal”) was acquired after 6 sessions (30 trials). ‘Gray’ (the target stimulus was presented, a gray index card, followed by the instruction, “what color is it?”) was acquired after 6 sessions (30 trials). Generalization tests were conducted for ‘teal’ expressively (untrained) and ‘gray’ receptively (untrained). ‘Teal’ resulted in 100% of correct responding after the generalization test, while gray resulted in also 100% of correct responding after
testing for generalization. Results suggested that both topographies generalized to the other modality. It is also suggested by the results that the receptive to expressive modality generalized and so did the expressive to receptive for both teaching procedures.

Figure 5 depict the data for Julian. For MET, targets included ‘on top’ and ‘under’ as the receptive (top panel) and expressive (bottom panel) target responses, respectively. ‘On top’ (an array of three different photos was presented, the three target stimuli rotated throughout trials included, a bunny on top of a table, a ball on top of a red square, and a bird on top of a tan box, followed with the instruction, “touch the one that’s on top”) was acquired after 35 sessions (175 trials). Error correction was implemented after the 24th trial with failure to reach mastery of the target. ‘Under’ (three stimuli were rotated and presented individually, target stimuli included photos of a bunny under a table, a ball under a red box, and a bird under a tan box, with the instruction “where is the target?”) was acquired after 9 sessions (45 trials). Generalization tests were conducted for ‘on top’ expressively (untrained) and ‘under’ receptively (untrained). Results suggested that generalization was not evident for the target of ‘on top’ when tested in the expressive modality. Since generalization was not evident, after teaching and testing two additional times, teaching was programmed for this target. ‘On top’ was acquired expressively after 6 sessions (30 trials). Results for ‘under’ suggest that generalization was evident across modalities.
Results suggested that for Isaac, both teaching procedures resulted in acquisition. They also suggest that the expressive to receptive modality resulted in generalization but not that receptive to expressive.

For DTT, targets included ‘in front’ and ‘behind’ as the expressive (left panel) and receptive (right panel) target responses, respectively. ‘In front’ (the target stimulus was presented, a cow in front of hay, followed by the instruction, “where is the cow?”) was acquired after 6 sessions (30) trials. ‘Behind’ (an array of three different photos was presented, the target stimulus was a photo of a cow behind hay, followed by the instruction “touch the one that is behind”) was acquired after 6 sessions (30 trials). Generalization tests were conducted for ‘behind’ expressively (untrained) and ‘in front’ receptively (untrained). ‘In front’ resulted in 90% of correct responding in the generalization test. Results suggested that generalization was not evident for “behind” when tested in the expressive modality. Since generalization was not evident, after re-teaching and testing two more times, teaching was programmed for this target. Behind was acquired expressively after 6 sessions (30 trials). Results suggested that for Julian, both teaching procedures resulted in acquisition. They also suggest that the expressive to receptive modality resulted in generalization but not that the receptive to expressive in either of the teaching procedures.
Discussion

We evaluated the extent to which DTT, a general teaching strategy, and MET, a specific type of DTT, produced acquisition of common targets for three individuals diagnosed with ASD. Overall, both teaching procedures reliably produced acquisition of targets. We also evaluated the extent to which DTT and MET teaching methods facilitated generalization across receptive and expression language teaching modalities. Thus, this study extended previous research on generalization between receptive and expressive language acquisition (e.g., Kelley, Shillingsburg, Castro, Addison, & LaRue, 2007; Watters, Wheeler, & Watters, 1981; Wynn & Smith, 2003). Results suggested that both DTT and MET facilitated generalization from receptive to expression teaching and from expressive to receptive teaching.

The research literature supports both DTT and MET as reliable and valid methods for teaching target skills to individuals diagnosed with ASD (Garcia-Albea, Reeve, Brothers, & Reeve, 2014; Kurt, 2011; Petursdottir & Carr, 2011; Newman, Needelman, Reinecke, & Robek, 2002; Sivaraman, 2017). Kurt et al. evaluated discrete trial teaching (DTT) with and without gestures or signs in teaching children with autism receptive language skills. Results showed that DTT with and without gestures or signs resulted in acquisition of language skills. However, DTT combined with gestures or signs produced faster acquisition for both participants. Sivaraman used MET to teach empathetic responding to
children with autism. Empathetic responses increased for all participants after treatment was introduced. Generalization to untrained stimuli was evident when tested after treatment and also maintained over time for the two participants.

The general efficacy of DTT and MET is not surprising, because both DTT and MET include best-practice teaching methodologies based on powerful basic principles. That is, both DTT and MET include (1) the presentation of a concise instruction or question serving as the discriminative stimulus/motivating operation, followed by (2) a gestural or verbal prompt, resulting in (3) a response, which is followed with (4) reinforcement for correct responding. Both DTT and MET typically use errorless training (Kurt, 2011; Sivaraman, 2017). In errorless teaching, the prompt provided following the initial instruction prevents any chance for incorrect responding. Thus, it is not surprising that both DTT and MET readily produced acquisition of targets. Future researchers might evaluate the extent to which acquisition rates might differ between a general DTT and MET with large numbers of targets across large numbers of individuals across long periods of time. That is, efficacy differences between DTT and MET might emerge only when the unit of measurement is extended beyond a few targets for a small number of individuals.

All participants in the current study received services in an early intensive behavioral intervention center. Thus, they are all experienced in learning using DTT teaching strategies. Their experience may be partially reflected in the rapid
acquisition of targets in both the DTT and MET teaching conditions. That is, all three participants have learned other skills using both DTT and MET, albeit in less structured formats than in the current study. It is possible that naïve participants might display slower acquisition of targets in one or both of the teaching methods. Future researchers might evaluate previous experience with early intensive behavioral intervention programs learner level in the VB-MAPP as mitigating variables for acquisition.

We also evaluated the extent to which targets trained in the receptive modality generalized to the expressive modality and vice versa. We viewed this evaluation as critical because generalization to other modalities could potentially save training time. For example, if weekly programming data show that (1) learning occurs more readily in the receptive condition than in the expressive condition and (2) a response consistently generalizes from the receptive to expressive modality, but not vice versa, these data would be useful for facilitating a more effective means of teaching. Time savings during training would be realized in the change in programming: during general teaching, only one modality would be programmed during teaching (receptive) and the other modality (expressive) would emerge without teaching. Furthermore, clinicians would also be guided to build in training of learning to be sensitive to expressive language teaching procedures.
For two of the three participants, generalization occurred for both modalities (for a total of 8 out of 8 targets). For the other participant, generalization occurred only for the expressive to receptive modality (for a total of 2 out of 4 targets). Consistent across both teaching procedures, after acquisition of the target that was taught receptively, the target responses did not generalize to the expressive modality. Therefore, those targets were exposed to teaching procedures specifically tailored to the modality which failed to generalize. These data are consistent with a body of literature suggesting that the extent to which generalization will occur with children diagnosed with ASD is likely to be idiosyncratic. For example, Kelley et al. (2007) examined the extent to which taught mands and tacts generalized across operants. Kelley et al. systematically taught specific topographies as either mands or tacts, and then tested whether the participants engaged in the untaught operant under baseline testing conditions. Results were idiosyncratic across and within individuals. Other published data (e.g., McDaniel, Yoder & Watson, 2017; Smeets, 1978; Wynn & Smith, 2003) suggest that overall, (1) effective interventions are likely to produce similar and/or idiosyncratic behavior change, regardless of procedural variations (e.g., the current study) and (2) generalization, when it does occur, is not generally specific to a teaching methodology or a training modality (e.g., Cuvo & Riva, 1980; Petursdottir & Carr, 2011; Petursdottir, Carr, Lechago, & Almason, 2008).
Some limitations of this study warrant discussion. We extended Wynn and Smith (2003) by directly comparing DTT and MET. Wynn and Smith evaluated the efficacy of DTT, and suggested that MET might facilitate generalization. We attempted to (1) directly compare the efficacy of DTT and MET for producing acquisition of targets and (2) determine whether DTT or MET might be associated with greater generalization. Results of our study were inconclusive because both teaching methods produced acquisition and facilitated generalization. Although it makes intuitive sense that MET might produce more efficient generalization than general DTT teaching, we did not capture that outcome in our study, as noted above. Thus, although the outcomes of the study were positive in the sense that both procedures were effective for both acquisition and generalization, it is not possible to determine relative efficacy from our data. Future researchers might further evaluate the potential advantages of MET training.

As noted above, all three of the participants were already receiving early intervention services and were previously exposed to discrete trial teaching methods. Because these participants were already exposed to the teaching methods, this skill could account for the rapid acquisition. Another limitation includes the targets that we chose for the inclusion in this study. On one hand, the targets used in this study were those that met the current programming goals of each of the participants. On the other hand, perhaps some targets were not ideally suited for inclusion in this study. For example, we used prepositions for Julian.
Julian was the individual who did not generalize targets from the receptive to expressive modality. It is possible that the relatively abstract nature of prepositions (compared to opposites or colors) were more difficult to teach and furthermore generalize.

Future research should examine matrix training, and generalization for novel targets after receptive and expressive language acquisition skills have been acquired. A key component of matrix training is its potential ability to facilitate the teaching of multiple relations using a single modality. If data shows one modality has reliably more pronounced generalization over the other for a participant, then, practitioners might not need to teach each noun-verb pair expressively and receptively. Instead they would benefit more from teaching a single modality if data showed more pronounced generalization within one modality. Such a strategy could cut training time in half, and would allow for more efficiency in teach noun-verb relations. Generalization that results from matrix training could also be taken a step further by determining the responses which generalize more efficiently; therefore, this could enable the production and use of a tool for determining the most efficient and effective methodology with respect to teaching language acquisition skills.

In conclusion, our data align with published studies showing that a variety of early intensive behavioral intervention strategies are effective for both producing acquisition of targets and facilitating generalization. Like suggested by Peturdottir
and Carr (2011), many general questions about early intensive behavioral
intervention strategies remain unknown (such as the relative efficacy of receptive
and expressive language training). Future research might focus on developing
general assessment and teaching strategies for facilitating efficient skill
acquisition.
References


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Figures:

Figure 1: Multiple exemplar teaching results are depicted in the top two graphs. The left graph depicts receptive teaching and generalization testing of the target ‘full’. The right graph depicts expressive teaching and generalization testing of the target ‘empty’. Discrete trial teaching results are depicted in the bottom two graphs. The left graph depicts expressive teaching and generalization testing of the target ‘clean’. The right graph depicts receptive teaching and generalization testing of the target ‘dirty’.
Figure 2: Discrete trial teaching results are depicted in the top two graphs. The left graph depicts expressive teaching and generalization testing of the target ‘dry’. The right graph depicts receptive teaching and generalization testing of ‘wet’. Multiple exemplar teaching results are depicted in the bottom two graphs. The left graph depicts expressive teaching and generalization testing of the target ‘big’. The right graph depicts receptive teaching and generalization testing of the target ‘small’.
Figure 3: Discrete trial teaching results are depicted in the top two graphs. The left graph depicts expressive teaching and generalization testing of the target ‘red’. The right graph depicts receptive teaching and generalization testing of the target ‘pink’. Multiple exemplar teaching results are depicted in the bottom two graphs. The left graph depicts receptive teaching and generalization testing of the target ‘yellow’. The right graph depicts expressive teaching and generalization testing of the target ‘green’.
Multiple exemplar teaching results are depicted in the top two graphs. The left graph depicts receptive teaching and generalization testing of the target ‘purple’. The right graph depicts expressive teaching and generalization testing of the target ‘tan’. Discrete trial teaching results are depicted in the bottom two graphs. The left graph depicts receptive teaching and generalization testing of the target ‘teal’. The right graph depicts expressive teaching and generalization testing of the target ‘gray’.
Figure 5: Multiple exemplar teaching results are depicted in the top two graphs. The left graph depicts receptive teaching and generalization testing of the target ‘on top’. The graph also depicts teaching of ‘on top’ expressively. The right graph depicts expressive teaching and generalization testing of the target ‘under’ and the right (bottom) receptive generalization testing of ‘under’. Discrete trial teaching results are depicted in the bottom two graphs. The left graph depicts expressive teaching and generalization testing of the target ‘in front’. The right graph depicts receptive teaching and generalization testing of ‘behind’. The graph also depicts teaching of ‘on top’ expressively.