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Mand Training: An Examination of Response-Class Structure in Three Children With Autism and Severe Language Delays

Erik Drasgow¹, Christian A. Martin¹, Laura C. Chezan², Katie Wolfe¹, and James W. Halle³

Abstract
Our primary purpose in this study was to examine the structure of a response class when new members are acquired through mand training. To do this, we replaced existing mands (e.g., reaching) in three children with autism with two new functionally equivalent mands. Next, we examined their responding under immediate- and delayed-reinforcement conditions. Then, we assessed generalization to novel social partners. We employed a reversal design to examine the effectiveness of mand training and to assess responding under both immediate- and delayed-reinforcement conditions. Our results suggest that all children acquired the new mands and that two of the children emitted these responses as replacements when the social partner did not provide access to the reinforcer contingent on the child's first mand. Generalization data indicate that all three children emitted the new mands and two of the children alternated between the new mands with novel social partners. We discuss the clinical implications and the conceptual significance of teaching multiple replacement mands to children with autism and severe language delays.

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Skinner (1957) defined a mand as “a verbal operant in which the response is reinforced by its characteristic consequence and is under the functional control of relevant conditions of deprivation or aversive stimulation” (pp. 35-36). That is, a mand is a verbal operant by which reinforcement is accessed through the mediation of a social partner. Young nonvocal children with autism spectrum disorder (ASD) may have existing communicative behavior that serves a manding function (e.g., Drasgow, Halle, & Ostrosky, 1998; Keen, Sigafoos, & Woodyatt, 2001; Lerman et al., 2005). For example, a child may mand a preferred toy that is in sight but out of reach by approaching the area and then by leading an adult’s hand toward the toy. Leading, however, may not be considered a socially appropriate mand by various social partners in the child’s natural environment.

A primary goal of language intervention programs for young children with ASD is to teach socially appropriate and effective mands that increase the probability of successful communication (e.g., Gutierrez et al., 2007; Kelley, Shillingsburg, Castro, Addison, & LaRue, 2007). The first step is to examine existing communicative behavior by employing interviews and observation to identify behavior that serves a manding function (Drasgow, Sigafoos, Halle, & Martin, 2009; Lerman et al., 2005). Next, potential reinforcing stimuli associated with the occurrence of existing mands are assessed. Then, a socially acceptable mand is selected as the instructional target to replace the existing mand. Teaching occurs under conditions in which existing mands are likely to occur and consists of prompting the new mand, differentially reinforcing the new mand while withholding the same reinforcer (i.e., extinction) for the emission of the less desirable existing mands, and then systematically fading out the prompts to decrease the likelihood of prompt dependence (Sigafoos, Arthur-Kelly, & Butterfield, 2006).

The concepts of functional equivalence and response class are central to effective mand training. Functional equivalence refers to a group of two or more topographically different behaviors that produce the same effect on the environment and are maintained by the same reinforcer (Carr, 1988). When two or more topographically different behaviors produce the same effect on the environment, a response class exists (Catania, 1998; Johnston & Pennypacker, 1993). For example, a child with ASD may obtain food in an adult’s possession either by reaching for it (an existing mand) or by handing the adult a card with the picture of food on it (the new mand). Reaching and
handing the card are functionally equivalent behaviors that are topographically different but produce the same effect on the environment, access to food, and thus form a response class.

Mand training consists of differential reinforcement of the new mand and extinction of existing mands. When reinforcement is withheld for a member of a response class such that the response fails to produce access to that reinforcer, the second most probable member of the same response class under those conditions may occur in a predictable sequence (i.e., a response-class hierarchy; Baer, 1982). For example, a child with ASD may request a toy from a peer by handing him or her a picture card (i.e., the new mand) and, if handing the card fails to produce the toy, then the child may move closer to the peer and reach (i.e., the previously existing mand) for the toy. Recently, investigators have conducted basic research and developed laboratory models to examine the concept of a response-class formation and response-class hierarchies when teaching new responses to preschool children with and without developmental disabilities (Shabani, Carr, & Petursdottir, 2009), to college students (Mendres & Borrero, 2010), and to adults with intellectual disabilities (Beavers, Iwata, & Gregory, 2014). The findings of the basic research studies on response-class formation and response-class hierarchies serve as a basis for understanding how various aspects of different strategies (e.g., utility of extinction as an intervention procedure) can be implemented in applied settings to address behaviors of social significance.

Thus, the literature on response-class hierarchies has made a substantial contribution to our understanding of communication and mand training. That is, mand training provides the child with another communication choice from several existing options in the response class of manding. The purpose of differential reinforcement and extinction during training is to increase the likelihood that the new mand is the most probable member of the response class to be emitted. Manding often occurs under a multiplicity of interacting natural environmental conditions that are characterized by activity and instability. Thus, social partners may not consistently respond immediately to new mands. If the new mand is not responded to immediately, then the child may emit other members of the response class (i.e., existing mands or problem behavior) in what is termed resurgence. Resurgence refers to the occurrence of previously reinforced behavior when new behavior is not immediately reinforced (Epstein, 1985). A child may also respond to this situation by repeatedly emitting the same mand (i.e., extinction burst; Lerman, Iwata, & Wallace, 1999) or by refraining from further interaction because of past communication failures (i.e., learned helplessness or extinction; Guess, Benson, & Siegel-Causey, 1985; Seligman, 1975).
A potential strategy in mand training that may delay resurgence of existing forms and other side effects of extinction is to increase response variability. Variability refers to the extent to which members of a response class differ from one another along some specified dimension (e.g., topography, latency; Neuringer, 2002). Variability may equip a child to tolerate delays to reinforcement that are inevitable in natural environments by emitting multiple forms. One way to produce this variability may be to teach more than one new functionally equivalent mand during training.

Betz, Higbee, Kelley, Sellers, and Pollard (2011) used script training to teach multiple new mands to three young children with autism. However, the acquisition of new responses alone did not produce varied responding. The authors then reinforced each mand only the first time it occurred within each session, and repetitions of mands were placed on extinction. The combination of teaching multiple forms with differential reinforcement of novel responses increased variability of mands for two of the three children. For young children with autism, teaching several responses is unlikely to be sufficient to produce varied behavior; thus, additional instruction or contingencies requiring variability are likely to be necessary. One strategy that has not been examined is directly teaching individuals to alternate between new mands. Alternation could be a fruitful instructional strategy because it may (a) increase emission of appropriate new mands during the delay to reinforcement (i.e., enhance persistence) and (b) prevent resurgence of existing mands.

In our study, we endeavored to investigate multiple factors related to mand training. First, we examined whether we could replace existing mands in young children with ASD by teaching new mands under the same conditions as those under which existing mands occurred. Each time the participants acquired a new mand, we assessed under immediate- and delayed-reinforcement conditions to determine the structure of their response class and to determine whether persistence of the new mands would increase while delaying resurgence of existing mands. We implemented delayed-reinforcement trials to replicate situations in the natural environment that the participants might confront when social partners could not immediately respond to the new mands because they missed or misunderstood the initial mands. We then taught the participants to alternate between the two new mands to assess how alternating influenced the structure of their manding response class and affected or delayed the resurgence of previous mands. Finally, we assessed whether teaching the new mands and their alternation under the same conditions that had evoked existing mands would produce generalization of the new mands to novel social partners without including any additional generalization-promotion strategies.
Method

Participants

Three children, Charles, David, and Jacob, participated in the study. Each had been diagnosed with autism based on a psychological evaluation conducted by a licensed psychologist at a local clinic. All three children attended a self-contained preschool classroom in a local suburban school. Charles was a 4-year-old Caucasian male; David was a 3-year-old Caucasian male; and Jacob was a 3-year-old Caucasian male who had a diagnosis of Fragile X syndrome and autism. The classroom teacher reported that each of the three children functioned within the severe range both intellectually and adaptively according to assessment data on the Bayley Scales of Infant Development, Second Edition (Bayley, 1993) and the Vineland Adaptive Behavior Scales, Second Edition (Vineland-II; Sparrow, Cicchetti, & Balla, 2005). The classroom teacher nominated these three children because each had no spoken language, had no symbolic forms of communication (e.g., American Sign Language, Alternative and Augmentative Communication, or conventional gestures such as pointing, head shaking, or head nodding), used leading and reaching to request access to preferred items and activities, and emitted frequent and disruptive problem behavior (e.g., crying, whining, grabbing others’ food, walking away).

Setting

The study was conducted at a local elementary school in the southeast. Training sessions and data recording occurred 4 to 5 days a week in the preschool classroom during snack time. Seven students, one teacher, and two paraprofessionals were present in the classroom during each session. We conducted one training session each morning during the normal classroom routine at a dining table at the back of the classroom where snack time activities typically occurred. The snack area consisted of a table and four chairs, cabinets where snack food and materials were stored, a sink and a trashcan. We conducted all sessions in a one-on-one format with an adult and no other peers. The other students and adults in the classroom continued to follow their normal schedule and activities during our sessions. We recorded each session using a digital camera and tripod positioned in front of the trainer.

Target Behaviors and Recording Method

We assessed four target behaviors. First, we recorded existing mand if the child used reaching or leading to gain access to food. Reaching was defined as extending an arm and hand toward food. Leading was defined as using one
or both hands to guide an adult’s hand or arm toward food. Second, we recorded “More” if the child gestured by making contact with the fingertips or knuckles or knuckles and palm of both hands in front of the body at chest level. Third, we recorded “Please” if the child patted the center of his chest 2 or more times with an open or closed hand (i.e., any part of the open or closed hand making contact with any part of the sternum). Acceptable forms of “Please” included patting with (a) the left hand only, (b) the right hand only, or (c) both hands simultaneously. Fourth, we recorded “Alternation” if the child switched from one new mand (e.g., “More”) as a first response to the second new mand (e.g., “Please”) as a second response when the first response did not produce access to reinforcer.

We selected a sign language modality for the new mands for several reasons. First, teachers were currently using that modality for other nonverbal children in their classrooms and were planning to implement the same training for these three participants at the conclusion of the study. Second, the speech therapists serving our participants recommended that we develop procedures and implement the sign language modality. Third, parents were in agreement with the teachers and speech therapists. Fourth, although in conventional spoken language, “more” and “please” may not be responded to as mands, the teachers and other adults in the children’s classroom responded to “more” and “please” as mands and thus their response determined the function of these communicative forms. Finally, because teachers, parents, and other adults were familiar with these signs, they could discriminate their occurrence and respond to them after the study was completed, thus enhancing maintenance.

We used a response-per-opportunity recording method. Each time the trainer presented a food item (i.e., a trial), it was an opportunity for a target response to occur. For each trial, we recorded the prompted or independent occurrence of the four target behaviors but we graphed only the independent responses to examine the acquisition of new mands. We further classified these target behaviors as the first form or as a delayed form based on the sequence in which they occurred during a trial. The first form was defined as the response that the child initially used when an adult partner (i.e., the trainer, the classroom teacher, or one of two graduate students) presented food in sight but out of reach. The trainer for this study was the second author. The two graduate students were master’s students in special education. Delayed forms were defined as any additional responses that occurred after the first form during a trial when the adult partner did not immediately reinforce the child’s first form. We recorded the first form on immediate-reinforcement trials and the first form as well as the sequence of all other forms during delayed-reinforcement trials. We coded each communication
form and sequence emitted during delayed-reinforcement trials when (a) a form met an operational definition and (b) there was at least a 1-s pause between identical forms.

**Experimental Design**

We used a reversal design (i.e., ABACADA) for each participant to assess the effectiveness of our mand training procedures for (a) teaching new mands, (b) teaching alternation between the new replacement mands, (c) producing generalization, and (d) producing persistence of the new mands and reducing resurgence of the existing mands. We assessed during both immediate- and delayed-reinforcement trials. An immediate-reinforcement trial consisted of an adult providing reinforcement immediately contingent on the first mand emitted by a child. A delayed-reinforcement trial consisted of an adult inserting a delay (i.e., 6-7 s during baseline trials and 2 s during “Alternation” training) between the emission of the first mand by the child and access to reinforcement.

**Procedures**

**Preference assessment.** We conducted a paired-stimulus preference assessment (Fisher et al., 1992) and then ranked the food items for each child. Our results indicated that the food items receiving the highest rankings were (a) oatmeal cookies and French fries (food that did not contain wheat or milk and thus was consistent with his gluten- and casein-free diet) for Charles; (b) Doritos, Cheetos, Goldfish, and Skittles for David; and (c) chips (i.e., Doritos and Lays), Cheetos, and Goldfish crackers for Jacob.

**Routine establishment and identification of existing mands.** We established a routine for each of the three children. The purpose of the routine was to provide the three children with controlled opportunities to mand so that we could assess current topographies as well as to teach new topographies in a stable context. The routine began when the trainer arranged preferred food in proximity to where the child would sit, but out of his sight and reach. Second, the trainer provided necessary materials (e.g., bowls, place mat, additional food, spoons, and napkins) by placing them on a table in front of where the child would sit. Third, the trainer brought the child to the table and had him sit. Fourth, the trainer placed a snack-size portion (e.g., three or four gold fish crackers or three potato chips or two pieces of candy) of food on a napkin or in a bowl on the table out of the child’s reach but in his sight, and then waited for the child to respond. The trainer randomly selected which preferred items from the highest ranked items to use during a session.
Each child responded by reaching toward the food or by leading the trainer’s hand toward the food. The trainer then placed the food directly in front of the child and the child consumed it. On occasional trials, the trainer provided noncontingent access to a preferred food by placing it directly in front of the child and close to his body where the child could independently access it. On these trials, reaching and leading did not occur. Thus, reaching and leading occurred only when access to food was restricted (i.e., the food was in sight but out of reach). Leading and reaching did not occur when children had noncontingent access to food (i.e., food placed close to the child). Based on this pattern of responding, we determined that reaching and leading served a manding function. After the child consumed the food, the trainer provided another portion of preferred food, in sight but out of reach. The trainer reinforced all responses emitted during this condition by providing access to the preferred item. The procedure was repeated for 8 to 10 min and conducted for 4 weeks prior to the child entering Phase A of the intervention (see below for a complete description of this phase). None of the three participants engaged in problem behavior during this time so we did not develop any operational definitions or recording methods for the measurement of problem behavior.

**Positive reinforcement (SR+) of all mands (A).** During this phase, the trainer reinforced all mands emitted by the child. Procedures were consistent with the routine establishment procedures. Each session consisted of 10 to 12 trials (opportunities) to mand for food during snack time in the preschool classroom. There was variability in the number of trials that we conducted because of the child’s rate of manding and rate of consuming food. When the child’s rate of manding slowed or he stopped manding, we ended the session. On six trials, immediate-reinforcement was delivered for the first mand emitted and on four to six trials, reinforcement was delayed for 6 to 7 s. We chose a 6- to 7-s delay (a) to simulate one type of naturalistic and frequent communication breakdown where social partners fail to respond immediately to a child’s initial mand because they do not recognize it (Reichle, Halle, & Drasgow, 1998), (b) to provide enough time for the child to persist and emit more than one mand, (c) to minimize the probability that the delay between mands and reinforcement would become aversive for the child, and (d) to reduce the likelihood of problem behavior during delay (Dixon & Cummings, 2001). We randomly selected when delayed-reinforcement trials were to occur; therefore, the immediate- and delayed-reinforcement trials were not conducted in a predictable sequence.

The protocol for conducting an immediate-reinforcement trial began when the adult (i.e., trainer, teacher, or graduate student) placed a small portion of preferred food on a napkin in front of the child, but out of his reach. Next, the
adult waited 3 to 5 s for a response (i.e., either with an existing mand or one of the two preestablished, functionally equivalent, replacement mands). We included the replacement mands as a possible response during this phase because all three children engaged in hand flapping and frequent other hand movements. Thus, there was a possibility that one or more of these movements could meet our operational definitions of the replacement mands. If the child did not respond during the 3 to 5 s delay, the adult “straightened or arranged” the food (to direct the child’s attention toward the food), and gave the child an additional 5 s to mand for the food. If the child did not respond to this second opportunity, the adult removed the food, assuming that it was not sufficiently reinforcing at that moment, and then 3 to 5 s later presented the next trial with a different food. If the child emitted a mand within 3 to 5 s, the adult immediately provided access to the food contingent upon the occurrence of the child’s mand. The adult did not provide verbal praise or physical touch during these trials to maintain food as the reinforcer.

The protocol for conducting a delayed-reinforcement trial consisted of the same protocol as the immediate-reinforcement trials except when the first mand was emitted, the adult looked at the child with a confused facial expression for 6 to 7 s and did not immediately reinforce the first mand. If the child emitted additional mands within the 6 to 7 s, the adult continued to look at the child with a confused facial expression and recorded each emitted mand. After 6 to 7 s the adult responded to the child’s mand(s) by saying “Oh, you want . . .” and then provided access to the food. The purpose of the adult response was to persist with a confused facial expression to encourage additional mands and, at the end of the delay, to indicate that the adult now recognized the child’s mand (Halle, Brady, & Drasgow, 2004).

If the child did not emit a second mand and persisted with the initial mand, the adult continued to look at the child and recorded each occurrence of the repeated mand (i.e., defined as a 1-s delay between mands). After 6 to 7 s, the adult responded to the child’s mand by saying “Oh, you want . . .,” and provided access to the food, and then presented the next trial. The situation in which a child emitted an initial mand and then did not respond again within 6 to 7 s never occurred throughout the study. The adult ended a session 30 to 40 s after the final trial and provided the child with a sufficient amount of food to finish the snack.

**Intervention**

SR+ “More”; Extinction (EXT) existing mands and “Please” (B). Phase B of the intervention began when the adult implemented the mand training to replace existing mands with the sign for “More.” The trainer reinforced all prompted or independent mands consisting of “More” and placed the existing mands
and “Please” on extinction. The trainer conducted all intervention sessions. An intervention session consisted of 10 to 12 immediate-reinforcement trials to teach the sign “More” to mand for the food. Similar to Phase A, each “More” trial began when the trainer placed a preferred food on a napkin in child’s sight, but out of reach. The trainer then waited 3 to 5 s for the child to emit a mand. If the child emitted an existing mand, the trainer immediately physically prompted (i.e., guided his hands) the child to form “More” and then provided a small portion of the food. If the child did not respond within 3 to 5 s, the trainer straightened or arranged the food and gave the child an additional 3 to 5 s to emit a mand.

If the child initiated with an existing mand, the trainer physically prompted “More”; if the child did not respond during this second opportunity, the trainer removed the food and then presented the next trial with a different food after 3 to 5 s had elapsed. If the child independently emitted “More” at any time during the intervention session, the trainer immediately responded by providing the child with a small portion of whatever food was available at the time.

For two students, David and Jacob, we embedded additional trials into typical sessions because of their slow rate of acquisition. These sessions did not differ from previously conducted sessions; however, we provided smaller food portions to maintain the reinforcing value of the snack items. We systematically faded our prompts across sessions as the children acquired the new mands. We did this by decreasing the amount of physical assistance needed for the child to emit the new response from full physical to partial physical, and then further to shadowing the hands of the child as he performed the new mand independently (Wolery, Ault, & Doyle, 1992). Acquisition criterion consisted of a child emitting “More” independently on at least 90% of the trials per session for three consecutive sessions, including initiating “More” on the first trial of each session. When data indicated that a child reached the acquisition criterion, we returned to “SR+ All Mands” phase.

**SR+ All Mands.** The procedures in the second “SR+ All Mands” phase were the same as those in the first “SR+ All Mands” phase with the exception of the number of immediate- and delayed-reinforcement trials. Specifically, on six or seven trials, immediate-reinforcement was delivered for the first mand emitted and, on four or five trials, reinforcement was delayed for 6 to 7 s to allow the child time to emit more than one mand. During delayed-reinforcement trials, we alternated social partners (i.e., trainer and either teacher or graduate student) each day before beginning the next phase of the intervention. The purpose of alternating social partners was to assess the students’
generalization of “More” with different adults other than the trainer. For Charles and David, the social partners were the trainer and the teacher. The teacher represented the novel social partner. For Jacob, the social partners were the trainer and the two graduate students. The two graduate students represented the novel social partners. The protocol for conducting delayed-reinforcement trials during the second “SR+ All Mands” phase (after acquiring the sign for “More”) was consistent with delayed-reinforcement trials procedures conducted during the first “SR+ All Mands” phase (Phase A). The only exception was that we now expected “More” in addition to existing mands as a potential response option.

**SR+ “Please”; EXT existing mands and “More” (C).** The instructional procedures for Phase C of the intervention were the same as those for Phase B, except if the child emitted an existing mand or “More” within 3 to 5 s, the trainer immediately physically prompted the child to use the sign “Please.” During this phase, the trainer reinforced all prompted and independent responses consisting of “Please” and placed existing mands and “More” on extinction. After meeting the criterion for acquiring “Please,” the protocol for conducting immediate- and delayed-reinforcement trials during the third “SR+ All Mands” phase was the same as that for previous “SR+ All Mands” phases.

**SR+ Second Form of Mand; EXT First Form of Mand (D).** We implemented Phase D to teach the children to alternate between the two newly acquired mands. During this phase, the trainer reinforced the second form of a mand (e.g., “More”) that differed from the first form of a mand (e.g., “Please”) and placed existing mands on extinction. Specifically, unlike Phases B and C in which we taught only one response, in this phase we taught an alternation strategy that required the child to independently substitute or switch to a different functionally equivalent mand when the first mand failed to produce access to reinforcer. Phase D consisted of five to six first-form trials and four to five alternation trials. We randomly selected when alternation trials occurred and, therefore, did not conduct first-form and the alternation trials in a predictable sequence. The first-form trials consisted of the trainer providing food contingent on the child’s production of either “More” or “Please” as a first mand to access the food. We implemented first-form trials to increase the likelihood of the children’s engagement during training and to minimize the possibility of creating an aversive situation because of a lean schedule of reinforcement or excessive response effort.

Each alternation trial began with a 2-s delay following the child’s use of either “More” or “Please” to mand for the food. The adult waited 2 s to assess
whether the child would emit the second functionally equivalent response during the delay to request access to food. If the child used the second mand that differed from the first mand (i.e., “More” or “Please”) within 2 s, then the adult provided the food. If the child used the same mand on both occasions, the adult prompted the other new mand. Specifically, if the child used “Please” both as a first mand and as a second mand within 2 s, then the adult physically prompted “More” and immediately provided the food. Similarly, if the child used “More” both as a first mand and as a second mand within 2 s, then the adult physically prompted “Please” and immediately provided the food. If the child did not respond with a functionally equivalent mand within 2 s, the adult physically prompted the mand not used as the first mand. If the child responded with an existing mand after a first mand of either “More” or “Please,” then the adult removed the food and waited 3 s before presenting the next trial. At the end of the 3 s, the adult represented the food, and provided access to it contingent on child’s use of “More” or “Please.” We implemented alternation trials to teach the children to alternate between the two newly acquired mands. For two children, David and Jacob, we reintroduced additional first-form trials and sessions to strengthen “More” as a response-class member during alternation training. These sessions did not differ from previously conducted sessions; however, we provided smaller portions to maintain the reinforcing value of the snack items. When data indicated that the child alternated mands for 90% or more of the alternation trials for three consecutive sessions, we returned to “SR+ All Mands” phase. The protocol for conducting immediate- and delayed-reinforcement trials in the fourth “SR+ All Mands” phase after Phase D was the same as that employed for the prior three “SR+ All Mands” phases. Finally, we did not have any programmed contingencies outside the context of our study, and asked teachers, parents, and others to continue to interact with the child as they normally would.

**Interobserver Agreement (IOA)**

All sessions were videotaped and coded after the session. The trainer served as the primary recorder during all immediate- and delayed-reinforcement trials conducted by him; the teacher or graduate students served as the primary recorder during immediate and delayed-reinforcement trials conducted by them during baseline sessions. Three additional special education graduate students conducted reliability observations for this study. The reliability observers received training prior to collecting IOA data. Training consisted of viewing previously recorded sessions and comparing agreement for whether or not the targeted behaviors occurred. Training was complete when the
trainer and a reliability observer reached 80% or higher agreement on forms and sequence for three consecutive sessions.

The primary recorder and the reliability observer independently watched the videotapes and coded the occurrence or nonoccurrence of each target behavior for each trial. We sampled IOA across all phases for each child. An agreement was scored if the primary recorder and the reliability observer recorded the occurrence or nonoccurrence and the sequence (i.e., point-by-point) of the target behaviors for each trial. We calculated the percentage agreement scores by dividing the total number of agreements by the total number of agreements plus disagreements and multiplying the quotient by 100. The IOA numbers for the delayed-reinforcement trials do not match the numerators for the total trials recorded because more than one response could occur during a delayed-reinforcement trial.

For Charles, we calculated IOA for 31% (173 of 565) of the immediate-reinforcement trials and for 44% (26 of 59) of the delayed-reinforcement trials. Agreement on immediate-reinforcement (i.e., first form) trials was 99% (171 of 173). Point-by-point agreement on delayed-reinforcement (i.e., multiple forms) trials was 93% (91 of 98). For David, we calculated IOA for 32% (839 of 2,643) of the immediate-reinforcement trials and for 31% (28 of 90) of the delayed-reinforcement trials. Agreement on immediate-reinforcement trials was 98% (825 of 839). Agreement on delayed-reinforcement trials was 95% (237 of 250). For Jacob, we calculated IOA for 33% (1,215 of 3,682) of the immediate-reinforcement trials and for 32% (130 of 410) of the delayed-reinforcement trials. Agreement on immediate-reinforcement trials was 98% (1,191 of 1,215). Agreement on delayed-reinforcement trials was 95% (389 of 410).

Results

Our purpose in Phases B, C, and D was to introduce two new mands (i.e., “More” and “Please”) into the participants’ behavioral repertoires and then assess whether we could teach them to spontaneously alternate between the two new mands. The purpose of the generalization probes in the four “SR+ All Mands” phases was to assess whether teaching the new mands and their alternation in the presence of the trainer would produce generalization to novel social partners without including any additional generalization-promotion strategies. The purpose of the delayed-reinforcement trials in the four “SR+ All Mands” phases was to assess whether the acquisition of two new mands and of alternating between them would increase communicative persistence and delay or eliminate resurgence of existing mands.
Figure 1. Charles’s percentage of independent first-form responses for each mand type under immediate (open) and delayed (closed) reinforcement trials and independent alternation from first form to second form. 

Note. First-form generalization responses are represented by gray icons (immediate-reinforcement trials) and pattern-filled icons (delayed-reinforcement trials). SR+ = positive reinforcement; EXT = extinction.

Charles

Figure 1 displays Charles’s percentage of independent first-form responses for each mand type under immediate- and delayed-reinforcement trials during Phases A (i.e., all four “SR+ All Mands”), B (i.e., “SR+ More; EXT Existing Mands and Please”), and C (i.e., “SR+ Please; EXT Existing Mands and More”), and the percentage of independent alternation in Phase D (“SR+ Second Form of Mand; EXT First Form of Mand”). Figure 2 presents the aggregate number of responses for each type of mand on delayed-reinforcement trials during the four “SR+ All Mands” phases for Charles. During the first “SR+ All Mands” phase, Charles emitted “Please” as a first form to access food during delayed-reinforcement trials with the trainer on one occasion. Generalization data indicated that he used “More” as a first form with the teacher on one occasion during immediate-reinforcement trials and “Please” as a first form on one occasion during delayed-reinforcement trials in Session 5. He did not use the two new mands as additional forms during delayed-reinforcement trials.

Charles required nine sessions and a total of 87 trials to reach the acquisition criterion for “SR+ More; EXT Existing Mands and Please,” 22 sessions and a total of 293 trials for “SR+ Please; EXT Existing Mands and More,” and
Figure 2. Each bar graph represents the aggregate number of responses for each form of mand in each of the four “SR+ All Mands” phases during delayed-reinforcement trials. Note. SR+ = positive reinforcement.
seven sessions and a total of 73 alternation trials for “SR+ Second Form of Mand; EXT First Form of Mand.” During the second “SR+ All Mands” phase, Charles emitted “More,” the newly acquired mand, as a first form on 100% of both the immediate- and the delayed-reinforcement trials with the trainer. Generalization data indicated that he used “More” as a first form on 86% of the immediate-reinforcement trials and on 100% of the delayed-reinforcement trials with the teacher. Delayed-reinforcement data revealed that Charles used “More” as a second, third, fourth, or sixth response during the 6- to 7-s delay.

During the third “SR+ All Mands” phase, he emitted “Please” as a first form on 100% of both the immediate- and the delayed-reinforcement trials with the trainer. Generalization data indicated that he used “Please” as a first form on 92% of the immediate-reinforcement trials with the teacher during the first session and on 100% of the immediate-reinforcement trials with the teacher during the second session. Data also show that he used “Please” as a first form on 100% of the delayed-reinforcement trials with the teacher during both sessions. Delayed-reinforcement data reveal that Charles emitted “Please” as a second, third, fourth, fifth, and sixth response during the 6- to 7-s delay, but he did not emit “More” as an additional response during the delay. During the fourth “SR+ All Mands” phase, Charles emitted the two new mands (i.e., “More” and “Please”) as first forms during both immediate- and delayed-reinforcement trials with the trainer and the teacher. Generalization data indicated that he alternated between the two new mands on 50% of the trials with the teacher during the first session and on 25% of the trials during the second session. Delayed-reinforcement data revealed that Charles emitted the two new mands as a second, third, fourth, and fifth response during the 6- to 7-s delay. Although we did not develop an operational definition and recording method for problem behavior, anecdotally, Charles had no occurrences of problem behavior during the study.

David

Figure 3 displays David’s percentage of independent first-form responses for each mand type under immediate- and delayed-reinforcement trials during Phases A (i.e., all four “SR+ All Mands”), B (i.e., “SR+ More; EXT Existing Mands and Please”), and C (i.e., “SR+ Please; EXT Existing Mands and More”), and the percent of independent alternation during Phase D (“SR+ Second Form of Mand; EXT First Form of Mand”). Data are presented in six-session blocks during Phase B and in eight-session blocks during Phase D with the exception of the last three sessions indicating the acquisition criterion. Figure 4 presents the aggregate number of responses for each type of
mand on delayed-reinforcement trials during the four “SR+ All Mands” phases for David.

During the first “SR+ All Mands” phase, David did not emit the two new mands to access food as a first form during both the immediate- and the delayed-reinforcement trials with the trainer or during the generalization probes with the teacher. He did not use the two new mands as additional forms during delayed-reinforcement trials. David required 57 sessions and a total of 1,115 trials to reach the acquisition criterion for “SR+ More; EXT Existing Mands and Please,” 10 sessions and a total of 96 trials for “SR+ Please; EXT Existing Mands and More,” and 44 sessions and an additional of 22 booster sessions for a total of 1,228 alternation trials for “SR+ Second Form of Mand; EXT First Form of Mand.” During the second “SR+ All Mands” phase, David emitted “More” as a first form on 100% of the immediate- and delayed-reinforcement trials with the trainer. Generalization data indicated that he used “More” as a first form on 100% of the trials with the teacher. Delayed-reinforcement data revealed that David used “More” as a second and third response during the 6- to 7-s delay.

During the third “SR+ All Mands” phase, David emitted “Please” as a first form on 100% of both the immediate- and the delayed-reinforcement trials
Figure 4. Each bar graph represents the aggregate number of responses for each form of mand in each of the four “SR⁺ All Mands” phases during delayed-reinforcement trials. 

Note. SR⁺ = positive reinforcement.
with the trainer. Generalization data indicated that he used “Please,” as a first form on 100% of all immediate-reinforcement trials with the teacher, on 80% of the delayed-reinforcement trials during the first session, and on 100% of the delayed-reinforcement trials during the second session. Delayed-reinforcement data revealed that David used “Please” as a second, third, and fourth response during the 6- to 7-s delay. He did not emit “More” as an additional response during the third “SR+ All Mands” phase. During the fourth “SR+ All Mands” phase, David emitted mainly one mand (i.e., “More”) as a first form during both immediate- and delayed-reinforcement trials with the trainer and the teacher. He emitted “Please” only on one occasion with the trainer. David did not alternate between the two new mands when the trainer or the teacher conducted the trials. Delayed-reinforcement data revealed that David emitted “More” as a second, third, and fourth response during the 6- to 7-s delay but he never emitted “Please” as additional responses during delayed-reinforcement.

**Jacob**

Figure 5 depicts Jacob’s percentage of independent first-form responses for each mand type under immediate- and delayed-reinforcement trials during
Phases A (i.e., all four “SR+ All Mands”), B (i.e., “SR+ More; EXT Existing Mands and Please”), and C (i.e., “SR+ Please; EXT Existing Mands and More”), and the percentage of independent alternation in Phase D (“SR+ Second Form of Mand; EXT First Form of Mand”). Data in Phases B and D are presented in 10-session blocks with the exception of the last three sessions indicating the acquisition criterion. Figure 6 presents the aggregate number of responses for each type of mand on delayed-reinforcement trials during the four “SR+ All Mands” phases for Jacob.

During the first “SR+ All Mands” phase, Jacob did not emit the two mands as a first form to access food during immediate- and delayed-reinforcement trials with the trainer or the graduate student. He did not use either of the two new mands as additional forms during delayed-reinforcement trials. Jacob required 141 sessions and a total of 3,078 trials to reach the acquisition criterion for “SR+ More; EXT Existing Mands and Please,” 12 sessions and a total of 178 trials for “SR+ Please; EXT Existing Mands and More,” and 33 sessions and an additional of 60 booster sessions for a total of 3,260 alternation trials for “SR+ Second Form of Mand; EXT First Form of Mand.” During the second “SR+ All Mands” phase, Jacob emitted “More” as a first form on 100% of the immediate- and delayed-reinforcement trials with the trainer or with the graduate students. Delayed-reinforcement data revealed that Jacob used “More” as a second and third response during the 6- to 7-s delay.

During the third “SR+ All Mands” phase, Jacob emitted “Please” as a first form on 100% of the immediate- and delayed-reinforcement trials with the trainer or with the graduate students. Delayed-reinforcement data revealed that he used both “More” and “Please” as additional responses during delayed-reinforcement. During the fourth “SR+ All Mands” phase, Jacob emitted the two new mands as first responses during immediate-reinforcement trials with the trainer and with the graduate students. He alternated on 71% of the trials with the trainer and on 100% of the trials with the graduate students during the first session. He did not alternate with the trainer or with the graduate students during the second session. Delayed-reinforcement data revealed that Jacob emitted both “More” and “Please” as additional responses during the 6- to 7-s delay. Although we did not develop an operational definition and recording method for problem behavior, anecdotally, Jacob had no occurrences of problem behavior during the study.

**Discussion**

We had three purposes for conducting this study: (a) to evaluate the effectiveness of mand training in replacing existing mands with two new functionally equivalent mands; then, after the acquisition of the two new mands, (b) to
Figure 6. Each bar graph represents the aggregate number of responses for each form of mand in each of the four “SR+ All Mands” phases during delayed-reinforcement trials.

Note. SR+ = positive reinforcement.
examine responding under two conditions: immediate- and delayed-reinforcement; and finally (c) to assess the emission of the new mands in the presence of novel social partners (i.e., generalization). Before introducing mand training, all three children used existing mands to mand food during both immediate- and delayed-reinforcement trials. When we ignored the children’s first mand during delayed-reinforcement trials, they either persisted with the initial existing mand (e.g., leading) or used a topographically different existing mand (e.g., reaching). Our results suggest that all children acquired the new mands and that two of the children emitted these responses as replacements when the social partner did not provide access to the reinforcer contingent on the child’s first mand. Alternation data reveal that two of the children alternated between the new mands when the social partner did not respond to the first mand. Generalization data indicate that all three children emitted the new mands and two of the children alternated between the new mands with novel social partners.

The findings of our study have clinical and conceptual significance. From a clinical perspective, the results support teaching young children with autism multiple functionally equivalent mands, and to alternate between those mands, so that they become more persistent communicators. During the third “SR+ All Mands” phase, before direct instruction on alternation but after acquiring two new mands, two of the three children generally engaged in the same mand repeatedly on delayed-reinforcement trials (i.e., they did not vary their responding). This pattern replicates Betz et al. (2011), who noted that teaching new responses alone was not sufficient to increase variability. The systematic alternation training was essential to produce the variability observed on delayed-reinforcement trials in the fourth “SR+ All Mands” phase for Charles and Jacob.

Moreover, teaching multiple functionally equivalent mands and to alternate between mands may promote repeated attempts at socially acceptable and conventional communication, thereby reducing the likelihood of resurgence of problem behavior when social partners in the natural environment do not respond immediately to existing mands. Emerging research suggests that teaching multiple socially appropriate mands may prevent or delay resurgence to problem behavior. For example, Hoffman and Falcomata (2014) taught sequential multiple mands (i.e., card exchange and micro-switch press) to three children with autism and severe problem behavior. After acquisition of mands, the authors placed the new mands on extinction to determine whether resurgence of each type of mand occurred and if these mands reemerged prior to problem behavior. For all three children, resurgence of newly acquired socially appropriate mands occurred before problem behavior,
suggesting that teaching multiple alternative mands may be an effective strategy for preventing or delaying resurgence to problem behavior. Although the difference between appropriate mands and mands labeled as problem behavior is based on social judgment, the underlying principles of response classes, response-class hierarchies, and resurgence are the same regardless of social perceptions.

The contingency in the alternation training has some features of a lag schedule of reinforcement, which dictates that a response must differ from a specified number of previous responses to be reinforced (Page & Neuringer, 1985). Researchers have investigated the effectiveness of lag schedules for increasing the variability of responses to social questions, block play, and labeling by individuals with ASD (e.g., Lee, McComas, & Jawor, 2002; see Wolfe, Slocum, & Kunnavatana, 2014, for a review); however, a unique feature of the present study was that the contingency requiring alternation was not in effect on every trial. In other words, varied responding was required only on alternation trials, which were interspersed with immediate-reinforcement trials (i.e., the first response was reinforced). This unpredictable arrangement, compared with a lag schedule, may better simulate real-world contexts in which an individual may benefit from varied responding where the initial response is sometimes reinforced and sometimes extinguished.

The conceptual significance of our study contributes to a more nuanced understanding of the structure of response classes. Our results suggest that our mand training procedures strengthened the two new mands as members of the same response class as existing mands. However, the children’s pattern of responding was not consistent with previous findings on response-class hierarchies (e.g., Magee & Ellis, 2000; Mendres & Borrero, 2010; Smith & Churchill, 2002). Our results indicate that the three response-class members (i.e., existing mands, “More,” and “Please”) did not occur in a predictable temporal sequence during delayed-reinforcement trials, thus providing emerging empirical evidence that the structure of response classes may not always be stable, but rather may vary as a function of unidentified factors. All children in our study emitted the newly acquired responses at rates either higher than or almost as high as existing mands on delayed-reinforcement trials. Before the “Alternation” training, Charles emitted a combination of the latest reinforced response and existing mands, and David and Jacob emitted the most recent reinforced response almost exclusively with very few existing mands responses. After the “Alternation” training, Charles emitted a combination of “More,” “Please,” and existing mands; David used “More” almost 90% of the time, occasionally emitting existing mands; and Jacob emitted exclusively “Please” and “More” with one exception when he used existing mands as a first form.
One potential explanation for the variable and unpredictable sequence of response-class members may be related to response covariation. Response covariation refers to changes in the probability of one response as a function of changes in the probability of other responses based on the frequency of reinforcement associated with each response (Herrnstein, 1970; Sprague & Horner, 1992). We strengthened a particular response-class member by reinforcing that member during training while placing the other response-class members on extinction, and thus increased the probability that the reinforced member would be emitted. For example, after acquiring “Please,” David and Jacob emitted this response as a delayed form on 100% of the occasions with the trainer. Although “More” had been established earlier as a member of the same response class, it occurred on only 20% of the occasions for David and 0% of the occasions for Jacob.

However, one has to consider other contextual variables present in children’s extant environment that may influence the probability that a particular response-class member would occur. For example, a child may display the sign for “More” to request access to food when the social partner is making eye contact with the child, yet may use grabbing when the social partner is engaged in a conversation with an adult or a peer. This discriminated behavior reflects the contingencies that a child has learned to associate with social partner stimuli. Future studies could examine the effectiveness of teaching a conditional discrimination for matching the contextual conditions operating when a communicative behavior fails to access reinforcement (e.g., clarify the communicative behavior by pointing to the desired object if the social partner is attending or gain attention by vocalizing or touching if the social partner is not attending) or for reaching for a preferred item when the item is in reach versus requesting a preferred item when the item is in a social partner’s possession or out of reach to determine whether the response-class hierarchies are contextually specific rather than ordered in a predictable temporal sequence.

The findings of our study suggest that extinction of a previously reinforced response-class member may account for some instances of response recovery during mand training. Our results are consistent with previous findings on resurgence during differential reinforcement procedures reported in the literature (e.g., Lieving, Hagopian, Long, & O’Connor, 2004; Wacker et al., 2011; Wacker et al., 2013). In our study, resurgence of existing mands was documented for Charles during delayed-reinforcement, but only rarely for David and Jacob. One potential explanation for the relative frequency of existing mands after the two new forms were acquired may be related to the history of reinforcement for existing mands both as a first form and as a delayed form. That is, responses with a longer history of reinforcement are
more likely to resurge when placed on extinction than responses with a shorter history of reinforcement (Bruzek, Thompson, & Peters, 2009). For example, Charles may have had a longer history of reinforcement for leading and reaching across different social partners and contexts than David or Jacob. Consequently, when we placed existing mands on extinction, Charles either persisted with the same existing mand or used a topographically different existing mand during delayed-reinforcement. Similarly, Charles may have received consistent reinforcement for existing mands on most occasions other than those programmed during the study (i.e., snack time at school).

One additional aspect of the study warrants further discussion. All three children emitted previously reinforced responses within 6 to 7 s of the social partner ignoring their first request, thus suggesting that although they acquired two new mands, these did not inoculate them against emitting other, more problematic, members of the response class under conditions of delayed-reinforcement (i.e., extinction). Practitioners working with young children with autism and other developmental delays in applied settings need to be aware of this possibility and program for different situations where delayed-reinforcement may occur to reduce the likelihood of resurgence to inappropriate communication forms. Future studies could examine the immediacy of resurgence by comparing the pattern of responding under delayed-reinforcement conditions varying in duration. The findings of our study suggest that extinction of a previously reinforced response-class member may account for some instances of response recovery during mand training.

The findings of our study provide supporting evidence that teaching new mands in the presence of existing mands may produce generalization of the new responses to novel social partners. Our results are consistent with previous studies on existing mands and generalization reported in the literature (Chadsey-Rusch, Drasgow, Reinoehl, & Halle, 1993; Schmidt, Drasgow, Halle, Martin, & Bliss, 2014). When teaching a new mand to replace an existing mand, the motivating operation controlling the existing mand will come to control the new response regardless of the supervising caregiver. Generalization may occur because the motivating operation controlling responding is internal and consistent rather than external and variable.

The results of this study should be interpreted with caution in the context of several limitations. First, the external validity of the study is compromised. Only three children participated in one restricted context (i.e., snack time) and thus the generalizability of the findings to other children and settings is unclear. Second, we did not collect social validity data to examine whether staff members perceived the new communicative responses as acceptable and efficient replacements for existing mands. Without assessing the social validity of the instructional procedures or the outcomes produced, it is difficult to
gauge the probable effect on maintenance and generalization of new communication responses. Practitioners are likely to abandon interventions that they deem to be ineffective or ones that require substantial effort and, thus, reduce the probability of response maintenance (Kennedy, 2002; Reid & Parsons, 2002).

Third, we did not collect procedural integrity data to document the consistent implementation of procedures throughout the duration of the study. Collecting procedural integrity data would enhance the trustworthiness of the results by providing evidence to support the findings that the acquisition of the new mands and the alternation strategy was the result of the intervention and not the result of modified procedures. Fourth, the vocalization (i.e., “Oh, you want . . .”) emitted by the trainer during the delayed-reinforcement trials may represent a potential confounding variable for strengthening the new mands as members of the response class because it may have served as a conditional stimulus that altered the function of the discriminative stimulus. Specifically, the new mands were reinforced by the trainer only in the presence of the vocalization and were not reinforced by the trainer in the absence of the vocalization, thus producing an increase in the use of new mands when the trainer emitted the vocalization.

Finally, children’s performance on generalization trials may be limited by two factors. One factor is that the teacher conducted the generalization trials for two children (i.e., Charles and David). This situation may have contributed to the children’s increased performance on using “More” because of past reinforcement history associated with the teacher. It is important to note that, although children did not experience any previous reinforcement history for alternation in the presence of their teacher, data indicated that generalization occurred for one child (i.e., Charles) when the teacher conducted alternation trials. The second factor is that we used the same food items during generalization trials as the ones used during training without introducing novel food items. The food could have served as the discriminative stimulus for the new mand.

In sum, the findings of this study document the effectiveness of mand training in replacing inappropriate existing mands with two new mands for young children with autism at snack time. Our results suggest that two of the three children included in the study emitted the new mands under both immediate- and delayed-reinforcement conditions although the responses did not occur in a predictable sequence and thus did not support the hypothesis of a stable response-class hierarchy. Resurgence was also documented for one of the three children under delayed-reinforcement conditions. In addition, generalization data suggest that all children used the newly acquired responses with social partners who were not involved in implementing the intervention and two of the three children alternated the replacement responses when the
first request failed to produce access to the desired outcome. Future studies need to extend the present findings by examining different mechanisms related to resurgence including various lengths of delayed-reinforcement, history of reinforcement for response-class members, and contextual variables present in the participants’ everyday settings.

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