The Use of Simple and Complex Samples to Teach Untrained Relations to Children with Autism Spectrum Disorders

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ABSTRACT

The purpose of the present study was to compare simple and complex samples during conditional discrimination training to teach spelling and typing on a keyboard to students with a diagnosis of autism. Two students, ages 5 and 8, were recruited. Using an adapted alternating treatment design, participants were exposed to a simple sample (visual image) and complex sample (image and word) stimulus set to determine the effectiveness of both procedures to establish untrained relations. Participants were directly trained in two relations during the simple sample condition: 1) matching words to their corresponding pictures, and 2) typing letters to spell words presented on the computer screen. Participants were directly trained in one relation during the complex sample condition: typing letters when given the corresponding picture and word on the computer screen. Three untrained relations were assessed using a pre-posttest design: 1) typing words when shown corresponding pictures, 2) typing words when provided with the dictated name of the picture, and 3) matching pictures to their corresponding words. Results indicate both simple and complex samples were effective in producing the untrained relation, but the use of complex samples required fewer trials to meet mastery criterion for both participants.

Keywords: simple samples, complex samples, fluency probes, autism, stimulus equivalence

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INTRODUCTION

The Use of Simple and Complex Samples to Teach Untrained Relations to Children with Autism Spectrum Disorders

The term stimulus equivalence was first defined by Sidman (1971) in a study where he described an experiment with a 17-yr-old institutionalized male, who demonstrated that certain learned auditory-visual relations are sufficient prerequisites for the emergence of reading comprehension. In the study, the participant was unable to read printed words or demonstrate reading comprehension. He could, however, select a picture when the spoken word was given, and name pictures when presented in isolation. After being taught to match spoken to printed words, he demonstrated reading comprehension (matching the printed words to pictures) and oral reading (naming the printed words aloud). With this study, Sidman demonstrated a new way of teaching different skills, and set the groundwork for an effective and frequently used teaching paradigm in the field of applied behavior analysis.

Sidman's seminal article conveyed an innovative methodology to teach individuals with disabilities. Namely, teaching relationships between stimuli to form other relationships that are not reinforced or directly trained (Sidman & Tailby, 1982). Sidman and Tailby identified three untaught outcomes of derived relations: reflexivity, symmetry, and transitivity. All three properties must be demonstrated to form an equivalence class. The first property, reflexivity, is identity matching (i.e., matching pictures to identical pictures, A to A, B to B, C to C). This is demonstrated when the learner selects a stimulus that is the same as the sample stimuli without previous knowledge, training, or reinforcement for doing so (Saunders & Green, 1999). An example of reflexivity would be saying “cat” and asking the learner to match or say the identical verbal response “cat” (Hall & Chase, 1991). The next property is symmetry, which is a stimulus to stimulus relation where the learner demonstrates the reversibility of matching a sample stimulus to a comparison stimulus (e.g., when taught that A is the same as B, and B is the same as C, the learner can also now state that B is the same as A, and C is the same as B). An example of symmetry occurs if a learner is provided with the verbal word “cat”(denoted as “A” stimuli) and taught to select the corresponding verbal word “gato” (denoted as “B” stimuli) from an array of samples, the learner will also now select “gato” (B) when presented with the word “cat” (A). The final property necessary to demonstrate an equivalence class is transitivity (e.g., if A to B and B to C, then A to C). An example of this relation would be demonstrated if after teaching a learner to relate the verbal word “cat” (A) to its corresponding verbal word “gato” (B), and the verbal word “gato” (B) to the verbal word “chat” (denoted as C stimuli); the learner also relates or says the word “cat” (A) when presented with the verbal word “chat”(C; Hall & Chase, 1991).

Stimulus Equivalence and Verbal Behavior

The use of stimulus equivalence is not only important or limited to the ideals of written language and educational activities, but in the formation and understanding of verbal behavior. Verbal behavior is defined as behavior that is reinforced through the mediation of another person’s behavior (whereas nonverbal behavior is reinforced directly through contact with the physical environment; Skinner, 1957, pg 2). Skinner elaborated on the ideas of verbal behavior, not only to encompass “typical language” (conversations between individuals) but also thinking, grammar, composition and understanding. He described verbal behavior as seven elementary verbal operants that are controlled by specific variables and consequences. The seven operants are all functionally independent of one another. : echoics, mands, tacts, intraverbals, textual, transcription, and copying a text According to Skinner (1957), this means that each operant must be taught independently in order to achieve mastery. These seven verbal operants formulate the way we communicate with others in the environment and receive reinforcement for these communicative behaviors (Sundberg & Michael, 2001).

An *echoic* is defined as a verbal operant in which the individual's verbal response is contingent upon hearing the same verbal stimulus from others in the environment, and is maintained by generalized conditioned reinforcement (Skinner, 1957, p. 55). An example of echoic occurs when a child hears the word "dog," says the word "dog" and is praised for doing so. A *mand* is a verbal operant in which the verbal response is controlled by a motivating operation (MO) and reinforcement is specific (Skinner, 1957, p. 35). For example, if an individual is thirsty and says "water, please" and in turn receives a glass of water from another individual, this would be considered a mand. A *tact* is an operant in which the verbal response form is controlled by a non-verbal stimulus within the environment and reinforced by generalized conditioned reinforcement (Skinner, 1957, p. 82). An example of a tact occurs when a child sees a dog and says "dog!" and is provided praise from his or her parents. An *intraverbal*, is the verbal operant in which the verbal response of the individual is controlled by an antecedent verbal stimuli that lacks point to point correspondence between the response and the stimulus and where a response given for this behavior serves as a generalized conditioned reinforcement (Skinner, 1957, p. 71). An example of an intraverbal occurs when the word “hi” is heard and an individual may say “hello” “how are you” or some other greeting. This behavior is maintained by the social consequences that follow the initial response. *Textual behavior* involves a response that is evoked by a verbal discriminative stimulus that has point-to-point correspondence between the stimulus and the response and is maintained by generalized conditioned reinforcement (Skinner, 1957, pp. 65, 69). An example would occur while reading a book or article. *Transcription* is the verbal operant involving a spoken verbal stimulus that evokes a written or typed response and is also maintained by generalized conditioned reinforcement (Skinner, 1957, p. 72). An example of transcription would be taking notes in class; while the professor says something the individual deemed important, he or she writes down what the professor says. *Copying a text* involves a response that is evoked by a verbal discriminative stimulus that has point-to-point correspondence and formal similarity with the response, and is maintained by generalized conditioned reinforcement (Skinner, 1957, p. 70). An example of this would be copying notes from a PowerPoint® or chalkboard.

Empirical Evidence for Stimulus Equivalence

There have been many applications of the stimulus equivalence paradigm to teach academic and functional skills to individuals of varying abilities. For example, studies have demonstrated the effectiveness of this paradigm to teach fraction and decimal relations to participants with perceived difficulties in this subject area (Lynch & Cuvo, 1995); algebra and trigonometry transformations to participants with no previous exposure to these formulas (Ninness, Rumph, McCuller, Harrison, Ford & Ninness, 2005); statistical analyses (Fields & Critchfield, 2011; Fields, Travis, Roy, Yadlovker, Aguir-Rocha Sturmey, 2009); Hebrew and Arabic letter discrimination (Fields, Arntzen, Narty & Eilifsen, 2012); and rule-following behavior to typically developing undergraduate participants (Hayes, Thompson & Hayes, 1989).

Stimulus Equivalence with Participants with Developmental Disabilities

In spite of the advancements in the equivalence paradigm, only 26 empirical articles have reported on outcomes of studies which have incorporated this paradigm in the *Journal of Applied Behavior Analysis* in the past three decades (1971 to 2009). Of those 26 empirical articles, only 12 (46%) of them recruited individuals with intellectual or developmental disabilities as participants (Rehfeldt, 2011). For example, the equivalence paradigm has been demonstrated to be effective in teaching adults with traumatic brain injury to relate names to faces of therapists (Cowley, Green, & Braunling-McMorrow, 1992); geography skills to children with autism (LeBlanc, Miguel, Cummings, Goldsmith, & Carr, 2003); Braille literacy skills to participants that are hearing impaired (Toussaint & Tiger, 2010); and complex auditory-visual samples to participants with autism (Groskruetz, Karsina, Miguel, & Groskruetz 2010).

Use of Complex Stimuli in Equivalence Procedures. Stimulus equivalence procedures have been somewhat limited to the use of simple samples, which consist of providing participants with an array of objects to match to one specific stimulus (Groskreutz et al., 2010). Though this method is effective, the use of simple samples may be time consuming (Stromer & Mackay, 1992). The use of complex samples addresses this limitation through the use of simultaneous presentation of multiple stimuli (e.g., a picture and a word; or two letters of the alphabet). An example of simple sample training would consist of teaching a student to select the written name of a person (B) when presented with that person's dictated name (A). Following this training, an additional training phase would consist of teaching the same participant to select the picture of that same person's face (C) when presented with the person's dictated name (A). Upon mastery of these two skills, untrained relations are tested: matching the face of the specific person (C) when presented with the written name of the person (B), and stating the name of the person when presented with a picture of the person in isolation (C) (Cowley et al., 1992).

In a complex sample, the participant is presented with two or more stimuli simultaneously and taught to relate these two stimuli to a third (A+B-C). Upon mastery of this complex sample relation, the participant is presented with another untrained relation (i.e., matching C-B and C-A). For example, if an experimenter teaches a student to select the written word CAT (C stimuli) when he/she says the word "cat" (A stimuli) and simultaneously shows a picture of a cat (B stimuli); we may expect that this same participant will also select the printed word that corresponds to the picture when presented in an array of stimuli (B-C), select the printed word that corresponds to the spoken word (A-C), select the picture that corresponds to the spoken word (A-B), say the word that corresponds to the picture (B-A), say the word that corresponds to the written word (C-A), and select the picture that corresponds to the word when presented with an array of stimuli (C-B), without further training.

An experiment by Lane and Critchfield (1998) evaluated the use of complex and simple samples to teach vowel and consonant classification to individuals with developmental disabilities. During the study the experimenters provided the participant with the spoken word "vowel" and two written vowel letters on a computer screen (A, E, I, O, U) or the spoken word "consonant" and two written consonant letters (A+B) as sample stimuli. The participant was then required to match the letter that corresponded to the spoken label and letters presented. Comparison stimuli were presented in an array of three, with two distracters and the correct sample (C). For example when the spoken word “vowel” was presented with the written letters A and O (A+B) the participant would match the vowel letter A (C) when given the array of letters A and D. After mastery of the training sequence the experimenters tested whether participants would match different vowels or consonants that were not used in training when given the same sample (i.e., “vowel” or “consonant”). Results demonstrated participants acquired these skills rapidly. Limitations of the study included the use of only one distracter during training and post training probes, and no comparison to a different teaching procedure or array of stimuli. Further research is needed to determine the effectiveness and efficiency of complex samples when they are directly compared to the simple samples.

Groskruetz and colleagues (2010) also emphasized the importance of using complex samples in their research with six participants diagnosed with autism. In this study, participants were shown complex samples consisting of a dictated word (A) and picture (B), and asked to match this sample to the corresponding printed word (C). After the mastery of the training phase the experimenters evaluated the emergence of three untaught relations: 1) sample of a picture to the written word (B-C), 2) auditory sample of a specific word to picture (A-B), and 3) tacting and textual (reading) relations of the visual samples (B-D). Results of this study indicated all participants acquired the untrained relations, supporting the use of complex samples during academic instruction for children with autism. However, since only complex samples were used in the training, the authors of this study emphasized the importance of future research to examine the efficiency of complex samples compared directly to simple samples to determine the number of trials required to demonstrate mastery criterion and its effectiveness in producing untrained relations. This is one of the goals of the present research.

Stimulus Equivalence in Reading and Spelling

Prior research has indicated the use of stimulus equivalence procedures is an effective approach to teach reading and spelling for individuals with developmental disabilities (Stromer & Mackay, 1992). Through the use of this procedure, researchers have advanced the efficiency and effectiveness of instruction in the areas of vowel and consonant formation (Connell & Witt, 2004; Lane & Critchfield, 1998); reading and spelling instruction (De Rose, De Souza & Hanna 1996; Hanna, De Souza, De Rose & Fonseca, 2004; Melchiori, De Souza & De Rose, 2000); sight word reading (Kennedy, Itkonen & Lindquist,1994); and rudimentary reading (Matos, Avanzi & McIlvane, 2006). In recent years, investigations have evaluated the possibility of further increasing the efficiency of these procedures by incorporating computer-based instruction (Stromer & Mackay, 1992; Stromer, Mackay, Howell, McKay & Flusser, 1996).

Computer Based Stimulus Equivalence for Reading and Spelling

The use of computer-based instruction may be more efficient in a classroom setting because teachers may not need to directly instruct every student through all academic tasks. Instead, students may work independently and at their own pace. Stromer and Mackay (1992) evaluated the use of computer-based stimulus equivalence procedures with three participants with developmental disabilities and cognitive delays. In Experiment 1, participants were directly taught two relations: 1) matching pictures to their corresponding printed words (A-B) when presented in an array of three words, and

2) matching letters to words of a sample provided on a touch screen computer when letters were presented in an array of 10 (B-C). The student used the touch screen to drag the letters under the word displayed on the screen. After mastery of these two relations, one untrained relation was assessed: spelling words when given a picture (C-A; picture of a dog, and spelling D.O.G). Upon completion of this phase, the experimenters taught different words for the original target words (e.g, dog/canine) with the same procedures. Finally, they assessed the skills of matching pictures to the new target words and original target words to the new target word (i.e., “Canine” to “Dog” and vice versa).

Stromer and colleagues (1996) conducted a similar study to evaluate the effectiveness of this procedure to teach spelling to individuals with hearing disabilities and developmental delays. The researchers sought to address the effectiveness of computer-based teaching across different settings and the generalization of this skill across these settings. In phase one of the study, the same procedure described by Stromer and Mackay (1992) was followed. In the second part of the study, generalization probes were conducted to assess for real world application. Specifically, participants were required to first write the words of a pair of objects on a piece of paper and then place the list in his/her pocket and walk to another room to retrieve the objects listed from a shelf and place them on the table in the first room. This process required application of spelling and reading skills, similar to a grocery shopping experience. In order to be successful, students needed to spell the word of a functional object given a picture, read the word in a different setting, and apply meaning by retrieving the given object.

A more recent study by Vedora and Stromer (2007) replicated some of the procedures from previous research by using a simple match to sample response with students with developmental disabilities. During this study, a computer with a touch screen keyboard was used. Three different sets of words were created and presented in three different ways: 1) spell to dictation, 2) spell to photograph, and 3) spell to printed word. After completion of each presentation the researchers evaluated the generalizability of the acquired skills to the actual environment by testing five untrained skills: 1) retrieving physical objects when told the name of the object, 2) naming pictures, 3) writing the name of an object when shown its picture, 4) reading the list of words after they had been written, and 5) sorting the physical objects to the written words. The study supported the use of computers to teach students with special needs, specifically spelling skills. Results suggested that simultaneous word construction tasks may be sufficient for establishing spelling performance.

Although there are many strengths and a body of knowledge regarding stimulus equivalence, limitations exist and the need for systematic and direct replications are evident. Specifically, Stromer and colleagues (1992, 1996) suggested that further exploration of different versions of computer-based relations would produce more realistic and naturalistic generalization and application of these skills. In other words, through the use of more advanced programs and developed procedures, generalization across other stimuli and application of these stimuli in the everyday environment could affect the way stimulus equivalence procedures can be implemented. In addition, and arguably the most crucial limitation to the studies that have incorporated computers to teach equivalence relations to date, is that only a specific pool of limited letters were available on the computer screen for the participant to select from and spell the indicated words presented. Further research should aim to increase functional use of the training program by teaching participants to use a standard keyboard. First, the use of a keyboard compared to a pool of letters may help participants generalize their skills to the natural environment. Additionally, participants may demonstrate an increase in fluency because keyboards have letters in the same place every time. Lastly, and most importantly, typing is a valuable skill for the future generation of citizens (Stromer et al., 1996).

Although the study by Vedora and Stromer (2007) addressed some of the limitations of Stromer and colleagues (1992, 1996) by using a virtual keyboard, this keyboard had illuminated keys. That is, the specific letters of the keyboard were highlighted to spell the correct word. Therefore, it is difficult to determine if the participant was able to distinguish and "type" the letters from all the letters or just the letters that were highlighted. Future research should look at the use of a keyboard in which all letters are represented and no cues are provided. This is another goal of the present study.

Fluency in Stimulus Equivalence

Despite the push for effective and efficient education and training programs, little is known about the concept of fluency in the uses of stimulus equivalence (Binder, 1996). Fluency is defined as the ability to express a learned relation with accuracy and speed. It has been demonstrated to assess and improve an individual's effectiveness and efficiency in the natural environment and increase endurance for individual performance over time (Binder, 1996).

The only study to date that has incorporated fluency with stimulus equivalence to determine both speed and retention was conducted with graduate participants learning Hebrew words (Bucklin, Dickinson, & Brethower, 2000). In this study, participants were taught the relations of Hebrew characters (denoted as 'A' stimuli) to the Hebrew word for numbers one through ten (denoted as 'B' stimuli), the Hebrew word for numbers one through ten to the American numbers one through ten (denoted as 'C' stimuli) and then tested for the untrained relation of Hebrew character of the word (A) to the American numbers one through ten (C). Results indicated participants correctly identified the untrained relation (A-C) with 100% accuracy and that with fluency training all individuals had higher levels of performance and retention after the training was complete and at sixteen weeks follow-up. The study helped to demonstrate there is room for improvement beyond 100% performance. Two major limitations of the study were outlined by the authors. First, individuals in the accuracy training had fewer opportunities to participate in the follow up training than individuals that where in the fluency training, which may have influenced the response rates when comparing the two trainings. Second, additional research is needed to isolate the components of the fluency training that contributed to its success.

The purpose of the present study is to replicate and extend previous research on the use of computer-based instruction to teach reading and spelling with a stimulus equivalence procedure to children with autism (Stromer et al., 1992, 1996; Vedora & Stromer, 2007). The study will directly compare the use of simple and complex samples to teach these skills (Groskruetz et al., 2010; Lane & Critchfield, 1998, Stromer et al., 1992 & 1996) and build upon previous research by teaching typing skills and assessing fluency with a standard QWERTY keyboard.

METHOD

Participants and Setting

Two participants, Devon and Bobby, were selected for participation in the study. Both participants were recruited from a Charter school for alternative learners. Devon was 5years old, enrolled in a Kindergarten classroom, and had a duel diagnosis of autism and Attention Deficit Hyperactivity Disorder (ADHD). He had been previously assessed by the school psychologist and scored low to proficient in math and reading on the Wechsler Individual Achievement Test (WIAT-III) (Psychological Corporation, 1992). However, Devon was selected as a participant in the study due to deficits in both spelling and word comprehension determined by weekly curriculum based assessments conducted in the classroom.

Bobby was an 8 year old student diagnosed with autism, enrolled in a third grade classroom. He scored proficient in math, but showed deficits in reading, spelling and word comprehension determined by the WIAT-III and curriculum based assessments given in the classroom.

Both participants were assessed by the classroom teachers using the Kindergarten Readiness Assessment - Literacy (KRA-L) (Ohio Department of Education, 2003) which assesses kindergarten readiness, including letter recognition and a technology checklist to assess experience with a keyboard. Both participants demonstrated the pre-requisite skills of tacting all letters of the alphabet, matching upper to lower case letters, and experience with using a standard keyboard and computer mouse.

Sessions were conducted three to four times per week in a room or hallway separate from the participants’ classrooms, and were scheduled during non-academic times throughout the day (i.e., movie time, free play, etc.). Each session lasted approximately 30 min with two 10-trial blocks conducted per session. The training areas were located away from other classrooms to minimize noise and distractions. One of the training areas was an empty classroom used as a testing area for the school psychologist. This room contained multiple tables and chairs. The second training area was the Individual Eductaion Plan coordinator's office, which contained three tables and multiple chairs. All windows were covered. The third training area was a desk in a hallway that was used on limited occasions if the first or second training areas were unavailable. The hall was secluded and used by the teachers for testing and one-to-one instruction.

Materials and Apparatus

A Dell Inspiron computer equipped with Windows 2007 operating system and Microsoft Office and PowerPoint™ was used throughout the study. The computer was equipped with a standard QWERTY keyboard and controlled with a standard mouse to manipulate the stimuli on the screen. The stimuli were presented on the computer via a PowerPoint™ presentation that was created prior to the start of the study. The slides showed a specific stimulus depending on the condition being trained or tested (see Figures 9-13, for examples of screens for each relation).

Two stimulus sets were created for each participant. Each set consisted of five words selected from the Dolch noun probes list (Dolch, 1936). Words were selected for each participant based upon four criteria: 1) misspelled words from an initial pre-assessment; 2) length of each word (limited to three to six letters), 3) number of syllables (limited to one to three syllables), and 4) ease of depicting the word in a picture (use of nouns as opposed to verbs or adjectives). For example, the words "bear" and "boat" were included because they could be represented in a single image, whereas the words "old" and "dirty" were omitted because they were more difficult to represent via a single image. Each word was presented twice during each trial block in a quasi-random order. The corresponding pictures were a standard size of ten cm. by ten cm. and were found using an internet search. All typed words were standardized in Times New Roman font size 24 (see Table 2). An Olympic stopwatch was used during fluency probes. The stop watch had a start/stop and reset button and calculated the time to a tenth of a second.

Initially, all the words included in the Dolch noun lists were presented verbally to both participants. Words were marked as correct if the participant typed the corresponding word on the computer screen with no mistakes within 10 s of the instruction "Type the word _____"; and incorrect if the participant omitted or added letters to a word, switched letters to spell a word, responded by stating "I do not know," "Pass," or "Next" or provided no response within 10 s of the instruction. Only words marked incorrect were considered for inclusion, in addition to the criteria described above.

Procedure

Experimental Design. An adapted alternating treatments design (Sindelar, Rosenberg & Wilson, 1985) was used to compare the relative effectiveness of simple and complex samples during training. One of the most distinguishable advantages of this design is its ability to compare instructional strategies used to teach behaviors that cannot be "unlearned" (i.e., teaching an academic task or skill). A potential limitation is the need to identify equally difficult stimulus sets. This was done in the current study by using a standard list of nouns (Dolch, 1936), while also selecting words based on the criteria as described above. At the beginning of the study, each participant was assessed during a pre-training phase as described below for a minimum of three sessions or until stability was demonstrated. Once stability was demonstrated, stimuli were assigned in a quasi-random fashion to either the simple sample condition or complex sample condition (see details below). Stimulus sets were not counterbalanced across both participants, but were equated by difficulty of the word based on the criteria previously described. This was done due to the fact that each participant correctly and incorrectly spelled different words, thus making it difficult to use the same words and counterbalance the stimulus sets. Training in both conditions continued until a criterion of 80% or higher is met across two consecutive sessions was demonstrated for both training conditions. Following demonstration of this mastery criterion, each participant was exposed to a post-training condition as described below. Finally, participants were assessed for fluency.

Independent Variable, Interobserver Agreement, and Treatment Fidelity. The independent variable consisted of an auditory-visual match to sample training procedure using either simple or complex sample stimuli. The dependent variable was the percentage of correct responses during pre-training, training, and post-training.

In the simple sample training condition, two relations were directly taught: 1) matching a picture of an item (denoted as PC) to its corresponding printed word (denoted as PW), whereby a correct response was recorded when the participant used his finger to point or placed the curser on the correct corresponding word within 10 s following delivery of the instruction. Incorrect responses were scored when the participant placed the curser on a word that did not correspond to the sample provided or did not respond within 10 s of the presentation of the instruction (see Figure 2). 2) Copying letters of a word presented in isolation using a keyboard (denoted as SP, see Figures 9 and 13), whereby a correct response was scored when the participant used the keyboard to type the letters that corresponded to the written word in the correct order or self-corrected within 10 s following presentation of the instruction. An incorrect response was scored if the participant typed letters in the wrong order, omitted or added letters to the words presented, or did not provide a response 10 s following presentation of the instruction.

In the complex sample condition, only one relation was directly taught: 1) copying letters of a word (SP) when presented with a picture and corresponding printed word (PC+PW) (see Figures 1 and 2), whereby a correct response was scored when the participant used the keyboard to type the letters that corresponded to the written word or self-corrected within 10 s following presentation of the instruction. An incorrect response was scored if the participant typed letters in the wrong order, omitted or added letters to the words presented, or did not provide a responses following 10 s of the instruction being presented.

For both conditions, the following relations were assessed during post-training probes to determine if any relationships between the stimuli emerged without direct training: **1)** identifies the picture of an object when given the word of the object in isolation (PW/PC). A correct response was recorded when the participant used his finger or cursor to point to the corresponding picture within 10 s of following delivery of the instruction. An incorrect response was scored if the participant placed his finger or the cursor on a word that did not correspond to the sample provided or there was no response after 10 s of the sample being presented (see Figure 4). 2) Typing the word that corresponds to an object when a picture of the object is presented in isolation (PC/SP).

Correct responses were recorded when the participant typed the word with all letters in the correct order within 10 s of the instruction being presented. Incorrect responses were scored if the participant omitted or added letters to the sample stimuli provided or did not provide a response following 10 s of the delivery of the instruction (see Figure 3). 3) Typing the word that corresponds to a dictated word (DC/SP; see Table 1). A correct response was recorded when the participant typed all letters in the correct order within 10 s following the presentation of the instruction. An incorrect response was recorded if the participant added or omitted one or more letters that did not correspond to the sample or did not provide a response after 10 s following presentation of the instruction.

Interobserver agreement (IOA) was assessed by a second observer during 60% of all sessions for Devon and 59% of all sessions for Bobby. The second observer independently collected data on correct and incorrect participant responses on data sheets created for the purpose of this study. IOA was calculated by summing the total number of agreements and dividing this number by the total number of responses and multiplying by 100 to obtain a percentage. During this time there was an average of 92.4% agreement with a range from 80% to 100% agreement for Devon, and an average of 96.7% agreement with a range from 80% to 100% agreement for Bobby.

Treatment integrity was also assessed by a second observer during 60% of sessions for Devon and 59% of all sessions for Bobby. The observer scored the experimenter's responses to ensure the procedure was implemented consistently (see Appendix B for an example of the treatment integrity checklist used). Treatment integrity was calculated by summing the total number of correctly implemented steps by the total available responses on the checklist items and multiplied by 100 to get the percentage of correct steps. During this time there was an average of 99.6% agreement with a range from 80% to 100% agreement for both Devon and Bobby.

Pre-assessment. Ten words from the list of dolch noun probes for each of the different grade levels were selected (Dolch, 1936). The experimenter presented one word at a time and instructed the participant to spell the word on a computer using a standard QWERTY keyboard. Correct and incorrect responses were defined in the same manner as described above for the D-C relation. The participant had the opportunity to self-correct, but only before moving on to the next word or at the end of the assessment. At the end of the assessment, the participant was given 2 min to make corrections. This was conducted twice with at least one day between the first and second assessment.

Prior to beginning the experiment, participants were taught how to use the computer program, keyboard, and mouse used in the study so that they could complete the task effectively. During the training the participant learned how to select a word to indicate a response and how to move to a different page after completion of a stimulus set. The participants were taught how to manipulate the keys on the keyboard by having them type a set of 26 randomly selected letters from a sheet of paper. Mastery of the keyboard training was defined as the participant correctly pressing the correct random letter with 80% accuracy or higher in one training session. Next, the participant was taught to use the computer mouse to identify words and advance the slides. The experimenter presented to the participant words that were correctly spelled during the Dolch noun probes, paired with one picture that corresponded to one of the comparison stimuli. Each participant was exposed to 10 trials to ensure they have the same training history. During this computer training a least-to-most correction procedure was used.

After completing the computer training, participants were introduced to five pictures of the stimuli to be used during training to ensure they could accurately identify the images as indicated by the experimenter. For example, if the word was “bear” the participant was shown five pictures of bears in isolation and asked to label each picture. Only pictures that were correctly labeled were included in the study. Following completion of the pre-assessment training, participants were exposed to pre-training probes as described below.

Pre-Training Probes. A total of five relations were assessed during pre-training probes. No prompting or feedback was presented for correct and incorrect responses during the pre-training phase, but the experimenter did provide verbal feedback to the student for working diligently after approximately every five trials. Mastery criterion was achieved once the participant responded correctly on 80% or better during a 10-trial block across two sessions.

During the PW/PC probe, participants were presented with one picture (PC) in a pre-determined random order on the computer screen with an array of six words presented in two rows below the picture (PW). The experimenter presented the instruction “Find the word that matches the picture.” One word corresponded to the picture and the other five words were distractors. Each distractor stimulus was selected based on the following criteria: 1) same beginning letter as the sample stimulus, 2) same number of syllables as the sample stimulus, and 3) words within the participant’s repertoire or reading level. Words were selected as distractors if they met one or more of these criteria.

During the WC/PW probes, participants were presented with one word (PW) in a pre-determined random order on the computer screen and the instruction to "Type the word that you see." Correct responses were scored when the participant used the keyboard to type the letters that corresponded to the written word or self-corrected within 10 s following presentation of the instruction. An incorrect response was scored if the participant added or omitted letters from the word, or there was no response after 10 s of the slide being presented.

During the PC/PW probes, participants were presented with one word (PW) in a pre-determined random order on the computer screen with five comparison pictures in two rows below the word (PC) and the instruction "Find the picture that matches the word." One picture corresponded to the word and the other five pictures met the criterion for distractor stimuli described above. Correct responses were recorded when the participant used his finger or cursor to point to the corresponding picture within 10 s following delivery of the instruction. Incorrect responses were scored if the participant placed his finger or the cursor on a word that did not correspond to the sample provided or there was no response after 10 s of the sample being presented.

During the SP/PC probes, participants were presented with a picture (PC) and the instruction "Type the word that you see" (SP/PC). The pictures were presented in isolation on the computer screen in a quasi-random order. Correct responses were recorded when the participant typed the correct letters that formulated the word of the sample shown. Incorrect responses were scored if the participant added or omitted one or more letters that did not correspond to the sample or there was no response after 10 s of the slide being presented.

During SP/DC probes, participants were presented with a verbal word (DC) and the instruction to “type the word (X)” (SP/DC). The word was presented in isolation verbally to the participant in a quasi-random order. Correct responses were recorded when the participant typed all letters in the correct order. Incorrect responses were recorded if the participant added or omitted letters that did not correspond to the sample or there was no response after 10 s following the instruction.

The last probe was one of initial fluency. This was defined as the duration plus accuracy of the participant’s responses to each stimulus set (McDowell & Keenan, 2001). An initial fluency probe was conducted instead of a full fluency due to time constraints. For the purpose of this study, an initial fluency probe was defined as one conducted over five trials, as opposed to hundreds of trials, as is typically done with fluency probes (Binder, 1996). During the initial fluency probe, participants were asked to type words that corresponded to the pictures presented on the computer screen. They were given the following instruction: “I am going to show you some pictures and I want you to spell the name of the item you see in the picture as fast as you can.” The experimenter calculated the duration using a stopwatch and assessed for percentage of correct responses. Fluency tested the same relation as the A-C pre-training probes. Procedures, correct responses and incorrect responses were defined in the same manner described during pre-training probes.

Simple Sample Training Condition. Training was conducted in the same manner described for pre-training probes above, with the exception that correct and incorrect responses were followed by corrective or approving feedback by the experimenter. Specifically, following a correct response, the experimenter provided verbal praise (e.g., "You got it!"). Incorrect responses were followed by a simple correction procedure in which the experimenter provided a gestural prompt (point) followed by re-presentation of the instruction.

During PW/PC training, the participant was presented with a sample of a single picture on the computer screen in a quasi-random order, along with two horizontal rows of three words each, in which one word was the correct response to the sample. Instructions and data collection were the same as described above for pre-training probes. Following the end of each session, the participant was allotted 5 min to play with a toy of his choice. Training continued until the mastery criterion was demonstrated.

During WC/PW training, the participant was presented with a word on the computer screen and the instruction to "Spell the word that you see." Correct and incorrect responses were defined in the same manner described during pre-training probes. Procedures for mastery criterion, feedback for correct and incorrect answers, prompting procedures and reinforcement were conducted in the same manner as those described in A-B training above. The only difference was, after mastery was met, each participant completed a set of five additional practice trials to ensure the skill was acquired.

During the sessions with Devon, a timer was set for 5 min. This was done to ensure he stayed on task due to the frequency and duration of Devon talking about different topics not related to the task at hand. When Devon completed the task before the timer went off, he was given a 5 min. break in addition to the remainder of the time left on the timer. In the event that Devon did not complete the task before the timer was completed, he was sent back to the room with no free time.

Complex Sample Training Condition. During PC+PW/SP training, the participant was presented with one picture and its corresponding printed word on the computer screen, followed by the instruction to “Type the word you see.” The words were in a pre-selected quasi-random order on the computer screen. For example when given the word “DOG” and picture of a dog, the participant was required to type the letters D.O.G. in the correct order. Procedures for mastery criterion, definitions for correct and incorrect answers, feedback for correct and incorrect answers, prompting procedures, reinforcement and practice trials were presented in the same manner as those described above. The only difference was, after mastery was met, each participant completed a set of five additional practice trials to ensure the skill was acquired.

Post-Training Probes. Following demonstration of the mastery criterion in both the simple and complex sample conditions, the experimenter tested to determine the emergence of untrained relations. The following relations were assessed during post-training probes: 1) when given the sample of a picture (PC) the participant spelled the word that corresponded to the sample shown (SP); 2) when presented with the written word of a specific object (PW) the participant matched the corresponding picture (PC); and 3) when given the dictated word (DC) the participant correctly spelled it on the computer (SP). These probes were conducted in the same manner described in the pre-training probes phase. While testing these relations the participant received no feedback for correct or incorrect responses.

Remedial Training. In the event the relations did not emerge or the participant did not receive 100% for all stimuli, the participant was entered into a booster session where each relation was taught until the criterion of 100% was demonstrated once more.

After completion of the booster session the participant was exposed to the post-training phase once more. After each of the participants reached 100% criterion during the post-training probes, fluency probes were conducted.

Initial Fluency Probe. Initial fluency probes were assessed in the same manner described during pre-training probes. The participants responses were timed during five trials to determine the average time it took to spell five words when only the pictures were presented on the screen.

Generalization Probes. Generalization was assessed following initial fluency probes. During these probes, participants were presented with five pictorial variations of each stimulus (pictures) that was directly trained. Participants were provided with the same instructions as in training (i.e., "Type the word that matches the picture"). Correct and incorrect responses were identical to that described above for SP/PC pre- and post-training probes and no feedback was provided at any time. The pictures during the generalization phase varied in different aspects: size of item shown, color, shape and brands or types of the stimuli. For example, for the word "horse," a variety of horses were used ranging in different sizes, colors, and backgrounds for the horse were incorporated into the images used during generalization probes.

Follow-Up Probes. Two weeks following the completion of all post-training probes, each participant was assessed for maintenance of the skills acquired. More specifically the follow-up phase evaluated the following: 1) spelling words when presented with pictures in isolation (SP/PC), 2) spelling words when presented with the dictated words (SP/DC), and 3) selecting corresponding pictures when presented with the printed word on the computer screen in an array of five stimuli (PC/PW). These probes were conducted in the same manner described above for pre-training.

RESULTS

Results of the study indicate both simple and complex samples were effective in producing untrained relations in children with autism. Both participants demonstrated increased percentage of correct responses in spelling words using a QWERTY keyboard. Participants also showed improvements in fluency, generalization, and maintenance of the skills acquired two weeks after training.

Devon

Simple Sample. During simple sample pre-training probes, Devon responded correctly during 20% of the trials presented across three probes for the PW/PC relation (i.e. identified the word when given the picture) (see Figure 3). During SP/PC (spelling the word when given the picture) and SP/DC (spelling the word when given the spoken word) probes, Devon did not type any of the words presented across all three probes (see Figures 5 and 6). During WC-PW (identified the letters when given the word) probes, Devon correctly identified the letters of the word in 100% of the opportunities, and it was determined that the skill was already in his repertoire (results not depicted in a graph). Finally, Devon responded correctly during 60% of the opportunities presented across three pre-training probes for the PC/PW relation (i.e. identified the picture when given the word). During training, Devon required seven trial blocks to achieve mastery criterion for the PW/PC relation; and 11 practice trials were conducted for the WC/PW relation. The extra practice trials were conducted during the WC/PW training to ensure the participant was able to spell the word rather than simply rote typing the letters shown in the sample with no attention to the word as a whole.

Following training, Devon correctly identified the picture when presented with comparison written words (PC/PW relation) in 100% of the trials presented. During the SP/PC and SP/DC probes, he scored 80% over two days for each relation, meeting the pre-determined mastery criterion (see Figures 5 and 6). Devon was later entered into a remedial phase to increase his score to criterion 100% for both the SP/PC and SP/DC relations.

Following completion of the post-training phase, Devon completed an initial fluency probe, generalization and follow-up phase. Prior to training, Devon typed the words in each set in 6 min 27 s. Following training, Devon's time decreased to 4 min 46 s (see Figure 7.). He responded correctly in 100% of the trials presented during generalization probes (i.e., correctly identified visually dissimilar stimuli and correctly typed words) for simple training conditions. After a two week period had elapsed, Devon completed follow-up probes for the SP/PC and SP/DC relations. In the simple sample set, he responded correctly during 70% of the trials presented.

Complex Sample. For the complex sample condition, Devon responded correctly in 40% of the opportunities presented during PW/PC (i.e. identified the word when given the picture) pre-training probes (see Figure 4.). He did not respond correctly on any trials for the SP/PC (spelling the word when given the picture) or SP/DC (i.e. spelling the word when given the spoken word) across three probes (see Figures 5 and 6). He did correctly identify letters of the corresponding words in 100% of the opportunities presented (WC/PW relation), and it was determined that this skill was already within his repertoire (i.e. identified the letters when given the word, the information is not graphed). Finally, during PC/PW pre-training probes, Devon correctly identified the picture when given the word in 40% of opportunities presented (see Figure. 11). Twelve training trials were required to complete training for PC+PW/SP relation (7 training trials to meet mastery criterion and 5 additional practice sessions).

Following training, Devon correctly identified the picture when presented with comparison written words (PC/PW relation) in 100% of the trials presented. During the SP/PC and SP/DC probes, he scored 80% over two days, meeting the pre-determined mastery criterion (see Figures 5 and 6). Devon was later entered into a remedial phase to increase his score to criterion 100% for both relations.

Following completion of the post-training phase, Devon completed an initial fluency probe, generalization and follow-up phase. Prior to training, Devon typed the words in each set in 6 min 34 s. Following training, Devon's time decreased to 4 min 42 s (see Figure 8.). He responded correctly on 100% of the trials presented during generalization probes (i.e., correctly identified visually dissimilar stimuli and correctly typed words) for complex training conditions. After a two week period of time had elapsed, Devon completed follow-up probes for the SP/PC and SP/DC relations. In the complex sample set, he responded correctly during 80% of the trials presented.

Bobby

Simple Sample. During the simple sample pre-training probes, Bobby responded correctly during 40% of the trials presented across three probes for the PC/PW relation (i.e identified the word when given the picture) (see Figure 3). During SP/PC (i.e. spelling the word when given the picture) and SP/DC (spelling the word when given the spoken word) probes, he did not type any of the words presented across all three probes (see Figures 5 and 6). During WC/PW probes, Bobby correctly identified the letters of the word in 100% of the opportunities, and it was determined that the skill was already in his repertoire. Lastly, during PC/PW probes Bobby correctly identified the picture when given the word during 80% of opportunities presented across all three probes. Nine trial blocks were required to achieve mastery for the PW/PC relation; and a total of eleven practice trial blocks were conducted for the WC/PW relation. The extra practice trials were conducted during the WC/PW training to ensure the participant was able to spell the word rather than simply rote typing the letters shown in the sample with no attention to the word as a whole.

Following training, Bobby correctly identified the picture when presented with comparison written words (PC/PWrelation) in 100% of the trials presented for the simple sample set. During the SP/PC and SP/DC probes, Bobby scored 100% over two days for the simple sample set, meeting the pre-determined mastery criterion (see Figures 5 and 6).

Following completion of the post-training phase, Bobby was entered into an initial fluency probe, generalization, and follow-up phase. Prior to training, Bobby typed the words in each set in 4 min 18 s. Following training, Bobby's time decreased to 3 min 46 s to complete one trial block, decreasing his total time by 34 s (see Figure 7). He responded correctly in 100% of the trials presented during generalization probes (i.e., correctly identified visually dissimilar stimuli and correctly typed words) for simple training conditions. After a two week period of time had elapsed he entered a follow-up probe for the SP/PC and SP/DC relations. In the simple sample training set, he correctly typed the words 60% of the time.

Complex Sample. During the complex sample pre-training probes, Bobby correctly identified the picture when given the word (PW/PC) during 20% of the opportunities presented (see Figure 4). During the SP/PC (i.e. spelling the word when given the picture) and SP/DC (i.e. spelling the word when given the spoken word) pre-training probes, he did not identify any words during three different probes across both relations (see Figures and 6). During WC/PW probes, Bobby correctly identified the letters of the word 100% of the time, and it was determined that the skill was already in his repertoire. During the PC/PW pre-training probe, Bobby correctly identified the picture when given the word 80% of the time. Twelve training trials were required to complete training for PC+PW/SP relation (7 training trials to meet mastery criterion and 5 additional practice trials).

Following training, Bobby correctly identified the picture when presented with comparison written words (PC/PW relation) in 100% of the trials presented. During the SP/PC and SP/DC probes, Bobby scored 100% over two days for each relation, exceeding the pre-determined mastery criterion (see Figures 5 and 6).

Following completion of the post-training phase, Bobby was entered into an initial fluency probe, generalization, and follow-up phase. Prior to training, Bobby typed the words in each set in 4 min 24 s. Following training, Bobby's time decreased to 3 min 50 s to complete one trial block, decreasing his total time by 34 s (see Figure 8). He responded correctly in 100% of the trials presented during generalization probes (i.e., correctly identified visually dissimilar stimuli and correctly typed words) for both training conditions. After a two week period of time had elapsed he entered a follow-up probe for the SP/PC and SP/DC relations. In the complex sample training set, he correctly typed the words 80% of the opportunities presented.

DISCUSSION

The current study aimed to replicate and extend results published by Stromer and colleagues (1992, 1996) and Vedora and Stromer (2007) by incorporating computer-based instruction to teach reading and spelling with stimulus equivalence procedures. Results provide additional support for the use of computer-based instruction to teach untrained relations to children with autism.

Stromer and colleagues (1992, 1996) used stimulus equivalence procedures to teach decoding and encoding reading skills to students with developmental disabilities. In their study, a pool of random letters was used instead of a full keyboard. This may be viewed as a limitation because the skills acquired were not assessed using a standard keyboard, thereby limiting the generalizability of the results. Vedora and Stromer (2007) also evaluated the use of computer-based equivalence procedures to increase spelling in students with developmental disabilities. They improved upon the results of Stromer and colleagues (1992,1996) by employing a virtual keyboard with the support of highlighted letters during each trial. Although the use of a standard virtual keyboard increased functionality of the task, limitations continued to exist because of the limited number of distractors (i.e., all letters of the alphabet were not available during each trial). The present study also employed computer-based instruction with two participants diagnosed with autism, but incorporated a standard QWERTY keyboard. Results provide additional support for the use of computers for equivalence based instruction with equipment that may be readily available in most classrooms.

A second aim of the present study was to extend results on the use of complex samples during conditional discrimination training. Lane and Critchfield (1998) assessed consonants and vowels as an untrained relation following the training of the spoken words "consonant" and "vowel" and matching specific letters. They suggested the use of complex samples produced untrained relations with less training time. A limitation was that only one distractor was incorporated across all training and assessment trials. In addition, the study did not directly compare simple and complex samples during instruction. Groskruetz and colleagues (2010) also demonstrated the efficacy of complex samples to teach academic skills to learners with autism. However, only a complex sample was used during training. The present study included a direct comparison between these two training conditions. Results indicated both simple and complex samples were effective in producing untrained relations, but complex samples were more efficient by producing the results in 12 trials (7 trials to achieve mastery and 5 additional practice trials) compared with the simple sample that obtained the results in 18 to 20 trials (13 to 15 trials to achieve mastery and 5 additional practice trials). The findings suggests that when directly compared with simple samples, complex samples produce the same learning result in fewer trials, therefore, less instructional time.

Lane and Critchfield (1998) suggest that skills gained through complex sample procedures have an economical advantage compared to simple sample procedures. In addition, the process results in teaching techniques that benefit both persons with disabilities and service providers who face practical constraints that limit the often extensive teaching time that is required for learners with disabilities (Lane & Critchfield, 1998). These benefits are vital to the successful instruction and programming for students with autism. One-on-one instruction with a professional trained in behavioral practices is extremely costly. Jacobson, Mulick and Green (1998) estimate that intensive early intervention delivered one-on-one costs approximately $32,820 annually per child. In comparison, regular education services, where instruction is delivered via a large group costs approximately $7,543 annually per child. The cost of one-on-one intensive behavior-based instruction is significantly higher than traditional education services. Therefore, it is imperative that professionals working with students with autism consider the most cost-effective and time efficient instructional methods to reach mastery.

From a longitudinal standpoint, intensive behavior intervention delivered one-on-one for three years early in life saves an average of $187,000 to $203,000 over the child's lifetime (ages 3-22; Jacobson et. al.,1998). The authors also predict that some students with autism would obtain even better outcomes if the one-on-one intensive behavior intervention continued for longer than three years. However, they also note that funding is closely monitored and the investment of public resources is often scrutinized. Research supports that a cost benefit occurs within three years of one-on-one services; therefore, it is imperative that professionals make the best use of time when this form of instruction is funded and available. The use of complex samples may allow for skills to be obtained at a quicker rate (Groskruetz et. al., 2010); therefore making the most of the costly one-on-one instruction.

Limitations and Future Direction

The results of the study should be interpreted with caution numerous limitations. First, there were a limited number of participants. Although results were promising for both simple and complex samples, only two participants were included. This is the first empirical study to directly compare these two training conditions, and there reasons, replications are necessary.

Second, probes for generalization may have been confounded with material presented to the participant outside of the training sessions. Although the classroom teachers were informed of the targeted words and specifically asked not to work with the participants on these target words, we cannot rule out this possibility. Future research should look to eliminate this confound by possibly using nonsense words or abstract stimuli. The use of nonsense words or abstract stimuli would ensure that the participants would be seeing the stimuli for the first time. However, skills gained in studies that use these stimuli may present difficulties with replication in real world contexts since the words would have no functional meaning. Social validity is also decreased because the training is not readily functional or progressive in learning to read and spell new words.

Third, the schedule of reinforcement was modified for Devon by offering increased break time upon the completion of the task. This was done to increase productivity, while decreasing off-task behavior. In the first 5 training sessions, Devon exhibited frequent off-task behavior (fifteen or more times per trial). The modification allowed for an accurate fluency score throughout the study. The present study found that both participants had increased fluency time from pre-training to post-training on fluency. More specifically, Devon had decreased his time by 1 min 41 s during simple sample and 1 min 52 s during complex compared to Bobby who only decreased by 32 s during simple sample and 34 s during complex sample. Devon's decreased time may have been influenced by the modification of reinforcement during training. Future research should eliminate this potential confound by standardizing breaks and reinforcement delivery across all participants.

Fourth, the number of fluency probes was limited. Fluency is generally conducted over hundreds of thousands of trials (Binder, 1996). Future studies should aim to conduct additional fluency probes to provide a more accurate account of this measurement for typing following training in a stimulus equivalence procedure.

Fifth, the stimuli used in the present study were not counterbalanced across participants. Due to a difference in pre-training probes, different words were used for some of the stimuli included for each participant. Future research should focus to eliminate this limitation by using individuals with the same academic level as well as grade level, thus potentially limiting this effect.

Finally, several post-mastery trials were conducted during the complex sample training. After completion of mastery of the complex sample set, participants were exposed to an additional 5 training sessions for practice. By incorporating these post-mastery trials, the efficiency of the complex sample was impacted by adding more trials to the procedures, and thus limits the possibility of suggesting the complex samples were more efficient.

Overall, the present study demonstrated that both simple and complex samples are effective in production of untrained relations in individuals diagnosed with autism. Current research in the field of complex and simple samples to date remains limited. Future research in this area may provide tutors, teachers, and paraprofessionals with more effective and efficient tools for teaching academics to a wide range of individuals. Complex samples allow professionals to teach students without using a sequential presentation. Teaching untrained relations using complex samples is more time efficient because items are presented simultaneously (Groskreutz et. al., 2010). These nonsequential teaching strategies allow for steps to be eliminated in comparison with a simple sample. Skills obtained at a faster rate allow for more new instruction to occur.

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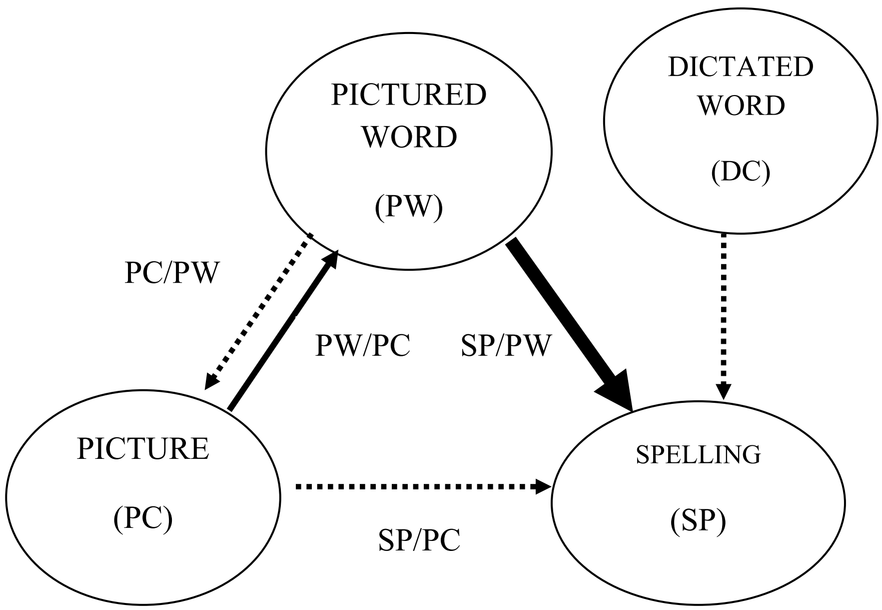

Figure 1. Depiction of the relations that were trained and tested in the simple sample condition: solid line arrows indicate relations that will be trained; dashed lines indicate relations that were tested; thick solid lines were within the students' repertoire.

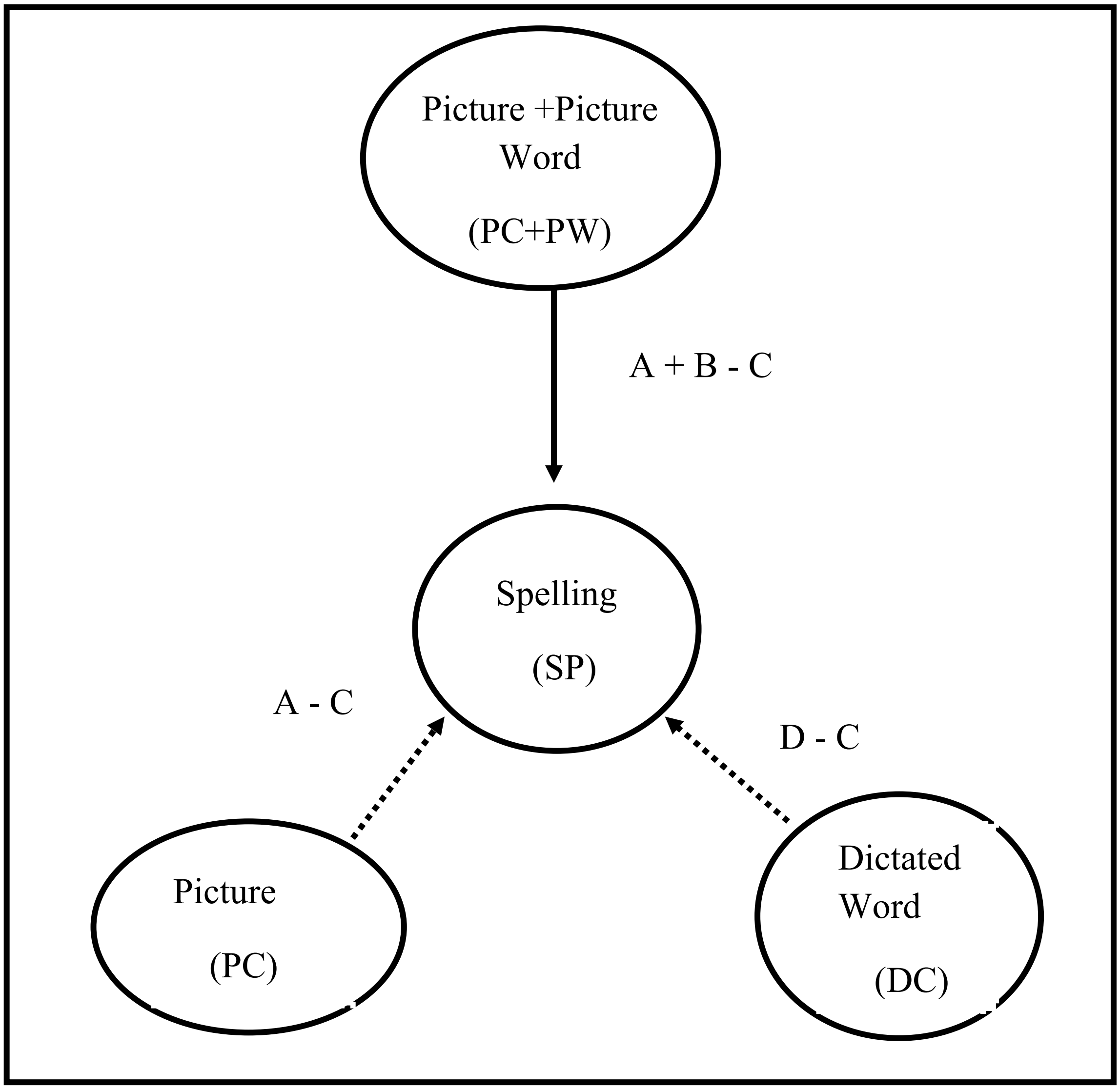

Figure 2. Depiction of the relations that were trained and tested in the complex sample condition: solid line arrows indicate relations that were trained; dashed lines indicate relations that were tested.

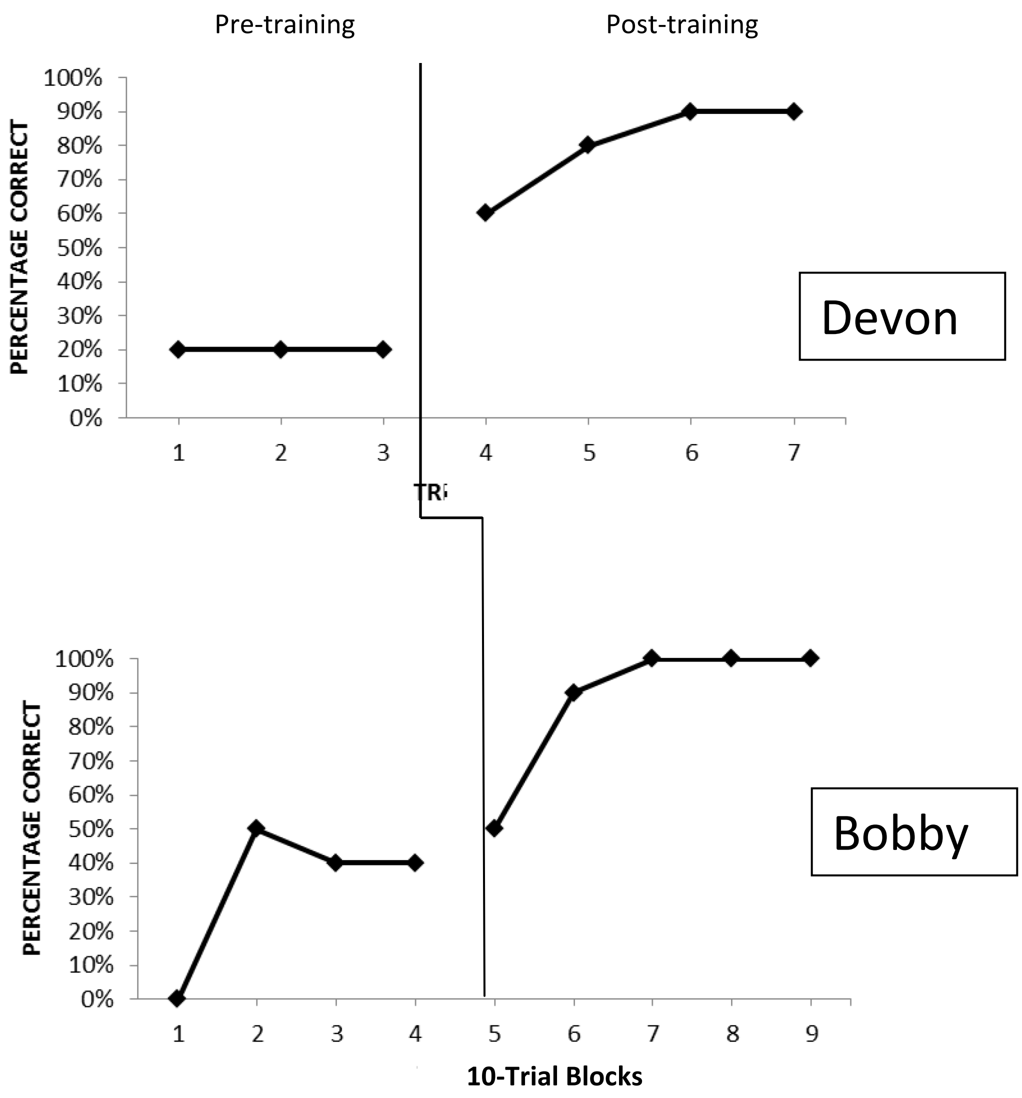

Figure 3. Depiction of the results for PW/PC pre- and post-training during simple sample condition for Devon and Bobby.

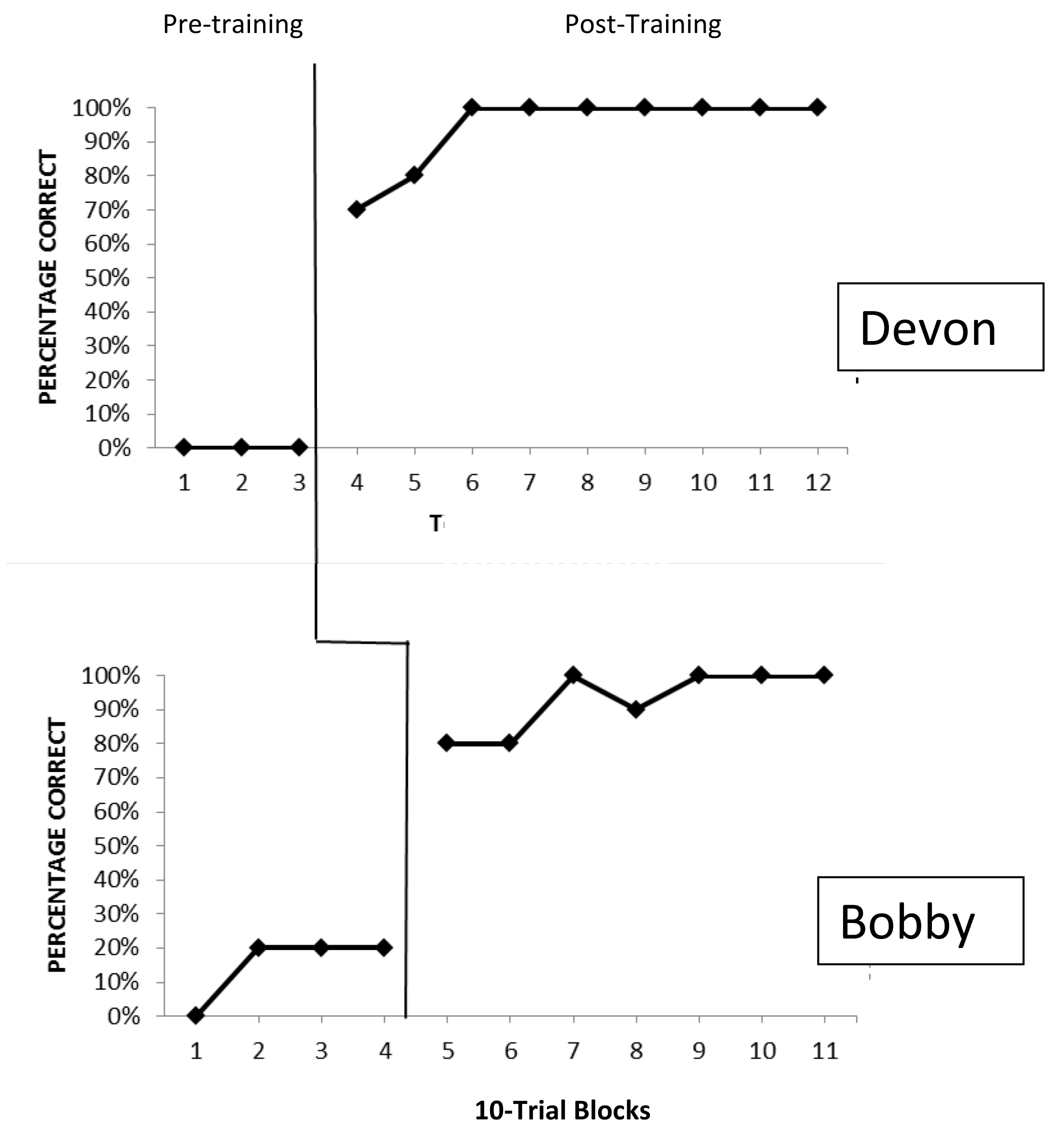

Figure 4. Depiction of the results for PC+PW/SP pre- and post-training during complex sample condition for Devon and Bobby.

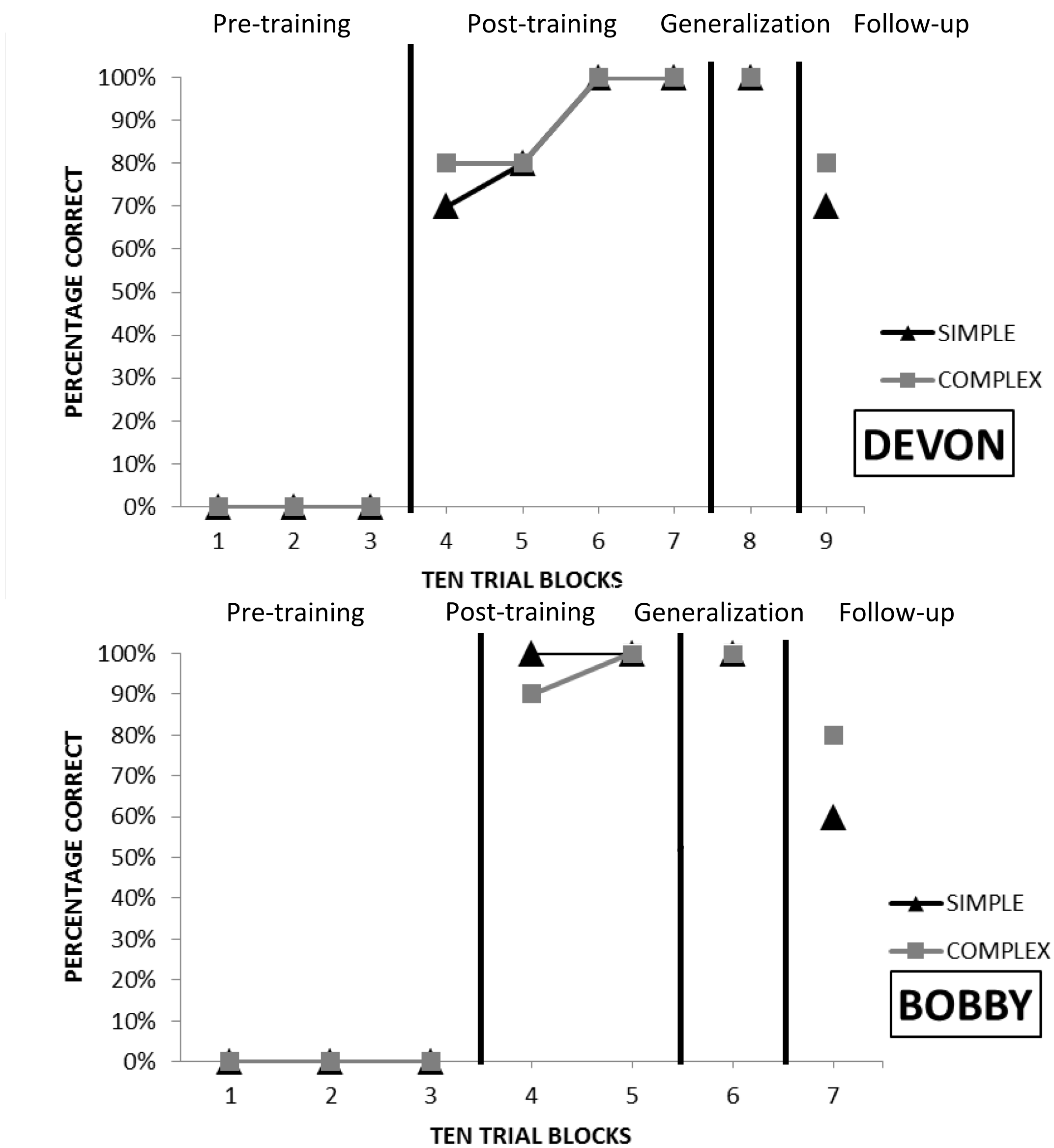

Figure 5. Depiction of the results of the pre-training, post-training and follow for the SP/PC relation for Devon and Bobby.

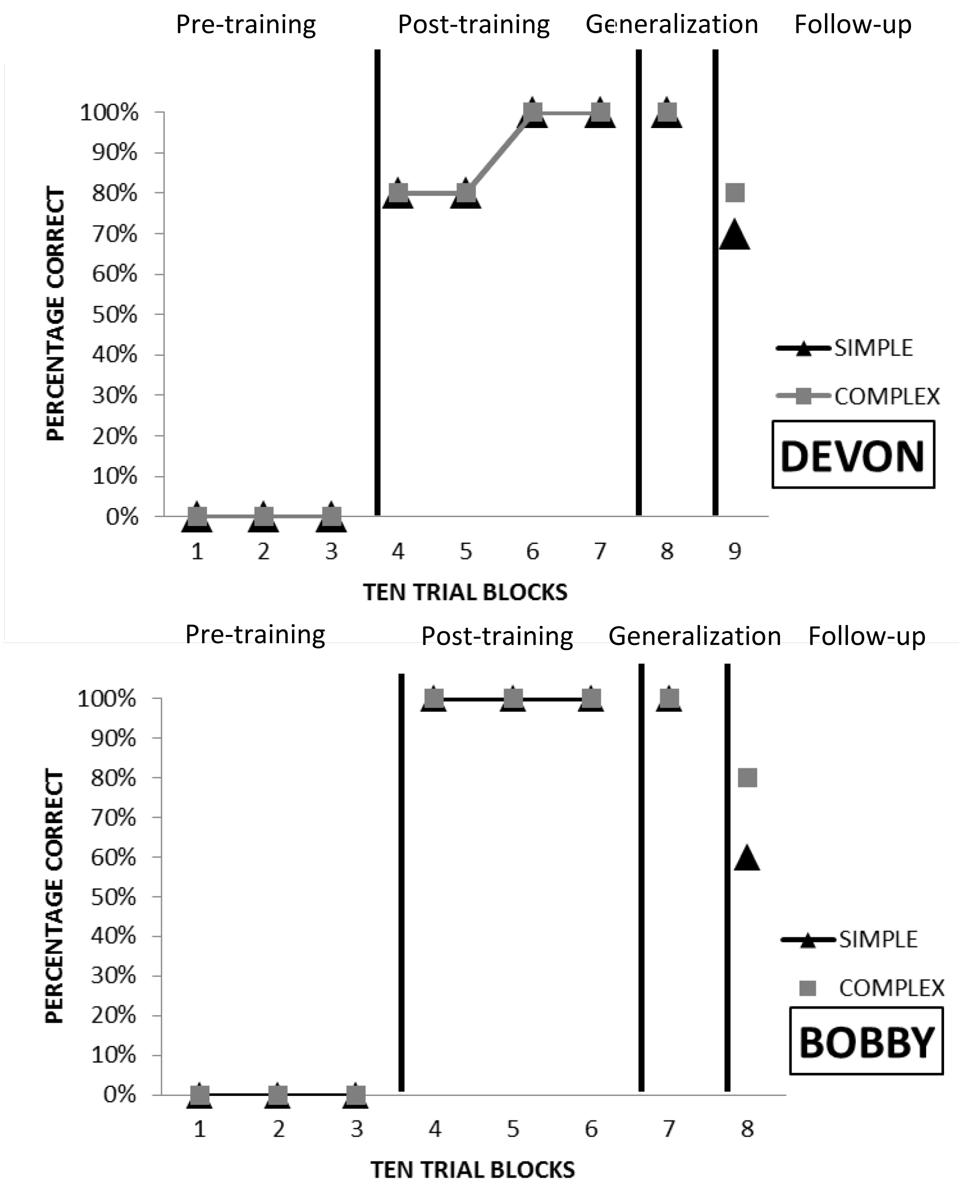

Figure 6. Depiction of the results of the pre-training, post-training and follow for the SP/DC relation for Devon and Bobby.

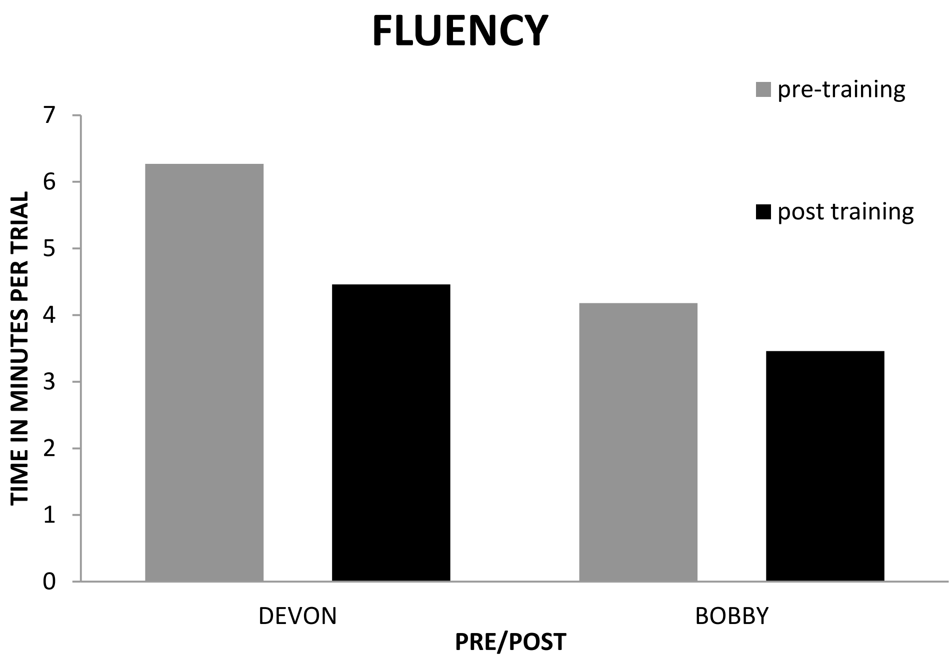

Figure 7. Depiction of the results of the initial fluency probes for pre- and post-tests for simple sample.

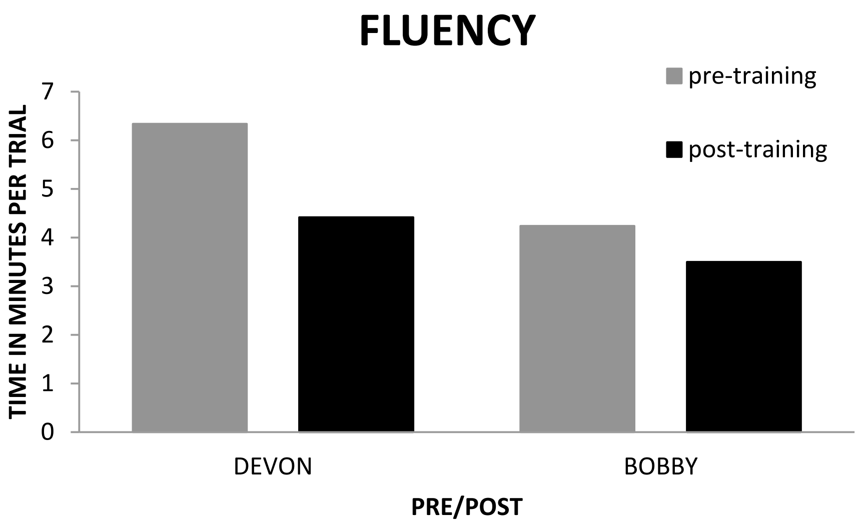

Figure 8. Depiction of the results of the initial fluency probes for pre- and post-tests for complex sample.

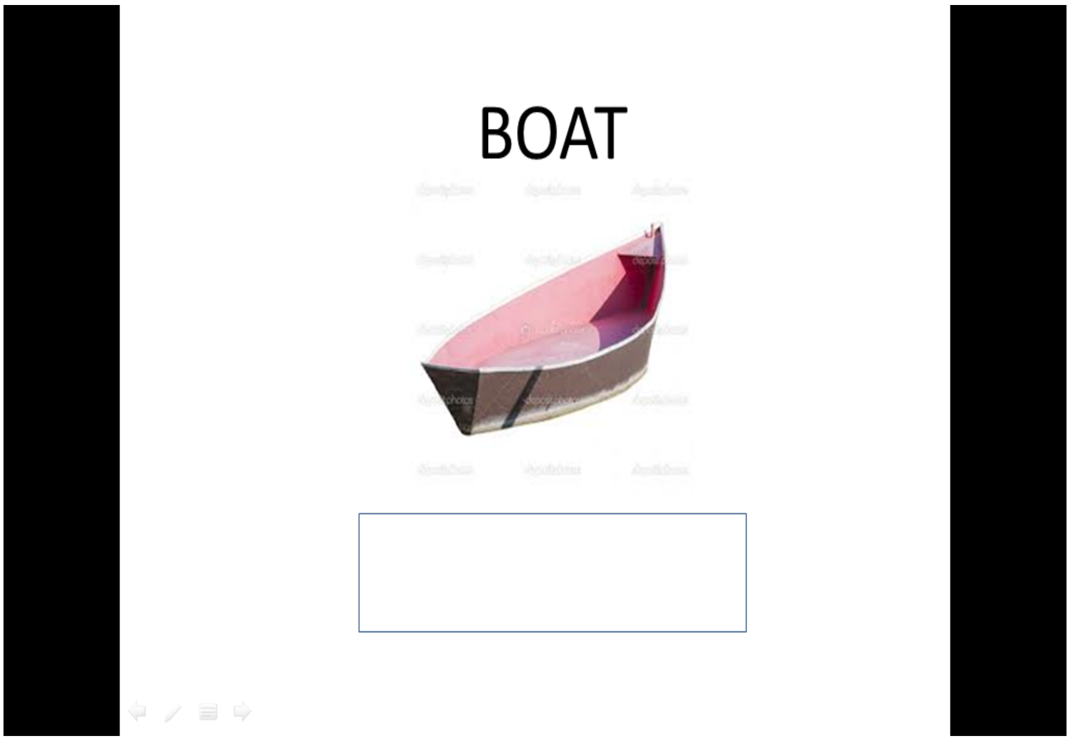

Figure 9. Depiction of the screen used for PC+PW/SP relation.

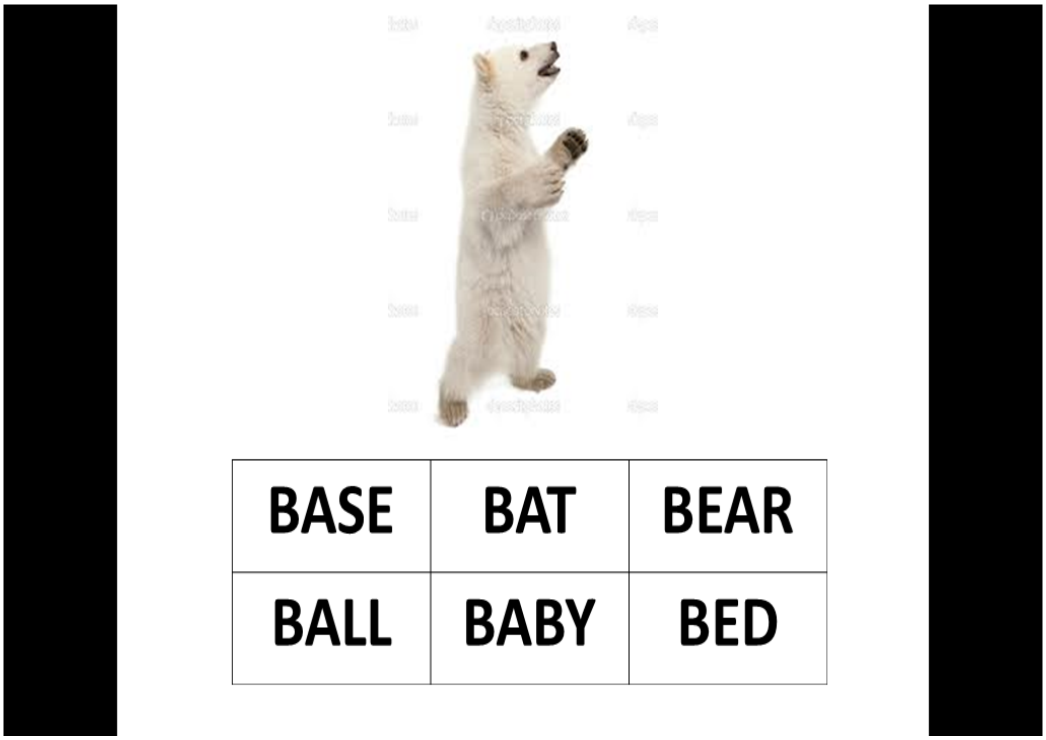

Figure 10. Depiction of the screen used for PW/PC relation.

Figure 11. Depiction of the screen used for SP/PC relation.

Figure 12. Depiction of the screen used for PC/PW relation.

Figure 13. Depiction of the screen used for WC/PW relation.

Table 1. Outline of Procedures and Trial Types

Pre-Training PW/PC: matching picture to corresponding word WC/PW: spelling the word when given the word visually (not graphed) SP/PC: spelling the word when given the picture SP/DC: spelling the word when given the word verbally PC/PW: matching the word to the corresponding picture
Training **Simple** PW/PC: matching the word when given a picture WC/PW: spelling the word when given the word (not graphed) **Complex** PC+PW/WC: Spelling the word when given both the picture and word
Post-Training Untrained relation PC/PW: matching picture to corresponding word SP/PC: spelling the word when given the picture SP/DC: spelling the word when given the word verbally **Fluency Probes** SP/PC: spelling the word when given the picture **Generalization Probes** ALT SP/PC: spelling the word when given the alternative pictures **Follow-Up** PC/PW: matching picture to corresponding word SP/PC: spelling the word when given the picture SP/DC: spelling the word when given the word verbally

Table 2. Example of stimuli used during training for Devon.

Devon	
Set 1: SIMPLE	**Set 2: COMPLEX**
Bear 	Boat 
Coat 	Plane 
Fish 	Sock 
Farmer 	Chair 
Sheep 	Horse 

Table 3. Example of stimuli used during training for Bobby.

Bobby	
Set 1: SIMPLE	**Set 2: COMPLEX**
Leg 	Eye 
Girl 	Milk 
Coat 	Apple 
Shoe 	Horse 
Shirt 	Trash 

APPENDIX A

	Data Collection	
STUDENT:__________________ DATE:_____________________ TARGET:___________________ PRESENTATION NUMBER:_____	+ -- :____________ + -- :____________ + -- :____________ + -- :____________ + -- :____________ + -- :____________ + -- :____________ + -- :____________ + -- :____________ + -- :____________	NOTES:
STUDENT:__________________ DATE:_____________________ TARGET:___________________ PRESENTATION NUMBER:_____	+ -- :____________ + -- :____________ + -- :____________ + -- :____________ + -- :____________ + -- :____________ + -- :____________ + -- :____________ + -- :____________ + -- :____________	NOTES:

Data sheet used to collect correct and incorrect responses for each trial. The + are correct answers and the – are incorrect answers. On each line the experimenter placed the targeted words which corresponded with the PowerPoint® presentation.

APPENDIX B1

Treatment Integrity Pre-/Post- Probes			
The experimenter presents instruction prior to each trial ("spell the word (X)")	+	-	**N/A**
Experimenter provides no correct prompting or feedback for phase of experiment.	+	-	**N/A**
Experimenter provides a break after completion of each ten trial block.	+	-	**N/A**
Experimenter provides break if the student asks for one and ends the trial if problematic behavior poses a threat to the participant or experimenter.	+	-	**N/A**
Experimenter records data following each trial.	+	-	**N/A**

APPENDIX B2

Treatment Integrity Training			
The experimenter presents instruction prior to each trial	+	**-**	**N/A**
Experimenter follows two step prompting procedure (gestural, verbal) if incorrect response occurs	+	**-**	**N/A**
Experimenter provides specific feedback for correct answers Example “great job, that is the word (X)”	+	**-**	**N/A**
Experimenter provides a break after completion of each ten trial block.	+	**-**	**N/A**
Experimenter provides break if the student asks for one and ends the trial if problematic behavior poses a threat to the participant or experimenter.	+	**-**	**N/A**
Experimenter records data following each trial.	+	**-**	**N/A**

APPENDIX C

SIMPLE AND COMPLEX SAMPLES 62

APPENDIX C

Youngstown STATE UNIVERSITY

One University Plaza, Youngstown, Ohio 44555
Office of Grants and Sponsored Programs
[illegible]
Fax [illegible]

March 21, 2013

Dr. Rocio Rosales, Principal Investigator
Mr. Anthony Miller, Co-investigator
Department of Psychology
UNIVERSITY

RE: HSRC PROTOCOL NUMBER: 123-2013
TITLE: The Use of Simple and Complex Samples to Teach [illegible] to Children with Autism Spectrum Disorders

Dear Dr. Rosales and Mr. Miller:

The Human Subjects Research Committee of Youngstown State University has [illegible] your response to their concerns regarding the above mentioned protocol and [illegible] that your protocol now meets YSU Human Subjects Research guidelines. Therefore, I am pleased to inform you that your project has been fully approved.

Please note that your project is approved for one year. [illegible] you must submit a project Update form at that time.

Any changes in your research activity should be promptly [illegible] Research Committee and may not be initiated without [illegible] eliminate hazard to human subjects. Any [illegible] should also be promptly reported to the Human Subjects Research Committee.

We wish you well in your study.

Sincer[illegible]

Cathy Bieber Parrott
Chair, YSU Institutional Review Board

CBP:cc

c: Dr. Karen Giorgetti, Chair
Department of Psychology

[illegible] YSU