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Establishing the Transformation of Motivating Operations Across Mands and Tacts for Preschoolers With Developmental Delays

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In 2 studies, we tested the effects of multiple exemplar instruction (MEI), using rapidly rotating mand and tact opportunities under relevant motivating conditions, on the transformation of motivating operations (MOs) across mands and tacts for sets of adjective-object pairs. The design for both studies was a delayed multiple probe across participants, using pre- and postintervention tests of untaught mand or tact functions. Two 3-year-old children with developmental disabilities participated in Experiment 1, and 5 4-year-old males with developmental delays participated in Experiment 2. At the outset of the study, none of the participants demonstrated both mand and tact responses for untaught functions. After MEI, untaught adjective-object functions for mands or tacts emerged for all children in both experiments, suggesting that the transformation of MOs is a verbal behavior developmental cusp. Our findings support Skinner's notion that mand and tact functions are acquired separately, but later join as a function of experience.

Keywords: multiple exemplar instruction (MEI), mands, tacts, transformation of motivating operations, verbal behavior development

According to Skinner's (1957) analysis, different verbal operants are acquired independently even though they may share the same form. Learning one form under a particular verbal function will not automatically result in the emergence of another; they are under the control of different motivational conditions. For example, if a child learns a form as a mand function under the control of a specific reinforcer, it does not necessarily mean that the child will use the form in a tact function. Unlike the mand, the tact is not reinforced by a specific consequence but by a generalized or social reinforcer; hence, a tact is not under the control of a specific motivating operation (MO) or of a motivating stimulus relevant to a specific reinforcer (Lamarre & Holland, 1985). Likewise, verbal operants acquired under the control of nonverbal discriminative stimuli do not automatically transfer to control by MOs (Stafford, Sundberg, & Braam, 1988).

The functional independence of mands and tacts has been demonstrated in several studies (Egan & Barnes-Holmes, 2009; Finn, Miguel, & Ahearn, 2012; Lamarre & Holland, 1985; Nuzzolo-Gomez & Greer, 2004; Petursdottir, Carr, & Michael, 2005; Sigafoos, Reichle, Doss, Hall, & Pettitt, 1990; Twyman, 1996b; Wallace, Iwata, & Hanley, 2006), although Gamba, Goyos, and Petursdottir (2015) suggest that these results be interpreted with caution because of some issues of construct validity.

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Lamarre and Holland (1985) taught participants to mand for the experimenter's placement of objects using the prepositional phrases "on the right" or "on the left" and tested for the emergence of untrained tacts with those prepositional phrases, and vice versa. The results demonstrated that mands and tacts were separately acquired. Twyman (1996b) taught children with disabilities to mand or tact using adjectives specifying abstract stimulus properties (i.e., whole, wooden, soft, and large) and tested for the emergence of untaught tacts or mands. These results, too, indicated the functional independence of mands and tacts. Further, Petursdottir et al. (2005) found that what the authors termed the "transfer of stimulus function across mands and tacts" did not occur reliably in typically developing children Ages 2 to 3 years. However, Skinner (1957) noted that untaught mand and tact functions, as well as other untaught verbal operants, do emerge in verbally competent individuals, and he speculated that the potential sources of control responsible for the emergence of untaught verbal functions may be related to stimulus control or a state of deprivation or aversion. Michael (1982) distinguished between stimulus discriminations and establishing operations, which he later termed *motivating operations* (Michael, 1993, 2007).

Research has demonstrated the emergence of untaught mand and tact functions, or what some have called the "transfer" of functions across mands and tacts, under certain antecedent conditions or MOs following specific procedures designed to induce them. Egan and Barnes-Holmes (2009) systematically replicated Lamarre and Holland's (1985) study with modified antecedent stimulus control and found that presenting specific antecedent stimuli resulted in the emergence of untaught mands and tacts following instruction in the other form for children with developmental disabilities. Wallace et al. (2006) reported that only highly preferred items trained under the tact condition resulted in the emergence of the untaught mand function, indicating that MOs play an important role in such emergence and providing some evidence that mand and tact functions can be integrated (Skinner, 1957).

Relational frame theory (RFT) attempts to explain the phenomenon of emergent verbal responding within the behavioral tradition (Hayes, Barnes-Holmes, & Roche, 2001). RFT proponents argue that verbal behavior involves a history of reinforcement for responding in accordance with a range of contextually controlled, arbitrarily applicable relations known as *relational frames* (Barnes-Holmes, Barnes-Holmes, & Cullinan, 2000; Roche, Barnes-Holmes, Barnes-Holmes, Stewart, & O'Hora, 2002). According to RFT, transfer of stimulus function occurs when a single stimulus comes to control more than one response, as long as the stimuli belong to the same response class. These stimulus relations may include new conditioned reinforcers or new discriminations. Further, when stimulus functions are related across response classes it is referred to as a *transformation* of stimulus function (Hayes, Fox, et al., 2001).

One account of derived or generative verbal behavior involves the emergence of untaught speaker or listener responses, as when a child demonstrates *naming* (Horne & Lowe, 1996). Naming is one of the earliest and most important forms of verbal development involving the transformation of stimulus function across speaker and listener responses. In this case, a single stimulus comes to control multiple responses. Research on naming has demonstrated that listener and speaker repertoires are acquired independently but then join through a history of experiences and reinforcement, known as *multiple exemplar instruction* (MEI; Cahill & Greer, 2014; Fiorile & Greer, 2007; Gilic & Greer, 2011; Greer & Longano, 2010; Greer & Ross, 2008; Greer & Speckman, 2009; Greer, Stolfi, Chavez-Brown, & Rivera-Valdes, 2005; Greer, Stolfi, & Pistoljevic, 2007). In the aforementioned studies, match-to-sample, listener (point-to), and speaker (tact and intraverbal tact) response opportunities were rotated using sets of training stimuli until participants could reliably respond to novel stimuli as both a listener and a speaker following experiences in which they heard the names of stimuli while observing them.

Many research studies have demonstrated the role of MEI in the acquisition of relational frames in young children (Barnes-Holmes et al., 2000; Barnes-Holmes, Barnes-Holmes, Roche, & Smeets, 2001; Lipkens, Hayes, & Hayes, 1993). Barnes-Holmes et al. (2001) argued that multiple exemplar training constitutes a useful means of motivating or facilitating repertoires of derived relational responding. They pointed

out that derived relational responding or relational framing is considered to be the result of generalized operant response classes that are established through a history of reinforcement across exemplars.

Greer, Yaun, and Gautreaux (2005) demonstrated the transformation of stimulus function across saying and writing, after an intervention that used MEI via a rapid alternation of spoken and written spelling responses to a set of words. Following MEI, participants in their study could spell aloud words they had learned only to write, and vice versa, whereas prior to the MEI intervention, they could not. MEI has also been used to establish derived relations through second language instruction (Rosales, Rehfeldt, & Lovett, 2011) and autoclitic frames (Luke, Greer, Singer-Dudek, & Keohane, 2011; Speckman, Greer, & Rivera-Valdes, 2012), and listener and speaker components of naming (Cahill & Greer, 2014; Fiorile & Greer, 2007; Gilic & Greer, 2011; Greer, Stolfi, et al., 2005; Greer et al., 2007).

Despite evidence that children with autism and developmental disabilities often benefit from verbal behavior instruction involving direct reinforcement, many of them require an extensive amount of training targeting stimuli for specific verbal functions. The studies that demonstrated the functional independence of verbal functions (e.g., listener/speaker, vocal/written responses) in children with autism and developmental disabilities indicated that the participants did not demonstrate the transformation of stimulus functions, thereby impeding their acquisition of more advanced verbal repertoires (Greer & Ross, 2008; Greer & Speckman, 2009).

Nuzzolo-Gomez and Greer (2004) employed a multiple exemplar intervention involving rapid alternations between MOs for mands and nonverbal stimulus control for tacts after demonstrating the functional independence of mands and tacts for four participants with autism or other developmental disabilities. Following the MEI intervention, they tested for the emergence of untaught mands with novel adjective-object pairs (e.g., large cup, last box) after the participants learned tacts with the same adjective-object pairs, and vice versa. The adjective-objects taught included sizes, spatial relations, and ordinal positions (small, medium, large; right, middle, left; first, second, last). Results indicated that the functional independence of mands and tacts was not evident after the implementation of MEI for all four participants.

Incorporating RFT's explanations of derived responding, Nuzzolo-Gomez and Greer (2004) suggested that rapid alternations of MOs between mands and tacts as a form of MEI may have resulted in the emergence of the untaught mand or tact function without direct training. They suggested that the momentary deprivation of a desired item, originally functioning as a generalized conditioned reinforcer to evoke a tact response, may act as a contrived MO to induce a mand for that particular item at that moment. That being the case, another response that previously functioned as a mand could be transformed to a tact function as a function of the introduction of a competing stimulus as a contrived MO for manding. Thus, the rapid alternations of MOs across mands and tacts results in the *transformation of MOs*, a term we use in the present study to describe the control responsible for the emergence of untaught mand and tact functions following the acquisition of a form in the other function. Unlike the transformation of stimulus function, in which one stimulus comes to control multiple responses, the transformation of MOs refers to a response that has been transformed from having one function (e.g., mand) to having another function (e.g., tact) as a result of the newly learned motivational control.

The evidence provided in prior studies of the functional independence of mands and tacts, and their eventual joining as a function of experience or deliberate intervention (Egan & Barnes-Holmes, 2009; Finn et al., 2012; Lamarre & Holland, 1985; Nuzzolo-Gomez & Greer, 2004; Petursdottir et al., 2005; Sigafoos et al., 1990; Twyman, 1996b; Wallace et al., 2006), suggests that the transformation of MOs across mands and tacts is a verbal behavior developmental cusp (Greer & Du, 2015; Greer & Speckman, 2009; Rosales-Ruiz & Baer, 1997). Mands and tacts needed to be taught separately prior to the onset of the cusp, whereas after the cusp was established, learning one function, or motivational control, resulted in the presence of responses under both MOs.

Given the theoretical and practical importance of establishing a verbal capability that allows for the acquisition of new verbal reper-

toires without direct reinforcement, more empirical investigations are necessary to further develop and examine specific procedures that occasion the transformation of functions across mands and tacts and accelerate the acquisition of verbal repertories. Research suggests that MEI may be a promising instructional method to establish the transformation of verbal functions (e.g., Nuzzolo-Gomez & Greer, 2004) or derived verbal functions (Murphy, Barnes-Holmes, & Barnes-Holmes, 2005). Rosales and Rehfeldt (2007) manipulated MOs to induce a derived mand function for individuals with developmental disabilities. Current research suggests the use of MOs as contextual control for the emission of untaught mand or tact responses and MEI as an intervention to acquire such an important verbal developmental cusp.

To further investigate the use of MEI procedures to establish the transformation of MOs across mands and tacts, we conducted two experiments. In the first study, we sought to replicate the procedures used by Nuzzolo-Gomez and Greer (2004) by examining (a) the functional independence of mands and tacts using adjective-object pairs for abstract stimulus properties, and (b) the effects of MEI on the transformation of MOs across mands and tacts, and vice versa, for preschool children with autism and other developmental disabilities at early speaker stages of verbal development. In the second experiment, we used a similar MEI intervention but improved the procedures for manipulating the MOs across mands and tacts for five preschool children with developmental disabilities. We also included additional postintervention probes using novel stimuli.

Experiment 1

Method

Participants and setting. Two 3-year-old children with developmental disabilities participated in the study. Participant A was a 3-year-old female and Participant B was a 3-year-old male. They attended a behavioral model preschool located outside a major metropolitan area. The school served children Ages 2 to 5 years with and without language delays and developmental disabilities, including autism. Behavior analytic principles and tactics were applied to all aspects of the students' education; frequent positive reinforcement in the form of praise and access to conditioned reinforcers as well as corrective feedback were paramount to the children's instruction.

Amy and Bill were selected for participation in this study because they used vocal mands reliably and emitted some tacts, but required prosthetic reinforcement for most of their instructional programs. At the outset of the study, Amy emitted mands with one adjective-object (e.g., "big cookie, please.") and tacted more than 100 objects and pictures with the adjective-object frame "a__." Bill manded using full sentences, and tacted more than 100 pictures of items as well objects in his environment using single words. Both of the participants had a history of receiving social reinforcement and opportunities to mand for desired items following correct tacts and other responses during their regular instructional sessions. We conducted all procedures with each participant individually at a small table in the participants' classroom, while other children and teachers worked at other tables. Neither of the children had any prior instructional history with any of the target adjectives in mand or tact function at the onset of the study.

Materials and stimuli. We selected four sets of three items that could be specified with target adjectives, as per the procedures used by Twyman (1996a, 1996b). With Set 1, three adjectives were targeted: "whole," "soft," and "wooden." For each target adjective, an exemplar of an item that could be specified with the target adjective was presented along with a nonexemplar. For example, a whole crayon was presented along with a broken crayon, a piece of soft play dough with a piece of hardened play dough, or a wooden puzzle piece with a paper puzzle piece. Other adjectives targeted throughout the experiment were "full," "long," and "small" (Set 2), "fuzzy," "plastic," and "large" (Set 3), and "tall," "round," and "shiny" (Set 4). Adjective-object pairs used for each set of stimuli are shown in Table 1.

Response definitions. During pre- and postintervention probes as well as during the intervention, we measured two response types. The first was mands, in the form, "I want (adjective) (object), please," or "(adjective) (object), please," under relevant MOs involving deprivation of the target adjective-objects. The second was tacts in the form, "(adjective)

Table 1
Adjective-Objective Pairs for Each Set and Establishing Operation Procedure for Each Item Across Mands and Tacts in Experiment 1

	Exemplar	Nonexemplar	MO for mand	Procedure for creating MO for mand
Set 1	Whole crayon	Broken crayon	ICP	Placing paper over a coin and tracing coins with crayon. Holding crayon as ICP.
	Soft playdough	Hardened playdough	ICP	Playing with playdough machine for making fake noodle or tools for pressing shapes out. Holding the machine as ICP.
	Wooden puzzle	Paper puzzle	ICP	Providing with favorite wooden puzzle. Holding pieces of puzzle and let the participants put the piece together as ICP.
Set 2	Full cup	Empty cup	IMP	Providing a cup full of preferred edibles and an empty cup as IMP.
	Long pencil	Shortened pencil	ICP	Tracing coins, or blocks; drawing faces; drawing + or – in the data sheet. Holding long pencil as ICP.
	Small ball	Large ball	ICP	Providing a toy pipe. Holding the small ball, which the child blows up in the air with the pipe as ICP.
Set 3	Fuzzy ball	Plastic ball	ICP	Decorating heart-shaped paper by gluing fuzzy balls on it. Holding a fuzzy ball as ICP.
	Plastic lion with colorful sand in it	Empty plastic lion	ICP	Providing a plastic toy lion with colorful sand in it. Letting the participant take colorful sand out of it and put it back using a funnel. Holding the plastic lion as ICP.
	Large LEGO	Small LEGO	ICP	Presenting large LEGOs and small LEGOs and letting the participant build. Holding large LEGO as ICP.
Set 4	Tall bottle	Short bottle	IMP	Providing a tall bottle with his/her favorite juice in it and an empty short bottle as IMP.
	Round box	Square box	IMP	Providing a round box with his/her favorite toy or edibles in it and empty square box as IMP.
	Shiny sticker	Sticker	IMP	Providing his/her favorite shiny stickers and nonpreferred, nonshiny stickers as IMP.

Note. The procedure for creating a motivational condition for a *tact* was an abolishing operation (satiation for the target stimulus), deprivation of social attention, and cuing availability for another stimulus. MO = motivating operation; ICP = interrupted chain procedure; IMP = incidental mand procedure.

(item)," under conditions of generalized reinforcement (e.g., praise) and opportunities to mand for desired items. The dependent variables were probes of adjectives untaught in one function (as either mands or tacts) after the participants acquired the other function. Praise and opportunities to mand following the emission of correct tacts were withheld during pre- and postintervention tact probes.

Intervention. The intervention consisted of MEI across MOs for mands and tacts. Mands and tacts with target adjective-object pairs were randomly rotated so that participants received training on mand and tact functions simultaneously within a session. For mand instruction, we used two procedures to create MOs in the form of deprivation of the target items: the incidental mand procedure and the interrupted chain procedure (Hall & Sundberg, 1987). For tact instruction, we presented target objects to the participants and provided praise and opportunities to mand for items under deprivation followed correct tacts.

Design. We utilized a delayed multiple probe design, counterbalanced across participants. In the first phase, we taught tacts to Amy using Set 1 stimuli and probed for untaught mand functions with the same set of the stimuli. We taught Bill mands and probed for untaught tacts with Set 1. Next, we implemented the first phase of the MEI intervention with Set 2 stimuli. After each participant met criterion for the MEI intervention, we repeated probes for the original untaught function using Set 1, without

reteaching the other function. If the participant did not demonstrate criterion-level responding (80% correct responses) in the untaught function, we implemented another round of MEI with Set 3, followed by probes for the untaught function with Set 1. In the last phase, in order to make sure that MEI was successful in establishing the transformation of MOs across mands and tacts, we repeated the probe procedures with a novel set of stimuli, Set 4.

Procedure and data collection.

Pre- and postintervention probes.

Mand/tact instruction with Set 1 stimuli. Initially, in order to teach the names of the stimuli, the experimenter provided cues for the participant to emit tacts. The participants were instructed to match identical stimuli or point to the target stimulus in the presence of a nontarget stimulus prior to the opportunity to emit the tact. The experimenter delivered praise for correct responses and corrections for incorrect responses. During the correction procedure, match or point responses were prompted with the experimenter gesturing the target stimulus. Praise was not provided for prompted correct responses during the correction procedure. This exemplar match or selection instruction was faded within one session. The criterion for mastery during mand or tact instruction was responding with over 90% of accuracy for two consecutive sessions.

For the tact instruction, the experimenter presented the target stimulus (e.g., whole crayon) and one nonexemplar (e.g., broken crayon) and pointed to the target stimulus. If the participant tacted the item correctly using the targeted adjective-object form within 2 s, the experimenter recorded a correct response (+) and delivered praise and an opportunity to mand for another reinforcer. If the participant tacted incorrectly or did not respond within 2 s, she recorded an incorrect response (–) and delivered an echoic correction. During the correction procedure, the experimenter provided an echoic correction while representing (holding up or pointing to) the stimulus. The participant was required to emit a correct tact response and no reinforcement was delivered for the target responses following the correction.

For the mand operants, the experimenter presented the target stimulus and a nonexemplar. Mand instruction was conducted under conditions of deprivation of the target adjective-object pair, using either an interrupted chain procedure or an incidental mand procedure. If the participant emitted the correct mand form within 2 s, the experimenter recorded a correct response (+) and the item was delivered immediately. If the participant emitted an incorrect response, or did not respond within 2 s, she recorded an incorrect response (–) and delivered an echoic correction. The correction procedure was same as the one for incorrect tact responses and the item was not delivered following the emission of a correct echoic.

The interrupted chain procedure consisted of the experimenter withholding an adjective-object pair that was needed in order to continue a preferred activity until the participant manded for the target adjective-object. For example, we gave the participant a toy pipe (to be used to blow a small ball above it) and presented a large ball and a small ball. The participant was required to specify the reinforcer (mand) using the target adjective-object "small ball." For the incidental mand procedure, the experimenter presented a choice between two stimuli. For example, the experimenter presented a round box that was full of desired items (e.g., small edible items, preferred toys) along with an empty square box. The participant was required to specify his reinforcer using the target adjective-object "round box."

Probe for untaught mands or tacts with Set 1 stimuli. Once participants achieved a mastery level of responding for either mands or tacts with Set 1, we conducted probe sessions the untaught tact or mand function in nine trial sessions. Mand and tact responses to probe trials were recorded the same as they were during training sessions. The difference between probe and training trials was the absence or the presence of experimenter-delivered consequences to tacts. Mands were always consequated with delivery of the item.

Intervention: MEI 1 with Set 2 and MEI 2 with Set 3. For the intervention, we first conducted MEI with Set 2 stimuli. During the MEI, mands and tacts with target adjective-objects were rotated in no particular order so that participants received training on mand and tact functions simultaneously within a session. Procedures for mand and tact instruction during the MEI were the same as the instruction implemented during the mand/tact preintervention training phase.

The rotation of mand and tact instruction during the intervention consisted of experimenter-controlled manipulation of moment-to-moment motivational conditions (i.e., deprivation and satiation). Creating an MO for mands meant placing the participants under deprivation of a target stimulus (MO for a specific reinforcer) utilizing an interrupted chain procedure or incidental mand procedure. The MOs for the mands for each target adjective-object pair are shown in Table 1. Tact instruction required the participant to be under control of generalized reinforcement for praise/approvals from the experimenter and, in many cases, deprivation of a reinforcer other than the adjective-object being targeted at that time. For example, for a tact trial with soft play dough, we provided soft play dough for the participant to play with before providing an opportunity for the participant to tact such that the targeted response ("soft play dough") was not controlled by deprivation of the soft play dough at the moment. At the same time, we provided the opportunity for the participant to mand for another stimulus with stronger momentary reinforcement value (e.g., a small ball that could be blown over a toy pipe). The experimenter presented two or three tact opportunities for a stimulus the participants had accessed previously, while using a novel stimulus as a reinforcer following an opportunity to mand, which was provided as a reinforcer for a correct tact.

Postintervention probe for untaught mands or tacts with Set 1 stimuli. Following the completion of MEI with Set 2 stimuli, we conducted another probe for untaught mands and tacts with the original set of stimuli (Set 1), without reteaching the original function. The probe procedure was conducted using the same procedures as the preintervention probe with Set 1. If the participant failed to meet the predetermined criterion for mastery (80% correct responses) during postintervention probes, we implemented a second phase of MEI with Set 3 stimuli.

Postintervention probe with Set 4 stimuli. In order to test whether the transformation of MOs across mands and tacts would occur with novel set of stimuli, we conducted another postintervention probe session. We trained a novel set of stimuli (Set 4) on the opposite function trained initially, to ensure that the transformation of MOs across mands or tacts was true for both directions (mand-tact and tact-mand), and then conducted probes for the untaught function. The procedures for postintervention instruction and probe sessions were same as the previous phases.

Interobserver agreement (IOA). We obtained IOA by video recording the sessions and having a second trained independent observer review and score the participants' responses as either correct or incorrect, according to the response definitions. We divided the number of agreements by the total number of agreements plus disagreements and multiplied that number by 100 to obtain percentage of IOA. Interobserver data were collected during 100% of probe sessions and 32% of training sessions across both participants. The mean of IOA was 97%, with a range from 95% to 100% during training sessions, and 100% during probe sessions.

Results and Discussion

Figure 1 shows the number of correct responses to each untaught adjective-object pair during pre- and postintervention probes. The data obtained during the probe sessions that preceded the MEI instruction demonstrated the independence of mands and tacts, as suggested by Twyman (1996b) and Nuzzolo-Gomez and Greer (2004). However, both of the participants showed some transformation of MOs across mands and tacts following MEI, and both emitted nine correct untaught responses out of nine probe trials to Set 1 following a second round of MEI. Figure 2 shows correct responses during MEI and instruction for mands or tacts. Amy needed fewer opportunities during the second round of MEI, possibly due to the increased accumulated number of exemplar experiences throughout the experiment.

The sequence for delivering mand or tact instruction was based on the moment-to-moment motivational conditions (i.e., deprivation and satiation) manipulated by the experimenter. For example, the student was under the deprivation of the large LEGO, which was one of the target stimuli for mands. The experimenter delivered two or three mand trials with the item, and then presented a plastic lion to set the MO for mands for the plastic lion, then presented a large LEGO for the tact. The form "large LEGO" emitted by the par-

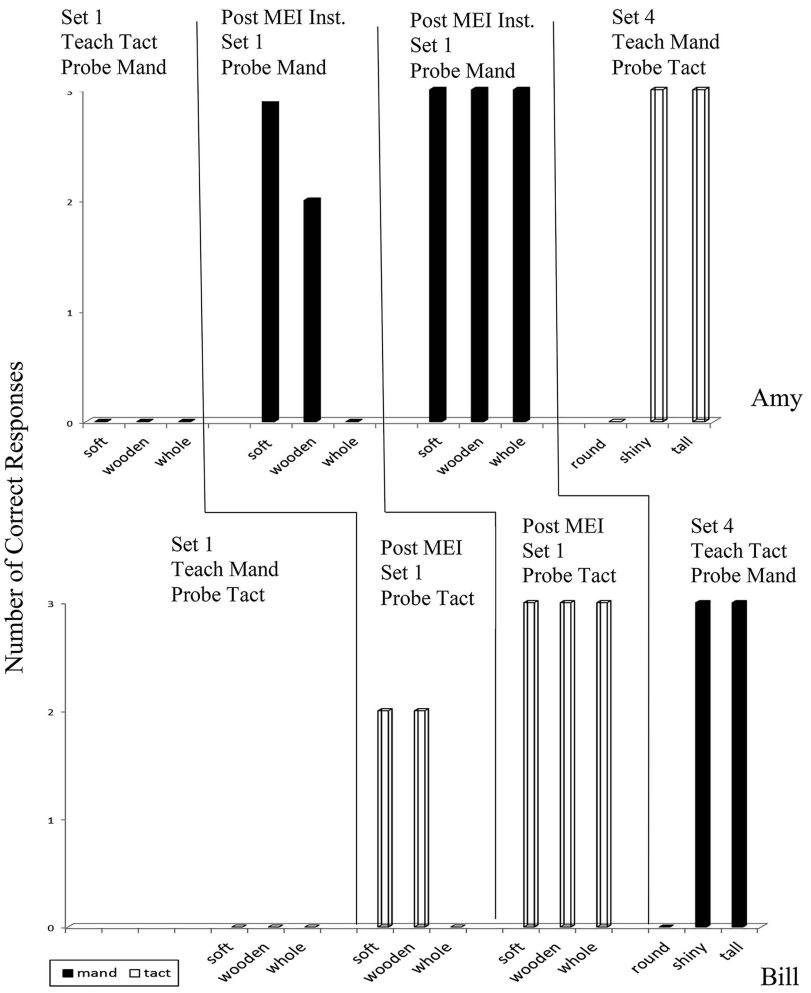

Figure 1. The number of correct mand and tact responses to untaught adjective-object pairs for Amy (top panel) and Bill (bottom panel) prior to and following MEI instruction. The black bars represent mands and the white bars represent tacts.

ticipant was not a mand because he or she was not under deprivation of the large LEGO any more with the presence of the plastic lion, which was a competing reinforcer. The experimenter could present two or three trials for tacts with large LEGOs or other stimuli (e.g., fuzzy ball) under the deprivation of plastic lion. The plastic lion was used as a reinforcer for tacting a large LEGO or other items. Following a tact of "fuzzy ball" or a tact of "large LEGO," under deprivation of the competing reinforcer (the plastic lion), the MO for the tact was transformed to the MO for the mand for the specific reinforcer of the plastic lion. However, we may have encountered some procedural limitations from this rapid manipulation of MOs.

The procedure for manipulating motivational conditions depended heavily on transitory motivational conditions from deprivation of specific reinforcers to nonspecific reinforcers, and vice versa. A more structured procedure for manipulating motivational conditions was needed for a more tightly controlled experiment. Therefore, in Experiment 2, across all target stimuli, we used only one procedure for MOs for mands, which consisted of placing desired edibles in or on the target adjective-objects.

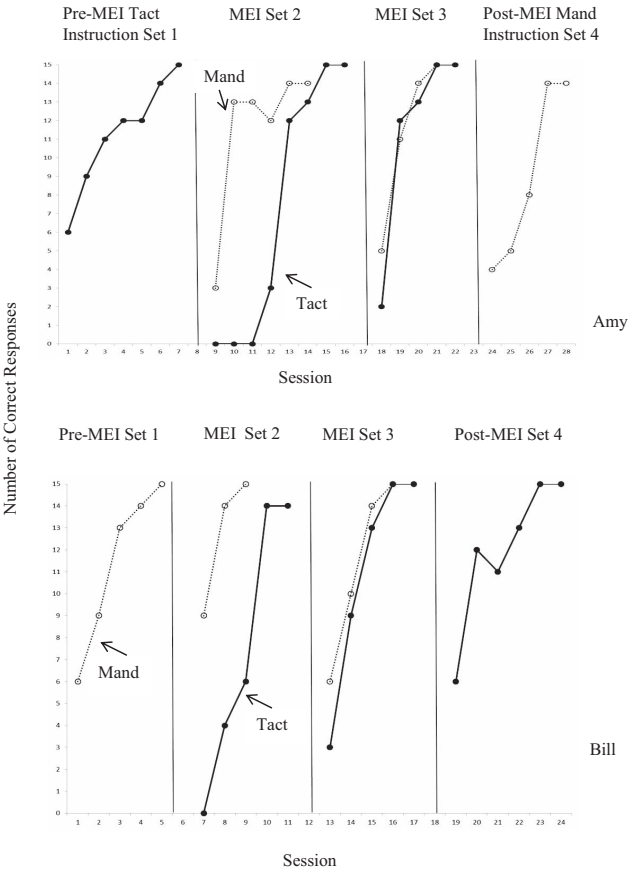

Figure 2. The number of correct mand and tact responses during multiple exemplar instruction for Amy (top panel) and Bill (bottom panel). The open circles represent mands and the closed circles represent tacts.

Neither participant emitted any correct responses for "whole crayon" following the first round of MEI (Set 2). During the probes, Amy made errors by inappropriately combining adjectives with relevant objects (e.g., "full crayon"). Similarly, both of the participants failed to demonstrate of transformation of MOs across mands and tacts for the adjective-object "round box" in Set 4, even with the instructional history of MEI. For "round," we used an empty round box along with an empty square box for tacts, and a round box full of preferred edibles and toys along with an empty square box for mands. In this case, it is possible that the abstraction of the stimulus control for "empty" might have occurred, rather than for "roundness." Adjectives that describe a stimulus property (i.e., roundness) might have been induced if more than one exemplar for the property had been provided, and this is the limitation of the study. In addition to this, having a different object paired with each adjective might cause confusion, which, in turn, might impact the control of motivational conditions on verbal responses: mands or tacts. In Experiment 2, we varied only the adjectives, holding the objects consistent within a set of stimuli.

Another limitation of Experiment 1 was that reinforcement for tacts included the opportunity to mand instead of purely social praise or approval, and this may have confounded the results (see Schmelzkopf, Greer, Singer-Dudek, & Du, 2017). Therefore, we eliminated the opportunities to mand following correct emission of tacts in the second experiment. Finally, another limitation of Experiment 1 was the design.

We only had two participants in the first experiment, when three or more would have been ideal. In addition, we only conducted one probe session for either mand or tact functions prior to the intervention. In order to strengthen the experimental design, we conducted two probe sessions across two different sets of stimuli prior to the intervention for each participant in Experiment 2.

Experiment 2

Method

Participants. Five male 4-year-old children with autism and developmental disabilities participated in the study. All participants demonstrated fluent listener behavior (i.e., following vocal directions) and emitted independent mands and tacts with autoclitic frames (e.g., "I want ____ please" or "It's a ____") at the time of the experiment. The participants had histories of responding to mand and tact instruction, and vocal praise functioned as a conditioned reinforcer for each of them. These participants were selected because they had not been observed to demonstrate both untaught mand and untaught tact functions for operants learned in the other function, which was later confirmed by preintervention probes. Participants were selected for participation if they demonstrated one function, but not both.

Chuck and Dylon were selected from a classroom of nine students at similar language and developmental levels. Ethan, Fred, and Gavin were selected from another classroom of eight students. They were all 4 years of age and were all educationally classified as a preschooler with a disability (a New York State educational classification for preschool-age children). In addition, all five participants functioned at similar levels of verbal behavior; they were all listeners, speakers, and beginning reader/writers. All participants attended the same school as described in Experiment 1. All participants were chosen for this study because they did not demonstrate transformation of MOs across mand and tacts, as confirmed by preintervention tests.

Setting and materials. We conducted preintervention and postintervention probes for the experiment at a child-sized table in the hallway right outside of the classroom, in order to ensure that other participants would not have additional opportunities to learn the mand and tact functions by observing participants receiving instruction. The participants had access to the stimuli only during the preintervention and postintervention probes and MEI sessions. MEI sessions were conducted at a child-sized table with child-sized chairs in the participants' classroom.

The materials used in this study are listed in Table 2. They included stimuli that could contain or hold other reinforcers, such as clear Ziploc bags with animal stickers attached, colored buckets, paper plates with designs on them, red paper plates that were different in size, different patterned gift bags, and character napkins (Sets 1–9, 12, 13). In addition, we used two sets of toys, consisting of puzzles and games, that were novel to the participants (Sets 10 and 11).

Response definitions. Response types targeted in this experiment were the same as in Experiment 1: untaught mands and tacts with adjective-object pairs under relevant motivational conditions. A correct mand was defined as the participant's vocal verbal response, "I want the _____ please," followed by delivery of the item specified. A correct tact was defined as the participant's vocal verbal response, "It's a _____" or "That's a _____." During pre- and postintervention probe trials, tacts were not consequated.

Intervention. As in Experiment 1, the intervention was MEI in which instructional trials were presented across two MOs under relevant motivational conditions, thereby functioning as either mands or tacts. We taught mands and tacts using a set of three adjective-object pairs. For mands, the MO consisted of an edible reinforcer, chosen by the participant at the start of each mand trial, that was placed in or on the target stimulus. Correct mand responses, for example, "I want the striped plate, please," were consequated by handing over the specified stimulus and allowing the participant to retrieve and consume the item it held.

For tacts, the experimenter pointed to the target stimulus, indicating that she was expecting a tact response. The participants had histories of responding to tact instruction and vocal praise functioned as a conditioned reinforcer for each of them. The experimenter delivered vocal social reinforcement in the form of praise immediately following correct tact responses. For

Table 2
Sequence of Training and Probes for Untaught Verbal Operants and Sets of Adjective-Object Pairs Used During Phases of Experiment 2

	Preintervention training & probe				MEI	Postintervention probes			
Chuck	**Tact training**	**Mand training**	**Tact training**	**Mand training**	**Rotating mand & tact training**	**Untaught mand probe**	**Untaught tact probe**	**Untaught mand probe**	**Untaught tact probe**
	Set 1 Small, medium, large plates	Set 2 Plain, polka-dot, striped bags	Set 11A Farm/ truck puzzles, wall/hippo games	Set 10A SpongeBob/ animal puzzles, whale/Spiderman games	Set 3 Left, middle, right bowls	Set 1 Small, medium, large plates	Set 2 Plain, polka-dot, striped bags	Set 11A Farm/truck puzzles, wall/hippo games	Set 10A SpongeBob/ animal puzzles, whale/Spiderman games
	Probe untaught mands	**Probe untaught tacts**	**Probe untaught mands**	**Probe untaught tacts**					
Dylon	**Mand training**	**Tact training**	**Mand training**	**Tact training**	**Rotating mand & tact training**	**Untaught tact probe**	**Untaught mand probe**	**Untaught tact probes**	**Untaught mand probes**
	Set 4 Diego, kitty, monster cups	Set 2 Plain, polka-dot, striped bags	Set 11A Farm/ truck puzzles, wall/hippo games	Set 10A SpongeBob/ animal puzzles, whale/Spiderman games	Set 5 Letter, number, shape box	Set 4 Diego, kitty, monster cups	Set 2 Plain, polka-dot, striped bags	Set 11A Farm/truck puzzles, wall/hippo games	Set 10A SpongeBob/ animal puzzles, whale/Spiderman games
	Probe untaught tacts	Probe untaught mands	Probe untaught tacts	Probe untaught mands					
Ethan	**Tact training**	**Mand training**	**Tact training**	**Mand training**	**Rotating mand & tact training**	**Untaught mand probe**	**Untaught tact probe**	**Untaught mand probe**	**Untaught tact probe**
	Set 6 Tiger, elephant, monkey bags	Set 7 Red, blue, green buckets	Set 10B Farm/ truck puzzles, pizza/peanut games	Set 11B SpongeBob/ dinosaur puzzles, hippo/monkey games	Set 8 Zig-zag, striped, polka-dot plates	Set 6 Tiger, elephant, monkey bags	Set 7 Red, blue, green buckets	Set 10B Farm/truck puzzles, pizza/peanut games	Set 11B SpongeBob/ dinosaur puzzles, hippo/monkey games
	Probe untaught mands	**Probe untaught tacts**	**Probe untaught mands**	**Probe untaught tacts**					

Table 2 (*continued*)

	Preintervention training & probe				MEI	Postintervention probes			
Fred	**Mand training**	**Tact training**	**Mand training**	**Tact training**	**Rotating mand & tact training**	**Untaught tact probe**	**Untaught mand probe**	**Untaught tact probe**	**Untaught mand probe**
	Set 9 Elmo, monster, Big Bird napkin	Set 8 Zig-zag striped, polka-dot plate	Set 10B Farm/truck puzzles, pizza/peanut games	Set 11B SpongeBob/dinosaur puzzles, hippo/monkey games	Set 6 Tiger, elephant, monkey bags	Set 9 Elmo, monster, Big Bird napkin	Set 8 Zig-zag striped, polka-dot plate	Set 10B Farm/truck puzzles, pizza/peanut games	Set 11B SpongeBob/dinosaur puzzles, hippo/monkey games
	Probe untaught tacts	**Probe untaught mands**	**Probe untaught tacts**	**Probe untaught mands**					
Gavin	**Tact training**	**Mand training**	**Tact training**	**Mand training**	**Rotating mand & tact training**	**Untaught mand probe**	**Untaught tact probe**	**Untaught mand probe**	**Untaught tact probe**
	Set 13 Pink, turquoise, gray basket	Set 12 Letter, number, shape bowl	Set 10B Farm/truck puzzles, pizza/peanut games	Set 11B SpongeBob/dinosaur puzzles, school bus/monkey games	Set 9 Elmo, monster, Big Bird napkins	Set 13 Pink, turquoise, gray basket	Set 12 Letter, number shape bowl	Set 10B Farm/truck puzzles, pizza/peanut games	Set 11B SpongeBob/dinosaur puzzles, school bus/monkey games
	Probe untaught mands	**Probe untaught tacts**	**Probe untaught mands**	**Probe untaught tacts**					

Note. MEI = multiple exemplar instruction.

incorrect responses, the experimenter provided a correction following the same procedures as in Experiment 1.

Experimental design. We used a multiple probe design for Chuck and Dylon, and a delayed multiple probe design for Ethan, Fred, and Gavin. The first two participants began the experiment simultaneously, whereas the entry of the last three participants was delayed. We taught two sets of adjective-object pairs to each participant and then conducted unconsequated probes for the untaught function. Thus, each participant received two preintervention probes for each untaught function of the adjective-object pair taught (mand or tact), with the exception of Dylon, who received a second set of probes. Chuck received the intervention first. Following completion of postintervention probes for Chuck, Dylon entered the intervention. Ethan entered the experiment following completion of the intervention and postintervention probes for Dylon. Fred and Gavin followed the same sequence of procedures, with Fred entering the experiment following completion of Ethan's postintervention probes.

The sequence of the experiment was as follows: (a) pre-experimental probes to confirm that participants did not emit correct mands or tacts of the adjective-object pairs, (b) instruction to mastery for different sets of adjective-object pairs under a single verbal operant condition (mand or tact), (c) probes for the untaught verbal operant using same sets of adjective-object pairs, (d) intervention using MEI across tacts and mands using a second set of adjective-object pairs taught to 80% correct mastery criterion (the set of adjective-object pairs was not used again), and (e) a repeat of the initial probes using the initial set of adjective-object pairs (probe for the untaught verbal function). The sequence of experimental phases and sets of stimuli used during the phases is shown in Table 2.

Procedure.

Preintervention instruction. First, we taught the participants either the mand or tact function for two sets of three adjective-object pairs under relevant motivational conditions, counterbalanced across participants. Mand and tact sessions consisted of 15 or 20 trials for each set, depending on the number of items in the set (sets of toys contained four items, whereas the other sets contained three items; see Table 2). Response opportunities were rotated in random fashion until each item had been presented five times. Instruction continued until the participant emitted 100% correct responses for one session. No vocal antecedents (e.g., echoic prompts) were provided under mand or tact conditions. During mand conditions, we gave the participants the opportunity to select a preferred edible reinforcer prior to each trial. We placed the chosen reinforcer on or in one of the stimuli (e.g., on a napkin, in a bucket, inside a Ziploc bag), depending on the target set. For Set 10a, Set 10b, and Sets 11a, 11b, and 11c, we presented the game or puzzle with two nonpreferred activities, such as note cards and paper clips. Once presented, the participant had 5 s to correctly mand for the item. Upon a correct response, the experimenter immediately presented the stimulus manded (e.g., tiger bag) so the child could access and consume the edible reinforcer inside. Following incorrect responses, which were mostly nonvocal mands rather than incorrect frames, the experimenter provided an echoic correction while representing (holding up or pointing to) the stimulus. The participant was required to emit a correct response and no reinforcement was delivered for the target responses following the correction. The procedures for data collection for mands were same as in Experiment 1.

During tact conditions the experimenter placed three objects on the desk and pointed to one of the objects. The participant was required to give the adjective-object name of the specified item. With sets of games and puzzles (Set 10a, Set 10b, and Sets 11a, 11b, and 11c), the experimenter presented 2D pictures of the games or puzzles and the student was required to give the adjective-object name of the game (e.g., dinosaur puzzle). The experimenter delivered vocal social reinforcement in the form of praise immediately following correct tact responses. Corrections for incorrect responses were the same as for mands. All other aspects of tact conditions and data collection were same as in Experiment 1.

Preintervention probes for untaught mands or tacts. Following mastery criterion for each set of stimuli, we conducted a preintervention probe for the untaught function, either mands or tacts. The probe procedures for untaught mands and tacts were the same as in preintervention instruction except one aspect of the procedure: neither reinforcement for a correct response nor

correction for an incorrect response was provided. The specific sets used during mand and tact probes for each participant are listed in Table 2.

Intervention: MEI. We implemented MEI with a new set of adjective-object pairs during the intervention. The specific sets of adjective-object pairs used for MEI for each participant are shown in Table 2. During MEI, instructional trials were rotated between mand and tact opportunities. Procedures for mand or tact instruction and data collection were the same as in the preintervention instruction conditions.

Postintervention instruction and probes with a novel set of stimuli. Once the participant met criterion across both mands and tacts during the intervention phase, we conducted postintervention probes to determine whether the untaught mands and tacts emerged. Postintervention probes were conducted in the same manner as preintervention probes.

IOA. The percentage of IOA was calculated for intervention and instructional phases by dividing the numbers of point-by-point agreements by the total number of agreements and disagreements and multiplying by 100%. For Chuck, IOA was collected for 38% of the instructional sessions, with a mean agreement of 100%. For Dylon, IOA was collected for 42% of the instructional sessions, with a mean agreement of 100%. IOA was collected for all probes conducted during the study for both Amy and Bill, with a mean agreement of 100%. For Ethan, IOA was conducted for 25% of preintervention and postintervention probe sessions and 6.25% of instructional sessions. The mean IOA across all sessions for Fred was 100%. IOA was conducted for 25% of preintervention and postintervention preintervention and postintervention probe sessions for Gavin and 14.3% of instructional sessions. The mean IOA for instructional sessions was 98.3% was a range of 96.7% to 100%. The mean IOA for preintervention and postintervention probe sessions for Dylon was 100%. For Ethan, IOA was conducted for 50% of probe session and 100% of intervention session. The mean IOA for Ethan was 100% across all session.

Results and Discussion

Figure 3 depicts the percentage of correct responses to untaught mand and tact operants during pre- and postintervention probe conditions for all participants. Responses are displayed as percentages due to the differing numbers of stimuli in each set. Prior to preintervention training, initial probes showed that four of the five participants did not emit any correct responses to sets of adjective-objective pairs as either mands or tacts. Gavin did not emit any correct responses for mands but emitted 7% (1/15) and 70% (14/20) correct responses to tacts during preintervention probes, demonstrating that he did demonstrate some transformation of MOs from mands to tacts, but not from tacts to mands. After MEI on a new set of objects, all participants emitted high percentages of correct responses for untaught mands and tacts during postintervention probes. Chuck emitted 67% correct mand responses and 73% correct tact responses for container stimuli, and 95% (mand) and 100% (tact) correct responses for novel toys. Dylon emitted 79% (mand) and 67% (tact) correct responses for container sets, and 95% (mand) and 50% (tact) correct for new toys. Ethan, Fred, and Gavin emitted untaught mands at 80%, 87%, and 100% correct, respectively, and untaught tacts at 87%, 87%, and 100% correct, respectively, for new sets of objects. They also emitted untaught mands for novel toys at 100%, 75%, and 100% correct, respectively, and untaught tacts at 95%, 100%, and 100% correct, respectively.

Figure 4 displays the number of correct responses during MEI training. As shown, Chuck, Dylon, and Fred achieved mastery criterion on the third instructional session for mands and for tacts. Ethan reached criterion performance for both mands and tacts on the fifth session; Gavin mastered mands in two sessions and tacts in three sessions.

The results of Experiment 2 replicated the results of Experiment 1, in that MEI induced transformation of MOs from mands to tacts, and vice versa, for all participants. In Experiment 2, we sought to address several limitations posed by Experiment 1, including the number of participants, the design of the study to include more than one preintervention probe, the MEI procedures, including the reinforcement operation for correct tacts, and, lastly, we included stimuli sets that were likely to be found in the participants' environment, such as games and puzzles. Notably, with the exception of Dylon's and Fred's tacts of novel games and puzzles, all participants performed slightly better on the toy probes than the container stimuli probes. Perhaps this is because the stimuli resembled things

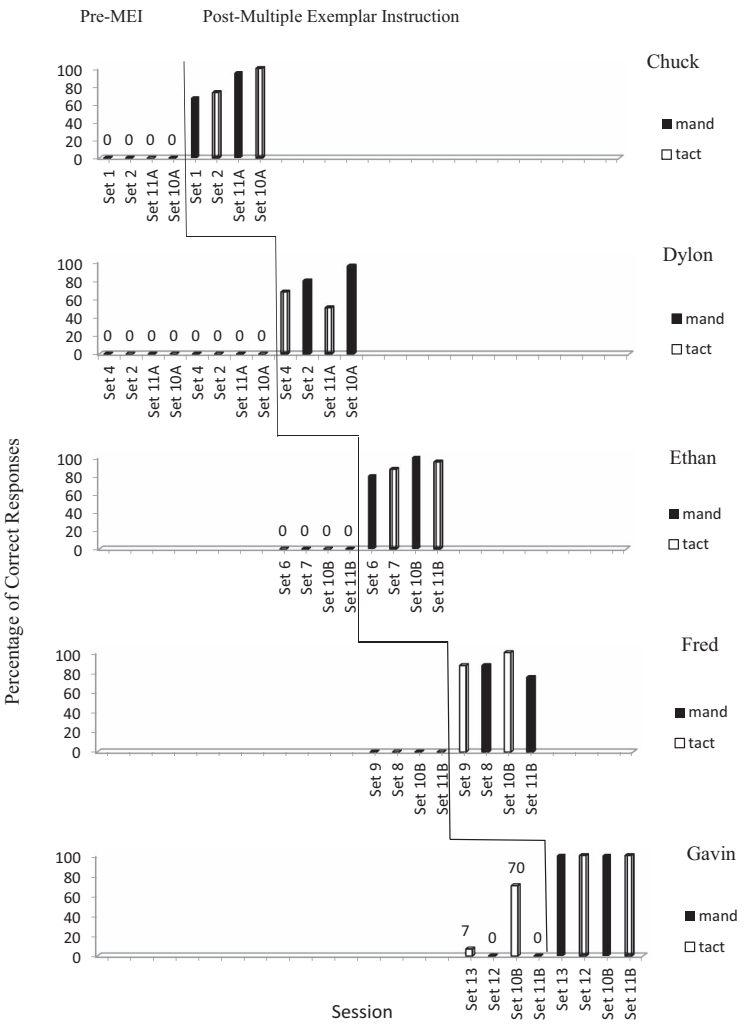

Figure 3. The number of correct mand and tact responses to untaught adjective-object pairs for Chuck, Dylon, Ethan, Fred, and Gavin prior to and following MEI instruction. The black bars represent mands and the white bars represent tacts.

that were in the participants' natural environments and for which they had a history of reinforcement, although the particular stimuli we used were novel. In any event, the stimuli were not important, what was important was whether, following MEI, the participants could emit untaught verbal functions.

General Discussion

The present studies demonstrated the emergence of untaught mands and tacts following MEI. Preintervention probes had confirmed that mands and tacts had to be separately acquired for all participants, whereas after the MEI intervention, the functional independence of mands and tacts was no longer evident in any of the participants. These results suggest that a critical developmental cusp, the transformation of MOs across mands and tacts, had been established for all participants.

The findings for our seven preschool children with autism and developmental disabilities are consistent with prior research (Egan & Barnes-

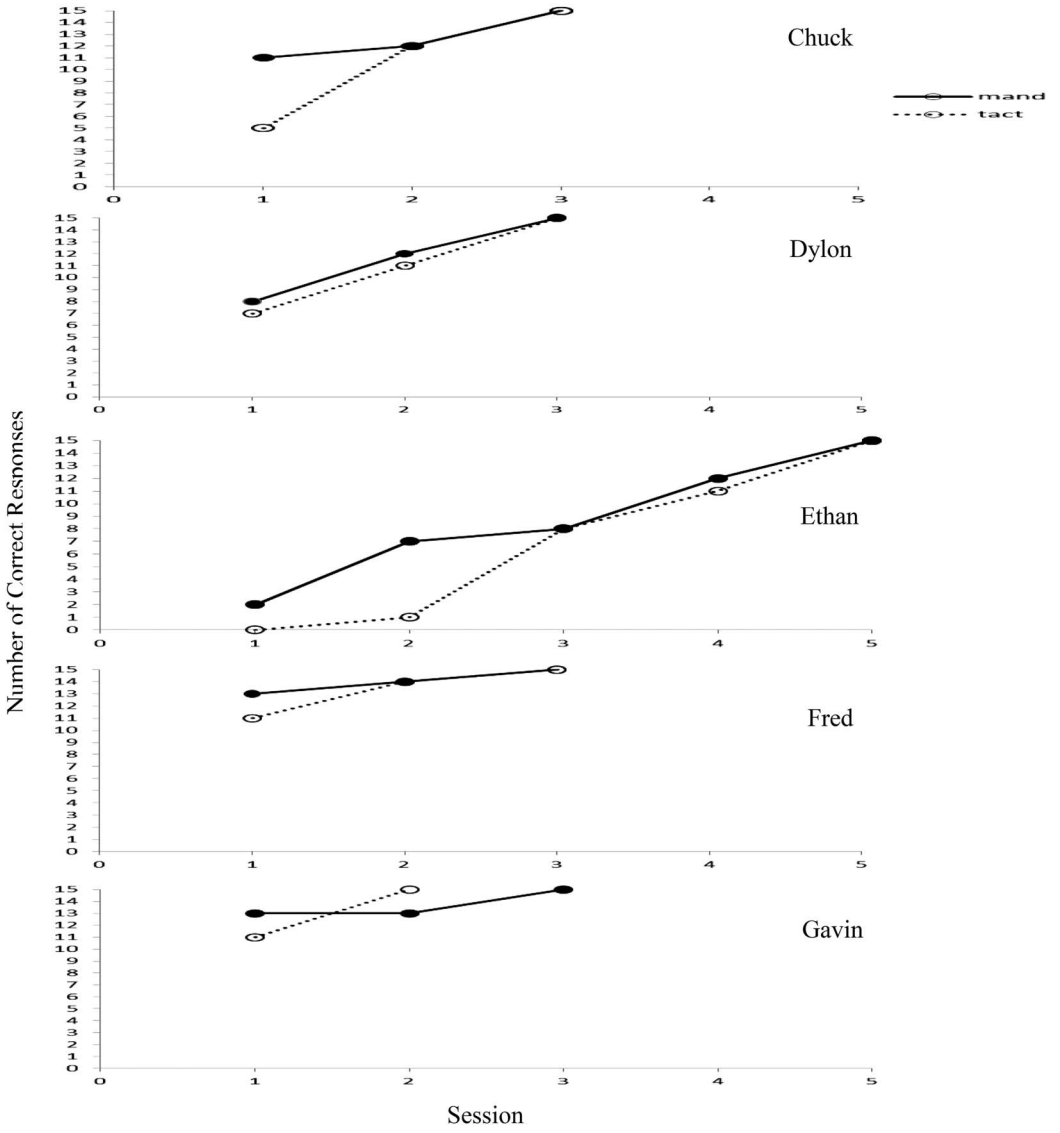

Figure 4. The number of correct mand and tact responses during multiple exemplar instruction for Chuck, Dylon, Ethan, Fred, and Gavin. The open circles represent mands and the closed circles represent tacts.

Holmes, 2009; Finn et al., 2012; Lamarre & Holland, 1985; Nuzzolo-Gomez & Greer, 2004; Petursdottir et al., 2005; Sigafoos et al., 1990; Twyman, 1996b; Wallace et al., 2006). It appears that the MEI involving rapid alternations of MOs to evoke mands and tacts resulted in the transformation of MO from mand to tact, and vice versa, such that a response learned in one function led to the emergence of the other untaught function for the same adjective-object. The results are consistent with Nuzzolo-Gomez and Greer (2004), suggesting that MEI played an important role in the transformation of MOs across mands and tacts.

In Experiment 1, the sequence of mand and tact training was controlled by momentary deprivation conditions, either by deprivation of a specific reinforcer or a nonspecific rein-

forcer, not by scheduled consequences. Specifically, in this study, the mand condition was controlled by the deprivation of the target stimuli. Under the tact condition, the motivational operation was contrived by adding a competing stimulus as a target stimulus for a new mand, thereby creating an abolishing operation by decreasing the reinforcement effects and increasing the probability of evoking a tact response for the previous stimulus. Thus, the tact response was evoked not only by the presentation of the target tact stimulus but also by the MO for the newly presented stimulus that occasioned the mand following the correct tact emission. Although the response was defined as a tact in this study, because the child might have indicated his desire for the newly presented item, and because the resulting consequence was generalized reinforcement for tacting the previous item initially used for to evoke a mand, such a tact response is possibly an impure one. Whether such an arrangement constitutes an MO that occasions a tact response remains questionable. In Experiment 2, no stimuli other than praise were delivered for correct tacts in order to address this issue.

In Experiment 1, the transformation of MOs across tacts and mands occurred due to deprivation of specific or nonspecific reinforcers, which was transitory in nature. This aspect of the procedure might have caused unclear stimulus control or contextual cues for mand or tact conditions. A unitary procedure (placing desired edibles on or in the target adjective-objects), which was used to occasion MOs for mands in Experiment 2, addressed the issue. However, further investigations should examine the effects of the specific sequence of procedures involved in the rapid alternations across mand and tact functions during MEI. The results of the present studies provide additional support for using MEI as an effective means to facilitate the emergence of untaught stimulus functions for early speakers with autism and developmental disabilities.

Prior research indicated that the use of MEI has been successful in establishing the transformation of stimulus functions, thus joining initially separate verbal repertoires such as the speaker and listener repertoires in naming (Cahill & Greer, 2014; Fiorile & Greer, 2007; Gilic & Greer, 2011; Greer & Longano, 2010; Greer & Ross, 2008; Greer & Speckman, 2009; Greer, Stolfi, et al., 2005; Greer et al., 2007) and speaker and writer repertoires in spelling responses (Greer, Yaun, et al., 2005). The MEI that involved rapid alternations of mand and tact opportunities, and manipulation of the corresponding MOs, resulted in the transformation of MOs across mands and tacts. These results, and those from prior studies, provide an account of generative language from a Skinnerian and verbal behavior development perspective.

Further research is certainly warranted, especially in light of Gamba et al.'s (2015) identification of issues with construct validity related to the functional independence of mands and tacts. In the vein of research related to verbal behavior development, future studies should test whether such an intervention that establishes the transformation of MOs also results in other outcomes, such as increases in participants' verbal repertoires, specifically mands and tacts in generalized settings, as has been indicated in prior studies on naming, such as those cited above.

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