

An Analysis of Compound Stimuli and Stimulus Equivalence in the Acquisition of
Russian Vocabulary

by

Vilmary Placeres

Submitted in Partial Fulfillment of the Requirements

for the degree of

Masters of Science

in the

Applied Behavior Analysis Program

YOUNGSTOWN STATE UNIVERSITY

May 2014

AN ANALYSIS OF COMPOUND STIMULI AND STIMULUS EQUIVALENCE IN
THE ACQUISITION OF RUSSIAN VOCABULARY

Vilmary Placeres

I hereby release this thesis to the public. I understand that this thesis will be made available from the OhioLINK ETD Center and the Maag Library Circulation Desk for public access. I also authorize the University or other individuals to make copies of this thesis as needed for scholarly research.

Signature:

Vilmary Placeres, Student Date

Approvals:

Dr. Michael Clayton, Thesis Advisor Date

Dr. Julie Boron, Committee Member Date

Dr. Jane Kestner, Committee Member Date

Dr. Salvatore A. Sanders, Associate Dean of Graduate Studies Date

Abstract

The stimulus equivalence paradigm is an empirically supported procedure that has been used to teach various populations and subject matter. Several methodological issues exist within this paradigm including differing definitions and various types of stimulus equivalence procedures. This particular study compared two types of stimulus equivalence procedures (i.e., compound vs. simple stimuli). Results of this study indicated that the simple stimuli procedure was more effective in deriving relations, but the compound stimuli procedure was more time-efficient in terms of reaching mastery criterion.

Table of Contents

Introduction.....	6
What has Stimulus Equivalence been used for?.....	7
Efficiency and Methodological Issues.....	9
Stimulus Equivalence and Verbal Humans.....	10
Stimulus Equivalence and Verbal Behavior.....	12
Second Language Acquisition.....	14
Compound (or Complex) Stimuli.....	17
Method.....	19
Participants & Setting.....	19
Materials.....	19
Research Design.....	19
Interobserver Agreement.....	19
Dependent Variables.....	19
Procedure.....	20
Results.....	25
Simple vs. Compound.....	25
Simple Stimuli.....	26
Compound Stimuli.....	26
Interobserver Agreement (IOA).....	26
Discussion.....	26
References.....	31
Tables.....	38

Figures.....39
Institutional Review Board Approval Letter.....45

An analysis of compound stimuli and stimulus equivalence in the acquisition of Russian vocabulary

The stimulus equivalence procedure, first introduced by Sidman (1971), has been characterized through its properties derived from mathematical relations: reflexivity, symmetry, and transitivity, also known as mediated transfer (Sidman, Cresson & Willson-Morris, 1974). The relation of reflexivity demonstrates the emergence of pairing the same stimuli to each other without prior training. For example, if a participant can match stimulus A to stimulus A and stimulus B to stimulus B without prior training, then the participant has demonstrated reflexivity. Symmetry, on the other hand, is demonstrated when a participant can reciprocally pair two stimuli together that have previously been paired. In other words, if a participant has been trained to pair stimulus A to stimulus B and can now pair stimulus B to stimulus A without receiving reinforcement (i.e., without training), then symmetry has been demonstrated. The last relation, transitivity, is demonstrated if a participant can pair two stimuli that were not previously paired and are not equal. An example of this is demonstrated when a participant is trained to match stimulus A to stimulus B and stimulus B to stimulus C and can then pair stimulus A to stimulus C without being directly trained to match this relation. In order for a participant to display equivalence, *all* of the relations have to emerge (or derive); that is, if any of the relations expected to emerge were trained, then equivalence has not been demonstrated.

This procedure usually consists of three phases: the pretest phase, the training phase, and the post-test phase. In the pre-test phase, or baseline, participants are tested and evaluated on their knowledge of various relations without receiving reinforcement

for correct responses. Then, during the training phase certain stimuli are arbitrarily paired (A1 is related to B1) and the participant selects (selection-based) or emits (topography-based) a particular response when comparison stimuli are presented (if A then B and if B then C; A:B and B:C) (Hall & Chase, 1991). Correct responses are reinforced during the training phase. Once the participant reaches mastery criterion, the post-test is administered, which evaluates the emergence of several relations, such as symmetry (e.g., B:A and C:B) and transitivity (e.g., A:C and C:A). These relations are expected to arise without being explicitly trained (i.e., no reinforcement is provided for correct responses). This phase is commonly identical to the pre-test phase. If, in fact, all of the relations emerge then the stimuli are said to be equivalent.

What has Stimulus Equivalence been used for?

A study conducted by Sidman & Tailby (1982) was one of the first studies to show the effectiveness of stimulus equivalence. This study expanded the stimulus equivalence procedure for the first time. In his original study, Sidman (1971) used three stimulus classes to demonstrate derived relations while the study by Sidman & Tailby (1982) used four stimulus classes instead of three. Since then, other studies have not only been able to show the effectiveness of stimulus equivalence (e.g., Minster, Jones, Elliffe & Muthukumaroswamy, 2006), but also expanded this procedure. Although it was originally used to teach children and adults with developmental disabilities (such as Autism, Down's syndrome, etc.), many studies have also used it to teach typical children (e.g., Lazar, Davis-Lang & Sanchez, 1984) and adults as well as college students (e.g., Fienup & Critchfield, 2001). In addition, several types of training procedures have been used to teach relations (i.e., one-to-many, many-to-one, and linear series; Arntzen, 2012).

Further research has found that meaningful stimuli aid in establishing equivalent relations (Arntzen, 2012; Fields, Arntzen, Nartey & Eilifsen, 2012) and that delayed matching to sample (DMTS) seems to provide stronger relations than simultaneous matching to sample (Arntzen, 2012; Bartoloti & de Rose, 2012). In fact, in the Fields, Arntzen, Nartey & Eilifsen (2012) study, effects of a meaningful stimulus, a discriminative stimulus and a meaningless stimulus on equivalence class formations were evaluated by comparing these types of stimuli and dividing 30 college student participants into three groups. Each group was assigned to either a meaningless (abstract) stimulus, a meaningful (picture) stimulus or a stimulus that had already acquired discriminative properties. The results suggest that the abstract stimulus did not acquire equivalent relations and that the group with the meaningful stimulus did acquire equivalent relations. Furthermore, only half of the participants that had been exposed to the discriminative stimulus acquired equivalent relations.

Other uses for stimulus equivalence include using auditory stimuli instead of visual stimuli (Dube, Green & Serna, 1993), teaching participants to play the keyboard (Hayes, Thompson & Hayes, 1989), extension to eight-member equivalence classes using conditional discrimination (Saunders, Wachter & Spradlin, 1988) and class merger (Fienup, Covey & Critchfield, 2010) in which two sets of stimuli are trained with a common stimulus in each set and transitive relations across sets can emerge. It can also be used for reading comprehension, auditory comprehension, auditory receptive reading and educationally relevant subject matter, such as US Geography (Leblanc, Miguel, Cummings, Goldsmith & Carr, 2003). In addition, Toussaint & Tiger (2010) used a matching to sample procedure to teach four visually impaired children Braille literacy

skills, while other researchers have used stimulus equivalence to teach college students statistical interactions (Fields, et al., 2009), brain anatomy and function (Fienup, Covey & Critchfield, 2010), inferential statistics and hypothesis decision making in a natural setting and single-subject design through a web-based program (Walker & Rehfeldt, 2012).

In fact, Fields et al., (2009) conducted a study in which a computer-based stimulus equivalence procedure was used to teach statistical interactions to a classroom of undergraduate college students. Since stimulus equivalence had already been demonstrated to be effective in a laboratory setting, this study evaluated its effectiveness in a natural setting and taught what has anecdotally been considered a difficult subject within statistics. The experimenters used a pretest-post-test design, as is commonly used in studies of equivalence, along with a control and experimental group. The study used a paper and pencil pre and post-test in order to measure generalization and found that equivalence based instruction was indeed effective within a classroom setting with nine out of ten participants demonstrating equivalence.

Efficiency and Methodological Issues

One reason why stimulus equivalence is of interest in the field of behavior analysis is due to its efficiency (Omara, 1991). Since all of the relations do not have to be explicitly taught, using the stimulus equivalence procedure to teach relations between some of the stimuli tends to save a significant amount of time. For example, if the picture of an apple and the word “apple” are paired, then the word “apple” does not have to be paired with the picture of an apple because this relation will emerge, thus saving time.

Many studies have shown the efficiency of the stimulus equivalence procedure (e.g., Sidman & Tailby, 1982; Devany, Hayes & Nelson, 1986); however, some methodological differences between experimenters exist (Omara, 1991). For example, Sidman's definition of equivalent classes based on the mathematical relations has been widely accepted. On the other hand, another definition has emerged. Vaughan (1988) changed Sidman's definition so that a partition, or subset, of the original stimulus set could form an equivalent class, but this definition has not been used since his study and has actually been opposed.

Other methodological issues include the types of stimulus equivalence procedures used. Some experimenters have taught one stimuli to many comparisons (i.e., one-to-many, OTM; A:B and A:C). For example, teaching preschool children to match the word "three" to its number (A:B) and training those children to also match the word "three" to a picture of three figures (A:C). Other experimenters have used many stimuli to one comparison (i.e., many-to-one, MTO; A:B, C:B, D:B, etc.). An example of this could be matching the word "three" to the number "3" and matching a picture of three figures to the number "3." However, studies have shown that these relations do not establish transitive relations as originally defined by Sidman (1971; Omara, 1991). On the other hand, Sidman's original procedure, linear series (LS; A:B and B:C), has demonstrated the emergence of transitive relations as originally described. For example, this procedure can be demonstrated by teaching a child to match the word of a number (e.g., three) to its corresponding figure (e.g., "3") (A:B) and afterwards by teaching the child to match the figure of the number to its corresponding pictorial representation (B:C).

Stimulus Equivalence and Verbal Humans

A specific area of interest within the stimulus equivalence paradigm is its relationship to verbal behavior. An overview of this relationship (Hall & Chase, 1991) indicated that all equivalent classes are in fact verbal behavior; however, all verbal behavior is not equivalent. Additionally, Clayton & Hayes (1999) mentioned that stimulus equivalence is more likely to occur in verbal humans than in non-verbal humans. As a result, the studies conducted using the stimulus equivalence procedure have focused on verbal behavior as previously mentioned (e.g., Pérez-González, et al., 2008; Rosales, Rehfeldt & Lovett, 2011), and previous research has not been able to establish stimulus equivalence with animals (e.g. Nissen, 1951) or nonverbal humans (Devany, Hayes & Nelson, 1986). Some research has shown that pigeons can learn relations trained by matching to sample (i.e., conditional discriminations) but cannot establish symmetry (Rodewald, 1974; Hogan & Zentall, 1977; Edwards, Jagielo & Zentall, 1983; Lipkens, Kop & Matthijs, 1988). For example, Fouts, Chown & Goodin (1976) tested mediated transfer, or transitivity, in a chimpanzee but did not demonstrate emergent relations. Furthermore, a study by Sidman, et al. (1982) compared rhesus monkeys, baboons and children. They found that only children could demonstrate emergent relations even though animals could demonstrate conditional discriminations.

In another study, Devany, Hayes, & Nelson (1986) compared three groups. The first group included normally developing children, the second group consisted of mentally disabled children with language abilities and the last group included mentally disabled children without language abilities. This study confirmed the hypothesis that only language-able children could demonstrate equivalent relations. Interestingly, a later commentary by Hayes (1989) stated that nonhumans have not demonstrated stimulus

equivalence although two specific research articles have demonstrated this (McIntire, Cleary & Thompson, 1981; Vaughan, 1988).

In the study by McIntire, Cleary & Thompson (1981) all of the relations tested and said to be derived were directly trained. In other words, subjects were provided with reinforcement for “derived” relations and; therefore, did not form equivalent relations as originally defined by Sidman (1971). In addition, Vaughan (1988), as mentioned previously, was able to establish equivalent relations in pigeons by changing the definition of stimulus equivalence. This definition included forming relations of subsets of the original set used instead of forming relations using the whole set as Sidman’s (1971) original definition implied. Another problem with this study, similar to the study by McIntire, et al. (1981), was that the relations that were “derived” were actually trained. In both studies, instances of correct responding for symmetrical relations were reinforced. On the other hand, in a true stimulus equivalence experiment these relations would emerge without being reinforced.

Stimulus Equivalence and Verbal Behavior

Another use of the stimulus equivalence paradigm has been to teach verbal behavior being that stimulus equivalence has only been shown to work with verbal humans. Some of the studies using this paradigm to teach verbal behavior rely on the verbal operants first described by Skinner (1957), who studied verbal behavior (vocal or non-vocal) and defined it as behavior in which a listener mediates the reinforcement. In other words, in order for a verbal response to be considered verbal behavior a listener must be present, regardless of whether the listener is the speaker or whether the listener is someone independent of the speaker that listens to the speaker.

There are four types of verbal operants: echoic, mand, tact, and intraverbal; each of which serves a different function (i.e., functionally independent). The echoic operant is usually the first operant that children acquire, in which the child simply imitates the verbal behavior of another person. For example, an instructor may hold up an apple and say “apple,” the child repeats the word “apple” and receives social reinforcement for repeating that word (e.g., “Good job!”) from the listener. A mand, derived from “demand,” is usually the second operant that a child acquires in which the child will say, for example, “apple” and is reinforced with an actual apple provided by the listener. As children get older, they begin to tact, or name things in their environment. A child may see an apple and say “apple” simply because the apple is in the child’s environment. In this case, children receive social reinforcement in the form of praise (e.g., “Good job! That is an apple”) provided by the listener. Finally, the intraverbal operant is the last operant to be acquired and produces social reinforcement as well. An instructor asks, “Where do you live?” and the child answers, “I live in Ohio,” to which the instructor may respond “Very good.” This particular operant is not necessarily reinforced through praise, but through the act of having a conversation with another person.

A study conducted by Sidman & Tailby (1982) replicated and expanded upon a previous experiment that also studied verbal behavior. In this early study, eight typical children between the ages of five and eight were trained using a conditional discrimination procedure in which participants were to select a response when given a comparison stimulus. The experimenters trained the dictated name of three Greek letters to two different variations of the written letters (A:B and A:C). Then, one variation of the Greek letters was taught to match a third variation (D:C). Finally, a post-test was

presented in which six out of the eight children acquired equivalent classes when tested for symmetry (C:D) and transitivity (A:D, C:B, B:C, D:B, and B:D). This study showed that stimulus equivalence could be demonstrated with more than just three sets of stimuli.

Another example of stimulus equivalence using one of the verbal operants described is a study conducted by Pérez-González, Herszlikowicz & Williams (2008) in which they used stimulus equivalence to examine the emergence of topography-based operants, or intraverbals. In the first experiment of this study, two sets of intraverbals were taught to participants. The first set consisted of naming the city capital (e.g., “Buenos Aires”) when told the country (e.g., “Argentina”) (A:B). In the second set, the participants were to name a particular park (e.g., “El Botánico”) when told the name of the city (B:C). It concluded by probing 12 intraverbals and testing for symmetrical and transitive relations. None of the participants in this first study demonstrated the emergence of all 12 intraverbals. However, one participant showed the emergence of eight intraverbals while another demonstrated the emergence of four intraverbals, and one participant showed emergence of two intraverbals. The last two participants did not show emergence of any relations.

In their second experiment, three new participants and a participant from the first experiment were taught categories (e.g. “What is Argentina?” or “What is Buenos Aires?”) and exemplars (e.g. “Tell me a country”) before being taught the relations trained in the first experiment. All four participants in this study demonstrated the emergence of the untaught relations with fewer sessions than those needed for the first experiment.

Finally, the last experiment in this study used new stimuli to replicate the previous experiments with four of the previous participants who demonstrated emergence of untaught relations. The procedure for this experiment was the same as the second experiment and resulted in all of the participants demonstrating emerged relations with fewer sessions and fewer errors. While this could have been due to the fact that these participants had already been included in at least one of the previous experiments, the participants from the second experiment acquired the untaught relations quicker than the participant from the first experiment.

Overall, this study demonstrated that teaching simpler categories and exemplars can still lead to the emergence of untaught intraverbals in children, and it can actually lead to quicker acquisition compared to the stimulus equivalence procedure alone. In fact, it implies that this simpler procedure of teaching categories and exemplars can be used instead of the stimulus equivalence paradigm for teaching intraverbals; although the stimulus equivalence procedure has been demonstrated to be efficient with other stimuli that are not related to teaching verbal operants.

Second Language Acquisition

An additional area of increasing interest in the field of Applied Behavior Analysis has been second language acquisition (Madrid & Torres, 1986; Joyce & Joyce, 1993; Houmanfar, Hayes & Herbst, 2005; Washio & Houmanfar, 2007; Siguroardóttir, et al., 2012). For instance, Mclaughlin (1977) reviewed several studies on second language acquisition and compared the differences of learning a second language and a native language simultaneously or successively. The role of external environments has also been demonstrated to be of importance in second language acquisition (Washio &

Houmanfar, 2007) and stimulus equivalence has been used as one of the many teaching tools for second language acquisition (Joyce & Joyce, 1993; Siguroardóttir, Mackay & Green, 2012).

For example, in a study by Joyce & Joyce (1993), stimulus equivalence was used to teach two adolescent males with head injuries relationships between English and Spanish words. First they conducted a pre-test to assess the participants' ability in matching several stimuli. Then, the participants were trained to match auditory words to printed words and pictures (A:B and A:C). After, a post-test was conducted to evaluate whether or not the participants had acquired equivalent relations. The results indicated that both participants demonstrated emergent relations and that using stimulus equivalence for teaching a second language can be both time-efficient and economical.

In comparison, Madrid & Torres (1986) took an experimental approach to second language training and acquisition by focusing on negation (i.e., using “does not” and “do not”). They compared three groups for this study: simultaneous teaching of two languages, independent training (i.e., one language at a time) and a control group (i.e., no teaching). Twenty-four participants were used in this study, and they were divided among the three groups. The study surmised that independent training was enough to reach mastery criterion for children who are proficient in English. However, for children who are not proficient in English, simultaneous presentation was shown to be more helpful in learning negation.

Finally, Siguroardóttir, Mackay & Green (2012) conducted a study in which stimulus equivalence was used to connect Icelandic singular nouns to their respective pictures and printed words (A:B and A:C). In the first experiment, the experimenters

measured generalization to the plural forms of those nouns (A:D). In the second experiment, a stimulus was present as an instruction. “Tala” was the instruction present when the participants were to compare singular and plural nouns and “kyn” was the instruction present when the participants were to compare feminine and masculine nouns. For example, in the presence of the word “tala” and a singular noun, the participants were to match another singular noun from the sample and in the presence of the word “kyn” and a feminine noun the participants were to match another feminine noun.

The results of this study found that contextual control was acquired and it confirmed the use of a stimulus equivalence procedure to teach a second language. However, this study also indicated that if gender differentiation occurs in the native language of the participant, then it might be easier for that participant to differentiate gender in another language. On the other hand, if gender differentiation does not occur in the native language, such as English, then it may be more difficult for that participant to differentiate gender in another language.

Liu (1995) took a different approach to second language learning. Instead of using a stimulus equivalence procedure, this study used a hypermedia technique, in this case a movie, to evaluate the use of contextual aids for non-native English speakers to understand the English language. The study concluded that second language learners could, in fact, access contextual aids when unfamiliar words were targeted, and it indicated that this procedure can also be useful in teaching a second language.

In addition, Petursdottir & Haflidadóttir (2009) conducted a study in which four strategies for teaching a small foreign language vocabulary were compared by systematically replicating the study conducted by Pérez-González, et al. (2008), as

previously described. Two subjects were trained in listener, tact and intraverbal behavior (Skinner, 1957) for both native to foreign language and foreign to native language. This particular study measured acquisition rate by using an alternating treatment and multiple baseline design. Emerged relations were measured using a pre-test and post-test. The results confirmed that all verbal operants as described by Skinner (1957) are functionally independent. Therefore, teaching one operant did not lead to the emergence of other relations.

Other areas of study in second language acquisition include multiple exemplar training (Rosales, et al., 2011) and native language interference in second language acquisition (Houmanfar, Hayes & Herbst, 2005; McLaughlin, 1977). Different learning contexts, such as communicative (i.e. study abroad) and learning (i.e. classroom) contexts, have also been studied and demonstrated to be no different. Simply, no one context is superior to the other (Collentine & Freed, 2004) as has been widely thought.

Compound (or Complex) Stimuli

One of the methodological issues previously described is yet another area of interest within stimulus equivalence. Markham & Dougher (1993) expanded the stimulus equivalence procedure by using compound, or complex, stimuli (AB-C). Their study resulted in some participants demonstrating equivalence but not others. Although insufficient research has been done using compound stimuli, this could be an important phenomenon in teaching stimulus equivalence. This procedure, if truly effective, can be considered to be more time efficient than the original procedure. This paradigm allows the combination of two stimuli to be matched to a third stimuli and implies that if effective, less relations can be trained to yield similar results to the linear series, or

simple stimuli method, that Sidman (1971) described. The study conducted by Markham & Dougher (1993) was a systematic replication of two earlier studies where compound stimuli were used to establish arbitrary relations, in which most participants demonstrated emergent relations (Stromer & Stromer, 1990a; Stromer & Stromer 1990b).

Afterwards, Lane & Critchfield (1998) conducted a study in which compound stimuli were used to teach two adolescent females with Down syndrome vowels and consonants. As previously thought, the use of compound stimuli led to very rapid acquisition; however, since this study did not compare the original simple stimuli, or linear series, method of stimulus equivalence to the complex method it cannot be ascertained that complex stimuli will lead to a quicker rate of acquisition than the simple stimuli method, but can simply state that using complex stimuli is effective.

In addition, Groskreutz, Karsina, Miguel & Groskreutz (2010) extended the research on compound stimuli by teaching children and adolescents diagnosed with autism auditory and visual stimuli. This demonstrated that equivalent relations could in fact emerge using the complex, or compound, stimuli method.

Since no studies to date have used the compound stimuli to teach second language acquisition, one purpose of this study was to investigate the usefulness and efficiency of the compound stimuli procedure in teaching a small Russian vocabulary. The second purpose was aimed at comparing the compound stimuli procedure to a simple stimuli procedure in order to determine if one particular procedure leads to quicker mastery. How can using a simple stimuli method differ from using a compound, or complex, stimuli method in teaching Russian vocabulary? Therefore, comparing these two types of

stimulus equivalence procedures will determine if one procedure is more effective than the other.

Method

Participants & Setting

Thirty-eight undergraduate students between the ages of 18 and 43 participated in this study and were randomly assigned to one of two groups. Sixteen of these participants were male and twenty-two participants were female of varying majors and academic standing (i.e., Freshmen, Sophomore, Juniors and Seniors). Participants volunteered for the study and received extra credit in their psychology courses for agreeing to participate. Participants signed a consent form prior to beginning the study and were told that they could withdraw from the study at any point without penalty. After completing the study, each participant was thoroughly debriefed. Each session was between 5 and 15 minutes long and each participant was tested individually.

Materials

A Dell Optiplex 780 computer with mouse and keyboard was used to present stimuli in a Microsoft PowerPoint[®] format. Nine stimuli, three Russian printed words, three corresponding Russian spoken words and three corresponding pictures were used (Table 1) and presented on the computer screen as either sample or comparison stimuli.

Research Design

A between groups research design was used to compare the effects of training Russian word relationships with simple vs. compound stimuli on the formation of untrained relations.

Interobserver Agreement

An additional independent observer collected data on 61% of the sessions. Reliability was calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying this number by 100.

Dependent Variables

The dependent variable measured was percentage of correct responses. This measure was recorded during pre-test and post-test phases. In addition, the number of trial blocks to reach mastery during the training phase was recorded for each individual and averaged for each condition.

Procedure

A match-to-sample (MTS) and a topography-based procedure was used to train and test participants. When a sample stimulus was presented with three comparison stimuli the participant was to select the correct comparison stimulus to go with the sample. On the other hand, when a sample stimulus was provided with no comparison stimuli, the participant was to emit (i.e. tact) the correct response that corresponded to the picture or Russian text. Participants selected their responses by manually pointing to the stimuli on the screen.

The samples consisted of the spoken Russian words (A stimuli) for the items chosen, pictures of each item (B stimuli) and Russian textual words (C stimuli) of each item.

Pre-Test

A pre-test phase was administered to all participants to assess their familiarity with sample and comparison stimuli before the training phase of the study began. Participants were presented with the following relations during the pre-test: the spoken

Russian word to Russian text (A:C), Russian text to the spoken Russian word (C:A), Russian text to picture (C:B), picture to the spoken Russian word (B:A) (Figure 1). Each relation was randomly presented during this phase and provided a total of 12 stimulus presentations. Performance feedback was not provided during this phase. The experimenter recorded the number of correct responses for each participant and a second independent observer collected data on 50% of the trials.

Before beginning this phase, the participants were presented with the following instructions:

Sometimes an object will appear at the top of the computer screen. You should look at the object and then select a corresponding object at the bottom of the screen by pointing to the response. Sometimes you will hear a Russian word. You should listen to the word and then select a corresponding response at the bottom of the screen by pointing to the response. Sometimes a word or picture will appear on the screen. You should state the word that corresponds with the textual word or picture. You will not be told whether your answer is correct or incorrect for this part of the study.

For example, the spoken word (A) “перец” was presented to the participant. The Russian textual words (C) “чеснок” “перец” and “тыква” were shown on the screen from left to right. The participant selected the Russian textual word that corresponded to the spoken Russian word and was presented with the next trial.

In order to maintain objectivity for the spoken Russian word as stated by the participant a method was devised. Each Russian word contained two syllables and; therefore, four distinct sounds (beginning and end of each syllable). If the participant

correctly stated three of the four sounds then the response was marked as correct. If fewer than three sounds were stated correctly than the response was marked as incorrect.

If participants received less than 40% of correct responses during the pre-test, it was assumed that exposure to the Russian stimuli was minimal and they were permitted to continue on to the training phase. The criterion was selected based on prior research. Participants who did not meet the criterion to enter the training phase were excluded from the study and replaced with other participants, which occurred on eight occasions.

Training

After the pre-test phase, participants were randomly assigned to one of two groups for training: Compound stimuli or simple stimuli.

Compound Stimuli.

In this condition (Figure 2) the experimenter presented participants with the spoken Russian word and the picture was presented at the top middle of the screen and three comparison stimuli at the bottom of the screen from left to right in random order. Only one relation was trained in this group (AB:C). Therefore, when presented with the Russian auditory word and the picture (AB) the participants were instructed to select the corresponding Russian textual word of the item (C). After participants selected their responses, performance feedback was provided (i.e., “Correct” or “Incorrect”) and the next trial was presented.

As in the pre-test, before the beginning of this phase the participants were presented with the following instructions:

A picture will be presented at the top of the screen and you will hear a Russian word. You should look at the picture and listen to the word then select

the corresponding written word at the bottom of the screen by pointing to the response. In this phase of the study, you will be told if your selection is correct or incorrect. Please pay attention and try your best.

For example, the experimenter spoke the Russian auditory word “ТЫКВА” and the picture of the item appeared at the top middle of the computer screen. At the bottom of the screen, from left to right, the comparison stimuli were presented. In this case, the Russian textual words “перец,” “ТЫКВА,” and “чеснок.” If the participant selected “ТЫКВА,” then the experimenter stated that the response was “correct” and the next trial was presented. On the other hand, if the participant selected any other response, the instructor stated that the response was “incorrect” and the next trial was presented.

Each trial block consisted of 6 presentations of each relation. This provided a total of 18 total trials in each trial block. Once the participants reached mastery criterion (100%), the post-test was administered. If mastery criterion was not reached within three trial blocks the session was terminated, which only occurred on one occasion. The experimenter collected data manually and a second independent observer recorded data on 50% of the trials.

Simple Stimuli

In the simple stimuli condition (Figure 3), participants were presented with the following relations: the spoken Russian word to the appropriate picture (A:B) and the picture of the item to the Russian text (B:C). In the A:B relation, the spoken Russian word was presented by the experimenter and the comparison stimuli were presented at the bottom of the screen from left to right in random order. In the B:C relation, the picture of the object was presented at the top middle of the computer screen and the

comparison stimuli were presented at the bottom of the screen from left to right in random order.

Once again, before beginning this phase participants were presented with the following instructions:

Sometimes a picture will appear at the top of the computer screen. You should look at the picture and then select a corresponding written word at the bottom of the screen by pointing to the response. Sometimes you will hear a Russian word. You should listen to the word and then select a corresponding picture at the bottom of the screen by pointing to the response. In this phase of the study, you will be told if your selection is correct or incorrect. Please pay attention and try your best.

For example, during A:B training, the participant was presented with the spoken Russian word “перец” and three pictures appeared from left to right at the bottom of the screen (see Table 1). The participant was to select the picture that corresponded with the Russian word that had been presented. If the participant chose the picture of pepper, then the instructor stated that the participant was correct and the next trial was presented. However, if the participant selected any other picture, the instructor stated that the participant was incorrect and the next trial was presented.

Each trial block consisted of 3 presentations of each relation. This provided a total of 18 total trials in each trial block. Training continued until participants reached mastery criterion (100%) or until three trial blocks were presented. If the participant did not reach mastery criterion within three trial blocks then the session was terminated,

which occurred on eight occasions. The experimenter collected data manually and a second independent observer recorded data on 50% of the trials.

Post-test

When participants reached criterion, the post-test was provided in order to test the emergent relations previously assessed by the pre-test. Therefore, the post-test was identical to the pre-test and tested symmetrical and transitive relations, as originally defined by Sidman (1971).

Participants were tested on several relations during the post-test phase. These included: spoken Russian word to Russian text (A:C), Russian text to the spoken Russian word (C:A), Russian text to picture (C:B), picture to the spoken Russian word (B:A) (Figure 1). Performance feedback was not provided during this phase.

Before beginning this phase, the participants were presented with the same instructions that were provided during the pre-test and correct responses for the spoken Russian word was assessed in the same manner. If participants received more than 80% of correct responses during the post-test congruent with previous research, it was assumed that symmetrical and transitive relations emerged. Interobserver agreement was calculated on 50% of the trials.

Results

Interobserver Agreement (IOA)

Reliability was calculated during 12 trials of the simple stimuli group and during 11 trials of the compound stimuli group. Overall, reliability was calculated on 61% of all trials. The overall average reliability was 98% for both groups combined ranging between 92% to 100%.

Simple vs. Compound

Overall, the simple stimuli group scored an average of 25% during the pre-test (Figure 4). The average number of trial blocks to reach mastery criterion was 2.45 (SD = 0.52) and the average post-test score was 86.27% (Figure 4), which suggests that participants did demonstrate equivalence on average. The scores for the participants who did not reach mastery during the training phase were not included in the calculations for average number of trial blocks to mastery and average post-test score (N=8).

The average score for participants in the compound stimuli group was 25% during pre-tests (Figure 4), which was identical to participants in the simple stimuli. The average number of trial blocks to reach mastery criterion was 1.58 (SD = 0.62) and the average post-test score was 72% (Figure 4). This suggests that, on average, participants did not demonstrate equivalence in this group. However, only one participant in this group did not reach mastery.

In addition, a t-test was conducted to compare the trials to criterion between groups. Only participants that met mastery during the training were included in the sample regardless of whether or not the participants demonstrated derived relations. This led to 11 of 19 participants in the simple stimuli group and 18 of 19 participants in the compound stimuli group. A significant difference was found between groups ($p < .001$) indicating that the compound stimuli procedure was more efficient in reaching mastery in fewer trials than the simple stimuli procedure.

Simple Stimuli

The simple stimuli group consisted of 19 participants (Figure 5). As in the compound stimuli group, nine of these participants were able to demonstrate derived relations. Eight participants in this group did not reach mastery criterion during the training phase and two participants did not demonstrate equivalent relations.

Figure 5 provides the results of each participant in the Simple Stimuli group. Participants that did not reach mastery criterion did not participate in the post-test; therefore, no post-test results are reported.

Compound Stimuli

Similar to the simple stimuli group, this group consisted of 19 randomly assigned participants. Nine of these participants were able to demonstrate derived relations. Eight participants on the other hand, scored below the criterion set for demonstrating derived relations, which was set at 83% or higher and one participant did not reach mastery.

Figure 6 details the results of each participant in the Compound Stimuli group. The participant that did not reach mastery criterion were not given the post-test; therefore, no post-test results are reported.

Discussion

In the present study, a between groups research design was used to compare two distinct stimulus equivalence procedures (simple vs. compound) to teach a small Russian vocabulary to undergraduate college students. On average, participants in both groups scored similarly in the pre-test suggesting that there were no significant differences between groups at the beginning of the study. In addition, participants met mastery in

fewer trials in the compound stimulus group than the simple stimulus group and participants in the simple stimulus group were more likely to demonstrate equivalent relations than participants in the compound stimulus group. This suggests that although the compound procedure allows participants to reach mastery in fewer trials, the simple stimuli procedure is more effective due to the fact that most of the participants who reached mastery were able to demonstrate equivalent relations.

First, the present study contributes further evidence of the effectiveness of the stimulus equivalence paradigm as first introduced by Sidman (1971). Participants in the simple stimuli group were presented with training that was similar to that of Sidman's (1971) original procedure, in which participants were to select a picture that corresponded with the spoken word (A:B) and select a written word that corresponded with a picture (B:C). Participants in this group were able to demonstrate equivalent relations on average, providing further support for using this teaching paradigm to teach a small Russian vocabulary.

Second, the present study extends previous research conducted on the compound stimuli procedure (Markham & Dougher, 1993; Stromer & Stromer, 1990a; Stromer & Stromer, 1990b; Lane & Critchfield, 1998; Groskreutz, Karsina, Miguel & Groskreutz, 2010). Studies have demonstrated that the compound stimuli method could yield equivalent relations. The present study extended and replicated these studies by demonstrating that the compound stimuli procedure can yield equivalent relations in undergraduate college students.

The present study also extends previous research by comparing the simple and compound stimuli methods to determine which procedure would be more efficient in

teaching a small Russian vocabulary. The participants in this study were able to reach mastery criterion quicker in the compound stimuli, but were more likely to demonstrate equivalent relations in the simple stimuli method. Overall, the implications of this study suggest that the simple stimuli method is more effective in demonstrating derived relations and that the compound stimuli method is more time efficient in terms of reaching mastery criterion in fewer trials. Future research should investigate whether or not the compound stimuli procedure would be more effective if the same amount of trial blocks were required for both groups regardless of mastery criterion.

The present study also provides further evidence for using the stimulus equivalence paradigm with verbal humans (Hall & Chase, 1991; Clayton & Hayes, 1999). Even though the present study did not make this comparison and future research should continue to explore this area, it should be noted that all participants used in this study were indeed verbal humans.

Finally, the present study extended previous research by using the stimulus equivalence paradigm to teach a second language (Joyce & Joyce, 1993). The stimulus equivalence procedure was effective in teaching a small Russian vocabulary although further research is needed to determine if stimulus equivalence would be an effective method in teaching a larger vocabulary and other languages. In addition, further research should also directly compare the stimulus equivalence paradigm to other methods such as negation training (Madrid & Torres, 1986) and hypermedia techniques (Liu, 1995). This would demonstrate which procedures are more effective and efficient in teaching a second language and which procedures would be more beneficial to use in a natural setting.

Several limitations exist for the present study. First, the spoken Russian word for “pepper” begins with a “p” sound, similar to the English word. This particular similarity may have made it easier for participants to learn the spoken Russian word for “pepper” and more difficult for the experimenter to know whether or not the participants were learning the word or simply matching sounds. Second, only three words were taught in both groups; therefore, it could be argued that the experiment was too simple. Further research should explore teaching a more extensive foreign language vocabulary. Another limitation of this study was that all participants were students of the same university with no developmental disabilities. Other studies should consider using a different population (e.g., students of different universities, students with developmental disabilities, children, etc.) and a larger sample size to further demonstrate the true effectiveness of the compound stimuli procedure. Additionally, future research can compare the differences between results obtained by participants who can only speak one language and participants who can speak more than one language.

The purposes of the study were met in that the usefulness and efficiency of the compound stimuli procedure in teaching a small Russian vocabulary were noted and the simple stimuli procedure was compared to the compound stimuli procedure. A third limitation is that the present study cannot determine the usefulness or effectiveness of these procedures in the classroom, suggesting that further research in a natural setting is necessary. Finally, participants volunteered for the experiment and it cannot be ascertained whether differences existed between students that participated in the study and those who did not.

In summary, the present study is the first to compare the compound and simple stimuli method in college undergraduate students to teach a small foreign vocabulary. Future studies should compare these teaching procedures in a classroom to determine effectiveness in the natural setting. Additionally, only Russian words were used in this study, other languages should be investigated using a larger vocabulary in order to determine if these procedures would still be effective. Finally, future studies should compare the simple and compound stimuli methods using rate of acquisition as a dependent variable instead of trials to criterion and percentage of correct responses.

References

- Arntzen, E. (2012). Training and testing parameters in formation of stimulus equivalence: Methodological issues. *European Journal of Behavior Analysis, 13*, 123-135.
- Bortoloti, R., & de Rose, J. C. (2012). Equivalent stimuli are more strongly related after training with delayed matching than after simultaneous matching: A study using the implicit relational assessment procedure (IRAP). *The Psychological Record, 62*, 41-54.
- Barnes-Holmes, D., Barnes-Holmes, Y., & Cullinan, V. (2000). Relational frame theory and Skinner's verbal behavior: A possible synthesis. *The Behavior Analyst, 23*, 69-84.
- Barnes-Holmes, D., Murphy, A., Barnes-Holmes, Y., & Stewart, I. (2010). The implicit relational assessment procedure: exploring the impact of private versus public contexts and the response latency criterion on pro-white and anti-black stereotyping among white Irish individuals. *The Psychological Record, 60*, 57-66.
- Clayton, M. C., & Hayes, L. J. (1999). Conceptual differences in the analysis of stimulus equivalence. *The Psychological Record, 49*, 145-161.
- Collentine, J., & Freed, B. F. (2004). Learning context and its effects on second language acquisition: Introduction. *Studies in Second Language Acquisition, 26*, 153-171.
doi: 10.1017/S0272263104062011
- Devany, J. M., Hayes, S. C., & Nelson, R. O. (1986). Equivalence class formation in language-able and language-disabled children. *Journal of the Experimental Analysis of Behavior, 46*, 243-257.

- Dube, W. V., Green, G., & Serna, R. W. (1993). Auditory successive conditional discrimination and auditory stimulus equivalence classes. *Journal of the Experimental Analysis of Behavior, 59*, 103-114.
- Edwards, C. A., Jagielo, J. A., & Zentall, T. R. (1983). "Same/different" symbol use by pigeons. *Animal Learning & Behavior, 11*, 349-355.
- Fields, L., Arntzen, E., Nartey, R. K., & Eilifsen, C. (2012). Effects of a meaningful, a discriminative, and a meaningless stimulus on equivalence class formation. *Journal of the Experimental Analysis of Behavior, 97*, 163-181.
- Fields, L., Travis, R., Roy, D., Yadlovker, E., de Aquiar-Rocha, L., & Sturmey, P. (2009). Equivalence class formation: A method for teaching statistical interactions. *Journal of Applied Behavior Analysis, 42*, 575-593.
- Fienup, D. M., & Critchfield, T. S. (2011). Transportability of equivalence-based programmed instruction: Efficacy and efficiency in a college classroom. *Journal of Applied Behavior Analysis, 44*, 435-450.
- Fienup, D. M., Covey, D. P., & Critchfield, T. S. (2010). Teaching brain-behavior relations economically with stimulus equivalence technology. *Journal of Applied Behavior Analysis, 43*, 19-33.
- Fouts, R. S., Chown, B., & Goodin, L. (1976). Transfer of signed responses in American Sign Language from vocal English stimuli to physical object stimuli by a chimpanzee (Pan). *Learning and Motivation, 7*, 458-475.
- Groskreutz, N. C., Karsina, A., Miguel, C. F., & Groskreutz, M. P. (2010). Using complex auditory-visual samples to produce emergent relations in children with autism. *Journal of Applied Behavior Analysis, 43*, 131-136.

- Hall, G. A., & Chase, P. N. (1991). The relationship between stimulus equivalence and verbal behavior. *The Analysis of Verbal Behavior*, 9, 107-119.
- Hayes, L. J., Thompson, S., & Hayes, S. C. (1989). Stimulus equivalence and rule following. *Journal of the Experimental Analysis of Behavior*, 52, 275-291.
- Hayes, S. C. (1989). Nonhumans have not yet shown stimulus equivalence. *Journal of the Experimental Analysis of Behavior*, 1989, 385-392.
- Hayes, S. C., & Barnes, D. (1997). Analyzing derived stimulus relations requires more than the concept of stimulus class. *Journal of the Experimental Analysis of Behavior*, 68, 235-270.
- Hogan, D. E., & Zentall, T. R. (1977). Backward associations in the pigeon. *The American Journal of Psychology*, 90, 3-15.
- Houmanfar, R., Hayes, L. J., & Herbst, S. A. (2005). An analog study of first language dominance and interference over second language. *The Analysis of Verbal Behavior*, 21, 75-98.
- Imam, A. A. (2001). Speed contingencies, number of stimulus presentations, and the nodality effect in equivalence class formation. *Journal of the Experimental Analysis of Behavior*, 76, 265-288.
- Joyce, B. G., & Joyce, J. H. (1993). Using stimulus equivalence procedures to teach relationships between English and Spanish words. *Education and Treatment of Children*, 16, 48-65.
- Lane, S. D., & Critchfield, T. S. (1998). Classification of vowels and consonants by individuals with moderate mental retardation: Development of arbitrary relations

- via match-to-sample training with compound stimuli. *Journal of Applied Behavior Analysis*, *31*, 21-41.
- Lazar, R. M., Davis-Lang, D. D., & Sanchez, L. (1984). The formation of visual stimulus equivalences in children. *Journal of the Experimental Analysis of Behavior*, *41*, 251-266.
- LeBlanc, L. A., Miguel, C. F., Cummings, A. R., Goldsmith, T. R., & Carr, J. E. (2003). The effects of three stimulus-equivalence testing conditions on emergent US geography relations of children diagnosed with autism. *Behavioral Interventions*, *18*, 279-289.
- Lipkens, R., Kop, P. F. M., & Matthijs, W. (1988). A test of symmetry and transitivity in the conditional discrimination performances of pigeons. *Journal of the Experimental Analysis of Behavior*, *49*, 395-409.
- Liu, M. (1995). Contextual enrichment through hypermedia technology: Implications for second-language learning. *Computers in Human Behavior*, *11*, 439-450.
- Madrid, D., & Torres, I. (1986). An experimental approach to language training in second language acquisition: Focus on negation. *Journal of Applied Behavior Analysis*, *19*, 203-208.
- Markham, M. R., & Dougher, M. J. (1993). Compound stimuli in emergent stimulus relations: Extending the scope of stimulus equivalence. *Journal of the Experimental Analysis of Behavior*, *60*, 529-542.
- McIntire, K. D., Cleary, J., & Thompson, T. (1981). Conditional relations by monkeys: Reflexivity, symmetry & transitivity. *Journal of the Experimental Analysis of Behavior*, *47*, 279-285.

- McLaughlin, B. (1977). Second language learning in children. *Psychological Bulletin*, *84*, 438-459.
- Minster, S. T., Jones, M., Elliffe, D., & Muthukumaraswamy, S. D. (2006). Stimulus equivalence: Testing Sidman's (2000) theory. *Journal of the Experimental Analysis of Behavior*, *85*, 371-391.
- Nissen, H. W. (1951). Analysis of a complex conditional reaction in chimpanzee. *Journal of Comparative and Physiological Psychology*, *44*, 9-16.
- O'mara, H. (1991). Quantitative and methodological aspects of stimulus equivalence. *Journal of the Experimental Analysis of Behavior*, *55*, 125-132.
- Pettursdotir, A. I., & Haflidadóttir, R. D. (2009). A comparison of four strategies for teaching a small foreign-language vocabulary. *Journal of Applied Behavior Analysis*, *42*, 685-690.
- Pérez-González, L. A., Herszlikowicz, K., & Williams, G. (2008). Stimulus relations analysis and the emergence of novel intraverbals. *The Psychological Record*, *58*, 95-129.
- Perkins, D. R., Dougher, M. J., & Greenway, D. E. (2007). Contextual control by function and form of transfer of functions. *Journal of the Experimental Analysis of Behavior*, *88*, 87-102.
- Rodewald, H. K. (1974). Symbolic matching-to-sample by pigeons. *Psychological Records*, *34*, 987-990.
- Rosales, R., Rehfeldt, R. A., & Lovett, S. (2011). Effects of multiple exemplar training on the emergence of derived relations in preschool children learning a second language. *The Analysis of Verbal*, *27*, 61-74.

- Saunders, R. R., Wachter, J., & Spradlin, J. E. (1988). Establishing auditory stimulus control over an eight-member equivalence class via conditional discrimination procedures. *Journal of the Experimental Analysis of Behavior*, *49*, 95-115.
- Sidman, M. (1971). Reading and auditory-visual equivalences. *Journal of Speech & Hearing Research*, *14*, 5-13.
- Sidman, M., Cresson Jr., O., & Willson-Morris, M. (1974). Acquisition of matching to sample via mediated transfer. *Journal of the Experimental Analysis of Behavior*, *22*, 261-273.
- Sidman, M., Rauzin, R., Lazar, R., Cunningham, S., Tailby, W., & Carrigan, P. (1982). A search for symmetry in the conditional discriminations of rhesus monkeys, baboons, and children. *Journal of the Experimental Analysis of Behavior*, *37*, 23-44.
- Sidman, M., & Tailby, W. (1982). Conditional discrimination versus matching to sample: An expansion of the testing paradigm. *Journal of the Experimental Analysis of Behavior*, *37*, 23-44.
- Siguroardóttir, Z. G., Mackay, H. A., & Green, G. (2012). Stimulus equivalence, generalization, and contextual stimulus control in verbal classes. *The Analysis of Verbal Behavior*, *28*, 3-29.
- Skinner, B. F. (1957). *Verbal behavior*. Acton, MA: Copely Publishing Group.
- Spencer, T. J., & Chase, P. N. (1996). Speed analyses of stimulus equivalence. *Journal of the Experimental Analysis of Behavior*, *65*, 643-659.
- Stromer, R., & Stromer, J. B. (1990a). The formation of arbitrary stimulus classes in matching to complex samples. *The Psychological Record*, *40*, 51-66.

- Stromer, R., & Stromer, J. B. (1990b). Matching to complex samples: further study of arbitrary stimulus classes. *The Psychological Record, 40*, 505-516.
- Toussaint, K. A., & Tiger, J. H. (2010). Teaching early Braille literacy skills within a stimulus equivalence paradigm to children with degenerative visual impairments. *Journal of Applied Behavior Analysis, 43*, 181-194.
- Vaughan, W. (1988). Formations of equivalence sets in pigeons. *Journal of Experimental Psychology: Animal Behavior Processes, 14*, 36-42.
- Walker, B. D., & Rehfeldt, R. A. (2012). An evaluation of the stimulus equivalence paradigm to teach single-subject design to distance education students via blackboard. *Journal of Applied Behavior Analysis, 45*, 329-344.
- Washio, Y., & Houmanfar, R. (2007). The role of contextual control in second language performance. *The Analysis of Verbal Behavior, 23*, 41-56.

Table 1. Stimuli used for both simple and compound stimuli groups.

	1	2	3
A (Spoken Word)	“перец”	“ТЫКВА”	“ЧЕСНОК”
B (Picture)			
C (Written Word)	Перец	ТЫКВА	Чеснок

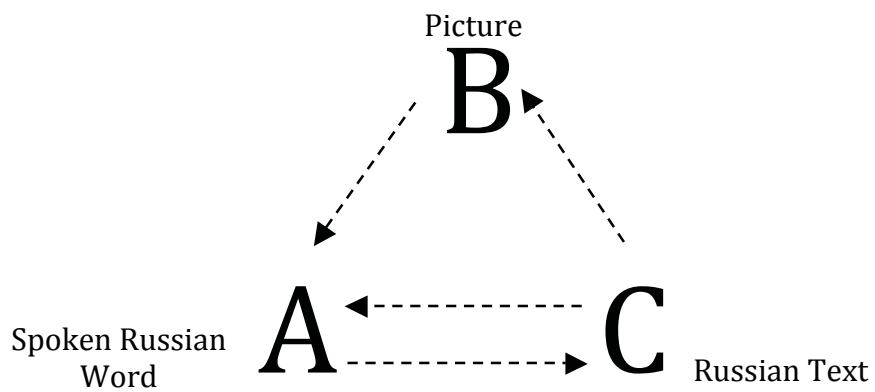


Figure 1. All relations tested during the pre and post-test phases for both groups.

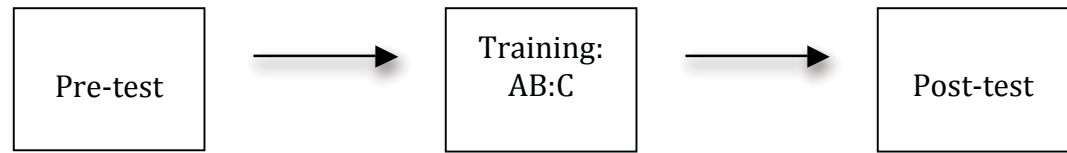


Figure 2. Flowchart demonstrating the sequence of testing and training that was followed for the compound stimuli group.

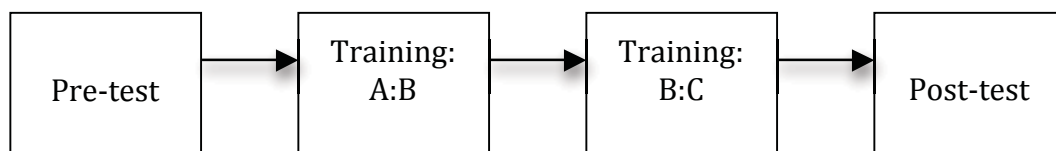


Figure 3. Flowchart demonstrating the sequence of testing and training that was followed for the simple stimuli group.

Simple vs. Compound Stimuli

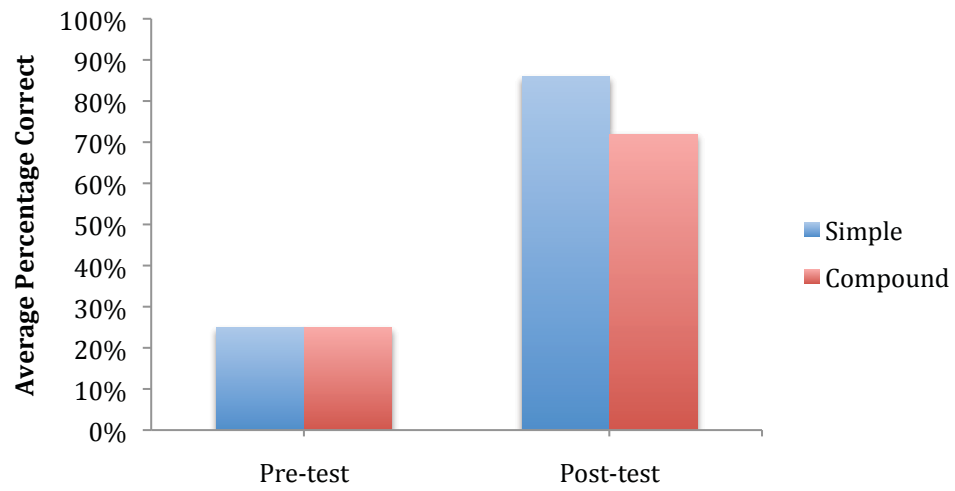


Figure 4. Average Pre-test and Post-test scores per group.

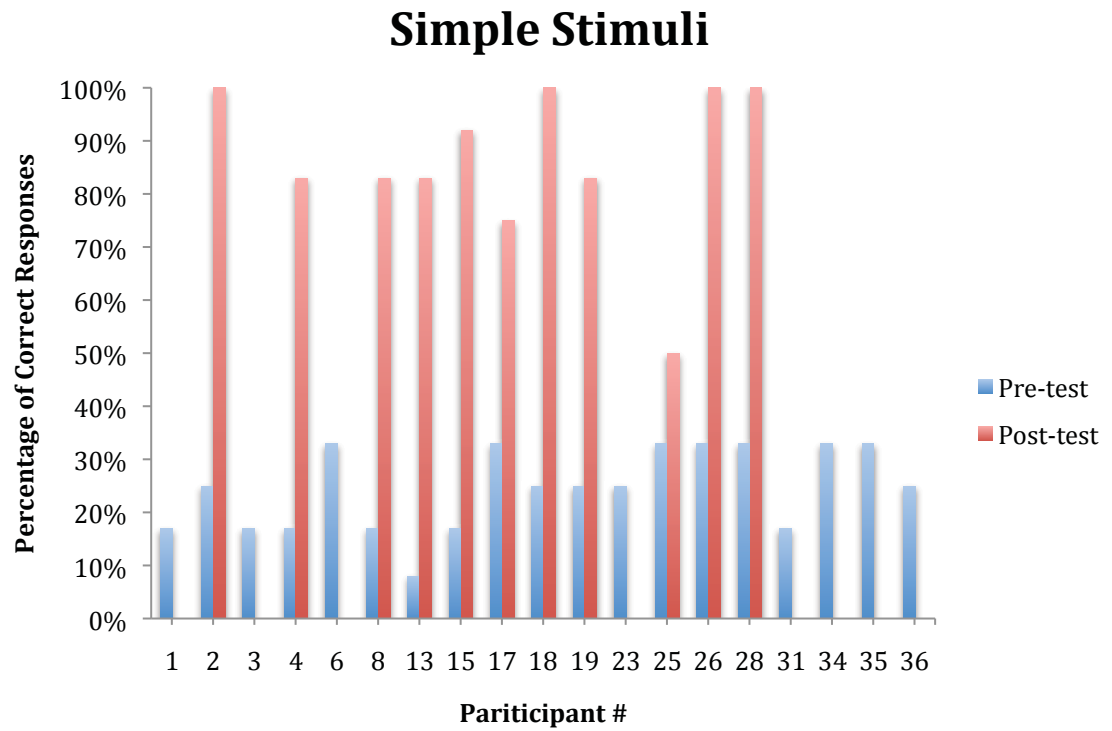


Figure 5. Pre-test and Post-test results per participant in the Simple Stimuli group.

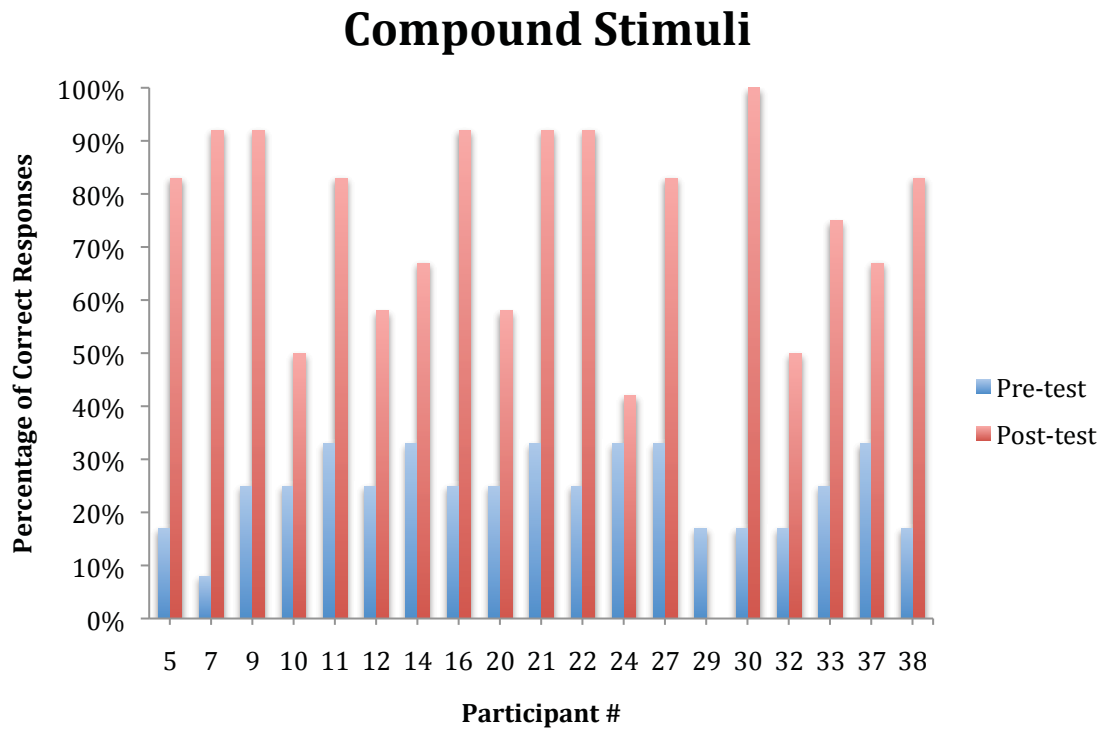


Figure 6. Pre-test and Post-test results per participant in the Compound Stimuli group.

December 3, 2013

Dr. Michael Clayton, Principal Investigator
Ms. Vilmary Placeres, Co-investigator
Department of Psychology
UNIVERSITY

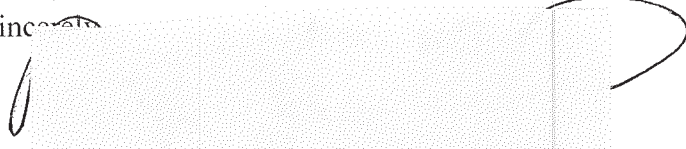
RE: IRB: 075-2013
Title: Comparison of Two Types of Stimulus Equivalence Procedures in Teaching
Spanish as a Second Language

Dear Dr. Clayton and Ms. Placeres:

The Institutional Review Board of Youngstown State University has reviewed the
aforementioned Protocol via expedited review, and it has been fully approved.

Any changes in your research activity should be promptly reported to the Institutional Review
Board and may not be initiated without IRB approval except where necessary to eliminate hazard
to human subjects. Any unanticipated problems involving risks to subjects should also be
promptly reported to the IRB. Best wishes in the conduct of your study.

Sincerely,


Pete
Dean, School of Graduate Studies and
Research Compliance Officer

c: Dr. Karen Giorgetti, Chair
Department of Psychology