A COMPARISON OF SIMPLE AND COMPLEX AUDITORY VISUAL DISCRIMINATION TRAINING

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Cecelia Maderitz

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Cecelia Maderitz

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Approvals:

Dr. Rocio Rosales, Thesis Advisor Date

Dr. Michael Clayton, Committee Member Date

Dr. Jane Kestner, Committee Member Date

Dr. Peter J. Kasvinsky, Dean of School of Graduate Studies and Research Date

Abstract

Stimulus equivalence is a teaching paradigm with empirical evidence for the establishment of a variety of skills (i.e., letter and number recognition, sight word reading, face-name recognition, etc.) in typically developing and non-typically developing children and adults with different levels of functioning. Simple and complex conditional discrimination training have both been demonstrated to be effective. However, the effectiveness of the two procedures has not been directly compared. The present study investigated the relative effectiveness of these two procedures to establish sight word reading and rudimentary reading comprehension to one typically developing children and two children with autism. An adapted alternating treatments design was implemented, whereby stimulus sets were assigned to either a simple-sample or complex-sample condition. The percentage of correct responses was scored for each training condition, and the number of trial blocks required to reach criterion was compared to assess the efficiency and effectiveness of the two conditions. Generalization probes were conducted for all three participants, and maintenance probes were conducted two weeks following the end of training for two of the three participants. Results indicate that complex sample training was more efficient than simple sample training with all three participants. Also, all participants scored higher on their post-training probes compared to their pre-training probes in both conditions which demonstrates utility of stimulus equivalence.

Descriptors: Autism, Stimulus Equivalence, Complex Auditory Visual Discrimination Training, Simple Auditory Visual Discrimination Training, Sight Word Reading, Reading Comprehension

Table of Contents

A Comparison of Simple and Complex Auditory-Visual Conditional Discrimination Training

The demand for the implementation of evidence-based practices is a growing concern for educators in the United States. For example, the *No Child Left Behind Act of 2001* (NCLB) was designed to ensure that all students met their state's academic goals. NCLB holds educators accountable for their students' progress by requiring them to demonstrate the effectiveness of their teaching practices via a variety of assessments. In accordance with NCLB, by 2014, all states would be required to demonstrate the proficiency of every student enrolled in their school in the areas of reading and mathematics (Executive summary of the *No Child Left Behind Act* of 2001, 2004). President Obama proposed a bill in March of 2011 to reform NCLB when it became obvious states would not meet this 2014 deadline. In this revised bill, he proposed that if states agreed to embrace reform and set high individual standards, they would be given flexibility within the law (Obama administration proceeds with reform of *No Child Left Behind* following congressional inaction, 2011). In addition to NCLB, *Race to the Top Fund* was put into motion in February 2009 to encourage states to improve their educational systems. This fund rewards states with grant monies when cost-effective and efficient methods of teaching are demonstrated via data collection (US Department of Education, 2009). NCLB and Race to the Top are geared and focused on the educational goals of all students.

In addition, *Response to Intervention* (RtI; Hale, 2008) focuses on the identification of children with disabilities by employing empirically-based techniques and collecting data on their effectiveness. RtI's goal is to help children with disabilities learn in the most efficient manner possible. To address the educational policies outlined above, it is important to conduct research in educational settings in order to determine how best to fulfill the policies' goals. A paradigm developed within the field of behavior analysis, referred to as *stimulus equivalence* (Sidman & Tailby, 1982) has received empirical support in a variety of settings, including educational environments (e.g., Connell & Witt, 2004; LeBlanc, Miguel, Cummings, Goldsmith, & Carr, 2003; Lynch & Cuvo, 1995). In a recent literature review, Rehfeldt (2011) indicated that utilizing stimulus equivalence in classroom settings could prove beneficial in teaching a variety of skills including receptive and expressive language skills. In addition, this teaching paradigm has demonstrated effectiveness with a variety of populations and individuals of varying levels of functioning (de Souza, de Rose, Faleiros, Bortoloti, Hanna, & McIlvane, 2009; Lane & Critchfield, 1998; Murphy, Barnes-Holmes, & Barnes-Holmes, 2005; Sidman, 1971). Utilizing this method of teaching may be one avenue to improving the educational system, and facilitating effective and efficient teaching methods in the classroom.

Stimulus Equivalence

Stimulus equivalence is a teaching paradigm that results in the learner obtaining information for "free." Stimulus equivalence is demonstrated when one stimulus is substituted for another stimulus in a stimulus class. If three properties (i.e., reflexivity, symmetry and transitivity) are demonstrated, then a *stimulus equivalence class* is said to be formed. *Reflexivity* is defined as being present when each stimulus is conditionally related to itself (A=A). *Symmetry* is defined as being present when conditional relations are bidirectional (If A=B, then B=A). Finally, *transitivity* is defined as being present when different relations share a common stimulus (If A=B, and A=C) which results in the emergence of untrained relations (then, B=C; Green & Saunders, 1998).

Many types of stimuli can be included in a stimulus class (i.e., abstract shapes, real objects, spoken or written words, nonsense syllables, or graphic symbols). Each stimulus in a stimulus equivalence study is typically represented by a letter and number. For example, when teaching individuals to relate the spoken word "dog" to the picture of a dog; "dog" is represented as A1 and the picture of a dog as B1. When teaching individuals to relate the spoken word "dog" to the written word dog; "dog" is still represented as A1 and the written word dog is represented as C1. Similarly, when teaching to relate the spoken word "cat" to the picture of a cat, "cat" is represented as A2 and the picture of a cat as B2. When teaching to relate the spoken word "cat" to the written word cat, "cat" is still represented as A2 and the written word cat is represented as C2. Therefore, A1B1C1 make up one *stimulus class* and A2B2B2 make up another stimulus class (Green & Saunders, 1998).

A major advantage of stimulus equivalence is that several new relations may emerge without the need for direct training, which saves time and other resources. This technique has been implemented successfully with typically developing children and adults (Fineup & Dixon, 2006; Markham & Dougher, 1993; Matos, Avanzi, & McIlvane, 2006), and with individuals with developmental disabilities (Green, 1990; Lane & Critchfield, 1998; Rehfeldt & Root, 2005; Stromer & Mackay, 1992). At the very least, a stimulus equivalence class needs three stimuli where two relations are taught and the third is expected to emerge. There is no maximum number of stimuli that can be included in an equivalence set. However, this may produce a class size effect, which results in additional training time as more stimuli are included. Therefore, development of equivalence classes may take longer to form (i.e., participants may not reach criterion during the first round of post-training probes; Arntzen & Holth, 2000b; Fields & Verhave, 1987).

Sidman (1971) used a match-to-sample (MTS) training procedure when conducting the first stimulus equivalence study to teach auditory-visual relations to an institutionalized 17-year-old boy diagnosed with severe mental retardation, who showed minimal reading comprehension and oral reading. Prior to the start of the study, the participant orally named all stimuli when pictures were presented individually; (i.e., said “cow” when presented with a picture of a cow; A-B relation). The experimenters directly taught the participant to relate spoken words (i.e. “cow,” “axe,” “man”) to their corresponding printed words (i.e. COW, AXE, MAN; A-C training). The spoken word was the sample stimulus, and the printed words were the comparison stimuli. After training was conducted, post-tests were conducted whereby the participant met criterion on all properties of stimulus equivalence (i.e., symmetry, and transitivity). That is, the participant matched the written words to their corresponding pictures (C-B relations), the pictures to their corresponding printed words (B-C relations) and read the written words when they were presented individually (D-C relation). This study demonstrated that it is possible for an individual with severe mental retardation to demonstrate reading comprehension and oral reading. In addition, this was the first study to demonstrate that directly reinforcing correct behavior during MTS while teaching certain auditory-visual relations may be a prerequisite for reading comprehension to emerge.

Types of Training Relations. In addition to auditory-visual (auditory and visual stimuli; Cowley, Green, & Braunling-McMorrow, 1992; Rehfeldt & Root, 2005;), visual-visual (all visual stimuli; LeBlanc et al., 2003; Lynch & Cuvo, 1995), gustatory-visual (gustatory and visual stimuli; Rehfeldt & Dixon, 2005), olfactory-visual (olfactory and visual stimuli; Annett & Leslie, 1995; Fineup & Dixon, 2006), tactual-visual (real objects; Belanich & Fields, 1999), tactual-tactual (real objects; O’Leary & Bush, 1996; Tierney & De Largy, 1995) and interoceptive-exteroceptive (drug and visual stimuli; DeGrandpre, Bickel, & Higgins, 1992) relations have also been taught via the stimulus equivalence paradigm.

Rehfeldt and Dixon (1998) compared visual-visual and gustatory-visual relations by teaching conditional discriminations between pictures and their corresponding printed English and Spanish words, or between tastes and their corresponding printed English and Spanish words. Four adolescents and adults with developmental disabilities participated in this study. Results indicated fewer trials to criterion were required with the gustatory-visual relations for three of the four participants. In addition, all participants scored higher on visual equivalence tests following training. However, all participants performed with higher accuracy on gustatory-visual equivalence tests during follow-up probes.

In a similar study, Fineup and Dixon (2006) compared visual-visual and visual-olfactory relations by teaching two arbitrary relations. The "A" stimuli in the visual-visual set were composed of pictures of small rocks, big rocks, and cement. The "B" and "C" stimuli were composed of pictures of patterns. In contrast, the "A" stimuli in the visual-olfactory stimulus set were composed of distinctive scents (i.e., rubbing alcohol, vinegar, and cinnamon), and the "B" and "C" stimuli were composed of pictures of patterns (similar but different than the patterns in the visual-visual set). The experimenters directly taught A-B and A-C relations and tested for B-C and C-B relations. After collecting follow-up data, the participants were trained to match B stimuli from the two sets and subsequently tested for the emergence of two stimulus classes. Finally, a sorting test was conducted to determine whether participants would sort the stimuli into three groups (A, B, and C). The visual-olfactory stimulus sets had slightly better results in acquisition and maintenance. Only one participant demonstrated stimulus equivalence in the class merger test, but all participants met criteria during the sorting test.

Resembling the two studies described above, DeGrandpre et al. (1992) used MTS procedures to form equivalence classes containing interoceptive (drug) and exteroceptive (visual) stimuli with four typically developing adults. The exteroceptive stimuli (B and C stimuli) were composed of black arbitrary symbols on white flashcards (A1 and B1). The interoceptive stimuli (A stimuli) were composed of the effects produced by a hypnotic and anxiolytic drug called triazolam and a placebo. The participant received a questionnaire inquiring on the effects of the drug they had received at the beginning of each session. A1B1C1 was designated as the triazolam stimulus class, and A2B2C2 was designated as the placebo stimulus class. First A-B relations were trained. Following this training, A-C, B-C and C-B relations were tested for emergence. An additional member was then added to the stimulus classes by training D-C. Afterwards, C-D, B-D, D-B and A-D relations were tested for emergence of derived relations and generalization was assessed on the following day. Before testing for generalization, three of the participants were taught to match stimuli that had never been associated with stimuli from either equivalence class. Equivalence classes emerged and were expanded to include novel stimuli for all four participants. Generalization was also confirmed when the participants chose visual stimuli that had been paired with the same interoceptive stimulus, which was the placebo.

While the all previous studies included visual relations, Belanich and Fields (1999) included tactual-tactual relations only. Belanich and Fields (1999) implemented stimulus equivalence techniques to teach tactual-tactual relations with six abstract objects composed of three stimulus classes to three typically developing individuals and three individuals that were deaf-blind. The hearing-sighted participants wore blind folds during the MTS procedures. A-B and B-C relations were directly trained, while B-A, C-B, A-C and C-A relations were tested. Afterwards, the blind folds were removed from the hearing-sighted participants and cross-modal generalization was assessed by testing for C-A visual relations. The participants were required to choose the correct comparison stimulus without touching any of the stimuli. Four of the five participants demonstrated emergence of equivalence classes consisting of tactual stimuli and the two hearing-sighted participants demonstrated cross-modal generalization.

O'Leary and Bush (1996) used MTS procedures to teach relations between tactile stimuli (e.g., real objects) to two typically developing six-year-olds and one typically developing seven-year-old. The three sets of stimuli included: a hair band, flat paper clip, and nail polish bottle (A1, A2 and A3); a wire hair roller, porcelain napkin holder, and cable TV part (B1, B2 and B3); a broken freezer knob, rose tube, and office binder (C1, C2 and C3). While blindfolded, participants were required to touch each sample with one hand while selecting the correct comparison stimuli with the other. All participants were taught A-B and B-C relations. Afterwards, emergence of A-C and C-A relations were assessed. Once the participants met criterion on the A-C (transitivity) and C-A (equivalence) tests, the emergence of symmetry (B-A and C-B) was assessed. All participants demonstrated emergence of A-C and C-A relations by following the fourth post-test, and B-A and C-B relations during the fifth post-test.

Last but not least, Stikeleather and Sidman (1990) and Guercio, Podolska-Schroeder, and Rehfeldt (2004) taught auditory-visual relations. Stikeleather and Sidman (1990) taught four typically developing children the dictated name, the upper case, and the lower case of four Greek letters using stimulus equivalence. Guercio et al (2004) used stimulus equivalence to teach emotion recognition to three adults with brain injury.

Green (1990) compared two of the more common types of stimuli outlined above: visual-visual and auditory-visual relations. They were taught by providing MTS training with two classes (i.e., one class with three visual stimuli and one class with two visual stimuli, and one auditory stimulus) using arbitrary stimuli with five women diagnosed with mental retardation. Results of this study demonstrated that the class involving the auditory-visual relations developed quicker than the visual-visual relations for four out of five participants, which indicated equivalence classes containing auditory-visual relations may be easier to formulate. Smeets and Barnes-Holmes (2005) replicated and extended Green (1990) by comparing the effectiveness of visual-visual and auditory-visual relations with 16 typically developing five-year-old children. All 16 children passed the auditory-visual equivalence test whereas only nine passed the visual-visual equivalence test replicating Green's (1990) results. Sidman (1990) also compared visual-visual and auditory relations and got similar results as the above studies. Clearly, past research has demonstrated that teaching auditory-visual relations is more effective in stimulus equivalence than visual-visual.

In summary, numerous studies requiring different senses have been conducted implementing the stimulus equivalence paradigm. However, the majority of the stimulus equivalence studies have incorporated visual stimuli relations. According to Rehfeldt (2011), 62% of the stimulus equivalence studies published in between 1992 and 2009 incorporated all visual stimuli, and 38% incorporated auditory and visual stimuli. Given that the majority of stimulus equivalence studies have incorporated all visual or visual and auditory stimuli, additional research should explore the other types of relations outline above. In addition, studies investigating the most efficient manner to teach auditory-visual relations should be conducted in order to determine the most effective presentation format. This will be one of the goals of the present investigation.

Using auditory visuals relations to teach sight word reading and rudimentary reading comprehension has been shown to be an effective teaching strategy. This may be related to the process in which children learn to read in the natural environment. That is, children usually understand the meaning of words before being able to read them. They typically learn to identify pictures before identifying words. Finally they are able to match the word to the corresponding picture and vice versa (Sidman, 1970).

Teaching Procedures. Many different teaching procedures to establish the prerequisites to stimulus equivalence exist within the literature. However, only three will be discussed here: respondent type training (Clayton & Hayes, 2004; Smeets, & Leader, 1997), sequence training (Lazar, 1977; Sigurdardottir, Green, & Saunders, 1990) and MTS (Cummings, Goldsmith, & Carr, 2003; Groskreutz, Karsina, Miguel, & Groskreutz, 2010; LeBlanc, Miguel, Rehfeldt, & Root, 2005; Stromer & Mackay, 1992).

Respondent type training is a procedure where no overt response is required. Participants are only required to observe stimulus pairings and are then probed for the emergence of derived relations (Clayton & Hayes, 2004). Smeets et al. (1997) used respondent type training to teach 10 college students six stimulus pairs with arbitrary stimuli. During respondent raining, the first stimulus in the pair was presented on a computer screen for one second and was then cleared for .5 seconds before the second stimulus in the pair was presented. There was a three second delay before the next pair was displayed. After training, derived relations emerged for the majority of the participants.

Sequence training is described as a procedure whereby participants are taught to select different sets of stimuli in a certain order (A1- A2- A3, B1- B2- B3, and C1- C2- C3). All stimuli trained to be selected first (A1, B1, and C1) form one stimulus class. All stimuli trained to be selected second (A2, B2, and C2) form another stimulus class and so on (Green & Saunders, 1998). Sigurdardottir et al. (1990) used sequence training to develop four stimulus classes composed of arbitrary stimuli. Specifically, participants were taught four sequences by reinforcing selection of three stimuli in a specific order from an array of five stimuli. Following this training, the experimenters assessed whether stimulus classes formed by conducting tests using MTS. Next, the experimenters taught the participants to match a novel stimulus with one stimulus from each class of the four classes using MTS procedures. Stimulus classes expanded to include the new stimuli, and participants also selected the new stimuli in the correct order as they pertained to their ordinal classes.

MTS is one way to teach conditional discriminations, which is defined as individuals learning to discriminate between different types of stimuli and match related stimuli. During MTS, participants are taught to select one stimulus (B; comparison stimulus) from an array of two or more stimuli in the presence of a specified stimulus (A; sample stimulus). Reinforcement is then provided for a correct response. The stimuli are something that can be touched, felt, heard, seen and/or smelled (Green, 2001). Once two conditional relations are formed (A-B and A-C), the next step is to test for equivalence. There are two types of MTS procedures: delayed or simultaneous presentation of the sample.

Delayed MTS includes presenting the sample stimulus, removing the sample, and presenting the comparison stimuli immediately before the instruction is provided (Green & Saunders, 1998). Stromer and Mackay (1992) implemented a delayed MTS procedure to teach spelling and picture-printed word relations to three boys with emotional, behavioral and learning disorders. The complex sample (discussed in more detail in the complex sample section) consisted of a picture and a printed word which was presented on a computer screen. After the participant clicked on the sample stimulus with the computer mouse, the sample disappeared and either words or letters appeared in the comparison stimuli area. The participants were required to either select the correct comparison word or construct the word that had appeared as part of the sample.

Simultaneous MTS is when the sample and comparison stimuli are presented together (Green & Saunders, 1998). LeBlanc et al. (2003) used simultaneous MTS procedures to teach two boys with autism printed state names and capitols and corresponding state shapes, while also comparing three testing procedures. Each MTS procedure was presented manually using a three-ring binder. The sample stimuli were displayed at the top of the page and the three comparison stimuli were displayed at the bottom. To be sure the participants attended to the sample stimulus on the page, the participant was required to lift the cardboard flap that covered the sample. All stimuli were presented at the same time, and were not removed until a selection was made (prompted or unprompted). As described above, sequence, conditional discrimination, and MTS training have been demonstrated to be effective in forming equivalence classes. However, MTS training is the most widely used of these three procedures.

Presentation of Stimuli. The majority of the stimulus equivalence studies described above used simple samples (stimuli consisting of only one element). Numerous studies have been conducted using a simple stimulus to teach a variety of skills including spelling and reading (de Rose, de Souza, & Hanna, 1996; de Souza et al., 2009; Matos et al., 2006); name-face recognition (Lowenkron & Colvin, 1995); fraction ratios (Lynch & Cuvo, 1995); foreign language skills (Polson, Grabavac, & Parsons, 1997; Polson & Parsons, 2000); letter-name and letter-sound recognition (Connell & Witt, 2004); and recognition of Greek letters (Stikeleather & Sidman, 1990) to typically developing adults and/or children. In addition, spelling and reading (de Souza, & de Rose, 2000; Greer, Yaun, & Gautreaux, 2005; Kennedy et al., 1994; Melchiori, Rehfeldt, Latimore, & Stromer, 2003); requesting skills (Halvey & Rehfeldt, 2005; Murphy et al., 2005; Rehfeldt & Root, 2005; Rosales & Rehfeldt, 2007); emotion recognition (Guercio, Podolska-Schroeder, & Rehfeldt 2004); and name-face matching (Cowley et al., 1992) have been taught to children and/or adults with disabilities using this same paradigm.

Retention. After demonstrating the emergence of equivalence relations, it is important to demonstrate the retention of these relations over time in order to provide support for the effectiveness of stimulus equivalence. Rehfeldt and Hayes (2000) demonstrated the retention of derived and generalized relations with typically developing adults. Rehfeldt and Root (2004) demonstrated retention of derived and generalized relations with adults with mental retardation. First, Rehfeldt and Root (2004) trained four participants in two relations: A-B and A-C. After reaching criterion, they were tested for symmetry, equivalence and assessed for generalization of the skills acquired. Then, after at least one month, they were provided with the same symmetry, equivalence and generalization tests once more. Two participants demonstrated the emergence of all symmetry and equivalence relations and generalization of those relations. The other two participants demonstrated the emergence of all symmetry relations and some of the equivalence relations. They also demonstrated the generalization of most of those relations. In addition, all four participants met criterion on most of the relations during the symmetry, equivalence, and generalization tests 49 and 102 days later. There have been a limited number of studies assessing retention over time. However, assessing the retention of skills in a study is very important because skill is useless to an individual if it is not retained over a period of time.

Complex stimuli. The use of compound or complex stimuli may also be incorporated when teaching using a stimulus equivalence procedure. A complex sample is defined as a sample that is composed of more than one stimulus and, each stimulus may have individual control over behaviors in the presence of other specified stimuli (Stromer, McIlvane, & Serna, 1993). For example, a dictated word (A) + a picture (B) are presented together as sample stimuli and a written word (C) as a comparison stimulus (AB-C). Several basic stimulus equivalence studies (e.g., containing stimuli with no immediate relevance to the participants and/or caregivers) have been conducted using complex samples (Augustson, Dougher & Markham, 2000; Carpentier, Smeets & Barnes-Holmes, 2000; Carpentier, Smeets & Barnes-Holmes, 2002; Maguire, Stromer, Mackay & Demis, 1994; Markham & Dougher, 1993; Perez-Gonzalez & Alonso-Alvarez, 2008; Stromer & Stromer 1990a; and Stromer & Stromer 1990b).

For example, Markham and Dougher (1993) conducted three experiments using complex sample stimuli (abstract shapes) to teach certain visual-visual relations while testing for the emergence of other relations to typically developing adults. More specifically, unlike previous studies using complex samples, Markham and Dougher (1993) tested for the emergence of equivalence relations in addition to symmetrical and transitive relations. In experiment 1, they taught nine AB-C relations, and 18 AC-B and BC-A relations emerged. In experiment 2, six participants were taught nine AB-C relations, and C-AB (symmetrical) relations emerged for five of the participants. Six participants were taught nine AB-C relations and three C-D relations, and then demonstrated the emergence of AB-D (transitive) relations. In experiment 3, five participants were taught nine AB-C relations and three C-D relations. Three of these participants performed with high accuracy when tested for nine (D-AB) equivalence relations and 18 AD-B and BD-A relations. AD-B and BD-A relations emerged for one participant, while no relations emerged for one participant. In addition to replicating past research, Markham and Dougher (1993) demonstrated that equivalence relations will emerge when teaching visual-visual relations using complex sample stimuli.

Maguire et al. (1994) used complex samples composed of arbitrary stimuli (abstract shapes) to teach certain relations before testing for emergence of other relations. Unlike Markham and Dougher (1993), Maguire et al. (1994) demonstrated formation of equivalence classes with adults with autism and young children instead of typically developing adults. They conducted five experiments. One visual-visual relation (AB-D) was directly taught, and six relations were probed during post-tests (i.e., A-D, B-D, A-B, B-A, D-A and D-B). Results indicated all participants demonstrated the emergence of the derived relations. This experiment was then replicated with automated procedures (experiment 1B) and with novel stimuli to result in a four-member class (experiments 2A and 2B). Relations C-D (in experiment 2A) and ABC-D (in experiment 2B) were trained. The formation of four-member stimulus classes emerged. Finally, the results of these experiments were combined to demonstrate the emergence of four-member stimulus classes with the original stimuli. In conclusion, Maguire et al. (1997) demonstrated that the above procedures are effective with adults with autism and young children.

Perez-Gonzalez and Alonso-Alvarez (2008) taught high school and college students arbitrary visual-visual relations using MTS procedures. Whereas, Markham and Dougher (1993) and Maguire et al. (1994) taught complex relations and tested for the emergence of simple relations, Perez-Gonzalez and Alonso-Alvarez (2008) taught four single simple discriminations (P-A, P-B, Q-1 and Q-2) and then were tested for emergent complex conditional relations (P1Q1- A1, P1Q2-B1, P2Q1-A2 and P2Q2-B2). Following this experiment, a replication was conducted with the addition of complex samples with a novel set of stimuli and then proceeded to probe for emergent single sample discriminations from the novel set of stimuli. All participants demonstrated transfer from single-sample discrimination training to complex sample discrimination probes. Perez-Gonzalez and Alonso-Alvarez (2008) extended stimulus equivalence research by demonstrating that it is possible for complex relations to emerge following direct training of simple relations, and these relations may also be reversed.

These basic research studies have contributed immensely to the growing literature on stimulus equivalence. They have demonstrated that it is not necessary to train every relation individually for untrained relations to emerge. Using complex samples versus simple samples more closely resembles learning in the natural environment. That is, more often than not, there are a multitude of stimuli in the environment that simultaneously influence learning, whether it is intentional or not (Stromer, McIlvane, & Serna, 1993). As described above, the use of complex sample stimuli to directly teach arbitrary relations, and demonstrate the emergence of other relations, is an effective teaching procedure. All the stimuli employed in the studies described above were arbitrary stimuli, which helps to control for potential threats to internal validity in the form of extraneous variables (i.e., it is very unlikely that participants had previous exposure to the stimuli before the experiment began). However, when using relevant stimuli and teaching relations that the participant and/or the caregivers find beneficial, the procedures are more socially valid. Several strategies can be implemented to help control for potential threats to internal validity that are often a part of conducting applied research. These strategies will be discussed below.

Contextual Control. Contextual control may be used in stimulus equivalence training procedures to help the participant determine which comparison stimulus belongs with the sample stimulus. A compound stimulus differs from contextual control in that each component of a compound stimulus exerts the same amount of control over another stimulus. In contrast, contextual control denotes which stimulus the compound stimuli have control over. For example, when separating people into two different contexts (discipline and nationality), the people will belong to different classes. For disciplines, Renoir, Constable, and Pollock belong to the same stimulus class (artists). Twain, Voltaire, and Byron belong in one stimulus class (writers), and Churchill. Kennedy, and De Gaulle in another stimulus class (heads of state). However, when separating them into nationalities, Renoir, Voltaire, and De Gaulle (French) would be in one stimulus class. Twain, Kennedy, and Pollack (American) would be in a separate class; Churchill, Constable, and Byron (British) would be in a third stimulus class (Sidman, 1994). The same stimuli belong to different stimulus classes depending on the context (discipline or nationality).

Complex relevant stimuli There are a few studies that have used complex *relevant* stimuli (relevant to the participants and/or caregivers) while demonstrating stimulus equivalence (i.e., Groskreutz et al., 2010, Lane & Critchfield, 1998, Stromer and Mackay, 1992). Stromer and Mackay (1992) taught spelling and demonstrated emergent picture-word relations composed of visual and auditory stimuli to three children with academic difficulties. Training consisted of delayed identity matching whereby participants were required to select the correct picture or construct a word after being presented with a complex sample stimulus consisting of a picture and a printed word. Three sets of sample stimuli were employed, all containing three pictures (dog, cat, and owl). The first set also consisted of the printed words: DOG, CAT, and OWL. The second set also consisted of the printed words: CANINE, FELINE, and AVIAN. The third set also consisted of the printed words: PISCES, VIRGO, and TAURUS (experimentally contrived). PISCES, VIRGO, and TAURUS were part of the stimulus class used to control for extraneous variables because they had no “real-world” basis. Therefore, the “dog class” was composed of a picture of a dog and the printed words DOG, CANINE, and PISCES; the “cat class” consisted of a picture of a cat and the printed words CAT, FELINE, and VIRGO; and the "owl class" consisted of a picture of an owl and the words OWL, AVIAN, and TAURUS. After training each set, the experimenters tested for emergent relations which included constructed spelling responses and arbitrary relations between pictures and words and matching words from different sets of the same sample stimulus. For example, after training the participants to match a picture of the dog and the word DOG to the dictated name "dog," the written word CANINE to the dictated name "canine" and the written word PISCES to the dictated name "pisces," the participants were able to match CANINE to the dictated word "dog." All tests for emergent relations were highly accurate across participants.

Lane and Critchfield (1998) taught classification of vowels and consonants to two adolescent females with moderate mental retardation. Specifically, the participants were taught to identify five vowels and five consonants by training two three-member "vowel" stimulus classes and two three-member "consonant" stimulus classes. The two vowel stimulus classes were "A", "E" "vowel" and "O" "U", "vowel." The two consonant stimulus classes were "D", "V", "consonant" and "K", "T", "consonant." There were 13 steps in the training process. For the first step of training, the participant was taught to match the correct letter to a complex sample composed of two sample stimuli ("vowel" and one letter). The last step of the training was matching the correct letter to the complex sample where all three sample stimuli were presented together. For example, once the letters A, E, and the spoken word "vowel" were presented and removed (delayed MTS), the participant was required to select the correct comparison stimuli in a field of two. Once the participants reached mastery criterion during training, emergent stimulus relations were tested (arbitrary matching and oral naming). For example, when testing for arbitrary matching, after showing the participants the letter A, E and D were displayed as comparison stimuli. The experimenter showed the participant one of the eight letters and the participant identified which class (consonant or vowel) the letter belonged to test for oral naming. Finally, tests for stimulus sets with common auditory elements were assessed in generalization and maintenance probes. Results indicated all participants demonstrated the emergence of vowel sets 1 and 2 merged into a single vowel class while consonant sets 1 and 2 merged into a single consonant class. The participants were also able to identify the vowels and consonants previously taught within the context of four-letter words, and these skills were maintained at six weeks follow-up.

Finally, Groskreutz et al. (2010) used complex auditory-visual samples to teach six children and adolescents with autism different types of educational material based on each participant's Individual Education Plan (IEP) goals and objectives. The only relation directly taught was dictated names (A stimuli) + pictures (B stimuli) to their corresponding printed word comparisons (C stimuli) ([AB] C). Specifically, the experimenter held up a picture while stating the name of the picture, and the participant was required to point to the correct printed word comparison when it was presented in an array of three comparison stimuli. A prompt delay procedure was used to teach the above mentioned relation. A pretest and posttest design was implemented to assess scores on each relation. The following relations were demonstrated to emerge across all six participants, thereby demonstrating the effectiveness of a stimulus equivalence teaching procedure using a complex auditory-visual sample: visual samples and comparisons (B-C and C-B), auditory samples and visual comparisons (A-B and A-C), and oral labeling of visual stimuli (B-D and C-D).

The purpose of present study is to replicate and extend the results of Groskreutz et al. (2010). The present study will compare the effectiveness of simple-sample conditional relations and complex sample conditional relations on emergent relations using an alternating treatments design. To date, no studies have been conducted to compare the effectiveness of the two procedures. In addition, the present study will extend the results of Groskreutz et al. (2010) by employing a true experimental design (i.e., alternating treatments design), as well as assessing maintenance and generalization of the skills learned, and recruiting both typically and non-typically developing children as participants.

Method

Participants, Settings, and Materials

Three children were recruited to participate in this study from a center in North East Ohio that provides services to children with autism. To be included in the study, all participants were required to meet criteria which included receptive and/or expressive identification of all 26 letters of the alphabet, and be under appropriate instructional control (i.e., sit and attend for at least 20 minutes).

Kara was a female, 6 years and 4 months old, diagnosed with autism at the age of three. She was enrolled in a Kindergarten classroom and had been at the Center for three years at the start of the study. She was not on any medication throughout the duration of the study, and had three years of previous experience with discrete trial training.

Cole was a male, 5 years and 6 months old, also diagnosed with autism at the age of three. He was enrolled in a preschool classroom and had been at the Center for 2 years and 5 months at the start of the study. He was not on any medication throughout the duration of the study and had 2 years and 6 months of previous experience with discrete trial training.

Evan was a male, 6 years old and typically developing. He was enrolled in a kindergarten classroom and had been at the center for two years as a typical peer role model. He was not on any medication during the present study and had no previous formal experience with discrete trial instruction.

All sessions (training, testing, generalization, and maintenance) were conducted in an assessment room (9 ft. by 16 ft.) located in the center. The room contained a small half circle table with two to three chairs, a desk with a computer and computer chair, a television placed on a high shelf in the corner of the room, and a separate high shelf with containers of various items that were unrelated to the present study.

During all sessions, a simultaneous match-to-sample (MTS) table-top procedure was implemented. Both participants with autism were familiar with the MTS format (due to previous exposure during discrete trial instruction). All participants were first assessed to ensure they understood the instructions presented throughout training. Initial assessments were conducted with familiar pictures (something they could already identify) by presenting the instructions to be used during training (including the observing response as described below). If a participant did not understand the instructions, these were directly taught to ensure all participants had the same training history. Once the participant attained 100% correct independent responses in one 9-trial block by pointing to a specified picture in an array of three, that skill was considered mastered. This controlled for the potential threat to internal validity of participants responding incorrectly due to their unfamiliarity with the task (or instructions).

Six to nine 9-trial block sessions were conducted daily, one to three days per week. Each session lasted between 20-30 minutes. During each session, the experimenter sat at a table directly across from or next to the participant and presented stimuli on a stimulus placement board to minimize unintentional cueing. The stimulus placement board was a manila folder with an outline of where the stimuli were placed and a piece of hook-and loop tape for each stimulus (see a more complete description of the stimuli to be used in training below). Visual stimuli were arranged on the stimulus placement board prior to each trial presentation to prevent the accidental prompting from the experimenter, and in order to present all stimuli simultaneously. Each intertrial interval was 10-20 s.

There were six sets of stimuli for each participant containing a dictated word, picture, and printed word. All stimuli were selected from the Dolch nouns word list (Dolch, 1936; Stuart, Dixon, Masterson, & Gray, 2003) or the classroom's curriculum to ensure the stimuli had high social validity. In addition, participants were assessed prior the presentation of pre-training probes to ensure the stimuli selected were not within their repertoire. If a participant identified any stimulus receptively or expressively, these were replaced with stimuli the participant could not identify. All stimuli presentation were randomized in advance by creating data sheets that indicated which stimuli were presented during every nine-trial block during pre-, post-, training, generalization, and follow-up probes. Visual stimuli were laminated on index cards (5.5 cm by 7.5 cm) with computer-generated pictures or words. For all sessions, the pictures were 3 cm by 3.5 cm, and printed words were in Century Gothic, 44-point font. During all generalization sessions, different pictures of the same stimuli (i.e., a picture of a golden retriever instead of a beagle to represent a dog), and different font of the same written words (Bradley Hand ITC) were used.

In addition, a token system was implemented to maintain attending behavior. Tokens (i.e., stars on a laminated piece of paper) were administered for correct responses during training and for attending behavior during all pre- and post-training sessions except for one participant who received tokens for attending behavior during all trials on a FI1-6 schedule of reinforcement. The participants were given the opportunity to exchange tokens for a preferred item immediately after obtaining a specified number of tokens (i.e., 2-5 depending on the participant). Data on all participant responses was collected using paper and pencil on a data sheet created for the purpose of this study (see Appendix A for an example of a data sheet used during training and testing).

Experimental Design, Response Measurement, and Interobserver Agreement

An adapted alternating treatments design was implemented (Sindelar, Rosenburg, & Wilson, 1985) to assess the difference between a simple-sample and complex-sample training condition. Both conditions were conducted at the same time, but randomly alternated (i.e., three 9-trial blocks with the simple sample, and then three nine-trial blocks with the complex sample). The nine-trial blocks were conducted in random order. For the simple-sample condition, participants were first trained to conditionally relate dictated names to their corresponding pictures (A1-B1, A2-B2, A3-B3 relations), until they demonstrate mastery criterion of 100% correct responses in one 9-trial block. A *correct response* was defined as the participant independently selecting the correct comparison stimulus by pointing to or handing the card to the experimenter within 10 s following the presentation of an instruction. Only the first response was scored unless the participant self corrected by pointing to a different stimulus within one second of pointing to the first stimulus and maintaining that response for 3-5 seconds. *Incorrect responses* were defined as any prompted response, selecting more than one comparison stimulus at a time, or making no response within 10 s following the presentation of an instruction by the experimenter. Participants were then trained to conditionally relate the dictated names to their corresponding printed words (A1-C1, A2-B2, A3-B3 relations) until they demonstrated the same mastery criterion. Correct and incorrect responses were defined in the same manner as described for A-B relations. Following training in A-C relations, the remaining relations (i.e., B1C1, B2C2, B3C3, C1B1, C2B2, C3B3, C1D1, C2D2, C3D3, B1D1, B2D2, B3D3) were probed in one 9-trial block, conducted under extinction.

For the complex sample condition, participants were trained to conditionally relate dictated names + pictures to their corresponding printed words (A4B4-C4, A4B4-C4, A5B5-C5 relations) until they demonstrate the same mastery criterion (i.e., 100% correct responses in one 9-trial block). Correct and incorrect responses were defined in the same manner described above. Following training in the AB-C relations, the remaining relations (i.e., A4B4, A5B5, A6B6, A4C4, A5C5, A6C6, B4C4, B5C5, B6C6, C4B4, C5B5, C6B6, C4D4, C5D5, C6D6, B4D4, B5D5, B6D6) were probed in one 9-trial block, conducted under extinction. Two dependent variables were assessed: **1)** the percentage of correct responses per 9-trial block for each participant; and **2)** the number of training sessions to attain mastery criteria and demonstrate the emergence of all derived relations for each participant. The independent variable was a presentation of either a simple (auditory) or complex (auditory and visual) sample. The experimenter initially conducted pre-training probes for all to-be-trained and to-be-tested relations, followed by pre-generalization probes. Specifically, the experimenter conducted one nine-trial block, under extinction (i.e., differential reinforcement was not be provided for correct or incorrect responses) for each of the following: **1)** relating dictated names to corresponding pictures (denoted as A-B relation), **2)** relating dictated names to corresponding printed words (denoted as A-C relation), **3)** relating pictures to their corresponding printed word (denoted as B-C relation), **4)** relating printed words to their corresponding pictures (denoted as C-B relation), **5)** reading printed words (denoted as C-D relation), and **6)** tacting pictures (denoted as B-D relation; see Table 1).

Following pre-training probes, the experimenter conducted pre-generalization probes by presenting the stimuli in different fonts and versions of the same words and pictures used in the pre-training, training, and post-training probes. Pre-generalization probes were assessed for all relations listed above. Following pre-generalization probes, training began for all sets of stimuli. Each set of stimuli was assigned to one of two conditions in a random order prior to the start of the study. For example, stimulus sets 1, 2, and 3 was assigned to the simple-sample presentation format; and stimulus sets 4, 5, and 6 were assigned to the complex-sample format (see Table 2 Table 3 for the stimuli that was used for Cole and Kara). The stimuli used for Evan were the same stimuli used for Kara except that they were counterbalanced. For example, the stimuli sets that were in the complex sample condition for Kara were in the simple sample condition for Evan.

Post-training probes were conducted following training in either simple or complex-conditional discriminations. These probes were conducted in the same manner as pre-training probes. A correct response during B-C and C-B pre- and post-training probes was defined as pointing to the correct comparison stimulus within 10 seconds after the sample stimulus and instruction are presented by the experimenter. Incorrect responses were defined as pointing to one of the two distracter stimuli (i.e., other comparison stimuli), or not responding within 10s following an instruction delivered by the experimenter. A correct response for C-D and B-D pre- and post-training probes was defined as stating the correct response within 10 s following the presentation of a sample stimulus and instruction by the experimenter. Incorrect responses were defined as stating the name of any other stimuli, saying "I don't know" or not responding within 10 s following the delivery of an instruction by the experimenter. After reaching criterion during post-training probes, stimulus generalization was assessed. Two weeks following the conclusion of training, maintenance probes were assessed in the same format described above for pre- and post-training probes, but were conducted for the derived relations only (B-C, C-B, B-D, and C-D for the simple sample condition and A-B, B-C, C-B, B-D, and C-D for the complex sample condition).

A second observer independently scored all participants' responses on 41% of all pre-training and post-training probes, training, generalization and maintenance probes across all participants. Interobserver agreement (IOA) was then calculated on an item-by-item analysis, by dividing the number of agreements by the number of agreements plus disagreements and multiplying by one hundred to report a percentage for each trial-block. For Kara, IOA was collected for 45% of sessions (ranging from 89% to 100%, an average of 99%); for Evan, IOA was collected for 50% of sessions (ranging from 89% to 100%, an average of 99%); and for Cole, IOA was collected 33% of sessions (ranging from 67% to 100%, an average of 98%).

Treatment integrity was also evaluated for approximately 41% of all pre-training, training, post-training, generalization and maintenance probes. Treatment integrity was assessed by scoring correct and incorrect (or missed) responses performed by the experimenter on checklists created for the purpose of this study (see Appendix B-D). This data was summarized by dividing the number of steps the experimenter completed correctly by the total number of potential steps during each trial block. For Kara, treatment integrity was collected for 45% of sessions (ranging from 98% to 100%, an average of 99 %); for Evan, treatment integrity was collected for 50% of sessions (100%); and for Cole, treatment integrity was collected 33% of sessions (ranging from 94% to 100%, an average of 99%). The experimenter trained the secondary observers on the training protocol, by providing each observer with a copy of the treatment integrity checklists, and definitions of correct and incorrect responses for the participants of the study. In addition, the experimenter modeled each step of the procedure for the secondary observer, and answered any questions he or she had prior to beginning data collection.

Procedure

Preference Assessment. Prior to the start of the study, the Reinforcement Assessment of Individuals with Severe Disabilities (RAISD; Fisher, Piazza, Bowman, & Almari, 1996) was conducted with the participants' instructors or parents. The RAISD is an interview designed for caregivers to identify preferred activities, items, food, hobbies, and toys that may function as reinforcers for a learner. After reviewing the outcome of the RAISD, a paired-choice preference assessment (Fisher et al., 1992) or a free operant preference assessment (Cooper et al., 2007) was conducted with each student to determine his or her preferred items. During the paired-choice preference assessment (Fisher et al., 1992), two items were presented simultaneously with the instruction to "Pick one." Each item was presented at least twice in order to present every stimulus at least once with every other stimulus and on each side. Once the assessment was complete, the experimenter rank ordered the participant's preferences. During the free-operant assessment (Cooper et al., 2007), five items were laid out on a table, and the child was instructed to play with the items. Ten second partial interval recoding was taken for five minutes to determine which items he engaged in. The items were then ranked highest preferred to lowest preferred depending on how long he engaged in each item. The identified preferred items were used as backup reinforcers for tokens earned in the token economy during training**.**

Pre-Training Probes. All pre-training probes consisted of one 9-trial block. During pre-training probes, the experimenter provided reinforcement in the form of praise for attending behavior (i.e., sitting quietly, looking at the experimenter and stimuli presented), and distributing tokens on a FI 30 s - 1 min schedule of reinforcement. During A-B and A-C pre-training probes, each stimulus was presented in random order three times as a sample stimulus during each nine-trial block. The sample stimulus was presented with three comparison stimuli on the stimulus placement board. The correct comparison stimulus was placed at least once in the left, middle, and right positions on the stimulus placement board during each trial block. The same sample was never presented across two consecutive trials. All sample stimuli remained present while the comparison stimuli were displayed, and both were removed after a response was made, or 10 seconds after the presentation of the comparison stimuli. Before each trial, a differential observing response (DOR; Walpole, Roscoe, & Dube, 2007) was required to ensure that participants were attending to the sample stimulus. For the DOR, the experimenter held a blank card and provided the instruction "Point to the card." After the participant did so, the experimenter provided the instruction "Point to ___ (e.g., dog)" and presented three comparison stimuli on the stimulus placement board (e.g., pictures for A-B probes and words for A-C probes). Correct and incorrect responses were scored as defined above.

During B-C and C-B probes, stimuli were presented in the same manner described above, but the experimenter held up the sample stimulus for the observing response. After the participant pointed to the card (pictures during B-C probes, or words during C-B probes), the experimenter presented the instruction "Match" and simultaneously presented three comparison stimuli (words during B-C probes, and pictures during C-B probes.) Correct and incorrect responses were scored as defined above.

During B-D probes, the experimenter held up one stimulus at a time for an observing response (i.e., a picture). After the participant pointed to the card, the experimenter provided the instruction "What is this?" The picture was removed after a response was made, or after 10 seconds. During C-D probes, the experimenter held up one stimulus at a time for an observing response (i.e., a picture). After the participant pointed to the card, the experimenter held up one stimulus at a time (i.e., a printed word) and provided the instruction "What does this say?" The printed word was removed after a response was made or after 10 seconds. Correct and incorrect responses were scored as defined above.

A-B Training (Simple Sample Condition; A1-B1, A2-B2, A3-B3). During this phase of training, participants learned to conditionally relate dictated names to their corresponding pictures. The training trials were conducted in the same manner described above for pre-training probes, with the exception that corrective feedback and reinforcement (i.e., praise and tokens) was provided following correct responses. A prompting procedure was also in place throughout training. Initially, if the participant emitted an incorrect response, or did not provide a response after 10 seconds, a simple correction procedure was implemented. This consisted of the experimenter pointing to the correct response and providing another opportunity for the participant to respond. If the participant did not respond correctly after an additional 10 seconds, the experimenter physically prompted the participant to select the correct response. After four consecutive trials of incorrect responses in a nine-trial block, a prompt delay procedure was implemented (i.e., 0s, 1s, 2s, 3s, 4s, and 5s). After responding correctly (prompted or unprompted), reinforcement was provided in the form of descriptive praise (i.e., "Good job pointing to cardinal!"). For Cole, this prompting procedure was changed after reviewing the data. The prompt delay procedure was modified for Cole. Specifically, the prompt delay procedure began only if Cole had responded incorrectly during one full nine-trial block instead after four consecutive incorrect responses. One token (a star) was delivered for each correct independent response, and after five tokens, tangible or edible reinforcement was immediately delivered. Participants were allowed access to the tangible item for 30 s- 1 min. After a participant demonstrated mastery criterion, A-C training was conducted.

A-C Training (Simple Sample Condition; A1-C1, A2-C2, A3-C3). During A-C training, participants learned to conditionally relate a dictated word to its corresponding printed word. The training trials were conducted in the same manner as described above for pre-training probes, with the exception that feedback was provided for correct and incorrect responses. This was provided in the same manner as described above for A-B training. **[AB]-C Training (Complex Sample Condition; A4B4-C4, A5B5-C5, A6B6-C6).** During this training, participants learned to conditionally relate a dictated name and picture to its corresponding printed word. Before each trial, a DOR was required to ensure that the participants were attending to the sample stimulus. The DOR was the same as outlined above. The same consequences and prompting procedures were in place as described for A-B and A-C training. Once mastery criterion was demonstrated, post-training probes were conducted.

Post-Training Probes. All post-training probes consisted of nine trial blocks and were conducted in the same manner described above for pre-training probes.

Remedial Training. If the participant did not reach mastery criterion (scoring 100% on a nine trial block) on any post-training probe, re-exposure to conditional discrimination training for that condition was repeated until the participant demonstrated mastery criterion once more in the training trial. Once the participant demonstrated mastery criterion during remedial training, post-training probes were conducted once more to assess the emergence of any derived relations. Remedial training was only conducted one time, regardless of post-training probe scores, due to time constraints.

Generalization Probes. Generalization probes were conducted in the same manner as described for pre-training probes. These probes were conducted initially before training, and again following the demonstration of mastery criterion for all trained and tested relations. Stimuli consisted of pictures similar, but not identical, to those stimuli used during training.

Maintenance Probes. Maintenance probes were conducted two weeks following the end of the training. These probes were conducted in the same manner described above for post-training probes.

Results

All three participants reached criterion more efficiently during complex sample training compared to simple sample training, and had higher scores on post-training probes compared to pre-training probes. Remedial training was required for all three participants due to the fact that mastery criterion was not attained in all derived relations during the initial post-training probe. Generalization probes were conducted for all three participants, and maintenance probes were conducted for Kara and Evan.

Kara

Kara performed at or below chance levels for all relations during pre-training probes for the training stimuli except the C-B relation (i.e., 56%; see Figure 3). After pre-training probes, simple and complex conditional discrimination training was conducted. In the simple sample condition, five nine-trial blocks were needed for Kara to reach criterion in the A-B relation and two nine-trial blocks were needed to reach criterion in the A-C relation. Since she did not reach mastery criterion during the initial post-training probes, remedial training was conducted where an additional two 9-trial blocks were needed to meet mastery criterion in the A-B relation, and one 9-trial block was needed to meet mastery criterion in the A-C relation. During complex sample training, two 9-trial blocks were all that was necessary to initially reach criterion during conditional discrimination training, and an additional three trial blocks were required during remedial training (see Figure 6). Kara met criterion on all the relations probed during post-training (i.e., B-C, C-B, B-D, and C-D) for the simple condition. She met criterion for one relation (i.e., B-C) during the post-training probes for the complex condition. In addition, Kara scored 89% (8 out of 9 trials) correct for the A-B relation, 78% (7 out of 9 trials) correct for the C-B relation, and 67% (6 out of 9 trials) correct for the B-C and B-D relations.

During pre-training generalization probes in the simple sample condition, Kara performed at or below chance levels on all relations except for the B-C relation (i.e., 56%, see Figure 3). During post-training generalization probes, she met criterion for all relations probed (i.e., A-B, A-C, B-C, C-B, B-D, and C-D). During pre-training generalization probes in the complex sample condition, Kara performed at or below chance levels on all relations. During post-training generalization probes in this condition, Kara met criterion for three relations (i.e., A-B, C-B, and B-D) and scored 89% correct in A-C and B-C and 67% correct in C-D relation. The results of maintenance probes were similar to the results of the post-test probes for training and generalization. Specifically, Kara met the mastery criterion requirement for the A-B, B-C, C-B, and B-D relations and scored 89% correct in the A-C relation and 69% correct in the C-D relation in the simple sample condition. In the complex condition, she met mastery criterion in the A-C, B-C, and C-B relations and scored 89% correct in the A-B relation and 67% correct in the B-D and C-D relation.

Evan

Evan performed at or below chance levels during all pre-training probes except for A-B (i.e., 56%) in the simple sample condition (see Figure 4). During the simple sample condition, two 9-trial blocks were all that was needed for Evan to meet mastery criterion in the A-B relation, and one 9-trial block to reach mastery criterion in the A-C relation. During remedial training, an additional two 9-trial blocks (i.e., one in each relation) were required to reach criterion a second time (see Figure 7). During post-training probes, Evan attained mastery criterion for two (i.e., B-C and C-B) of the four relations and scored 0% correct for the remaining relations (i.e., B-D and C-D. In the complex sample training, Evan performed at or below chance levels on all relations. Two 9-trials blocks were all that was needed to reach mastery criterion and an additional one 9-trial block during remedial training. He met criterion for A-B and B-C relations and scored 78% correct for the C-B relation and 33% correct for the B-D and C-D relations in this condition.

During generalization pre-training probes, Evan performed at or below chance levels for all relations except A-C (56%) in the simple sample condition. For the post-training generalization probes, Evan attained mastery criterion in four of the six probed relations (i.e., A-B, A-C, B-C, and C-B) and scored 0% for the remaining two relations (i.e., B-D, C-D) in the simple sample condition. During generalization pre-training probes in the complex condition, he performed at or below chance levels. Evan then met criterion for the A-B, A-C and B-C relations and scored 0% for the B-D and C-D relations during post-training generalization probes in this condition. During the maintenance probes, Evan met mastery criterion in A-B, A-C, B-C, and C-B relations, and scored 0% for the B-D and C-D relations in the simple and complex conditions.

Cole

Cole scored at or below chance levels on all pre-training-probes in both conditions (see Figure 5). During the simple sample condition, 13 nine-trial blocks were required to reach criterion for the A-B relation, and 11 nine-trial blocks to reach criterion for the A-C relation. An additional four 9-trial blocks were required for both the A-B and A-C relation during remedial training. Cole then demonstrated mastery criterion for the B-D relation during post-training probes, and scored 89% correct for the C-B relation and 78% correct for the B-C and C-D relations. During the complex sample condition, 22 nine-trial blocks were necessary to initially reach mastery criterion, followed by an additional three 9-trial blocks during remedial training (see Figure 8). He then met mastery criterion in the A-B, B-D, and C-D relations and scored 89% correct for B-C and C-B relations with the complex sample training stimuli.

During generalization pre-training probes, Cole scored at or below chance levels on relations probed for both conditions (see Figure 8). He did not reach mastery criterion in any of the relations for the generalization post-training in either condition. Specifically, Cole's scores for post-training generalization probes in the simple sample condition were 89% correct in the A-C relation, 44% correct in the A-B relation, 33% correct in the B-C and B-D relations, 11% correct in the C-B relation, and 0% correct in the B-D relation. In the complex sample condition, his scores were 67% correct in the B-C relation, 56% correct in the C-B relation, 44% correct in the A-B and B-D relations, 33% correct in the A-C relation, and 22% correct in the C-D relation.

Discussion

In the present study, an adapted alternating treatments design was used to compare simple and complex auditory visual discrimination training with two children with autism and one typically developing child. All three children performed with more efficiency in the complex sample condition. They also scored higher on the post-training probes than on the pre-training probes in both conditions, which helps illustrate the utility of the stimulus equivalence paradigm as a teaching technique for children with and without developmental disabilities. One strength of the present study was that training stimuli were selected with careful consideration. That is, stimuli used during training for Kara and Evan were counterbalanced across the conditions to control for the possibility that stimuli in one condition were easier to learn than stimuli in the other condition. In addition, the stimuli selected for all three participants had high social validity since they were based directly off their current academic curriculum (for Kara and Evan) or the Dolch Nouns Word list (for Cole).

The first contribution of the present study is that it provides further support for the effectiveness of the stimulus equivalence paradigm (Sidman, 1971). In his seminal study, Sidman demonstrated that after a participant diagnosed with mental retardation was trained or assessed in two relations (A-B and A-C, or selecting a picture that corresponded to a dictated name, and a written word that corresponded to a dictated name, respectively), three other relations between the same stimuli emerged without any further training (i.e., B-C, C-B and C-D, or matching pictures to words, words to pictures, and reading words, respectively). Although the participants in the present study did not all demonstrate the mastery criterion set by the experimenter (i.e., 100% correct independent responses across one 9-trial block), they all demonstrated increases in their correct independent responses during post-training probes, providing support for this teaching paradigm to establish rudimentary reading comprehension skills in children with and without disabilities.

The second contribution of the present study is that it replicates and extends Groskreutz et al. (2010), Lane and Critchfield, (1998); and Stromer and Mackay, (1992). All three studies demonstrated the effectiveness of using complex samples with relevant stimuli during conditional discrimination training by showing the emergence of untaught relations with children with different diagnoses and of different ages. Specifically, with six individuals with autism, ages 4- 18, in Groskreutz et al (2010); two individuals with Down syndrome, ages 14 and 12, in Lane and Critchfield (1998); and 3 boys with emotional, behavioral, and learning disorders, ages 9-13, in Stromer and Mackay (1992). With the participants in these studies, it was not necessary to train each relation individually (i.e., A-B and A-C) for untrained relations to emerge. The present study replicates these results by demonstrating the effectiveness of complex sample training with children with autism (ages 5-6), and one typically developing child. As outlined above, none of the previous studies demonstrated the effectiveness of complex sample training with a typically developing individual.

In addition, the present study extends previous results by directly comparing simple and complex sample training in an adapted alternating treatments design to determine which procedure was more efficient. For the participants in this study, both training procedures were effective in establishing the directly trained relations, but the complex sample condition was more efficient in demonstrating mastery criterion across all three participants. That is, all participants reached criterion quicker in the complex sample condition than in the simple sample condition despite differences in their developmental and educational levels. Cole was in a preschool classroom and all his academic instruction was conducted in one-on-one format, with goals based off his IEP (Individualized Education Plan) goals and ABBLS-R scores (Assessment of Basic Learning and Language Skills Revised) (Sundberg & Partington, 2012) which is an assessment and curriculum guide often used in practice for children with developmental disabilities. He had never been exposed to formalized reading instruction prior to the start of this study. Kara was in a Kindergarten classroom where all the academic instruction was provided in a small group format (3-5 students), and followed a kindergarten curriculum. Part of the curriculum consisted of formalized reading instruction. Evan was in the same Kindergarten classroom as Kara and therefore exposed to the same instruction and educational material. However, Kara was developmentally delayed, with a diagnosis of autism; and Evan was typically developing. Their performance and learning curve in particular reflect their individual differences. Cole required the most amount of training to reach criterion in the training for both conditions. Kara took the second longest, and Evan took the shortest amount of time to reach criterion during training. Despite the differences, complex training was the most efficient for all three participants. This demonstrates that the utility of the stimulus equivalence paradigm as an effective teaching strategy with children who have had and who have not have a previous history of formalized reading instruction, as well as with children with and without developmental delays.

The results also generalized across materials and were maintained at two weeks follow-up for two of the three participants (i.e., Kara and Evan). The results did not generalize across materials for Cole and maintenance was not conducted with him due to time constraints. The implications of these results suggest that a previous history of formalized reading instruction may be necessary for skills to generalize across materials. Despite the fact that the relations attained during training did not generalize for Cole, and that maintenance was only assessed for two out of the three participants, neither of these skills were assessed in previous studies that evaluated the effectiveness of complex sample training with relevant stimuli (Groskreutz et al., 2010; Lane & Critchfield, 1998; and Stromer & Mackay 1992). Assessing generalization and maintenance increases the social validity of the present study since a skill is more useful to a child if that skill generalizes and is retained over time. That is, the more a skill is generalized across individuals, materials, and settings, and the longer they are able to retain the skill, the more the skill will be of use to an individual. As outlined in the introduction, Rehfeldt and Hayes (2000) and Rehfeldt and Root (2004) both demonstrated generalization and maintenance of the skills that they taught their participants. However, there are few stimulus equivalence studies in the literature that have assessed these skills.

Finally, an interesting finding from the present study is that for one participant, Evan, a listener repertoire was clearly established (i.e., he could identify the correct picture in an array when given the dictated name, match printed words to their corresponding pictures, and pictures to their corresponding printed words), yet he did not tact the pictures or read the words when they were presented in isolation during post-training probes. One explanation may be that he did not have as much exposure to the training stimuli compared to Cole and Kara. That is, more nine-trial blocks were needed for Cole and Kara to reach mastery criterion during training in both conditions. Therefore, both of these participants had more exposure to hearing the names of the stimuli spoken by the experimenter. Cole and Kara also both displayed immediate echolalia. Specifically, both participants were observed to repeat the instruction presented by the experimenter immediately following its presentation (i.e., said "Touch frog" or "frog" after the experimenter provided the instruction). These statements correspond to the naming hypothesis, which states that successfully acquiring stimulus equivalence relations may be a result of the child being a speaker-listener (Horne & Lowe, 1996). In other words, when a discriminative stimulus is presented, a child listens to it and then proceeds to repeat it back to him/herself as s/he orients to the stimulus. This in turn helps produce equivalence classes. Since Cole and Kara were exposed to the stimuli more than Evan, they had more exposure to hearing the discriminative stimulus, and then potentially echoing the response, and orienting to the stimuli. As previously stated, Evan had less exposure to the stimuli, and the instruction (i.e., discriminative stimulus) did not produce an overt echoic response.

Several limitations should be noted for the present study. First, none of the participants reached mastery criterion for all the relations assessed, even following remedial training. It is unknown whether the participants would have eventually reached this mastery criterion following additional training sessions. Remedial training was only conducted once regardless of the scores on the post-training probes due to time constraints. However, it should be noted that the mastery criterion was more stringent in the study (i.e., 100% correct) compared to previous research in this area (80% correct). Despite this limitation, all participants' performance improved on the post-training probes compared to the pre-training probes. Future research should address this limitation by using the same mastery criterion and evaluating how much remedial training is needed to reach criterion. Future research could also compare the levels of mastery criterion on the retention level of the skills taught.

Second, Cole's stimulus set was not counterbalanced with another participant. Therefore, it is unknown whether one stimulus set may have been easier to learn. Cole's stimulus set was not counterbalanced. Originally, there were six participants. Three participants were to be trained with the stimuli from the kindergarten curriculum, and three were to be trained with the stimuli from the Dolch Nouns Word List. However, due to various reasons (i.e., time restraints, unavailability of participants with the same repertoires), there only ended up being three participants. Although, the stimuli across the stimulus sets for Cole were made as similar as possible. That is, they were all chosen off of the Dolch Nouns word list and were all one syllable and composed of 3-4 words. Future research should address this limitation by replicating this methodology counterbalancing the stimuli across multiple participants.

Third, Cole's schedule of reinforcement was different from Kara's and Evan's. That is, Cole's reinforcement schedule was carried over from that used in his classroom in which he earned tokens for compliant behavior (i.e., sitting and having a quiet mouth) for a specified duration of time instead of for correct independent responses. This could have potentially contributed to the differences in skill acquisition between Cole and the other two participants. However, because Cole was already successful with a token economy, it was hypothesized that implementing a different token economy for the purpose of the present study would be unethical. Therefore, the same reinforcement system was implemented during data collection. However, after evaluating his data and noting no progress was being made in the complex condition, the frequency of reinforcement was increased and a modification to the prompting procedure was implemented on the twenty-first trial block in the simple condition and the twenty-second trial block in the complex condition. Specifically, the prompt delay procedure was removed and reinforcement was provided after every correct response in the form of tangibles, edibles or physical reinforcement in addition to the token economy system. The prompt delay procedure was removed because his skill acquisition rate was not improving. The reinforcement procedure was modified to increase the frequency of reinforcement which would in turn increase his motivation to respond correctly. After making these modifications, his skill acquisition rate and learning curve increased immediately. Kara and Evan never came into contact with the prompt delay procedure. Modifications were not made to the reinforcement system for Kara and Evan because of their high skill acquisition rate during training. Future research should compare the prompt delay procedure with a simple prompting procedure across different participants and conditions. The frequency of reinforcement should also be analyzed to determine what is most efficient in training children in the different relations.

Finally, the stimuli used during both training conditions included words that began with different letters. Therefore, participants may have been attending to the first letter of each word during conditional discrimination training (in the A-C condition for simple sample training, or AB-C during complex sample training). However, this most likely did not happen. The DOR was put into place to increase the probability that the participants attended to the whole word instead of just a part of it. Future research should address this limitation by using stimuli that are topographically similar to minimize unintentional cuing or responding by exclusion. This may include words that have the same beginning letter(s) and/or ending letter(s) and pictures that are similar in shape, color and/or size.

In summary, the present study is the first to directly compare a simple sample and complex sample conditional discrimination procedure to teach rudimentary reading comprehension to young children with and without a developmental disability. Therefore, the present study should be replicated with multiple participants of different levels of functioning to determine if complex training is more efficient. These results indicate that it is not necessary to train relations individually, which may result in more efficient instruction. Finally, to add another level of control, future studies may conduct a formalized assessment (i.e., ABBLS-R) of each participant's skill level in sight word reading and rudimentary reading comprehension before and after the study to assess differences as a result of this teaching procedure.

Using the stimulus equivalence paradigm to teach sight word reading and rudimentary reading comprehension with complex auditory visual samples is an evidenced based practice that was shown to be an efficient teaching method with children with and without autism in the present study. Therefore, it may be one option for teaching children these skills in the classroom when typical instruction is not effective. As NCLB (Obama administration proceeds with reform of *No Child Left Behind*) following congressional inaction, 2011 states, each school has to set high standards and embrace reform. Using complex sample training in the classroom may help schools attain the high standards also aligned with RtI (Hale, 2008) which is focused on finding the most efficient method to teach children with disabilities. Stimulus equivalence may be the answer. Future research should compare the efficiency of complex sample training with other teaching methods in the classroom.

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Table 1. Summary of relations to be directly trained and tested during simple and complex training conditions.

Type of Sample	Relations Pre and Post-tested	Relations Trained
Simple Sample	A-B (dictated name-picture)	A-B (dictated name-picture)
	A-C (dictated name-printed word)	A-C (dictated name-printed word)
	B-C (picture-printed word	
	C-B (printed word-picture)	
	B-D (tacting pictures)	
	C-D (reading printed words)	
Complex Sample	A-B (dictated name picture)	[AB]C (dictated word+picture-written word)
	A-C (dictated name-printed word)	
	B-C (picture-printed word	
	C-B (printed word-picture)	
	B-D (tacting pictures)	
	C-D (reading printed words)	

Table 2. Stimuli used during conditional discrimination training for Kara and Evan.

Stimulus Sets	A (Dictated Word)	B (Picture)	C (Written Word)
Simple Stimulus Set 1	"Killdeer" (A1)	 (B1)	Killdeer (C1)
Simple Stimulus Set 2	"Cardinal" (A2)	 (B2)	Cardinal (C2)
Simple Stimulus Set 3	"Robin" (A3)	 (B3)	Robin (C3)
Complex Stimulus Set 1	"Caribou" (A4)	 (B4)	Caribou (C4)
Complex Stimulus Set 2	"Narwhal" (A5)	 (B5)	Narwhal(C5)
Complex Stimulus Set 3	"Muskox"(A6)	 (B6)	Muskox (C6)

Table 3. Stimuli used during conditional discrimination training for Cole.

Stimulus Sets	A (Dictated Word)	B (Picture)	C (Written Word)
Simple Stimulus Set 1	"Can" (A1)	 (B1)	CAN (C1)
Simple Stimulus Set 2	"Nest" (A2)	 (B2)	NEST (C2)
Simple Stimulus Set 3	"Top" (A3)	 (B3)	TOP (C3)
Complex Stimulus Set 1	"Shop" (A4)	 (B4)	SHOP (C4)
Complex Stimulus Set 2	"King" (A5)	 (B5)	KING (C5)
Complex Stimulus Set 3	"Frog"(A6)	 (B6)	FROG (C6)

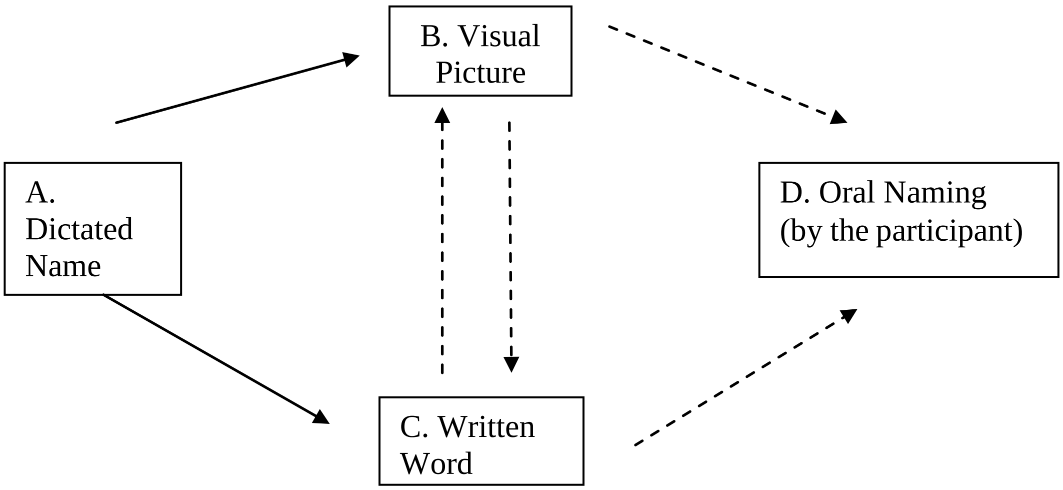

Figure 1. Simple-Sample Training. Solid arrows denote trained relations, dashed arrows denote derived relations.

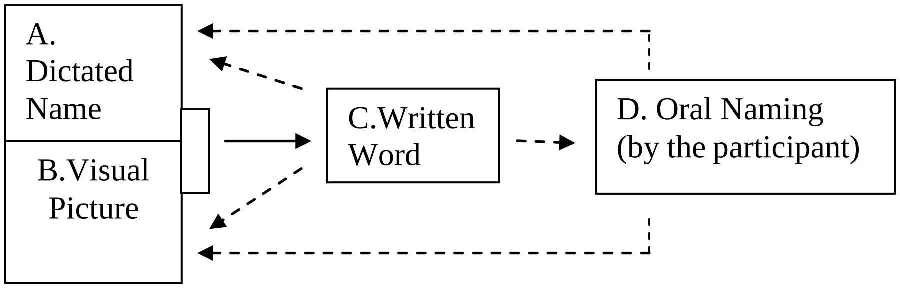

Figure 2. Complex-Sample Training. Solid arrows denote trained relations, dashed arrows denote derived relations.

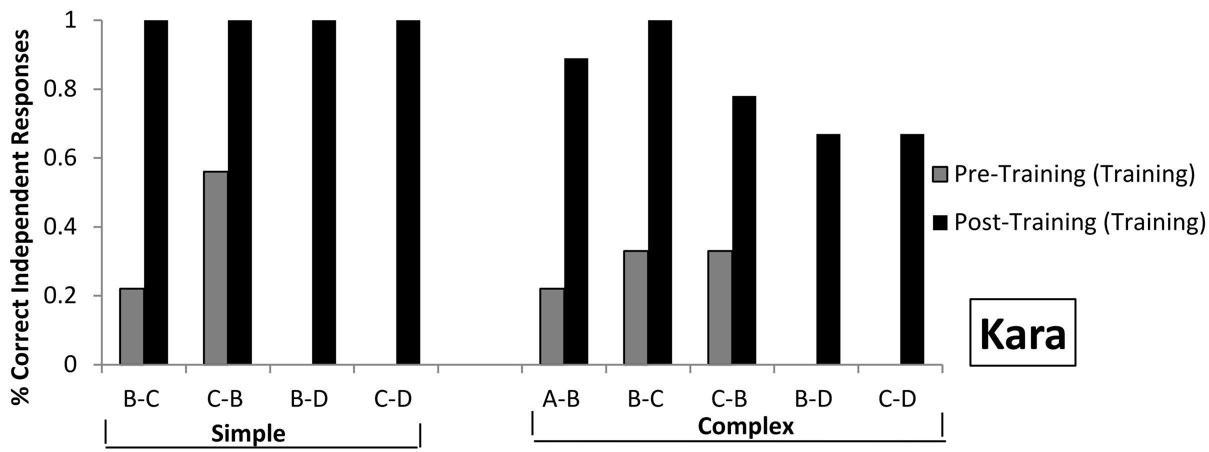

Figure 3. Pre and post-training probes before and after conditional discrimination training for Kara.

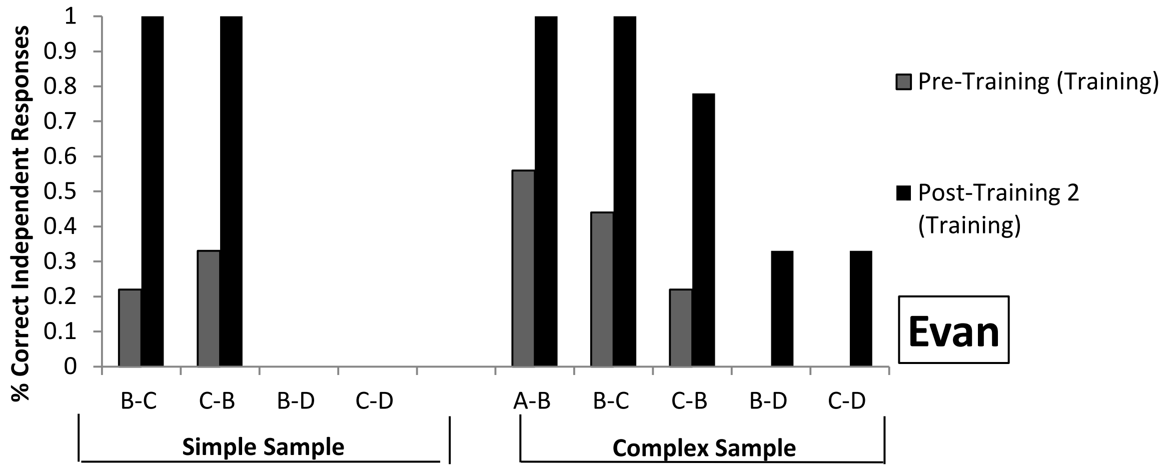

Figure 4. Pre and post-training probes before and after conditional discrimination training for Evan.

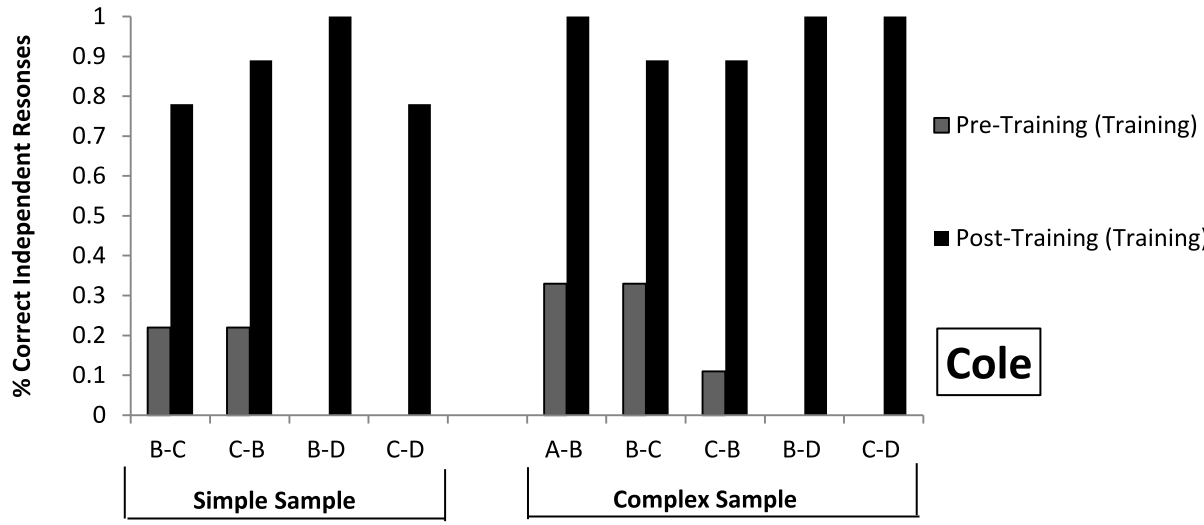

Figure 5. Pre and post-test training before and after conditional discrimination training for Cole.

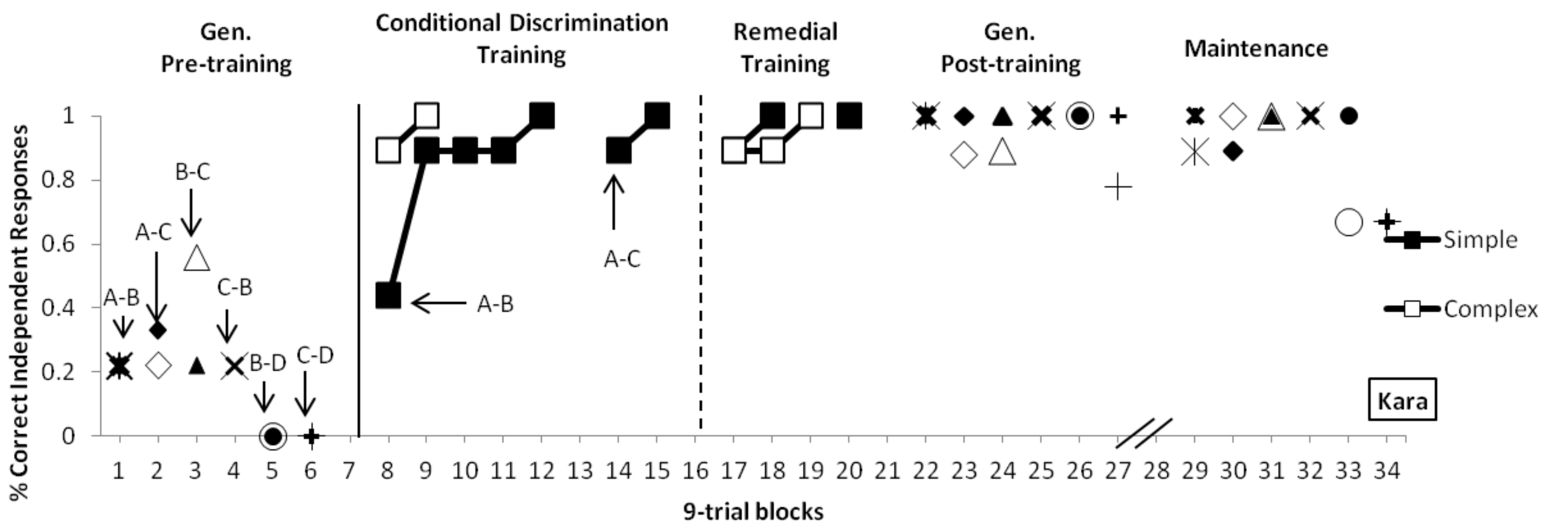

Figure 6. Conditional discrimination training and generalization probes for Kara.

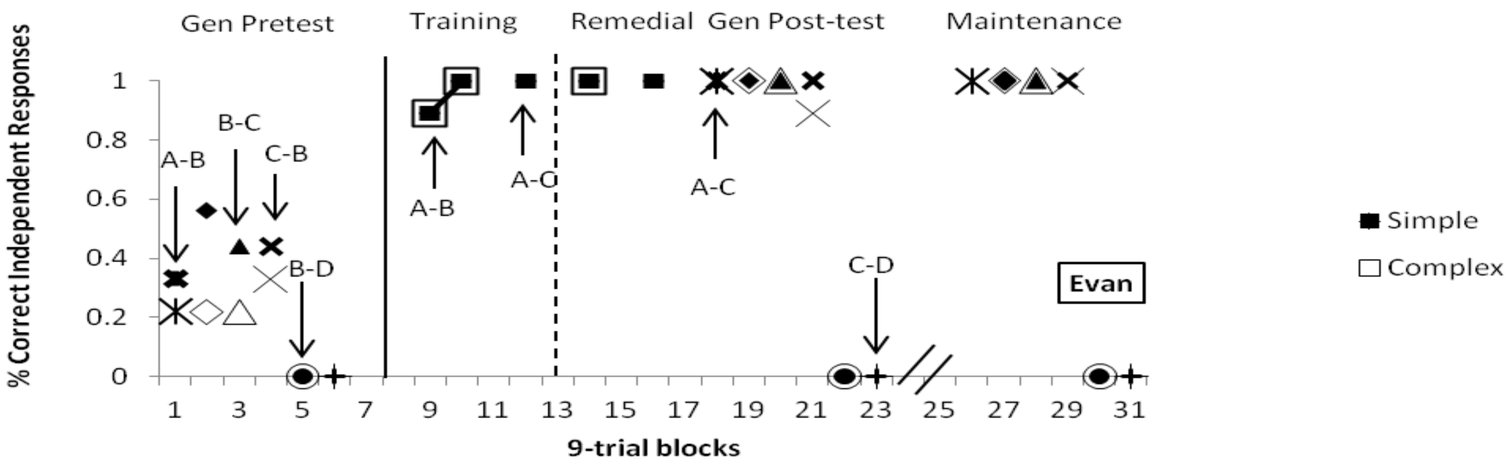

Figure 7. Conditional discrimination training and generalization probes for Evan.

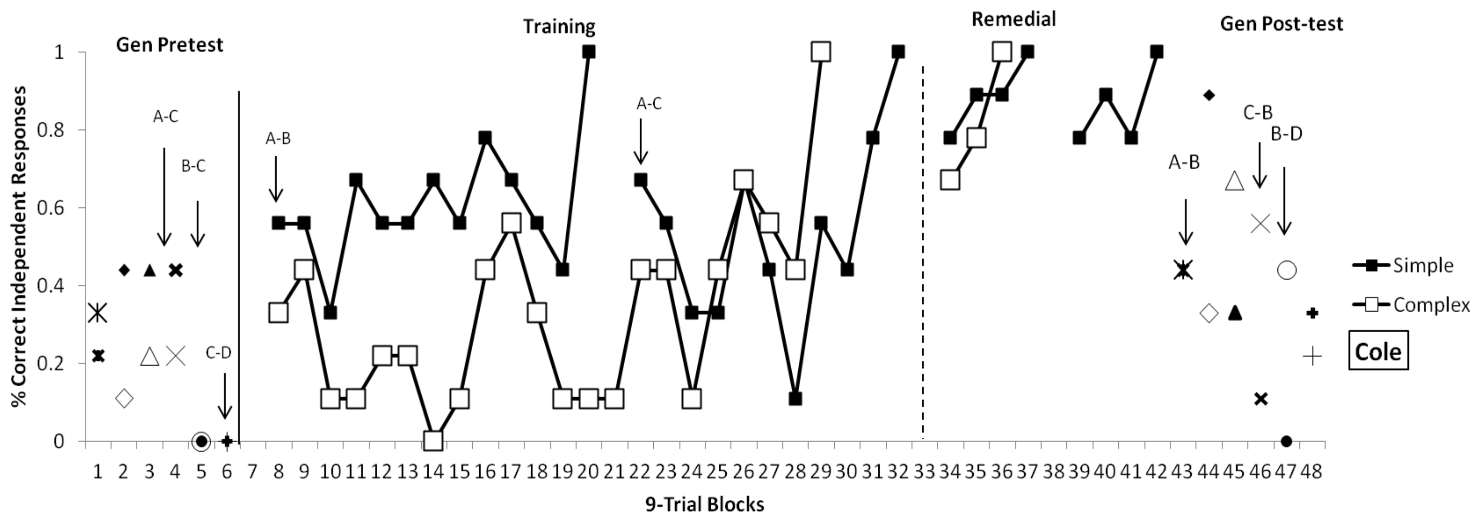

Figure 8. Conditional discrimination training and generalization probes for Cole.

APPENDIX A

Participant Initials: _____________

Date: ______

Pre-Test 1 - Dictated Name - Picture: MTS

(Present instruction "Point to ______" and three comparison stimuli from same word set)

Trial	Stimulus	Response
1		
2		
3		
4		
5		
6		
7		
8		
9		

% Correct =

APPENDIX B

Treatment Integrity Forms Used During Pre-, Post-, Generalization, and Maintenance Probes

Pre-Test/Post-Test/Gen./Main. Probes	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9
1. Experimenter prevents participant access to stimulus materials and reinforcers (ensures items are out of reach).									
2. Experimenter presents a blank card and says "point to the card" for A-B and A-C trials. Experimenter presents the sample stimulus and says "point to the card" for B-C, C-B, B-D and C-D trials.									
3. After the observing response, the experimenter presents 3 comparison stimuli on stimulus placement board for A-B, A-C, B-C, and C-B while simultaneuosly presenting the sample stimulus and gives instruction "Point to _____" or "Match. "									
4. After the observing response, the experimenter presents one stimulus at a time (for B-D and C-D trials only) with the instruction "What is it?" or "what does it say?"									
5. Switches placement of stimuli on board after every trial for A-B, A-C, B-C and B-C trials.									
6. Allows 10 s for participant to respond.									
7. Does not provide any prompts at any time.									
8. Presents trials in random order.									
9. Does not provide any differential consequences for responses.									
10. Records participant response on data sheet.									
TOTAL									

APPENDIX C

Treatment Integrity Forms Used During A-B and A-C Training

A-B, A-C Training	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9
1. Experimenter prevents participant access to stimulus materials and reinforcers (ensures items are out of reach).									
2. Experimenter presents a blank card and says "point to the card"									
3. After the observing response, the experimenter presents 3 comparison stimuli on stimulus placement board and gives instruction "Point to _____."									
4. Switches placement of stimuli on board after every trial.									
5. Allows 10 s for participant to respond.									
6. Provides differential reinforcement for correct independent responses (i.e., praise and/or token delivery).									
7. Delivers Correction Procedure.									
8. Presents trials in random order.									
9. Records participant response on data sheet.									
TOTAL									

APPENDIX D

Treatment Integrity Forms Used During AB-C Training

AB-C Training	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9
1. Experimenter prevents participant access to stimulus materials and reinforcers (ensures items are out of reach).									
2. Experimenter presents the sample stimulus and says "point to the card"									
3. After the observing response, the experimenter presents 3 comparison stimuli on a stimulus placement board simultaneously with the sample stimulus and says "Point to									
4. Switches placement of stimuli on board after every trial.									
5. Allows 10 s for participant to respond.									
6. Provides differential reinforcement for correct independent responses (i.e., praise + token delivery).									
7. Delivers Correction Procedure.									
8. Presents trials in random order.									
9. Records participant response on data sheet.									
TOTAL									

Youngstown
STATE UNIVERSITY

One University Plaza, Youngstown, Ohio 44555
School of Graduate Studies and Research
330.941.3091
Fax 330.941.1580
graduateschool@cc.ysu.edu

October 26, 2011

Dr. Rocio Rosales, Principal Investigator
Ms. Cecelia Maderitz, Co-investigator
Department of Psychology
UNIVERSITY

RE: HSRC PROTOCOL NUMBER: 018-2012
TITLE: A Comparison of Simple and Complex Auditory-Visual Conditional Discrimination Training

Dear Dr. Rosales and Ms. Maderitz:

The Human Subjects Research Committee has reviewed the modification you submitted for the above mentioned protocol and determined that your project can be fully approved as long as you conduct a one-on-one information session with the parent or guardian of the participant to ensure their complete understanding of the project, and use only the revised Informed Consent document during the recruitment process.

Any other changes in your research activity should be promptly reported to the Human Subjects Research Committee and may not be initiated without HSRC approval except where necessary to eliminate hazard to human subjects. Any unanticipated problems involving risks to subjects should also be promptly reported to the Human Subjects Research Committee.

The HSRC would like to extend its best wishes to you in the conduct of this study.

Sincerely,

Peter J. Kasvinsky
Dean, School of Graduate Studies and Research
Research Compliance Officer

PJK:cc

c: Dr. Karen Giorgetti, Chair
Department of Psychology