The Effects of Multiple Exemplar Instruction on Generating Functional Interdependence between Listener and Intraverbal Categorization Repertoires

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THE EFFECTS OF MULTIPLE EXEMPLAR INSTRUCTION ON GENERATING FUNCTIONAL INTERDEPENDENCE BETWEEN LISTENER AND INTRAVERBAL CATEGORIZATION REPERTOIRES

by

Sarah A. Lechago

A Dissertation
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The effects of multiple exemplar instruction on generating functional interdependence between listener and intraverbal categorization repertoires

Sarah A. Lechago, Ph.D.
Western Michigan University, 2009

The results of the present study extend the literature on multiple exemplar instruction (MEI) by demonstrating that MEI was ineffective in producing functional interdependence between listener and intraverbal categorization repertoires. Four typically developing children between the ages of 3 years 11 months and 4 years 7 months participated in the study in which two categorization types (listener and intraverbal) were targeted. Previous research has demonstrated functional independence between these two categorization response forms (Petursdottir, Carr, Lechago, & Almason, 2008). The present study examined the efficacy of MEI in the form of alternating categorization response forms (listener and intraverbal) during training in producing emergent intraverbal categorization responding after training listener categorization responses. For two participants for whom there was some evidence of functional interdependence between listener and intraverbal categorization repertoires, responding was variable. For the remaining two participants, 72 to 100 MEI training trials produced minimal improvement in responding or no functional interdependence at all. The results are discussed in terms of Skinner's analysis of verbal behavior and naming theory (Horne & Lowe, 1996).
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Sarah A. Lechago
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INTRODUCTION

Early and intensive behavioral intervention (EIBI) programs are comprehensive behavior-analytic programs that are used to teach a wide variety of functional skills including self-help skills and pre-academic skills to individuals with developmental delays, most notably autism (Leaf & McEachin, 1999; Lovaas 1977, 2003; Maurice, Green, & Luce, 1996, Sundberg & Partington, 1998). In these programs, skill areas are separated into curricular targets, and protocols are developed and implemented to train each target skill. In an effort to create successful teaching opportunities, each skill is divided into small manageable steps with the size and number of steps determined by the individual’s current repertoire. Most skills are trained using a discrete-trial format in which antecedent stimuli and consequences are delivered in a clear and consistent fashion. Programs are sequenced in a manner that mimics typical development in that simpler skills are targeted before more complex skills. For example, sitting and attending skills are targeted before motor imitation skills, which in turn are targeted before writing and drawing. Finally, most EIBI programs are implemented for at least two years.

Curricular targets designed to teach verbal or language skills are embedded within all EIBI programs and constitute a large and critically important part of an individual’s curriculum. While all EIBI programs include language training, they differ from one another with respect to the way language or verbal skills are conceptualized and implemented. Many EIBI programs target language skills using a traditional psycholinguistic approach that typically includes separate programs to train what are termed “receptive” and “expressive” skills (e.g., Leaf & McEachin, 1999; Lovaas, 1977, 2003). Simply put, expressive language is verbal behavior that the individual produces
(e.g., responding "It's a cat" when shown a picture of a cat and asked "What is it?") and receptive language involves selection or motor behavior in response to a speaker's instruction (e.g., pointing to a red card in response to the instruction "Touch red").

Many EIBI texts that adhere to the psycholinguistic approach to teaching language recommend sequencing language skills in specific ways, for example teaching receptive skills before expressive skills (Lovaas, 1977, 2003). Although these recommendations make intuitive sense and in some cases follow a logical and natural progression (e.g., imitating sounds must be targeted before teaching an individual to answer questions about his or her day), in some cases these recommended sequences are not supported by the research. For example, some studies within the behavior-analytic literature have found that teaching receptive language does not facilitate the acquisition of expressive language (Petursdottir, Carr, Lechago & Almason, 2008) and in some cases, teaching expressive skills may facilitate the acquisition of receptive skills (Wynn & Smith, 2003).

Skinner's Analysis of Verbal Behavior

Other EIBI programs promote and utilize what is termed the "verbal behavior approach" as an alternative to the traditional psycholinguistic approach to teach language or verbal behavior (Sundberg & Partington, 1998). This approach is predicated on a conceptual framework first described by Skinner (1957). According to this approach, what distinguishes verbal behavior from other behavior is its source of reinforcement. Verbal behavior is reinforced through another individual's behavior. In other words, it is socially mediated behavior, whereas non-verbal behavior is reinforced through mechanical action (Skinner). For example, making a sandwich when food deprived
(nonverbal behavior) exemplifies a source of non-social reinforcement and may be labeled nonverbal, and obtaining the sandwich through someone else's behavior after asking, "Make me a sandwich please" exemplifies a source of social reinforcement (verbal behavior).

Skinner's analysis involves the use of functional analysis to identify variables that control verbal behavior. Based on its function, verbal behavior is then classified according to one of the major verbal operant classes. Teaching language using this approach involves assessing skills in reference to the different verbal operants (Sundberg & Partington, 1998). A curriculum is subsequently developed based on the results of the assessment. Curricular programs target the different verbal operants, which typically include mands, tacts, intraverbals, and echoics. These verbal operants exemplify different functional relations of verbal behavior.

**Speaker and Listener Behavior**

While many EIBI curricula target language skills using the "receptive" and "expressive" distinction (Lovaas, 2003), as discussed previously, the verbal behavior approach conceptualizes these different types of verbal behavior functionally in terms of the antecedent variables that influence their emission and the reinforcing consequences that maintain them over time. Additionally, the verbal behavior approach highlights the topographical distinction between receptive and expressive responding.

According to Skinner's conceptual framework, expressive language can essentially be translated to what he termed "speaker behavior". There are a variety of operants that come under the classification of speaker behavior. The *mand* is a verbal response evoked by a relevant motivating operation (MO) (Laraway, Sncerski, Michael,
and which specifies its reinforcer (although not always explicitly). For example, the mand “banana” might be emitted under the relevant MO of food deprivation and is reinforced by the attainment of a banana. Another operant classified under the omnibus term of expressive language is the tact. This response is evoked by a nonverbal discriminative stimulus (S°) and reinforced by nonspecific generalized reinforcement. For example, the sight of the banana itself evokes the tact “banana” and may be reinforced by praise or acknowledgement (e.g., “That’s right. That is a banana”). The intraverbal is yet another form of expressive behavior that is evoked by a verbal S^D; for example the verbal stimulus “What is your favorite fruit?” evokes the response “banana.” An elaboration of the intraverbal is provided below.

**Intraverbal behavior**

The intraverbal is a type of verbal behavior controlled by a verbal S^D with which it has no point-to-point correspondence, and is reinforced by a generalized reinforcer (Skinner, 1957). For example, the intraverbal response “fish” is evoked by the S^D “Tell me an animal that lives in the water.” Based on Skinner’s definition, it is fair to conclude that intraverbal behavior is ubiquitous in our daily communication. For example, intraverbal behavior is evident in problem solving when reciting the traffic rules during a driving exam, in social contexts when holding a conversation, and in academic contexts when answering a question in class. Intraverbal behavior also accounts for a great number of EIBI curricular targets including story telling, conversations, answering questions, reciting the alphabet, and singing songs. These targets play an important role in the development of social, play, academic, and safety skills (Partington & Bailey, 1993; Sundberg & Michael, 2001). Given the central role of intraverbal behavior in a
great number of curricular programs, it is critical to ensure successful acquisition of this
operant in its multiple forms. In an effort to fully appreciate Skinner’s account of verbal
behavior, a description of listener behavior is pertinent.

*Listener behavior*

Receptive programs teach what is described in the behavioral literature as
“listener behavior” (Michael, 1985). These programs teach students to emit motor or
selection responses (e.g., pointing to a card) in response to a verbal S^D_. For example,
teaching a child to point to a blue card in response to the S^D_, “Touch blue”. According to
Skinner (1957), the listener functions in multiple capacities for the speaker. The listener
can function as an S^D_ or as an MO for the speaker. Listener behavior is in no special
sense verbal behavior according to Skinner’s analysis; however, often times listener
behavior is verbal behavior when it is in turn reinforced by the behavior of another
person. The listener becomes an important part of the situation in which verbal behavior
is emitted and therefore comes to influence control over the speaker’s responding.
Additionally, the specific action a listener takes with respect to the verbal behavior of the
speaker will come to influence the strength of the presence of the listener over the
speaker’s verbal behavior. In the aforementioned example, touching the blue card on the
part of the student (listener) will likely reinforce the response “Touch blue” of the
speaker. Listener behavior is a necessary repertoire for becoming a viable part of the
verbal community which, in turn, is important for the child’s independent functioning.

*Functional Independence Between Verbal Operants*

There is more than one account of how a person comes to learn to use language
and more specifically how a person comes to emit a word in a variety of contexts.
Traditional psycholinguistic accounts assert that humans are neurologically predisposed to understand and produce language (Chomsky, 1966; Pinker, 1999). According to some psycholinguistic theories, generation of words and rules (the way words are put together into phrases and used) are regulated by different neural subsystems (Pinker). The meaning of a word is linked to an entry of the concept of that word that is registered or “stored” in an individual’s “mental encyclopedia”. People combine words into phrases and sentences and the meaning of the sentences or phrases is inferred from the meaning of the words and the way they are arranged. Individuals have a neurological protocol that specifies how words can be arranged into meaningful combinations (Chomsky; Pinker). This is referred to as generative grammar by linguists. Adopting the psycholinguistic viewpoint implies adopting the assumption that once we understand the “meaning” of a word, we are able to “use it” in a variety of contexts and ways. For example, when an individual understands the “meaning” of the word “apple”, he or she will be able to automatically label it upon seeing an apple, ask for an apple when food deprived, or produce this as a response to the request, “Tell me a fruit that grows on trees”.

The receptive/expressive distinction of verbal behavior can become problematic when teaching individuals with language delays. As mentioned earlier, receptive and expressive language encompasses a variety of verbal skills with different controlling variables. Based on the assumptions inherent in the traditional psycholinguistic conceptualization of language detailed above, verbal behavior taught using this approach is at risk of being taught in a manner that is insensitive to these critical controlling variables. When this happens, verbal skills may be taught in a way that is superficial and topography based. For example, when teaching an individual to request a desired food
item (e.g., cookie) to the instruction “What do you want?”, if care is not taken to ensure the relevant controlling variables are present (e.g., the MO of food deprivation), it is unlikely that future responding will occur under the relevant controlling variables, which represents a threat to generalization and maintenance of the target response.

Proponents of the verbal behavior approach, while not necessarily disputing the influence of neurological variables in the production of language, place a much greater emphasis on environmental variables and assert that verbal operants are functionally independent from one another as well as from listener behavior due to differing sources of stimulus control and histories of reinforcement (Skinner, 1957). Therefore, the circumstances that influence the emission of a word are related to a specific history of reinforcement. To take the above example of the apple, an individual may ask for an apple when he or she is food deprived; receiving the apple reinforces this response. Receipt of the apple while food deprived is the variable that teach the learner to emit the response, “apple”, under future similar environmental conditions. Similarly, the individual will learn to label the apple upon seeing the apple after receiving praise for labeling it correctly. These controlling variables are distinct from the variables that control emission of the response “apple” when the individual is food deprived. According to this analysis, it is not assumed that once an individual learns to emit a word under one set of controlling variables, she will automatically be able to emit the same word under a different set of controlling variables. This analysis has implications for how language is taught. For example, if an individual is taught to ask for water when he is water deprived, different manipulations of antecedents and consequences are required.
to ensure the individual will be able to emit the same response (water) when shown a picture of a glass of water and asked, "What is this?"

There is support in the research literature to lend credence to the assertion that the verbal operants are functionally independent from one another and from listener behavior. Petursdottir et al. (2008) conducted a study to evaluate the effects of listener and intraverbal training on the emergence of listener and intraverbal relations in typically developing children ages 3 to 4 years. Training listener categorization relations did not result in the emergence of intraverbal categorization relations and vice versa. Another study examined the effects of multiple-tact and receptive discrimination training on the acquisition of intraverbal behavior in typically developing children ages 3 to 5 years (Miguel, Petursdottir, & Carr, 2005). Results indicated that multiple-tact and receptive discrimination training did not significantly influence the emission of intraverbal behavior. Lamarre and Holland (1985) conducted a study in which the functional independence of mands and tacts was examined in typically developing children ages 3 to 5 years. Children were initially trained to mand or tact the experimenter's placement of objects on a table and collateral responses for the untrained operant were probed. After the untrained responses were trained, the reverse form of the originally untrained operant was trained (i.e., if the participant was initially trained to mand, then he was trained to reverse tact and vice versa) and responding in the reverse form of the untrained operant was probed. The authors demonstrated that tacts and mands were functionally independent during acquisition. Additionally, during reversal training collateral reverse responding in the untrained operant occurred for only 3 out of the 9 participants.
Emergent Relational Responding

Despite existing evidence demonstrating functional independence across verbal operants, it appears that some populations of individuals generally learn to respond seamlessly across verbal operants without explicit training (Skinner, 1957; Taylor & Harris, 1995). These individuals are able to emit a response under conditions in which they had not received any direct training. However, such functional interdependence between verbal operants and between listener and speaker repertoires is notoriously deficient in many individuals with language delays (Guess & Baer, 1973; Lamarre & Holland, 1985; Lee, 1981; Partington & Bailey, 1993). As such, it behooves researchers to develop procedures that generate functional interdependence across verbal operants for those individuals for whom functional interdependence does not naturally occur.

Multiple-exemplar instruction (MEI) represents one way to achieve functional interdependence between verbal operants and listener and speaker repertoires.

Multiple-Exemplar Instruction

Multiple-exemplar instruction is a strategy that encompasses a family of procedures. Generally, this strategy involves exposing a learner to multiple exemplars of a given target skill in an effort to train a generalized operant. For example, in order to teach a motor imitation repertoire, the learner is exposed to multiple targets (e.g., touch nose, pat tummy, stand up) before a generalized imitation operant is established and the learner is able to respond immediately (without additional training) to a novel target or stimulus. The utilization of MEI is ubiquitous in training multiple curricular targets within EIBI programs and has been a common teaching strategy for many decades.

The term MEI is sometimes used to refer to a procedure which results in joint
stimulus control of initially functionally independent verbal operants or response forms (Fiorile, & Greer, 2007; Greer, Yuan, & Gautreaux, 2004). It consists of alternating instruction between two or more response functions in a subset of exemplars. For example, teaching a student to emit both the mand and tact for the stimuli, "cookie", "juice", "book", and "Barney". Instructions would be presented in an alternating format for each stimulus (e.g., mand/tact/mand/tact). This training creates a history of reinforcement with respect to each of the operants/response forms to generate contextual control over and derived relational responding between the two.

Several studies have examined the effectiveness of MEI in generating functional interdependence across verbal operants or response forms. Nuzzolo-Gomez and Greer (2004) tested the effects of MEI on the emergence of untrained mands or tacts of adjective-object pairs in four children ages 6 to 9 years with a diagnosis of autism. The experimenters presented three sets of object-adjective pairs (e.g., small cup, third box, middle bowl). The pre-experimental probe condition included both tact and mand probes for all three sets. Following the pre-experimental probe conditions, the participants were taught to either mand or tact for the first or second set of adjective-object pairs. These conditions were identical to the pre-experimental conditions, except emission of the correct response during the mand condition produced the object with the edible inside. Emission of the correct response during the tact condition produced praise and a sticker or chips. Baseline consisted of probes for the untaught function. Multiple-exemplar instruction was conducted with a new set of adjective-object pairs following baseline. This condition consisted of alternating mand and tact training trials with the each adjective-object pair. Post-MEI, probes were once again conducted with the untrained
operant. Following these probes, an additional set (Set 3) of adjective-object pairs were trained either as mands or tacts and probes for the untrained operant were conducted. A delayed multiple-probe design across participants was used to evaluate treatment effects for each participant.

Nuzzolo-Gomez and Greer (2004) demonstrated that during pre-experimental and baseline probes, none of the participants emitted the untrained operant. However, post-MEI, all four participants responded an average of 90% correct (range, 80% to 100%) on the untrained operant. Additionally, on Set 3 all the participants responded an average of 88% correct (range, 73% to 93%) on the untrained operant.

A serious consideration needs to be addressed in the aforementioned study. The trial format for the tact and mand conditions may not have produced functionally independent response forms. During the mand condition, the target items were within the participants' view, as was the case during the tact condition. Additionally, during the mand condition the participant saw the experimenter place an item (desired food item) inside the target stimulus resulting in a compound stimulus formally similar to that of the experimenter pointing to the target stimulus, which occurred during the tact condition. During both conditions, correct responses produced preferred edible items. Due to the similarities between these conditions, it is difficult to discern whether responding was under the control of different controlling variables. It may have been the case that responding in these two conditions was functionally identical, bringing into question the role of MEI in generating interdependence between these two operants. Perhaps, it was simply additional practice obtained through MEI, and not necessarily the development of joint stimulus control over two functionally independent responses that was responsible
for the improvement in responding. This precludes the ability to confidently conclude that MEI effectively generated responding between two functionally independent response forms in this study.

Another methodological limitation of Nuzzolo-Gomez and Greer (2004) study includes the specific iteration of the delayed-multiple probe design used. Participants whose performances were represented in the second and third panels of the multiple-probe design were probed only once during baseline versus throughout baseline before the MEI condition was introduced. As a result, potential threats to experimental integrity were introduced because participant maturation cannot be discounted as a potential confounding variable. Additionally, conducting multiple probes during the baseline conditions may have at least partially controlled for practice effects.

In another study conducted by Greer and colleagues, the effect of MEI on generating joint control between novel dictation and intraverbal responses was examined (Greer, Yaun, & Gautreaux, 2005). The participants were four kindergarten students with emergent reading and writing repertoires all of whom displayed delays in speech and language and had a diagnosis of MR, autism, or both. During pre-experimental probes, both written and spoken spelling responses were probed. Following the pre-experimental condition, participants were taught one of two response forms (spelling or saying) for Set 1 stimuli. Following baseline, MEI was conducted with a new stimulus set (Set 2). During MEI, the participants were taught both written and spoken responses for Set 2 words in an alternating format. After MEI, the participants were taught to spell step 3 words and probes for the untrained response form were conducted. A delayed multiple-probe design across participants was used to evaluate treatment effects.
Greer et al. (2005) demonstrated that the participants were unable to spell any of the words using either response form during the pre-experiment probe condition. During baseline probes, two participants did not show any emergent responding with the untrained response forms, one participant emitted 12 correct responses (60%) to written probes after being trained with the vocal response form, and another participant emitted 2 correct vocal responses (10%) after being trained with the written response form. After MEI, the two participants that did not demonstrate any emergent responding during baseline probes emitted responses at an average of 95% correct (range 90% to 100%). The participant who emitted 12 correct responses (60%) during baseline emitted 18 correct responses (90%) after MEI, and the participant who emitted 2 correct responses (10%) during baseline emitted 20 correct (100%) after MEI. For Set 3, all four participants emitted an average of 94% correct (range 80% to 100%) on the untrained response form. In a second experiment (a systematic replication), Greer et al. (2005) all participants were unable to emit more than one untrained response form during baseline probes. After MEI training, all of the participants emitted the untrained response form an average of 90% (range, 80% to 100%) correct.

As was the case in the Nuzzolo-Gomez and Greer (2004) study, Greer et al. (2005) also used questionable experimental methodology by using the delayed multiple-probe design. Participants were probed only once during baseline before the MEI procedure was introduced, making it impossible to discount maturation as a potential confounding variable. Also, conducting multiple probes during the baseline condition may have helped to partially control for practice effects. This methodological procedure was especially risky with the participants in this study as they were advanced learners,
thereby increasing the potential for maturation effects to confound the results of the study.

Methodological limitations notwithstanding, the results from both experiments by Greer and colleagues demonstrated that MEI was effective in establishing joint control between novel dictation and intraverbal responding in children diagnosed with autism. Additionally, results from both experiments demonstrated that when there was emergent responding during baseline, it occurred below chance levels (i.e., it was not near mastery criterion) and it did not consistently correspond to a specific training order strengthening the evidence for functional independence between these repertoires. Finally, results from both experiments demonstrated that MEI is successful in generating interdependence between novel dictation and intraverbal repertoires in individuals with beginning and advanced repertoires and with targets of varying levels of complexity.

Greer, Stolfi, Chavez-Brown, and Rivera-Valdes (2005) examined the effects of MEI on the transfer of stimulus function between listener responses (matching and pointing) and speaker responses (pure and impure tacts) with three typically developing children ages 2.5 to 4 years. Three sets of five pictures were used in the study. Pre-experimental probes consisted of testing all four response forms (matching, pointing, pure tact, and impure tact) for each of the five stimuli per set yielding 20 probes for each set. Following pre-experimental probes, a baseline teaching condition was introduced during which each participant was taught matching responses. After the matching responses were trained to mastery criterion, a probe was conducted for each of the untrained responses (pointing, pure tacts, and impure tacts). Following baseline, the MEI condition was introduced. During MEI, all four response forms were trained with a new
set (set 2). Trials for each response form were presented in alternating format for each of the five stimuli in the set. Matching trials were conducted with pictures 1-5, then pointing trials for pictures 1-5, and training with the rest of the response forms was continued in the same fashion. Post-MEI, probes for the three untrained response forms (pointing, pure tact, impure tact) were conducted again for set 1. At this point, matching responses were trained with a new set (Set 3). After matching responses were trained to mastery criterion for Set 3, probes were conducted with the three untrained response forms (pointing, pure tact, impure tact). A multiple-probe design across participants was used to evaluate treatment effects.

Greer, Stolfi et al. (2005) demonstrated that the participants had some matching responses, fewer pointing responses, and minimal to no responses for pure or impure tacts during the pre-experimental condition. After the baseline teaching condition, during which the participants were taught matching responses to criterion with the first set of words, pointing responses, pure tacts, and impure tacts were probed. For 2 out of the 3 participants, correct pointing responses occurred 19/20 times, and for the third participant, pointing responses occurred 6/20 times. For all three participants pure and impure tacts occurred between 4 and 8 out of a possible 20. After MEI with a second set, there was a significant increase in correct impure and pure tact responses for all three participants and a significant increase in pointing responses for the participant for whom this response form was weak prior to MEI. When Set 3 was introduced, responses for all three responses forms (pointing, impure tacts, pure tacts) were between 12/20 and 20/20 for two participants and for one participant (Participant A), responding was 10/20 for pure tacts and 8/20 for impure tacts. Despite some variable responding for the untrained
response forms post MEI, the data show functional interdependence across listener and speaker repertoires.

One major limitation of the Greer, Stolfi et al. (2005) study was with the MEI trial format the authors employed. The different response forms were targeted in an alternating format for all the stimuli at one time instead of alternating trials of the different response forms for each stimulus one at a time. Presumably, part of what functions to produce functional interdependence is the presentation of the target response forms in close temporal proximity such that joint stimulus control is produced. When verbal operants/response forms are targeted with all the stimuli at one time, then this temporal proximity is reduced for each of the stimuli, thereby potentially weakening the production of joint stimulus control between the targeted response forms. As such, this may weaken the argument that the essential feature of the alternating format during MEI resulted in joint contextual control over the response forms and produced the observed increases in responding. It may be the case that transitions between response forms during MEI were in close enough temporal proximity to produce some joint control, which produced the emergent responding observed in the study. However, for some responses the improvement was not substantial post-MEI, further bringing into question the integrity of the specific MEI procedure used in this study. It may be the case that greater responding would have been achieved had the alternating format been used between response forms for each stimulus.

Another potential procedural limitation of Greer, Stolfi et al. (2005) study was that multiple probes (60 probes per set for each participant) of the untrained responses forms were conducted and it is possible that response extinction is what contributed to
weaker responding post-MEI for Set 3, for Participant A. Although the experimenters suggest future researchers intersperse unrelated previously mastered tasks during probe conditions so that participants contact reinforcement and possible extinction effects may be avoided, this may represent a confounding variable as task interspersal has been demonstrated to effectively increase correct responding (Neef, Iwata, & Page, 1977; 1980). In future MEI research, initial training of one operant or response form during baseline and training during MEI should include a component in which the schedule of reinforcement for correct responding is thinned and the mastery criterion includes some percentage of correct responding under extinction. This procedure may best prepare the participants for subsequent probing in the absence of feedback and has been used successfully in previous research with typically developing preschool children (e.g., Horne et al., 2004; Lowe et al., 2002). Finally, as was the case with the two aforementioned studies, the delayed multiple-probe design failed to control for potential maturation effects and possible practice effects.

Luciano and colleagues conducted three studies in which they examined the effects of MEI (which they referred to as multiple exemplar training) and naming in establishing derived equivalence in an infant. During the first experiment, the experimenters attempted to demonstrate the effect of MEI on immediate and delayed receptive symmetry on the emergence of delayed generalized receptive symmetry including naming probes. The second experiment examined visual-visual equivalence relations with a two comparison MEI procedure. The third experiment was a systematic replication of the second experiment in which a three-comparison MEI procedure was used.
In the first experiment, Luciano et al. (2007) showed that the participant was unable to emit the symmetrical receptive responses (selecting the correct item from the box) or tact the object vocally or non-vocally prior to MEI. After MEI, the participant was able to emit the receptive responses (i.e., select the correct object) but did not emit nor approximate any vocal or non-vocal tacts.

During the second experiment, the authors attempted to establish visual-visual equivalence responding with two comparisons. The experimenter's examined whether training four visual-visual conditional discriminations (A1-B1, B1-C1, A2-B2, B2-C2) presented in a match-to-sample format with two comparisons would result in derived equivalence responding (emergent relations A1-C1, A2-C2, C1-A1, C2-A2). After mixed training trials, the authors tested for emergence of the A-C and C-A relations. After testing for emergent transitive relations, a third test for tacting was conducted. The results for Experiment 2 showed that the participant demonstrated emergent equivalence responding for relations A-C and C-A and maintenance of correct delayed receptive symmetry responding with new objects, but no tacts (naming).

Experiment 3 was identical to Experiment 2 except that three comparisons were used during MEI instead of two. In this experiment, visual-visual equivalence relations appeared after MEI for audio-visual symmetry but in the absence of direct reinforcement history of multiple exemplars that included transitivity and equivalence relations. The results for Experiment 3 showed that the participant demonstrated emergent equivalence responding and tacting.

Due to the fact the equivalence responding was not tested prior to MEI in Experiment 1, it could be argued that the participant already had an equivalence
repertoire independent of any MEI training. Future studies should probe the target repertoire prior to the implementation of any procedure to be evaluated. The authors note that because equivalence requires bi-directional responding and the participant did not have any audio-visual symmetrical responding in experiment 1, and given that those relations are reportedly easier to establish over visual-visual relations, this makes it unlikely that the participant had any equivalence relations prior to MEI training in experiment 1. Due to the fact that naming did not appear until experiment 3, the authors also concluded that naming could not account for the observed equivalence responding. Although it is unlikely that naming emerged prior to experiment 3, the authors did not conduct a formal language assessment nor did they conduct any naming probes with familiar stimuli to ensure that the instructions used during naming probes would effectively evoke responding. This precludes the ability to firmly state that naming did not appear prior to Experiment 3 and therefore could not account for the equivalence responding. In conclusion, however, this study did demonstrate the effectiveness of the MEI procedure in generating symmetrical receptive responding and equivalence relations and most remarkably, did so with an infant.

Mechanism of action in MEI

A potential mechanism of action for MEI involves the individual participating as both a speaker and a listener in relation to the target stimulus. During MEI, certain stimuli are present throughout all training conditions and after a number of training trials involving all targeted response forms, these common stimuli could influence joint control over responding. After a sufficient number of training trials using MEI, derived relational responding is achieved as the individual learns to respond to those common
stimuli as both a speaker and a listener. For example, after a history if MEI involving vocally spelling and writing words, if a child learns to spell the word “book” vocally, when asked to write the word “book”, he or she might vocally spell (covertly or overtly) the word (respond as a speaker) and respond to his or her vocal stimulus as a listener to write the word “book”. Conversely, if a child learns to write the word “book”, when asked to vocally spell the word “book”, he or she might write the word overtly or covertly, respond to the stimulus as a speaker, and vocally produce the response “b-o-o-k”. This conceptualization of the mechanism of action for MEI most closely resembles naming theory (Horne & Lowe, 1996). According to this theory, naming is a higher-order class of behavior that involves a bi-directional relation between the stimulus and the individual’s responding to the stimulus as both a speaker and a listener. Indeed there is empirical evidence for the role of naming (responding as a speaker and a listener) in generation of emergent responding especially as it pertains to categorization skills (Horne, Hughes, & Lowe 2006; Lowe, Horne, & Hughes, 2005; Miguel, Petursdottir, Carr, & Michael, 2008), which was targeted in the present study.

Rationale for the Present Study

Despite methodological limitations in prior research, evidence exists that MEI may produce functional interdependence between verbal operants or different response forms (Fiorile et al., 2007; Greer et al., 2004; Nuzzolo-Gomez et al., 2004). The present research study was an extension of the Petusdottir et al. (2008) study, which demonstrated that training listener categorization relations did not result in the emergence of intraverbal categorization relations, and vice versa, in typically developing pre-school aged children. In turn, this study endeavored to determine the effectiveness of MEI in
generating functional interdependence between intraverbal and listener categorization repertoires. Because there is a substantial amount of research that suggests that to some degree, listener behavior generally emerges after tact training (e.g., Barnes-Holmes, Barnes-Holmes, & Cullinan, 2000; Lowe, Horne, Harris, & Randle, 2002; Wynn & Smith, 2003), the current study targeted the emergence of functional interdependence in a single relation from the listener categorization repertoire to the intraverbal categorization repertoire. Categorization skills were targeted in this study since they are a critical part of daily functioning, and emergent responding is an essential feature of categorization.
METHOD

Participants, Setting, and Materials

Participants were four typically developing children. Doug was 4 years 7 months, Sophie was 4 years 2 months, Alex was 4 years 2 months, and Rick was 3 years 10 months at the start of the study. English was the participants’ primary language and none had documented developmental delays.

Sessions were conducted at the participants’ preschool in a partitioned corner of the children’s dining area. Sessions were conducted one to two times daily depending on the participant’s willingness to come to the session, absenteeism, experimenter availability, and whether the session time conflicted with special scheduled events (e.g., field trips). Sessions occurred 5-10 times per week. One to two graduate students, and one to two undergraduate research assistants were present during each session.

Sessions were conducted at a child-sized table with 3 to 4 child-sized chairs. A folding screen was set up around the table in order to obscure the area from view and to minimize the view of potential distractions from the participants. A token board was used during sessions to help participants track their progression through the scheduled trials. Additionally, tokens were delivered for correct responding and appropriate sitting. A small audio recorder was placed on the table within the child’s view. The audio recorder was turned on during sessions to record participants’ vocal behavior. The participants had the opportunity to select a toy or snack from a large plastic tub containing small age-appropriate toys and parent-approved snacks at the end of each session. The plastic tub also contained cleaning and office supplies such as a stapler,
unused data collection sheets, binders containing stimuli (pictures of items to be used in the study), pens, clip boards, sanitary wipes, and participant folders.

A folder was assembled for each participant that contained data related to his or her performance on tasks in the study. Three-ring binders contained the stimuli that were used in the study. The stimuli were placed on sheets measuring 8.5 in x 11 in and all the pages were oriented horizontally when presented to the participants. Each sheet was placed inside a page protector. The tact training binder contained the stimuli used to train the participants to label (tact) each of the novel stimuli. One picture (stimulus) was shown on each sheet. The listener training binder contained the stimuli used to train the participants to point to each of the novel stimuli upon the experimenter's request. There were pictures of three stimuli per sheet.

The preexperimental listener categorization training of familiar stimuli binder contained stimuli to test for the participants' ability to respond to instructions to engage in listener categorization responding (e.g., "Which one is food?"). The pictures of the stimuli were in a horizontal line across a sheet of paper and there were three stimuli per sheet. The binder contained stimuli typically familiar to preschool-aged children such as a dog, a hot dog, a shirt, etc.

The listener categorization training/probes of novel stimuli binder contained novel stimuli to be targeted during listener categorization training and probes. Stimuli on each sheet belonged to three separate categories: the target stimulus, one from an alternate category (positive comparison), and one from an untrained category (negative comparison) of similar stimuli (e.g., a picture of a region in the west of India, a picture of
a region in Japan, and a region from an untrained country). Refer to Figure 1 for pictures of the experimental stimuli.

**CATEGORY 1 – “JAPAN”**

- Sapporo (Japan)
- Kyoto (Japan)

**CATEGORY 2 – “WEST”**

- Bombay (W. India)
- Udaipur (W. India)

**CATEGORY 3 – “EAST”**

- Darjeeling (E. India)
- Calcutta (E. India)

Figure 1. Visual depiction of three sample categories and their stimuli
The *data collection sheets* were used during the study to collect data during each phase: 1) listener and intraverbal categorization testing/training with familiar stimuli, 2) tact training with novel stimuli, 3) listener training with novel stimuli, 4) listener categorization training with novel stimuli, 5) intraverbal categorization test probes, and 6) MEI.
DATA COLLECTION

Dependent Variables

The primary dependent variable was the emission of untrained intraverbal categorization responses after initial listener categorization training before and after MEI. Note that for one participant (Sophie), examination of the reverse relation was attempted, (training of the intraverbal categorization responses and probes for the untrained listener categorization responses); however, she displayed perfect (100%) interdependence during baseline probes. Consequently, only the listener-to-intraverbal categorization relation was examined for all four participants. For example, after training the participant to point to the Japanese character, “Na” in response to the instruction, “Which one is Japanese?”, a probe for the participant’s untrained emission of the vocal response “Japanese” in response to the instruction, “Na is _____” was conducted. Additionally, data were collected on the participants’ responding during tact and listener training of the exemplar stimuli, pre-experimental listener and intraverbal categorization training, listener and intraverbal categorization training/probing of novel stimuli, and listener and intraverbal categorization training of the multiple exemplar instruction (MEI) stimuli sets.

Response Measurement

Tact training involved training participants to tact novel experimental stimuli. Independent responses were operationally defined as emission of the correct tact within 10 s of the instruction, “What is it?” A response was counted as incorrect if the participant emitted the incorrect tact or did not respond within 10 s of the experimenter’s instruction. Data were analyzed as a total number of correct responses out of a possible
eight opportunities per set. The mastery criterion was 100% responding for all eight stimuli under extinction.

**Listener training**

**Listener training** involved training the participants to point to the novel experimental stimuli upon the experimenter's instruction (e.g., "Which one is Kyoto?"). An independent response was operationally defined as pointing to the correct stimulus within 10 s of the experimenter’s instruction. A response was counted as incorrect if the participant pointed to the incorrect stimulus or did not respond within 10 s of the experimenter's instruction. Data were analyzed as a total number of correct responses out of a possible eight opportunities per set. The mastery criterion was 100% responding for all eight stimuli under extinction.

**Listener categorization training/testing**

For **listener categorization training/testing**, an independent response was operationally defined as pointing to the correct stimulus within 10 s of the experimenter's instruction (e.g., "Which one is an animal?"). A response was counted as incorrect if the participant pointed to a stimulus that did not belong to the category in the experimenter’s instruction or did not respond within 10 s of the experimenter’s instruction. Data were analyzed as the total number of correct responses out of a possible eight. The mastery criterion was 100% for all eight stimuli under extinction. Two stimuli from four categories comprised the eight stimuli. Categories that were targeted were animals, food, clothes, and toys.
Intraverbal categorization training/testing

For **intraverbal categorization training/testing**, an independent response was operationally defined as emitting the correct vocal response to the experimenter’s instruction (e.g., “A ball is ____”). A response was considered incorrect if the participant emitted the incorrect vocal response to the experimenter’s instruction or did not emit the response within 10 s of the experimenter’s instruction. Data were analyzed as total number of correct responses out of a possible eight. The mastery criterion was 100% independent responding for all eight stimuli under extinction. As was the case with listener categorization training/testing, two stimuli from four categories comprised the eight stimuli.

Listener and intraverbal categorization training/probes

**Listener and intraverbal categorization training/probes** were conducted with novel stimuli. For **listener categorization training**, an independent response was operationally defined as pointing to the correct stimulus within 10 s of the experimenter’s instruction (e.g., “Which one is North?”). A response was considered incorrect if the participant pointed to the incorrect stimulus or did not point to the correct stimulus within 10 s of the experimenter’s instruction. Each stimulus was presented with one positive comparison stimulus and one negative comparison stimulus. For **intraverbal categorization probes**, an independent response was operationally defined as emitting the correct vocal response within 10 s of the experimenter’s instruction (e.g., “Bombay is ____”). A response was considered incorrect if the participant emitted an incorrect vocal response to the experimenter’s instruction or did not emit the response within 10 s of the experimenter’s instruction. These data were analyzed and reported as a total.
number of correct responses out of a possible 20 responses. The mastery criterion for listener categorization training sessions was 100% independent responding for all 20 stimuli under extinction. The mastery criterion for intraverbal categorization probe sessions was 80% or higher of independent responding for all 20 stimuli under extinction.

*Multiple exemplar training*

*Multiple exemplar training* involved training a new set (Set A) using eight stimuli alternating between intraverbal and listener categorization trials. There were four stimuli included which served as negative comparisons during listener categorization training. Independent and incorrect responses for each type of categorization training were operationally defined as described in the section above. Data were analyzed and reported as a total number of correct responses out of a possible 32 responses. Mastery criterion was 100% independent responding for one trial block under extinction per stimulus. This resulted in a total of eight trial blocks of four trials for each stimulus, for a total of 32 trials (16 listener trials and 16 intraverbal trials).

*Interobserver agreement*

A second observer independently collected interobserver agreement (IOA) data across tact and listener training, listener and intraverbal categorization training with familiar stimuli, listener and intraverbal categorization training with novel stimuli, intraverbal categorization probes, and MEI conditions. An agreement was scored for each trial in which the experimenter and the observer both recorded the same correct or incorrect response. Point-by-point agreement was calculated for each session by dividing the number of agreements by the sum of agreements and disagreements and multiplying
Interobserver agreement was collected for all four participants and was acceptable. Please refer to Table 1 for the outcomes of the IOA analysis for each participant.

<table>
<thead>
<tr>
<th>Experimental Condition</th>
<th>Doug</th>
<th>Sophie</th>
<th>Alex</th>
<th>Rick</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tact</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Trials</td>
<td>93</td>
<td>97</td>
<td>99</td>
<td>96</td>
</tr>
<tr>
<td>Average (%)</td>
<td>99.17</td>
<td>99</td>
<td>99</td>
<td>99</td>
</tr>
<tr>
<td>Range (%)</td>
<td>75-100</td>
<td>87-100</td>
<td>87-100</td>
<td>75-100</td>
</tr>
<tr>
<td><strong>Listener</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Trials</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Average (%)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Range (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Listener/IVB cat (familiar)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Trials</td>
<td>100</td>
<td>92</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Average (%)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Range (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Listener cat training (Novel)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Trials</td>
<td>100</td>
<td>85</td>
<td>94</td>
<td>100</td>
</tr>
<tr>
<td>Average (%)</td>
<td>98.75</td>
<td>100</td>
<td>99</td>
<td>99</td>
</tr>
<tr>
<td>Range (%)</td>
<td>85-100</td>
<td></td>
<td>99-100</td>
<td>97-100</td>
</tr>
<tr>
<td><strong>IVB cat probes (Novel)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Trials</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
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<tr>
<td>Average (%)</td>
<td>100</td>
<td>99</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Range (%)</td>
<td></td>
<td>95-100</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MEI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Trials</td>
<td>79</td>
<td>96</td>
<td>95</td>
<td>90</td>
</tr>
<tr>
<td>Average (%)</td>
<td>100</td>
<td>99</td>
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</tr>
<tr>
<td>Range (%)</td>
<td></td>
<td>97-100</td>
<td>97-100</td>
<td>97-100</td>
</tr>
</tbody>
</table>

Table 1. Outcomes of IOA analysis for each participant
PROCEDURES

General Teaching Procedures

Similar prompting and error correction procedures were used throughout all the experimental conditions. For the conditions that involved motor responses (listener training and listener categorization training of familiar and novel stimuli), pointing to the correct response independently within 10 s of the instruction (e.g., “Which one is South?”), produced enthusiastic praise by the experimenter (e.g., “Wow! That’s right!”). For all conditions that involved speaker behavior (tact training and intraverbal categorization training of familiar and novel stimuli), emission of the correct response independently within 10 s of the instruction (e.g., “What is it?”), produced enthusiastic praise by the experimenter. Tokens were provided on an intermittent schedule of reinforcement (e.g., FR 2 to FR 4 depending on how many more trials remained in the block and whether responses were newly acquired or well established) contingent only on the emission of an independent response. If the participant pointed to the incorrect response or did not respond within 10 s of the experimenter’s instruction during conditions that involved motor responses, the experimenter provided a point prompt and a verbal prompt (e.g., “It’s this one. Can you point to it?”). If the participant emitted the incorrect response or did not respond within 10 s of the experimenter’s instruction during tact and intraverbal categorization conditions, the experimenter provided an echoic prompt (e.g., “South. Can you say it?”). Imitation of the experimenter’s model produced praise (e.g., “You’re right!”) and no imitation or pointing to or emission of a response other than the target stimulus resulted in additional point and verbal prompts. Prompts were provided until the participant pointed to or emitted the correct stimulus. After the
participant was able to independently point to all the stimuli on an FR 1 schedule of reinforcement, the experimenter re-presented the stimuli under extinction.

Preliminary Conditions

Upon giving permission for their child to participate, a preference survey was conducted with the participants’ parents. They were asked to list and rank their child’s favorite foods and toys. The assessment also included information regarding food allergies, or items that they preferred their child not be given as rewards during the study. The results of the survey were used to select toys and snacks that were made available to the children upon the completion of each session.

The experimenter conducted an informal echoic assessment with each participant. She read a list of words that were used during tact and listener training, and during intraverbal and listener categorization training and probes. The experimenter asked the participant to repeat each word, for example “Say Jaffna.” This assessment was conducted to ensure that the participants were able to respond to the echoic prompts. The names of stimuli were modified as necessary to accommodate the participants’ ability to imitate (e.g., “Jeeling” was used for the target “Darjeeling”). Participants were not excluded from participating in the study based on their ability to imitate the stimulus name.

During the tact training condition, the experimenter taught the participants to vocally tact the stimuli in Set 1 (eight stimuli - including positive and negative comparison stimuli), Set 2 (MEI – eight stimuli), and Set 3 (eight stimuli - including positive and negative comparison stimuli). Each set was comprised of four categories with two stimuli per category. Additionally, participants were taught to tact stimuli from
similar but untrained categories (eight additional stimuli) that served as negative comparisons. Participants were initially trained to tact 24 stimuli in total. Additional sets of stimuli (eight stimuli per set) were trained if the participants required a second round of MEI or if additional replication sets were required. The experimenter presented the picture of the stimulus on the table in front of the participant and provided the instruction, “What is it?” Tact maintenance trials were typically conducted every other session in alternation with listener maintenance trials.

During listener training, the experimenter taught the participants to point to the stimuli in Sets 1, 2, and 3. Additional sets of stimuli (eight stimuli per set) were trained if the participants required a second round of MEI or if additional replication sets were required. The experimenter presented the picture of the target stimulus along with two comparison stimuli on the table in front of the participant and provided the instruction, “Show me Kyoto.” Listener maintenance trials were conducted every other session in alternation with tact maintenance trials.

Listener and intraverbal categorization training trials were conducted with stimuli familiar to the participants. This testing was conducted to ensure that the participants were able to emit listener and intraverbal categorization responses to instructions presented in the same format as were subsequently presented to them with novel stimuli. Additionally, listener and intraverbal categorization testing with familiar stimuli was conducted at the beginning of nearly every session except during MEI.

Listener categorization training involved teaching the participants to point to the stimulus that corresponds to the category provided in the experimenter’s instruction (e.g., Point to the cat in response to the instruction “Which one is an animal?”). An
independent response was operationally defined as pointing to the correct stimulus within 10 s of the experimenter's instruction. *Intraverbal categorization training* involved teaching the participants to emit the name of the category that corresponds to the stimulus provided in the experimenter's instruction (e.g., Said "animal" in response to instruction "A cat is __"). An independent response was operationally defined as emission of the correct response within 10 s of the experimenter's instruction.

*Listener categorization training with novel stimuli* was conducted with one set of experimental stimuli (eight stimuli). Training was identical to the procedure described above except stimuli unfamiliar to the participants, were used. Additionally, negative comparisons were used during listener categorization training. An independent response was operationally defined as pointing to the correct stimulus within 10 s of the experimenter's instruction ("Which one is West?").
EXPERIMENTAL EVALUATION

The *experimental design* used to evaluate the effects of MEI on functional interdependence between intraverbal and listener categorization repertoires was a nonconcurrent multiple-baseline design across participants. Participants were trained to engage in listener categorization responses for a set of stimuli (Set 1 for Doug, Sophie, and Rick and Set 2 for Alex). Probes for intraverbal categorization responses were conducted during the baseline condition. Multiple exemplar instruction was conducted with a different set of stimuli (MEI A). After MEI was conducted, listener categorization probes were conducted with Sets 1 or 2 to ensure responding was still occurring at mastery criterion. If responding fell below mastery criterion, then listener categorization responses were re-trained until mastery criterion was achieved. If responding was still at mastery criterion, then intraverbal categorization responses were probed with the original set of stimuli (Set 1 for Doug, Sophie, and Rick and Set 2 for Alex). After this, listener categorization training was conducted with a new set (e.g., Sets 2 and 3 for Doug and Set 3 only for Sophie). For example, if a participant was originally taught listener categorization with Set 1 and subsequently probed for intraverbal categorization responses, then he was taught listener categorization responses for Set 3 and subsequently probed for intraverbal categorization responses. After this, intraverbal categorization responses with the new sets were probed. The order of trial presentations was preprogrammed in trial blocks. Please refer to Figure 2 for a flowchart displaying the experimental conditions of the study.
Tact Training: Novel Exemplar

Listener Training: Novel Exemplars

Intraverbal/Listener Categorization Training: Familiar Exemplars

Listener Categorization Training: Novel Exemplars (First Set)

Intraverbal Categorization Pre-MEI Probe: Novel Exemplars (First Set)

MEI (A)

Listener Categorization Probe: Novel Exemplars (First Set)

Intraverbal Categorization Probe: Novel Exemplars (First Set)

Intraverbal Categorization Mastered: (First Set)

Listener Categorization Training: (Second Set)

Intraverbal Categorization Probe: (Second Set)

Intraverbal Categorization NOT Mastered: (First Set)

MEI (B)

Listener Categorization Probe: (First Set)

Intraverbal Categorization Probe: (First Set)

Figure 2. Flowchart depicting the study's conditions
After listener categorization training was conducted with Set 1, intraverbal categorization baseline probes were conducted. For example, after training the participant to point to an outline of Delhi and Leh in response to the instruction, “Which one is North?”, a probe was conducted to see if the participant emitted the response “North” in response to the instruction, “Leh/Delhi is ______.” If the participant failed to emit the vocal response or emitted the incorrect response within 10 s of the experimenter’s instruction, the experimenter terminated the trial and presented a new trial. If the participant emitted the correct response, the experimenter presented a new trial. Correct and incorrect responses did not result in any differential consequences on the part of the experimenter. Baseline was conducted until each stimulus within each of the categories (two categories – four stimuli) was presented five times for a total of 20 trials.

After the baseline condition, multiple-exemplar instruction (MEI) was conducted with a second set of stimuli (Set A). The participant was taught to point to or vocally emit the correct response within 10 s of the experimenter’s instruction (“Which one is Armenian?” or “Poro is ______”). Four categories (eight stimuli) were targeted. Blocks of four trials were presented, each of which contained two trials of intraverbal categorization training and two trials of listener categorization training alternating between trial types. Only one stimulus was targeted per trial block. Data were graphed and analyzed per trial as total number of correct responses out of a possible 16 correct per categorization type. Refer to Figure 3 for an illustration of two sample trial blocks of MEI.
List: "Which one is....?"

IVB: "Exemplar name is....?"

Block 1

<table>
<thead>
<tr>
<th>Type</th>
<th>SD</th>
<th>Correct Resp.</th>
<th>Comparisons</th>
<th>C</th>
<th>I</th>
<th>Echoic</th>
<th>Tact</th>
<th>R-IVB</th>
<th>Instr?</th>
<th>Praise?</th>
<th>Prompt?</th>
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<tbody>
<tr>
<td>IVB</td>
<td>Poro</td>
<td>Japan</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LIST</td>
<td>Japan</td>
<td>Baa</td>
<td>T'oh, Sapporo</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>IVB</td>
<td>Poro</td>
<td>Japan</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>LIST</td>
<td>Japan</td>
<td>Vev</td>
<td>Poro, Aswan</td>
<td></td>
<td></td>
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Block 2

<table>
<thead>
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<th>Correct Resp.</th>
<th>Comparisons</th>
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Figure 3. A depiction of two blocks during MEI

After MEI training was conducted with Set A, post-MEI test probes for intraverbal categorization responses were conducted again with Sets 1 or 2. Before the probes for intraverbal categorization responses were conducted, probes for listener categorization responses were conducted to ensure the participants were responding to mastery criterion. If the participant was not responding to mastery criterion, then listener categorization training was conducted until responding to mastery criterion was re-achieved. After this, probes for intraverbal categorization responses were conducted. Probes were identical to those described under the baseline condition. If the participant responded to mastery criterion for listener categorization responses, then probes for intraverbal categorization responses were conducted right away. If responding for
intraverbal categorization responses was at mastery criterion (80% or higher), then a new set was introduced and tested.

If mastery criterion responding was achieved during intraverbal categorization probes for set 1, listener categorization training was conducted with a new set (e.g., Set 3). Prior to listener categorization training with Set 3 for Sophie, an intraverbal categorization probe was conducted with Set 3. This step was conducted to demonstrate that the participant was unable to emit intraverbal categorization responses prior to listener categorization training. This step was not conducted with Doug due to experimenter error. Given the advanced nature of the targeted stimuli (pre-school aged children were unlikely to come into contact with characters from foreign writing systems or outlines of foreign countries during their daily daycare activities), however, it is very unlikely that Doug would be able to emit intraverbal categorization responses for Sets 2 and 3 in the absence of listener categorization training. Listener categorization training was conducted with Set 3. Immediately after mastery criterion responding was achieved during listener categorization training, probes for intraverbal categorization responses were conducted for Sets 2 or 3. Each stimulus in the set (two categories – four stimuli total) was presented five times each for a total of 20 presentations. These data were analyzed and reported as a total number of correct responses out of a possible 20 responses. If the probes for intraverbal categorization responding were at 80% or higher for 20 total presentations, the participant was dismissed from the study.

If responding during intraverbal categorization probes after MEI for Sets 1 or 2 was not at mastery criterion, additional MEI was conducted with a new set (Set B) which contained four categories for a total of eight stimuli. This initially involved tact and
listener training for all eight stimuli. The mastery criterion for tact and listener training was the same as was for the originally trained Sets 1 through 3. After tact and listener training were completed, MEI was conducted with Set B. The mastery criterion for MEI (B) was the same as was for set MEI (A).

After MEI was conducted to mastery criterion for Set B, probes were again conducted with Set 1. Before the probes for intraverbal categorization responding were conducted, probes for listener categorization responding were conducted to ensure the participants were responding to mastery criterion. If the participant was not responding to mastery criterion, then categorization training was conducted until responding to mastery criterion was achieved. After this, probes for intraverbal categorization responding were conducted. Probes were identical to those described under the baseline and first post-MEI testing conditions.

If the participant was responding to mastery criterion for listener categorization responding, then probes for intraverbal categorization responding were conducted immediately. As described above, a new set was introduced at this time. If responding to mastery criterion was not achieved after a second round of MEI with Set B, then the participant was dismissed from the study. If mastery criterion was not achieved for intraverbal categorization responding for Sets 1 and 3 after MEI (B), the participant was dismissed from the study.
PROCEDURAL FIDELITY

In an effort to ensure correct and consistent implementation of the treatment procedure during tact and listener training, listener and intraverbal categorization training with familiar stimuli, listener categorization training with novel stimuli, intraverbal categorization probes, and MEI phases of the study, a secondary observer was present and recorded antecedents and consequences delivered by the experimenter on each trial. A trial was scored as correct if the experimenter delivered the instruction, prompts, and consequences appropriate to the phase and the child's response. Finally, point-by-point IOA was assessed on all procedural fidelity measures.

During the tact training phase the observer recorded whether the experimenter provided the appropriate instruction (e.g., “What is it?”), presented the participant with a picture of the target stimulus, and provided echoic prompts within 10 s of the instruction. In addition, the observer recorded whether the experimenter provided verbal praise for independently tacting the stimulus or for imitating the experimenter’s model (e.g., “Good job. That’s right!”).

During the listener training phase, the observer recorded whether the experimenter provided the appropriate instruction (e.g., “Which one is ___?”), presented the participant with a picture of the target stimulus along with 2 comparison stimuli, and provided point prompts within 10 s of the instruction. In addition, the observer recorded whether the experimenter provided verbal praise for independently pointing to the stimulus or for imitating the experimenter’s model (e.g., “That’s right! Way to go!”).

During listener categorization training phases, the observer recorded whether the experimenter provided the appropriate instruction (e.g., “Which one is food?”), presented
the participant with a picture of the target stimulus along with 2 comparison stimuli, and provided point prompts within 10 s of the instruction. In addition, the observer recorded whether the experimenter provided verbal praise for independently pointing to the stimulus or for imitating the experimenter’s model (e.g., “That’s right! Way to go!”).

During intraverbal categorization training phases, the observer recorded whether the experimenter provided the appropriate instruction (e.g., “A doll is ____?”), and provided echoic prompts within 10 s of the instruction. In addition, the observer recorded whether the experimenter provided verbal praise for independently emitting the correct vocal response or for imitating the experimenter’s model (e.g., “That’s right! Way to go!”).

During intraverbal categorization probes phases before and after MEI, a second observer recorded whether the experimenter provided the appropriate instruction (e.g., “Jeeling is ____?”). Additionally, the observer recorded whether the experimenter provided any prompts or consequences.

During MEI, a second observer recorded whether the experimenter provided the appropriate instruction (e.g., “Which one is Hebrew?” – listener categorization; “Shin is ____” – intraverbal categorization), and provided a picture of the target stimulus and 2 comparison stimuli (during listener categorization trials only). Additionally, the observer recorded whether the experimenter provided the appropriate prompts and consequences and whether the experimenter alternated between listener and intraverbal categorization trials.

For Doug, procedure fidelity (PF) was assessed across 97% of all experimental conditions and averaged 99% (range, 75 to 100). Interobserver agreement on Doug’s PF
measure was assessed across 63% of all experimental conditions and averaged 99% (range, 62 to 100). For Sophie, PF was assessed across 95% of all experimental conditions and averaged 99% (range, 88 to 100). Interobserver agreement on Sophie’s PF was assessed across 52% of all experimental conditions and averaged 99% (range, 88 to 100). For Alex, PF was assessed across 99% of all experimental conditions and averaged 99% (range, 98 to 100). Interobserver agreement on Alex’s PF was assessed across 63% of all experimental conditions and averaged 99% (range, 95 to 100). For Rick, PF was assessed across 96% of all experimental conditions and averaged 99% (range, 91 to 100). Interobserver agreement on Rick’s PF was assessed across 42% of all experimental conditions and averaged 99% (range, 75 to 100).
RESULTS

Tact and Listener Training

Results for all four participants’ performance during tact training are depicted in Figure 4 and their performance during listener specific training are depicted in Figure 5.

![Graphs showing performance during tact training for all participants]

Figure 4. Number of correct responses during tact training for all participants

Doug required 95 trials to master four sets of stimuli (32 stimuli total) during tact training ($M$ trials per set = 23; range, 19 to 29). No additional training was required to teach the listener specific responses for the four sets of stimuli. Doug was able to select the correct responses at 100% under extinction by the second trial. The first trial was conducted under FR 1 so it may have been the case that he would have been able to master listener specific training on the first trial had we started with a probe under extinction.
Sophie required 122 trials to master five sets of stimuli (40 stimuli total) during tact training (\(M\) trials per set = 26; range, 14 to 32). Sophie mastered all five sets (40 stimuli) during listener specific training on the first trial, which was conducted under extinction.

Alex required 139 trials to master four sets of stimuli (32 stimuli total) during tact training (\(M\) trials per set = 35; range, 25 to 55). During listener specific training, he required three trials to master the first set (eight stimuli) and required only one trial for the remaining three sets (24 stimuli). Rick required 92 trials to master four sets of stimuli (32 stimuli) during tact training (\(M\) trials per set = 23; range, 14 to 44). Rick was able to master all four sets of stimuli (32 stimuli) during listener specific training on the first trial.
Listener and Intraverbal Categorization Training (Familiar Stimuli)

Results for all four participants' performance for listener/intraverbal categorization training with familiar stimuli are depicted in Figure 6.

![Graphs showing performance of four participants.]  

Figure 6. Number of correct responses during listener and intraverbal categorization training (with familiar stimuli) for all participants.

Doug was able to master all eight stimuli by the second trial block (eight stimuli targeted per trial block). During the eighth session, he emitted an echoic response during a
listener trial and a tact response during a listener trial. Sophie required three trial blocks (three sessions) to master both intraverbal and listener categorization responding. Her responding was 100% for listener categorization responses from the initial trial but she required three trial blocks before achieving mastery for the intraverbal categorization responses. Alex required two trial blocks to obtain the mastery criterion. During the initial trial block, listener categorization responses were at 100%, but he missed three of the intraverbal categorization targets. It took Rick four trial blocks to achieve the mastery criterion. During the first two trials he missed both intraverbal and listener responses. At the sixth trial block (6th session during which listener/intraverbal categorization training with familiar stimuli was conducted), Alex requested to play “teacher” during which he would present intraverbal categorization trials to the experimenter which included the novel stimuli, familiar stimuli targeted in the study and common stimuli not targeted in the study (e.g., “A leaf is ____”). He corrected her incorrect responses and provided her with tokens for correct responses.

**Listener Categorization Training of Novel Stimuli**

Results for all four participants’ performance during listener categorization training are depicted in Figures 7 and 8.

Doug required a total of five trial blocks (20 trials per trial block) to master listener categorization training for Set 1, four trial blocks for Set 2, and four trial blocks for Set 3. Sophie required a total of five trial blocks to master listener categorization training for Set 1, and seven trial blocks for Set 3. Alex required four trial blocks to master listener categorization training for Set 2. However, during the second trial block under extinction he scored only 60% correct and said, “I don’t know any of these in this
book”. After this, only three more trial blocks were required for Alex to achieve mastery again.

For the remainder of the study, he responded at or near mastery under extinction. During two trials, he echoed the word “East.” Rick required four trial blocks to master listener categorization training for Set 1.

Figure 7. Number of correct responses during listener categorization training for Doug (3 sets)
Figure 8. Number of correct responses during listener categorization training for Sophie (2 sets), Alex, and Rick

*Multiple-Exemplar Instruction*

Results for all four participants' performance during MEI is depicted in Figures 9 and 10.
Figure 9. Number of correct responses during MEI (Set A) for all participants

Each trial targeted eight categories that were grouped into blocks of four trials (two listener categorization trials and two intraverbal categorization trials). Doug achieved mastery (100% under extinction) by trial 14 for MEI Set A. However, his performance declined (88%) during the next trial under extinction. Mastery was achieved again by trial 24. Doug only required MEI training with one set. Sophie required 37 trials before she achieved mastery for MEI Set A. Throughout training trials 14-27, she would imitate categories and their members ("Japan", "Brew") or make comments regarding the
difficulty of this task (e.g., “This is hard.” “I was close.” “That’s kinda hard.” “I keep forgetting.”)

Figure 10. Number of correct responses during MEI (Set B) for Sophie, Alex, and Rick

Sophie required 33 trials before she achieved mastery for MEI Set B. Alex required 43 trials to achieve mastery for MEI Set A. It is important to note that until mastery was achieved he would obtain 100% under FR 1 and miss only one or two when tested under extinction. This happened for nearly 28 trials. Concerned that this decline in responding may have been a function of the schedule of reinforcement, after he achieved a score of 97% under extinction on trial 39, the experimenter implemented an FR 4 schedule of reinforcement under which he achieved responding at 100% for three trial blocks before
achieving mastery (100% under extinction) by trial 43. For MEI Set B, Alex required 56 trials before mastery (100% under extinction) was achieved. As was the case for MEI Set A, for most trials prior to mastery Alex would only miss one to four responses during extinction trials. Rick required 40 trials to achieve mastery (100% under extinction) for MEI Set A. As was the case with Alex, he would achieve 100% under FR 1 but miss only one or two when probed under extinction. During trials 30 and 31, Rick imitated five member and category names per trial (e.g., “Brew”, “Lanka”, “Armenian”, “Japan”). Due to time constraints and concern of a potential decline in motivation, the experimenters modified the mastery criterion for MEI from 100% to 80%, such that the participant would have to score 26 or higher out of 32 under extinction to achieve mastery. Using the new mastery criterion, Rick required 32 trials to master MEI Set B.

Primary Experimental Evaluation (Intraverbal Categorization Probes)

Baseline. Results for all four participants’ performance during intraverbal categorization probes pre- and post-MEI training are depicted in Figure 11. During baseline, Doug scored 45% for Set 1. He responded with targets from both categories. For Sophie and Rick, for whom Set 1 was initially targeted, they scored 0% during baseline. For Alex, for whom Set 2 was initially targeted, he scored 0% during baseline.

Post MEI (A). After ensuring listener categorization responses for Set 1 were still at mastery, intraverbal categorization probes were conducted with all four participants. Doug responded with 100% under extinction during the first post MEI probe. In attempts to replicate these robust effects, probes were conducted with Sets 2 and 3. Listener categorization responses were tested for Sets 2 and 3 before each intraverbal categorization probe was conducted to ensure that responding was still at mastery.
Additionally, MEI (A) was tested before each intraverbal categorization probe to ensure responding was still at mastery. During the probes with Set 2, Doug initially scored 50%. A second probe with Set 2 resulted in a score of 90%. In response to these mixed results, another intraverbal categorization probe was conducted with Set 3. During the initial probe with Set 3, Doug scored 50%. He was able to provide the responses for one
category (African countries) but missed all of the targets for the other category (Greek writing characters). A second probe was conducted with Set 3 and this time, Doug scored 70%. Interestingly, this time he was able to provide all the Greek targets and missed one African target four times and one other African target one time. Given the mixed results, probes for Set 3 were conducted a third time. This time Doug responded with 95% and missed only one African target. Due to experimenter error, intraverbal categorization probes for Sets 2 and 3 were not conducted before listener categorization training for each set was conducted.

For Sophie, two probes with Set 1 resulted in a score of 0% both times. During both probes, Sophie shrugged during each trial and said “I don’t know these” or “I don’t know”. For Alex and Rick, probes with Sets 2 and 1 respectively, resulted in scores of 0% for each probe. For Alex, on the second probe post MEI (A), he emitted an echoic (yoo) on the first trial and said nothing for the remainder of the trials. During the third probe post MEI (A), he repeatedly said, “I don’t know” and “nothing”. Toward the end of the probe he said, “I said ‘Shah’. Can’t you hear me? What’s on your mind?” For Rick, during the first probe post MEI (A), he emitted the exemplar and category names for stimuli targeted during tact and MEI (A) training (e.g., brew, lanka, yoo) for 8 out of the 20 trials. Neither of the category names (brew and lanka) was correct for the targeted set (Set 1). During the second post MEI (A) probe, he emitted three exemplar names (madras, senza, and chi) one time each, and then names of random common stimuli not targeted in the study (e.g., apple head, pancake, leaf, clock, coconut, milk) for 13 trials. Madras was a target in Set 1, so this response was functionally an echoic.
Post MEI (B). A second set of MEI (B) training was conducted with Sophie, Alex, and Rick. During the first probe for Set 1, Sophie scored 45%. During the second probe with Set 1, Sophie scored 95% and remarked, “That’s kinda hard. I know you have to say South and Arabic now.” South and Arabic were the two categories that were targeted with Set 1. In an effort to replicate the effects achieved with Set 1, intraverbal categorization probes were conducted with Set 3. Before listener categorization training for Set 3 was conducted, intraverbal categorization probes were conducted and Sophie scored 0%. The first intraverbal categorization probe post listener categorization training resulted in a score of 0%. Two more intraverbal categorization probes with Set 3 resulted in a score of 50%. Alex scored 20% on his intraverbal categorization probe. During the probe post MEI (B), Alex emitted category names targeted during MEI (A) and MEI (B) (inese, german, japan) and he emitted the correct category name “East” during three consecutive (east) trials and during one trial near the end of the probe. Rick scored 0% on this intraverbal categorization probe. He did not respond during the probe. Time constraints prohibited more than one intraverbal categorization probe post MEI (B) for Alex and Rick.
DISCUSSION

The results of this study extend the literature on MEI by demonstrating that it was not effective in producing functional interdependence between listener and intraverbal categorization repertoires. Previous research demonstrated functional independence between these two categorization response forms (Petursdottir et al., 2008). This study examined the efficacy of MEI in the form of alternating categorization response forms (listener and intraverbal) in producing emergent intraverbal categorization responding after training listener categorization responses. Four typically developing children between the ages of 3 and 4 years participated in the study.

For Doug, for whom only one MEI set was trained, there was an initial improvement in responding from baseline (45% correct) to the initial post-MEI-testing probe (100% correct). However, two post-MEI attempts at replicating the effect (with Sets 2 and 3) produced the same response pattern with respect to number of correct responses, observed from the original baseline probe to the initial post-MEI probe (i.e., 45%-50% correct with the first probe to 90%-100% correct during the second probe). Given the aforementioned response pattern and that after every intraverbal categorization probe, listener categorization probes and MEI probes were conducted to ensure that responding was still at mastery criterion before second and third probes were conducted, it is more likely that practice effects contributed to the improvement in responding and not MEI.

Doug’s responding during MEI may provide additional information regarding his significantly superior categorization responding compared to the other participants in the
study. He required only 14 trials to achieve mastery with MEI (A), which was one-third less than the number of trials to mastery required by the other participants (see Figure 8). Additionally, he only required training with one set of MEI compared to the other participants, all of whom required training with two sets. This may indicate a more extensive history with respect to categorization training compared to the other participants, and hence a stronger categorization repertoire.

It is plausible that Doug engaged in some sort of covert responding that produced the emergent intraverbal categorization responding observed during baseline and post-MEI probes. To better understand these outcomes, a consideration of naming theory is warranted. Naming constitutes a relation between a stimulus, a specific speaker behavior, and the corresponding listener behavior (Horne & Lowe, 1996; Lowe, Horne, Harris, & Randle, 2002). When an individual has learned to respond to a given stimulus as both a speaker and a listener, it can be said that he has acquired naming. Echoic responding in the presence of the stimulus figures prominently in the establishment of the naming relation. For example, if an individual is taught to respond to a book as a listener by pointing to the book upon hearing the word "book" spoken, he may initially imitate the original response as he points to the book and receive praise for this response. This would function to strengthen the speaker response in the presence of the stimulus. He would then be able to respond to his own listener behavior as a speaker and emit the response "book" in the presence of the book and in response to the instruction "What is it?"
A critical feature of the naming account is that many stimuli may come to produce a common speaker and listener response, heavily implicating the naming relation in the establishment of categorization (Lowe et al.). For example, an individual may learn to emit a listener response (point to) in the presence of a book, a picture of a book, and the written word "book" upon hearing the word "book". Through echoic responding, the emission of the word may be strengthened in the presence of any of these three stimuli. In responding to one of these stimuli as a speaker, he may respond to his own speaker behavior as a listener and orient his responding to all three stimuli. Features of stimuli that are common to conditions under which the listener and speaker behavior are learned (the sight of the book and the auditory stimulus "book") may come to exert joint contextual control over responding and result in emergent responding. For example, during listener categorization training, when the experimenter asked Doug, "Which one is South?", he was taught to point to the outline of the cities Madras and Cochin. While pointing to Madras and Cochin, he may have responded to his own listener behavior (pointing to the picture of Madras or Cochin) as a speaker and covertly tacted the exemplar and echoed the corresponding category ("Madras, South" and "Cochin, South"). During intraverbal categorization probes, the experimenter asked Doug "Madras is ____?", during which time he may have engaged in covert responding "Madras, South", established during listener categorization training, and then emitted the response "South". Teaching Doug to respond to both Madras and Cochin as a listener to a common name (South), may have then resulted in Doug responding to both Madras and Cochin as a speaker using a common name (South). The auditory stimulus "Madras",
served as a stimulus common to both instructional contexts, possibly resulting in joint contextual control over both instructional contexts (listener and intraverbal categorization) and influencing the establishment of functional interdependence. The listener categorization probes conducted prior to each intraverbal categorization probe to ensure mastery of responding, may have afforded Doug additional opportunities to engage in the relevant listener and speaker behaviors to produce functional interdependence. While consideration of the naming theory offers a cohesive and parsimonious explanation for Doug’s performance, this account remains speculative as experimental control for potential covert responding was not possible and hence, inferred.

The alternating format of MEI training in this study was the critical feature that would presumably result in functional interdependence between both categorization response types. This is a fair conclusion given the temporal proximity unique to the alternating trials format and positive outcomes using this format in previous MEI studies (Fiorile et al., 2007; Greer et al., 2004; Greer et al, 2005). The assumption was that this temporal proximity along with stimuli common to both instructional contexts (listener and intraverbal categorization trials) would create a history of reinforcement that would produce joint contextual control over responding and result in functional interdependence. Based on evidence of emergent responding during baseline probes, the similar response pattern between baseline to post-MEI probes for Set 1 and initial and second and third probes for Sets 2 and 3, Doug’s superior performance during MEI, and the fact that listener categorization and MEI probes were conducted prior to each intraverbal categorization probe, it is most likely that Doug acquired intraverbal
categorization responding for Sets 1, 2, and 3 as a result of the pre-experimental emergence of the naming relation and practice effects, and not MEI. Had MEI produced a history of reinforcement that firmly established joint contextual control over and derived relational responding between both listener and intraverbal categorization responding, it is assumed that every intraverbal categorization probe post-MEI training would have been at mastery criterion (80%) or higher. Because there was no substantial improvement in responding from baseline to post-MEI probes for Set 1 as compared to probes conducted with Sets 2 and 3, the instructional utility of MEI is questionable.

Sophie required extensive exposure to MEI (2 sets), which yielded comparatively little emergent responding. During initial probes with Set 1 post-MEI (B), Sophie scored 45% correct. A second intraverbal categorization probe resulted in 95% correct performance. Interestingly, Sophie remarked, "I know you have to say 'South' and "Arabic" now." This remark may indicate that additional exposure to the probe trials was responsible for the improvement in responding post MEI. Replication with a second set (Set 3) yielded 0% correct on the first probe and then 50% correct on the second and third probes with Set 3 post MEI (B). This sudden and significant improvement in responding between the first and second post-MEI (B) probes again suggests that additional exposure to the probe trial format may have been responsible for this pattern of responding. In addition, Sophie required nearly three times as many trials as Doug to master both MEI sets. This may indicate that she had a less extensive history with categorization training and hence a weaker categorization repertoire compared to Doug. Additionally, she initially missed some intraverbal categorization responses during listener/intraverbal
categorization training with familiar stimuli, also supporting the notion that she may have
had a weaker categorization repertoire compared to Doug. An elaboration of the
potential influence of weaker categorization repertoires is provided below.

The reverse categorization relation was originally examined with Sophie. That is,
the intraverbal categorization repertoire was trained and listener categorization responses
were probed. However, when the experimenter probed listener categorization responses
during baseline, she demonstrated 100% functional interdependence (i.e., 100% correct
on listener categorization). This provided evidence of functional interdependence
between the two categorization types in one direction (from intraverbal to listener),
indicating an emerging naming relation for Sophie. There is empirical evidence that
training speaker behavior produces the corresponding listener behavior (Barnes-Holmes,
Barnes-Holmes, & Cullinan, 2000; Lowe, Horne, Harris, & Randle, 2002; Wynn, &
Smith, 2003). Horne and Lowe (2002) stated, based on this well-established
phenomenon, that to train tacts is to effectively train naming. For Sophie perhaps those
stimuli present during intraverbal categorization training (hearing the instructor produce
the auditory stimulus of both the exemplar name and the category name (e.g., “Madras is
South”) exerted greater control over responding during listener categorization probe trials
than was the case with the reverse relation. During listener categorization training, the
experimenter provided only the auditory stimulus of the category name (e.g., “South”).
Perhaps learners with a more extensive history with respect to categorization, like Doug,
are more likely to produce, overtly or covertly, the auditory stimulus of the exemplar
name (e.g., “Madras”) during listener categorization training trials than those learners
who have less experience with categorization. As such, the learner produces an additional relevant auditory stimulus during listener categorization ("Madras") that will be present during intraverbal categorization probes ("Madras is ____"), which would subsequently increase the likelihood of joint contextual control over, and hence functional interdependence between, the two categorization types. For Sophie, variable increases in intraverbal categorization with Set 3 after nearly 70 training trials of MEI may indicate that she was not producing the relevant verbal behavior during listener categorization training that would have produced emergent intraverbal categorization.

The results for Alex demonstrate that training two sets of MEI yielded minimal functional interdependence. Three intraverbal categorization probes for Set 3 post-MEI (A) training resulted in 0% correct for each probe. After a second round of MEI (B) training, intraverbal categorization probes yielded 20% correct performance. The probes in which Alex performed correctly all included the "East" target. Given that he got the same target consistently correct may indicate that functional interdependence was emerging. It is noteworthy that during listener specific training Alex missed the first three trials for the first set of eight targets, which is different from the other participants whom achieved 100% correct responding immediately after mastering tact training. This may be symptomatic of weak functional interdependence with more fundamental relations (tacts and listener responding). Additionally, Alex required 43 trials to master MEI (A) and 56 trials to master MEI (B) for a total of 99 trials for both MEI sets. This large number of training trials indicates that Alex might not have engaged in relevant verbal behavior to generate joint contextual control over the two categorization response
types. The fact that 99 MEI training trials were required to produce only four correct responses weakens the instructional utility of MEI. For Alex, categorization targets may have been too complex and perhaps MEI targeting simpler relations (tact and listener responses) is indicated along with more exposure to categorization training.

Rick required training with two sets of MEI. Two intraverbal categorization probes with Set 1 were conducted in baseline and he failed to answer correctly in both probes. After MEI (A) training, three probes with Set 1 similarly yielded 0% correct for all three probes. In the second probe, he responded with the names of the specific exemplars and in the third probe, he emitted responses that were in not related to the study (e.g., waffle head, pancake). After MEI (B), an additional intraverbal categorization probe with Set 1 resulted in 0% correct. Rick required 40 trials to master MEI (A) and 32 trials to master (under the new mastery criterion of 80%) MEI (B) for a total of 72 trials. As was the case with Alex, this large number of trials required to master MEI indicated he might not have engaged in the relevant verbal behavior to produce functional interdependence. Rick was nearly one year younger than Doug and the only participant under the age of 4 years old at the start of the study. This may be important when considering the types of skills typically targeted with children between the ages of 3.5 and 4.5 years. These skills commonly include tacts, listener responses (matching and pointing), and categorization. Three to nine months of experience with these skills can make a significant difference with respect to developing the verbal behavior necessary to establish functional interdependence.
There are a few limitations with the current study that are worth acknowledging. The mastery criterion for MEI was especially stringent (100% correct trials under extinction) and the number of targets included in MEI (32) may have been too great for this young population. As a result, it took a long time for participants to reach the mastery criteria, which may have affected motivation during experimental trials. One experimenter reports that after a few weeks of training, Sophie, Alex, and Rick engaged in “silly” behavior such as emitting verbal behavior during experimental trials not related to the study (e.g., apple-head, waffle-head), pointing to target stimuli with their noses, and wiggling in their seat. Over time, participants increasingly refused to come to sessions especially when other enjoyable activities were concurrently available (e.g., camping outside, sledding). The experimenters introduced fun activities (e.g., making a stained glass window with colored tissue paper) at the beginning of each experimental session to increase the motivation to come to session and engage with the experimenter. These activities proved to be moderately successful. However, a modification of the mastery criterion for MEI was still required for one participant. It may have been the case that waning motivation over time affected attending responses which in turn negatively impacted intraverbal categorization responding. Future research studies in this area may consider using half the number of targets during MEI training (e.g., 16 trials – two categories) and reducing the MEI mastery criterion to 80 or 90%.

Another limitation may have been the trial probe format failing to effectively evoke desired responding. Although listener and intraverbal categorization training with familiar stimuli was conducted to control for this potential problem, these trials were not
presented in the same way the listener categorization training trials and subsequent intraverbal categorization probe trials were presented. Future studies may, for example, present the listener categorization trials and the intraverbal categorization trials with familiar stimuli separately mimicking the training and probe trial formats, instead of presenting them in an alternating trial format as was done in the current study which mimicked the MEI trial format.

Future research might also examine the effects of directly training exemplar and category tacts during MEI on generating functional interdependence between listener and intraverbal categorization repertoires. During listener categorization training, it may be more effective to train the pointing response, the echoic for the category name, and the tact for the specific exemplar. For example, the experimenter would provide the discriminative stimulus, “Which one is South?” and then train the participant to point to “Madras”, then echo the category in the instruction “South” while looking at the picture of “Madras”, and tact the exemplar name “Madras”. Although previous research has indicated that multiple-tact and receptive discrimination training does not significantly influence the emission of intraverbal behavior (Miguel et al., 2005), perhaps embedding this training in an alternating format with intraverbal categorization trials in the context of MEI may teach the child to emit relevant responses that would generate joint contextual control over categorization responding and result in emergent intraverbal categorization. Previous studies found MEI to be effective when the trained responses was topographically identical to the probed responses (Nuzzolo-Gomez et al., 2004), or when acquisition of the necessary behavior to produce emergent responding was more
straightforward, as is the case between pointing and matching responses, and tact responses (Greer, Solfi, Chavez-Brown, & Rivera-Valdez, 2005; Greer, Yuan, & Gautreaux, 2005). However, generating functional interdependence between categorization repertoires may be more complex and may require the previously described modification to the MEI procedure to successfully generate interdependence between listener and intraverbal categorization.

Categorization skills are ubiquitous in our daily functioning. They constitute a critical part of individual's academic, social, and professional success. For some learners, categorization skills and interdependence between categorization skills comes with apparent relative ease, and minimal or no instruction. However, for other learners, especially those with language delays and other developmental disabilities, this functional interdependence is not easily acquired. Therefore, it is important to identify those procedures that help establish functional interdependence between categorization skills. The present study contributes to this endeavor by identifying the limitations of the MEI procedure in generating functional interdependence between listener and intraverbal categorization repertoires.
REFERENCES


APPENDIX A

Preferred Items Assessment
**Preferred Items Assessment**

**Directions:** Please write in a list of your child’s favorite toys and snacks. Examples of some snacks are skittles or chocolate. Examples of some toys are little books, animal stickers, dinosaur toys.

* Please be sure to note any food allergies, and snacks and toys you explicitly do **NOT** want provided to your child in the space provided at the bottom of the page.

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Allergies: ____________________________________________
APPENDIX B

HSIRB Approved Letter
Date: June 9, 2008

To: James Carr, Principal Investigator
Sarah Lechago, Student Investigator for dissertation

From: Amy Naugle, Ph.D., Chair

Re: HSIRB Project Number: 08-05-09

This letter will serve as confirmation that your research project entitled "The Effects of Multiple Exemplar Instruction on Functional Interdependence between Listener and Intraverbal Categorization Repertoires" has been approved under the full category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you may only conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: May 21, 2009