USING BRIEF FUNCTIONAL ANALYSIS TO

DETERMINE GENERALIZATION STRATEGIES

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CHAPTER I

INTRODUCTION

Since Stokes and Baer's (1977) foundational article on generalization, researchers have attempted to classify and define the procedures and principles involved in producing generalization (e.g., Alessi, 1987; Kirby & Bickel, 1988; Stokes, 1992; Stokes & Osnes, 1989). Although little research has been conducted that examines the principles involved in producing generalization (Mesmer, Duhon, & Dodson, 2007), effective generalization procedures have been identified (e.g., Ayllon, Kulman, & Warzak, 1982; Weinstein & Cooke 1992). Research on the procedures associated with generalization have proven useful in practice, however, individuals display differential responding to these procedures (e.g., Freeland & Noell, 2002; Lloyd, Saltzman, & Kauffman, 1981; Noell, Roane, VanDerHeyden, Whitmarsh & Gatti, 2000). For example, when taught an academic strategy, some students may immediately generalize the strategy to novel problems without any apparent programming, other students may require a cue to use the strategy for the novel problems, and other students may respond to the cue to use the strategy but at a slower and more variable rate than their peers (Lloyd et al., 1981). These differences in responding may be due to a lack of focused procedures that target the function of the generalized behavior.

To understand what procedures will result in generalized effects, the critical variables involved in the production of generalization must be analyzed (Stokes & Baer, 1977). Currently, there is a lack of understanding about the functional variables that produce generalized behavior, and until these variables are identified it will be difficult to develop generalization strategies that address individualized responses to generalization procedures.

Generalization

Generalization occurs when a person performs a learned behavior in the presence of novel stimuli (Mazur, 2002). To be considered generalization, a minimal amount of training must occur in the presence of the novel stimuli to produce the learned behavior (Stokes & Baer, 1977). For example, if students are taught how to perform appropriate behaviors in a resource classroom with a token economy, but do not transfer these appropriate behaviors to their general education classrooms then the students have not generalized the appropriate behaviors. Furthermore, if a token economy is required for students to perform appropriate behaviors in the general education classroom, then generalization has not occurred because explicit training in both settings was required for the students to perform the behavior. However, it would be considered generalization if the students performed appropriate behaviors in the general education classroom with a simple rule-card placed on their desk as a cue to perform the learned behaviors.

Functional Nature of Generalization Programming

It was posited by Stokes and Baer (1977) that generalization does not occur without explicitly programming it into interventions. Stokes and Baer outlined several types of generalization programming that have been empirically researched. These generalization techniques were later categorized into three functional categories: *exploit current functional contingencies, train diversely,* and *incorporate functional mediators* (Stokes & Osnes, 1989).

Each of the categories defined by Stokes and Osnes (1989) involve manipulation of either the antecedents or consequences of the generalized behavior. The first category, *exploit functional contingencies*, focuses on consequent manipulations or exploitations to produce generalized behavior. The second category, *train diversely*, encompasses both antecedent and consequent manipulations. Training diversely involves using multiple variations of the generalized behavior with different consequences and antecedents in the training environment to reduce the narrow training effects of the learned behavior. The final category of generalized behavior outlined by Stokes and Osnes is *incorporating functional mediators*. This process focuses on the antecedents of the generalized behavior by incorporating salient stimuli to cue the generalized behavior.

The procedures described by Stokes and Baer (1977) and later categorized by Stokes and Osnes (1989) are based on the basic behavioral principles of stimulus control and reinforcement (Kirby & Bickel, 1988). Generalization of behavior occurs as a result of the presence of antecedent or consequent stimuli. For example, research has shown that antecedent cues, such as providing a common stimulus, can promote generalization of academic responding from training settings to non-training setting (Ayllon et al., 1982). Research has also shown that the consequent manipulation of reinforcing occurrences of generalization can increase the probability that the generalized behavior will occur (Weinstein & Cooke, 1992).

Review of empirical literature on generalization procedures confirms that effective procedures involve manipulation of antecedent or consequent stimuli, or a combination of the two (e.g., Ayllon et al., 1982; Freeland & Noell, 2002; Rhode, Morgan, & Young, 1983; Walker & Buckley, 1972). In addition, the literature reveals that individual students have varied responses to the generalization procedures. Some students require more antecedent or consequent support than other students to fully generalize across settings, tasks, or time (e.g., Freeland & Noell, 2002; Lloyd et al., 1981; Noell, et al., 2000). Therefore, it is important to consider both the functional principles of the generalization behavior and also the individual differences in response to generalization techniques.

Brief Functional Analysis

A method of assessment that examines functions of behavior and individual responses is functional analysis. Historically, functional analysis has been utilized to determine the maintaining mechanisms of a behavior which can lead to effective methods for changing the behavior (Iwata, Dorsey, Slifer, Bauman, & Richman, 1994). These functional analyses involve systematic manipulations of environmental variables to develop functional hypotheses. However, functional analyses can be extensive and time consuming. To reduce the amount of time and effort required for functional analyses, a more efficient process was developed to determine the likely maintaining variables of behavior called brief functional analysis (BFA; Khang & Iwata, 1999). Both functional analysis and BFA have been adapted to the educational setting to be used with academic problems.

In 2004 the Individuals with Disabilities Education Improvement Act (IDEIA) was reauthorized and outlined the need for efficiently determining effective academic interventions (PL-108-446). One way to efficiently assess an academic need and determine an appropriate intervention is BFA. One of the most common forms of BFA that has been adapted for academic interventions is skill versus performance deficit assessments (Duhon et al., 2004). These assessments are based on the theory that behavioral deficits occur either due to a skill deficit or a performance deficit (Lentz, 1988; Noell, Freeland, Witt, & Gansle, 2001). If a student has a skill deficit, then their academic failures will most likely be remediated through use of an intervention that uses antecedent manipulations to improve the skill (i.e., instruction; Duhon et al., 2004). If the student has a performance deficit, their academic failures will most likely be remediated through use of an intervention that provides reinforcement for appropriate academic responding (i.e., reward; Duhon et al., 2004). Skill versus performance deficit assessments allow the practitioner to identify quickly the function of the student’s academic failures and develop an appropriate intervention for the individual student.

Generalization and BFA

Generalization is a behavior that is subject to the behavioral principles of antecedent and consequent manipulations (Stokes & Osnes, 1989). When generalization does not occur it can be viewed as a behavioral deficit (Kirby & Bickel, 1988). Behavioral deficits typically occur for one of two reasons, either a skill deficit or a performance deficit of the target behavior (Lentz, 1988; Gresham, 1981). Therefore, it can be hypothesized that generalization deficits are due to either a lack of skill or a lack of performance of the generalized behavior. Furthermore, it can be hypothesized that once a skill or performance deficit in generalization is identified an appropriate intervention can be developed.

To remediate skill deficits in generalization, an appropriate intervention will focus on antecedent manipulations that teach the student when it is appropriate for generalization to occur. For example, if a student is taught how to solve addition problems displayed in a vertical format, but does not generalize this skill to problems displayed in a horizontal format, a cue (such as highlighting the addition sign) may be used to teach the student to generalize the addition skill across the two formats. If the student has a performance deficit in generalization, an appropriate intervention will focus on a consequent manipulation to provide enough environmental support to generalize. For example, if the student who could not perform the addition problems in horizontal format (after being taught the vertical format), significantly increased his performance on the horizontal problems with a reinforcement, it can be determined that his lack of generalization was not due to a skill deficit but due to a performance deficit.

Understanding the production of generalized behavior at the functional level has critical implications for learning. The lack of generalized behavior has never been conceptualized as occurring due to skill or performance deficits. However, the individualized responses of students to generalization procedures suggest that students fail to generalize for individualized reasons. Some students may not produce generalization because they do not have enough environmental support (i.e., performance deficit), while others may not produce generalization because they do not possess the skills to identify when to perform the learned behavior (i.e., skill deficit). Currently, most generalization procedures are applied in a “shot-in-the-dark” approach in which there is a lack of targeting to meet individuals’ needs. Identifying the function of the generalized behavior has the potential for developing targeted procedures that will increase the likelihood that generalization will occur across settings, tasks, and time.

Current Study

The concept of generalization has mostly been studied in terms of the techniques used to produce it. Proposals have been made to study the underlying behavioral principles that are involved in the production of generalization (Kirby & Bickel, 1988), but there is a paucity of research that examines the antecedent and consequent manipulations that produce generalization. Specifically, research has not considered that a lack of generalization represents a behavioral deficit, and that this behavioral deficit can be assessed and intervened on as any other behavioral deficit. The current study utilized the principles of BFA to develop hypotheses about the functions of the generalization deficits and the most effective interventions for individual students. Furthermore, there is a lack of research examining generalization across academic behaviors, specifically in the area of math. A few studies have examined generalization of math strategies (e.g., Carnine, 1980; Lloyd et al., 1981; McIntyre, Test, Cooke, & Beattie, 1991); however, the results of these studies did not produce clear results about the generalized behavior and did not examine the functional nature of the generalization techniques. Therefore, due to the lack of literature in this area, the current study applied the generalization procedures and BFA to generalization of a multiplication strategy across sets of multiplication facts.

CHAPTER II

REVIEW OF LITERATURE

After Stokes and Baer (1977) wrote their cardinal article there was a spark of generalization research throughout the 1980's that focused on validating generalization techniques. While this research has produced broad recommendations for practitioners to use when programming for generalization, it has failed to identify the basic functional principles of generalization (Stokes, 1992). Without knowledge of the functional nature, it is difficult to develop generalization techniques that meet individuals' needs. A potential method for gaining knowledge about the functional nature of generalization techniques is functional analysis. Specifically, BFA is an efficient procedure for identifying functional variables that could lead to the development of effective individualized generalization techniques.

Generalization

Definition of Generalization

Generalization is "… the occurrence of relevant behavior under different, non-training conditions (i.e., across subjects, settings, people, behaviors and/or time) without the scheduling of the same events in those conditions as had been scheduled in the training conditions" (Stokes & Baer, 1977; p. 350). To be considered generalization, the relevant behavior in the non-training conditions must occur with minimal manipulations, in which the extent of training is significantly less than the original training conditions (Stokes & Baer, 1977). Furthermore, generalization does not occur "naturally," but must be programmed into interventions (Stoke & Baer, 1977).

There are several different proposed techniques for programming generalization into interventions. In Stokes and Baer's (1977) article on generalization they reviewed approximately 120 articles that utilized generalization techniques. These techniques were then categorized into nine main categories. Stokes and Baer concluded that the two most frequently used techniques, *Train and Hope* and *Sequential Modificatio*n, were not actual generalization procedures due to a lack of reliable generalization occurring without extensive extra training in the generalization condition. The other seven categories were less frequently present in the literature, but were considered true generalization procedures. Later, Stokes and Osnes (1989) classified these generalization procedures into three functional categories: (a) exploit current functional contingencies, (b) train diversely, and (c) incorporate functional mediators.

The first category, *exploit current functional contingencies*, includes procedures that focus on manipulating or exploiting consequences of the behavior to produce generalization effects. For example, using a transferable self-monitoring technique to maintain a behavior across time and settings exploits the functional contingency of performance feedback (Rhode et al., 1983). The second category established by Stokes and Osnes (1989) is *train diversely*. This process involves using frequent and controlled variations of the direct and generalization targets that occur in the training environment, to reduce the focused effects of the training. An example of diverse training would be providing multiple exemplars of word-use in different passages to facilitate generalization of reading the word in new passages (Ardoin, McCall, & Klubnik, 2007). The final category of generalization programming is that of *incorporate functional mediators*. A mediator is a stimulus that facilitates generalization and can be in the form of salient physical or social stimuli or self-mediated physical or verbal/covert stimuli. The most common example of using functional mediators in generalization is the use of programmed common stimuli (e.g., Ayllon, et al., 1982; Mesmer et al., 2007). In this procedure a common stimulus is usually programmed into the training and generalization environments as a cue to perform the target behavior in both settings (Ayllon et al., 1982). All three of these categorizations focus on either manipulation of stimuli that occur before or after the target behavior.

Functional nature of generalization

Prior to Stokes and Baer's (1977) article, the process of generalization was primarily seen as a "natural" outcome of the overall behavior change process. However, with the conclusion that generalization requires specific programming to ensure its occurrence, it can be concluded that generalization is not an unexplained phenomenon, but an active response (Kirby & Bickel, 1988; Stokes & Baer, 1977). Kirby and Bickel proposed that the generalization procedures outlined by Stokes and Baer are based on the behavioral principles of stimulus control, and changes in generalization behavior are subject to the same antecedent and consequent manipulations as any other behavior (Kirby & Bickel, 1988). Therefore, it is critical to examine the underlying behavioral principles that are related to the production of the generalized behavior when analyzing and developing generalization procedures.

This functional nature of generalized behavior can be seen in the three categories outlined by Stokes and Osnes (1989). All the proposed generalization procedures are either primarily antecedent or consequent based. For example, a generalization strategy that involves exploiting current functional contingencies would be primarily focused on manipulation of the consequences of the response. Whereas, a generalization strategy that involved functional mediators would be focused on manipulation of the antecedents. Additionally, the use of diverse training could focus on multiple examples of the antecedents or the consequences associated with the generalized response.

Review of Generalization Literature

A large focus of the generalization research has been examination of the specific generalization techniques outlined by Stokes and Baer (1977). The empirical literature on these generalization procedures confirms that programming is necessary for generalization to occur. Furthermore, the literature on generalization can be categorized based on the primary behavioral manipulation of the generalization procedure, which provides a structure for examining the functional variables involved in generalization programming (Kirby & Bickel, 1988; Stokes, 1992).

Functional Variables of Generalization Procedures

Antecedent-based procedures. In a tightly controlled small-N study, Ayllon et al. (1982), demonstrated the utility of a simple antecedent manipulation in the generalization environment. A common stimulus was used to promote generalization of work completion across resource rooms and regular education classrooms. Eight students who were displaying high amounts of work completion in the resource room but not in their regular reading and math classrooms were instructed to select an item from home that would be their "lucky charm." The lucky charm was first placed on the students' desks in the resource room, and they were instructed that the item was there to remind them to do good work. After eight sessions in the resource room with the lucky charm, students were instructed to take it to one of their regular education classrooms. After eight more sessions, the students began taking their lucky charm to both of their regular education classrooms. In this study, the lucky charm was programmed in the resource room as a stimulus to cue high levels of work completion. For all eight students, the introduction of the lucky charm in each regular education classroom produced greater levels of work completion. The study demonstrated that a simple antecedent manipulation such as carrying a common item across rooms can serve as a cue to produce a learned behavior across settings.

Mesmer et al. (2007) also demonstrated the utility of a common stimulus across conditions to cue generalization. The study examined the effectiveness of using common educational stimuli to facilitate generalization of rates of work completion across special and general education settings for students with emotional disturbances. The three students in this study were referred for low rates of work completion in the special and regular education classrooms. A multiple baseline design across subjects was utilized to examine the effects of the three conditions: baseline, treatment, and common stimuli. Baseline procedures occurred in both the treatment and generalization settings. The treatment phase procedures included goal setting, a stimulus (a thumbs-up or a digital timer) and performance feedback, in which the students were able to receive reinforcement if they beat their goal. During the treatment phase, baseline procedures continued in the generalization setting (i.e., the regular education classroom) to assess for spontaneous generalization effects. After treatment was shown effective in the treatment condition, the common stimuli of goal setting and the stimulus of a thumbs up or digital clock were introduced in the generalization classroom to cue the students to continue with their high rates of work completion, however, reinforcement was not provided in the generalization classroom.

The results indicated none of the students spontaneously generalized across settings in the treatment condition. For two of the students the target behavior actually decreased to lower levels in the generalization setting during the treatment phase; for the other student, his target behavior remained the same as baseline in the generalization setting. During the common stimuli phase, all three students increased their responding in the generalization setting, but two of the students showed slight decreases in their responding in the training setting with the common stimuli. Overall, the results of this study demonstrated the utility of using an antecedent-based generalization strategy combined with reinforcement in the training environment.

Consequent-based procedures. Rhode et al. (1983) demonstrated the utility of a consequent-based self-management generalization strategy for six students with behavioral disorders. During phase one of this study, students received academic instruction in a resource room. While in the resource room, students were rated by the teacher for appropriate behavior and correct academic work; the students received points as part of a token economy system based on these ratings. Students also began to rate their own behavior and compare their ratings to the teacher's ratings. Eventually the teacher's ratings were faded out, and only the students' self-ratings were used to determine their number of points for the day. Once students displayed appropriate behavior and correct academic work in the resource room, they were able to re-enter their general education classroom for phase 2 of the study. While in the general education classroom, the teacher asked students to rate their behavior and academic performance every 30 minutes and then every 60 minutes; students still received reinforcers based on their number of daily points. Eventually, the reinforcers and the occurrence of self-ratings were faded out.

Results of this study showed that the self-evaluation procedure was effective in generalizing appropriate behavior from the resource room to the regular education classroom. During phase 1 of the study, all six students averaged 90% - 96% appropriate behavior in the resource room, and 28% to 58% appropriate behavior in the regular classroom, indicating little to moderate spontaneous generalization across the two settings. During phase 2, five of the six students immediately displayed high rates of appropriate behavior with the introduction of the self-evaluation procedures in the regular education classroom. Four of these students continued to maintain their high levels of performance throughout phase 2 of the study, in which their average percentage of appropriate behaviors increased from 54% in phase 1 to 93% in phase 2. The other two students required some treatment modifications during phase 2 to produce and maintain high rates of appropriate behaviors. One students was given booster sessions of the treatment from phase 1. The other student showed unstable responding at the beginning of phase 2, and therefore, was required to match his self-ratings with the teacher every 15-minutes and given three booster sessions of the treatment. These results demonstrated that consequent-based strategies, such as the self-evaluation procedure, have potential for producing generalization of appropriate behaviors across settings. Furthermore, it is important to note that while the procedure worked for the majority of the students, two students required extra modifications to generalize successfully across the settings.

Another consequent-based generalization procedure was used by Noell et al. (2000) to promote generalization from a training setting to a classroom setting. Three preschool students with speech delays participated in the study. Students were taught to respond to the question “What is your name?” in an out-of-class therapy setting. Each student was exposed to a baseline condition within their regular classroom and in the therapy room prior to treatment. Also, prior to treatment, each student was given a contingent reward to test the possibility of a performance deficit. The students were then trained to answer the question “What is your name?” through a constant time delay procedure, in which the students were given 15-seconds of exposure to their preferred reward item if they responded correctly to the question within 2-seconds. If they responded incorrectly, they were given feedback on the correct response, and presented with a new trial. Once the students had six consecutive correct responses in the training condition, the generalization condition began. For the generalization condition the students were in their regular education classroom and they were still given their preferred item for a correct response, but no feedback was given. The reinforcements were then faded out in a thinning condition, and maintenance and follow-up phases were used to determine the consistency of correct responding without rewards and over a three week period.

The results of this study indicate that all three students produced generalized responding from the therapy setting to the regular education settings. One student produced variable responses with the contingent reward condition prior to the training; therefore, it was hypothesized that he had a performance deficit, and did not need the training sessions. During the generalization setting, this student needed a time-out procedure to reduce his access to competing reinforcements. Another student responded correctly 78% of the intervals during the generalization setting, but became non-compliant during the thinning session. For this student, an alternate generalization procedure was selected in which the trials took place during *toy play*, a time when the student was usually compliant. The student said his name 6 out of the 7 times with this new setting, and continued to produce correct responses in thinning and maintenance phases with *toy play*. These results demonstrate individual needs of the students. While all three students displayed generalization and maintenance, each student required a different amount of antecedent and contingent support to produce the correct responses.

Combination of antecedent- and consequent- based procedures. A study that provides an example of both antecedent and consequent manipulations to produce generalization was conducted by Walker and Buckley (1972). In a longitudinal study, they compared three different strategies for promoting generalization and maintenance of appropriate classroom behaviors across settings and time. Upon completion of a two-month treatment in a token-economy classroom, students were moved back to their regular classroom and were assigned to one of four groups: peer reprogramming, equating stimulus, teacher training, and a control group. Two of the conditions, peer reprogramming and equating stimulus, can be considered true generalization procedures because they required small amounts of extra-training to produce effects in the generalization environment. The condition of equating stimulus involved antecedent manipulations of matching stimuli with the variables that were used in the treatment classroom. The academic materials, systematic social reinforcements, and the token reinforcements were matched between the two settings. The other generalization procedure of peer reprogramming involved consequent manipulations through the use of a group contingency. In this condition, the target student earned points for performing the appropriate behavior that was taught in the training environment. Once the student received a certain amount of points the whole class was given a reward.

The results of this study demonstrated modest effects for the generalization techniques of equating stimuli and peer reprogramming for promoting appropriate classroom behaviors across settings. Specifically, students in the equating stimuli group maintained 74% of their appropriate behaviors, and students in the peer reprogramming maintained 77% of their appropriate behavior in the regular classroom; whereas, the control group maintained 67% of their appropriate behavior. This study provides an example of how antecedent-based procedures may provide a cue for students to maintain appropriate behavior in non-training settings, and the utility of consequent-based procedures in facilitating generalization across settings. However, the overall effects of this study were modest and the group design made it difficult to maintain tight control over other variables that may have impacted the generalization across settings.

Freeland and Noell (1999) combined the simple common stimuli strategy with a consequent manipulation of reinforcement in the training setting to facilitate the maintenance effects of a math intervention. A reversal design with five different phases was utilized: baseline, reinforcement, delay 2 and 4, and maintenance. During the baseline phase students were asked to complete math worksheets for five minutes, no reinforcements or feedback on their performance were given during this phase and all baseline worksheets were blue. During the reinforcement phase students were given a prize from the "goody box" if they beat their goal that was written at the top of their individual pages. In the delay 2 phase, after students completed two sessions, one of the completed worksheets was selected at random and reinforcement was given based on the score of the selected worksheet. To replicate findings after the reinforcement phase and the delay 2 phase, a return to baseline was initiated. The return to baseline was indicated to students through use of blue paper and the absence of a goal at the top of the page. The delay 4 condition was identical to the delay 2 condition except the reinforcement was given after every 4^{th} session, instead of every 2^{nd} session in order to fade out the occurrence of the reinforcements. For the maintenance condition common stimuli from the delay conditions were programmed as cues to continue high math performance. Specifically, the worksheets were the same color (white) as the delay condition, the goal was written at the top of the worksheet, and the wording of the directions was identical to the delay conditions. However, no reinforcements were given during the maintenance phase.

The results of this study demonstrated that the use of the colored paper and goal as common stimuli served as appropriate cues to continue high performance once reinforcements were completely withdrawn (Freeland & Noell, 1999). Since reinforcements were paired with these common stimuli in the training condition, it is likely that the color of the paper and goal functioned as a discriminate stimulus (SD) to signal the potential for reward for correct responding in the maintenance phase. The individual responses of each student in the different conditions varied. Two of the students were exposed to the maintenance condition after the Delay 2 condition. One of these student maintained high rates of responding for eight sessions, while the other student maintained for fourteen sessions. A third student was exposed to the Delay 4 condition before maintenance and displayed maintenance of the math performance for twenty-three sessions. The final student was never exposed to the maintenance, due to decline in performance in the Delay 4 condition.

This study was replicated with a different mathematic target skill (Freeland & Noell, 2002). Both participants in the replication study displayed increases in performance with the Delay conditions and decreases in performance during the return to baseline. Furthermore, both students initially maintained their high rates of performance after the Delay 4 condition. However, one of the student's performance became variable after the 18^{th} session, while the other student maintained high performance for 24 sessions. The overall results of these studies demonstrate the utility of common stimuli and reinforcement to facilitate generalization of a skill over time. However, since the common stimuli served as an SD for potential reinforcement, the maintenance effects eventually dropped off for each of the students when the reinforcement was no longer present. Furthermore, individual differences in responding demonstrate the need for individual considerations when programming for generalization.

In summary, the functional nature of generalization is evident in the literature of generalization programming. Each technique emphasizes either an antecedent-based manipulation such as incorporating a common stimuli (e.g., Mesmer et al., 2007), a consequent-based procedure such as reinforcing generalized behavior (e.g., Rhode et al., 1983), or a combination of the two (e.g., Walker & Buckley, 1972). Furthermore, the literature reveals individual differences in generalized responses (e.g., Freeland & Noell, 1999), which indicates there is a need to develop generalization procedures that meet individuals' needs.

Generalization Across Academic Skills

The literature presented thus far has emphasized generalization across settings and focused mainly on problem behaviors. However, generalization procedures are also important to consider with academic deficits. Interventions for academic deficits should not only remediate the deficit, but also prevent future academic deficits in the targeted area (Skinner, 1998). Part of preventing academic deficits is ensuring the student is able to generalize the skills learned to novel contexts and tasks. Overall, there is a lack of literature that focuses on generalization of academic skills; however, a few studies have presented preliminary evidence that antecedent- and consequent- based procedures are effective in producing generalization across academic tasks (e.g., Bryant & Budd, 1982; Lloyd, et al., 1981; Weinstein & Cooke, 1992).

Weinstein and Cooke (1992) conducted a study that examined the generalization of oral reading fluency to novel passages with two different reading interventions. Each intervention involved a different application of a consequent-based procedure. Four students who had been diagnosed with learning disabilities in reading were given two different fluency-based interventions. The first intervention was a fixed-rate intervention in which students had to reach a criterion of 90 correct-words per minute before they moved on to a new passage. The second intervention was an improvements technique in which students had to make three successive improvements in their correct-words per minute rate before moving on to a new passage. The level of generalization of oral reading fluency to an unfamiliar passage was examined following each of these two treatment conditions.

The results showed that students were more likely to generalize the oral reading fluency gains to unfamiliar passages after the improvement intervention than after the fixed-rate intervention. In fact, the students' rates of oral reading fluency on unfamiliar passages actually decreased following the fixed-rate intervention. These results suggest that some interventions that increase immediate responding rates, such as the fixed-rate intervention, do not facilitate response generalization to unfamiliar material. The authors of this study speculated, from anecdotal information, that the improvements intervention was more reinforcing for the students than the fixed-rate interventions because of their frequent movements upward and notation of their personal improvements. From this information, it can be hypothesized that more reinforcements on an intervention skill may lead to greater response generalization on novel related tasks (Weinstein & Cooke, 1992).

Another study used a combination of antecedent and consequent manipulation to facilitate generalization of a self-instruction problem-solving strategy across settings and materials for preschool students (Bryant & Budd, 1982). Three preschool students who had lower academic ability participated in the study. Students were taught a self-instruction strategy for *working maze*, *finding the same*, and *size sequencing* worksheets. The strategy was taught using modeling, feedback and reinforcement during nine self-training sessions that occurred in a training classroom that was adjacent to their regular classroom. During the training sessions, students were given worksheets in the classroom that were similar and dissimilar to the ones in the training environment. While in the training environment students were told that their strategy would help them in the classroom, however, while in the classroom students were not given instructions, prompts, or feedback regarding the self-instructional strategy. After the training phase, a classroom intervention was implemented to produce generalization of the instructional strategy to the similar and dissimilar worksheets in the classroom. The classroom intervention included minimal antecedent prompts to cue the use of the strategy and a sticker on a card as reinforcement for the use of the strategy.

During the training phase, all three students in the study demonstrated increases in accuracy on the classroom worksheets that were similar to the training worksheets. One of the students made and maintained immediate gains over baseline in performance on similar worksheets once the self-instruction strategy was introduced in the training environment, while the other two students made steady gains in their performance of similar worksheets. These results indicated that the three students were able to generalize the self-instruction strategy to similar worksheets across the training and classroom environment without explicit generalization programming. However, only one student showed gains on the dissimilar classroom worksheets during the training phase. The other two students made gains on the dissimilar worksheets during the classroom intervention in which the students were cued to use their instructional strategy and reinforced for its use. These results demonstrated the variability of individual student's responses to academic intervention and generalization procedures. All three students displayed some level of spontaneous generalization across the settings, with similar tasks. However, only one student also generalized to dissimilar tasks. The other two students required a cueing and reinforcement procedures in the classroom to generalize the self-instruction strategy to the dissimilar tasks. Since the classroom procedure utilized the cue and the reinforcement, it is difficult to determine if the antecedent or consequent procedure, or a combination of the two was the functional variable for the generalization.

Lloyd et al. (1981) also did a study to examine the generalization of a strategy across skills using antecedent training to produce generalization. The purpose of their study was to determine if pre-skills training of specific counting strategies and specific multiplication strategy training would facilitate generalization across multiplication facts. Four children with low accuracy in basic multiplication skills participated in the study. Three types of multiplication problems were measured: (a) *Direct Training* were items used in both the preskills and strategy training; (b) *Near-Transfer* were items used in the pre-skills training but not the strategy training; and (c) *Far-Transfer* were items that were not used in either the pre-skills or the strategy training. Three different phases of intervention occurred during the study. The first phase was *preskills training*, in which students were taught to skip-count by 5s, 7s, 2s, 10s, 3s and 4s through modeling, practice, and corrective feedback procedures. The second phase was *strategy training* that was two sessions after the pre-skills training. During these sessions, students were taught to use the skip-counting procedure to solve multiplication problems with the facts of 7s, 3s, and 2s. The final session was cue training for multiplication facts, 6s, 8s, and 9s. During this phase, students were given a strip of paper with the skip-count numbers of 6s, 8s, and 9s and were told to practice skip counting and to use the strips to solve problems with these numbers.

During the pre-skills training, all four students maintained low levels of accuracy on all three types of problems. One student showed more variability in their performance on the problems than the other three students during this phase, but did not perform above 50% accuracy on any of the skills. After the strategy training, all four students made gains on both the Direct and Near-Transfer items. Two students, who had less than 20% accuracy on all skills during the pre-skills training, immediately increased and maintained accuracy levels ranging from 80% to 100% after the strategy training. The other two students made immediate but variable improvements in accuracy on the Direct Skills after the strategy training and slower and more variable gains in accuracy on the Near-Transfer skills. By the end of the post-strategy training phase, all four students were performing at least 80% accuracy on both the direct and near-transfer skills, however, none of the students made increases over baseline on the far-transfer skills. After the cue training, two students were able to increase and maintain their accuracy on the far-transfer skills to 100%. The other students made gains on the far-transfer skills immediately following the cue training, but these gains were not maintained. One student dropped to approximately 30% accuracy and the other to 70% accuracy on the far-transfer skills.

These results demonstrated that pre-skill or antecedent training may be key in producing generalized effects because students were able to generalize the explicit strategy to the near-transfer skills, but the pre-skills training alone was not sufficient in producing changes. Therefore, students needed a combination of pre-skills training and strategy training to generalize to the near-transfer skills. Furthermore, the students required simple training and a cue to use this strategy on the far-transfer skills.

The literature presented on generalization of academic skills confirms the theory that spontaneous generalization across skills is unlikely to occur without specific training. Overall, students were not able to generalize to unfamiliar reading passages, puzzle tasks, or multiplication facts without explicit generalization programmed in the training condition. For the majority of students in these studies, the generalization procedures were effective in producing generalized responses on the novel academic tasks; however, there was an individualized effect of the generalization procedures with some students requiring more environmental support to generalize to novel tasks than other students.

This individualized effect is present in most of the generalization literature presented above, which represent the most common forms of generalization procedures found in the literature. Each of these studies provides examples of both antecedent and consequent manipulations that influence generalized behavior. However, the authors of these studies did not define their procedures in terms of functionality; therefore it is not always clear if the antecedent or consequent manipulation had the most effect on the student's responding. The antecedent-based procedures presented (Ayllon et al., 1982; Lloyd et al., 1981) appear to be effective and so do the techniques that use consequent-based procedures (Noell et al., 2000; Rhode et al., 1983). Furthermore, the lack of functional definitions makes it difficult to determine why some students needed extra support and others did not. It may be that the function of their generalization deficits is different, and individualized generalization programming should be considered for each individual student.

Functional Analysis

Definitions of Functional Analysis

Functional analysis is a method for examining individual differences in behavioral responses and for developing individualized interventions. It is a process in which antecedents and consequences in the environment are manipulated to determine their effect on the target behavior (Cooper, Heron, & Heward, 2007). Through functional analysis, a hypothesis about the relationship between the behavior and its functions can be developed (Broussard & Northup, 1995). The goal of these analyses is not only to identify the controlling variables, but to use the information to decide how to best intervene on the behavior (Martens, Eckert, Bradley & Ardoin, 1999). Functional analysis has been applied in different clinic and school settings to determine functions of problem behaviors (e.g., Iwata et al., 1994; Broussard & Northup, 1995). It has also been adapted to a brief format that is often used for academic behaviors to identify potentially effective interventions and functions of academic deficits (e.g., Daly, Martens, Dool, & Hintze, 1998; Duhon et al., 2004).

The utility of functional analysis for determining maintaining variables and appropriate interventions was demonstrated by Iwata et al. (1994). In this study Iwata and colleagues used a functional analysis procedure to identify the function of self-injurious behavior. Eight subjects displaying self-injurious behaviors were exposed to four different conditions, each of which represented a different hypothesized function of the behavior. Six of the eight students displayed higher levels of self-injurious behavior when exposed to a specific stimulus condition. Iwata et al. (1994) proposed that specific interventions could be developed for these students based on the results of the functional analysis. For example, two of the students displayed higher rates of self-injurious behaviors when they were exposed to the condition of difficult academic tasks. An intervention that reduced academic demand or included more non-demand periods with the academic tasks would likely reduce the amount of self-injurious behavior for these two students. This study displays the utility of using functional analysis to identify a hypothesis for the function of the behavior.

Advancements in the use of functional analysis have been made since Iwata's and colleagues' (1994) work. Functional analysis has been adapted from the clinic setting to be used in education settings (Broussard, & Northup, 1995). For example, Broussard & Northup used functional analysis to identify the functions of disruptive behaviors for three students by assessing the students' responses to the hypothesized functions of contingent teacher attention, contingent peer attention, and escape from work. Furthermore, the functional analysis process in which each function is tested out in a lengthy experimental design has been shorten into a brief analysis of the functional variables (Cooper, Wacker, Sasson, Remiers & Donn, 1990; Northup et al., 1991). In this brief format the functional variables are typically administered in alternating formats for one to three trials, and a hypothesis is developed about the most effective procedure based on the responses to these brief trials. Research has demonstrated that the BFA procedure is as effective as full functional analysis in identifying the functions of behaviors and determining effective treatments for individuals (Derby et al., 1992; Khang & Iwata, 1999).

Review of literature on BFA for academics

In education, BFA has been used to link assessments to academic interventions. Specifically, researchers and practitioners have applied BFA principles to academic problems to determine the most effective interventions to remediate academic deficits, based on the theory that students' academic deficits are functionally related to the stimuli in the classroom that precede or follow the student's performance (Daly, Witt, Martens & Dool, 1997). Typically when BFA is used for academics, different intervention options are briefly applied in a systematic format, and the intervention resulting in the highest academic gains is the hypothesized best intervention for the individual student (Gilbertson, Witt, Duhon, & Dufrene, 2008).

Daly et al. (1998) used a BFA to determine appropriate interventions for oral reading. Three students with reading difficulties were given brief exposure to three different oral reading interventions on instructional passages: contingent reward, repeated readings, and listening passage preview with phase drill. The interventions were arranged in an order of least to most invasive and time-consuming, in order to determine the most efficient and effective intervention for the individual students. The contingent reinforcement was always implemented first in this study to rule out the possibility that the student's academic problems were due to performance deficits. If students did not show improvements under the contingent reward condition, then it was assumed that their deficits were due to lack of skill in the area of oral reading fluency. A brief multielement design was utilized in which students were given one session of each of the interventions; then the intervention that produced the most improvement on the instructional passage was repeated with a mini-replication. For each of the three students in this study, a hypothesized effective oral reading intervention was selected and confirmed through the mini-replication design. These results suggested that brief functional analyses are appropriate for use with academic performance.

In the study by Daly et al. (1998) it was proposed that the BFA identified the most effective intervention for each of the students based on the results of the mini-replication of the hypothesized best intervention. However, the true treatment utility of the selected interventions was not directly assessed. Treatment utility refers to "…the degree to which assessment is shown to contribute to beneficial treatment outcome" (Hays, Nelson & Jarrett, 1987, p. 963). VanAuken, Chafouleas, Bradley and Martens (2002) used an extended analysis to determine the treatment utility of the hypothesized most effective oral reading intervention. A BFA was conducted with three elementary students who had reading difficulties. Through the BFA, the intervention that produced the greatest amount of change over baseline and the intervention that produced the least amount of change over baseline were identified. An extended analysis was then conducted in which the two identified interventions were applied in an alternating treatment design. To control for carry-over effects between the two interventions during the extended analysis, each intervention was applied to different instructional passages. Initially each student displayed a greater amount of performance with the hypothesized most effective intervention, but for two students, their performance with both interventions started to converge. The results of this study showed preliminary evidence for assessing the treatment utility of academic interventions selected through BFA and extended analysis. However, even with attempts to control for carryover effect, it is likely that improvements with one intervention impacted the student's performance with the other intervention.

Noell et al. (2001) also examined the treatment utility of using BFA to select oral reading interventions. In this study, four elementary students with reading difficulties were given a BFA for three different reading skill levels, a total of 12 brief analyses. For each level there were two different types of treatments applied in a brief withdrawal design: contingent reward and instructional procedures with contingent rewards when rewards alone appeared to be effective. The treatment conditions were then examined in an extended multiple-baseline analysis across skill levels for each student. For 83% of the brief analyses, the hypothesis about the most effective intervention was confirmed in the extended analysis. These results supported that treatment utility does exist when using BFA to select appropriate oral reading interventions.

To date, the majority of studies that have examined the utility of BFA for selecting academic interventions have focused on reading interventions (see Bonfiglio, Daly, Persampieri & Anderson, 2006; Daly, Martens, Hamler, Dool, & Eckert, 1999;

Eckert, Ardoin, Daisey, & Scarola, 2000; Eckert, Ardoin, Daly, & Martens, 2002). Gilbertson et al. (2008) conducted a study that used BFA to select interventions for math fluency and on-task behavior. In this study, four students who had difficulties staying on-task and had deficits in math performance were given a BFA to examine two possible hypotheses for their deficits: either that their current math performance was related to incentives or it was related to incentives *and* insufficient practice. During the BFA, students were exposed to two different treatment conditions: contingent reward and contingent reward combined with instruction. All four students displayed greater gains with the combined treatment; therefore, it was hypothesized that all students had a combination of performance and skill deficits and needed instructional and motivational interventions. This hypothesis was confirmed in the extended analysis, in which all four students made gains in math performance over baseline with the combined treatment.

Skill vs. Performance Deficits

It is common practice for researchers and practitioners to offer a contingent reward prior to intervention to determine if the behavior increases with reward alone (e.g., Daly et al., 1998; Gilbertson et al., 2008; Noell et al., 1998). This process of providing contingent reinforcement alone is a type of BFA called skill versus performance deficit assessment (Lentz, 1988; Gresham, 1981). Skill deficits occur when there is a lack of skill in performing the behavior, whereas, performance deficits occur when there is a lack of environmental support for performing the behavior (Duhon et al., 2004; Lentz, 1988). Skill deficits can be remediated through antecedent manipulations that improve the skill level, while performance deficits can be remediated through providing rewards for performance that are powerful enough to compete with other available rewards in the environment (Duhon et al., 2004). In skill versus performance assessments, students are exposed to consequent motivational procedures for one session, if their performance increases over baseline, it is determined they have a performance deficit (Duhon et al., 2004). These assessments are important because although individual students may display deficits in the same area, the reasons for these deficits may not be the same (Skinner, 1998).

In Noell and colleagues' (2000) study on generalized responses of language development, a skill versus performance deficit assessment was used to identify potentially effective interventions for three students displaying behavior deficits in language development. Contingent reward was given to students prior to training to determine if students had performance deficits. One student showed improvement over baseline with the contingent reward condition, and it was determined that a contingency management treatment would be most effective for this student. For the other two students, the contingent reward was ineffective in producing gains in language production, which provided empirical evidence for providing an antecedent-based skill training intervention to remediate skill deficits.

Duhon et al. (2004) used BFA to hypothesize skill and performance deficits for struggling learners. The study extended the previous research by focusing on math and writing, as opposed to reading. Four students with poor academic performance in math, written language and/or spelling received assessments and interventions tailored to their individual academic performance. The brief assessment procedures for this study consisted of an in-class group assessment and an out-of class individual assessment. The in-class group assessment was conducted to obtain a point of comparison of the class's performance for the individual students. The out-of-class individual assessment was conducted to determine if the student's academic problems were due to performance or skill deficits. In the out-of-class assessment, students were given an assignment parallel to the ones given in-class and told if they beat their score they would receive a prize. The results of the out-of-class assessment were used to develop hypotheses about the function of potentially effective interventions for the students' academic deficits. It was hypothesized that two students had skill deficits, and the other two had performance deficits. Interventions were developed that addressed both skill and performance deficits, and the effectiveness of these interventions was examined in an extended analysis.

There were three main phases after the brief analysis: baseline, performance feedback, and extended analysis. The performance feedback served as a control phase to ensure that feedback alone was insufficient for increasing the student's behavior. The extended analysis consisted of two alternating conditions: reward and instruction. In the reward condition students were not given any instruction, they were simply given a goal to beat on the academic task and told if they beat their goal they would receive a prize from the prize box. The goal was based on the median performance of the previous three goal or baseline sessions. The instructional procedures varied between students, depending on their area of academic deficits. For two students, the intervention focused on writing, and the students were instructed on how to generate a list of main ideas of a story and were then able to use this list during the writing session. One student was instructed on 3-digit-by-3-digit multiplication using a fact sheet. For the final student the academic task was proof-reading to detect grammatical errors in sentences and correct them. The instructional component consisted of reviewing the previous day's assignment and giving the student performance feedback. The results of the extended analysis confirmed the hypotheses of skill or performance deficits for all four students.

In summary, functional analysis is a well established assessment procedure for developing hypotheses about the functions of individuals' behaviors and interventions that will be most effective for individuals. The advancements in functional analysis have made it a practical tool to be used in the educational setting to identify effective interventions quickly for behavioral and academic problems. Specifically, BFA has been shown to be effective in identifying specific academic interventions that will be the most efficient and effective for an individual student. Furthermore, the use of skill versus performance deficit assessments, allow researchers and practitioners to identify potentially effective individualized interventions to remediate academic deficits.

Brief functional analysis as a generalization assessment

The goal of academic functional analysis is to identify the instructional contingencies affecting academic behavior (Daly et al., 1997). The skill versus performance deficit assessment is a powerful tool for developing interventions that target individual's academic needs. However, an area of research that has not been examined is the individualized responses to generalization procedures and tools for addressing the individualized generalization needs of students.

Since generalization procedures are subject to behavior change mechanisms, it is hypothesized that these mechanisms can be assessed at a functional level to determine the generalization procedure that will be most effective for an individual student (Kirby

& Bickel, 1988). The goal of functional analysis of generalization should be to identify the contingencies affecting the generalized behavior. Through using BFA the generalization procedures that will work for an individual student may be quickly identified.

Lack of generalization can be conceptualized as a behavioral deficit that occurs either due to a skill deficit or a performance deficit (Gresham, 1981). A skill deficit in generalization occurs when a student does not know how to generalize the behavior across different skills, contexts, or time. Whereas, a performance deficit would occur if a student knows how to perform the behavior across skills, context and time, but does not have enough environmental support to perform the generalized behavior. A BFA can be used to identify the type of deficit and develop the function of potentially effective intervention (Duhon et al., 2004). Interventions to remediate skill deficits involve antecedent manipulations, whereas interventions to remediate performance deficits involve consequent manipulations (Duhon et al., 2004). Therefore, a skill versus performance deficit of generalization would involve exposure to both consequent and antecedent based procedures to determine the type of deficit and the function of a potentially effective intervention.

Multiplication Strategy: Skip Counting

Until recently, mathematic skills have been largely overlooked in the academic intervention literature (Skinner, 1998). In addition, the literature on generalization of academic behaviors and BFA of academic behaviors has mostly focused on reading skills (e.g., Gilbertson et al., 2008). Preliminary evidence on teaching multiplication strategies suggests that students do not always generalize skills they learn for one set of problems to other sets of problems (Lloyd et al., 1981); however, the extent of this research is limited.

The generalization study by Lloyd et al. (presented above; 1981), demonstrated that pre-training of a skip-counting procedure increased students' performance on multiplication facts. Skip-counting is a commonly taught multiplication strategy in which students are taught to count by a number for a specific set of multiplication facts (Sherin & Fuson, 2005). For example, to teach a student to multiply 4-facts, the student is taught to count-by 4s (i.e. 4, 8, 12, 16, 20…). Often this skip-counting procedure is accompanied by a number-line or number-chart for the students use as a visual cue for the numbers (Fennell, Altieri, & Silver Burdett Ginn Firm, 1998). In the study by Lloyd et al. (1981) students were taught how to use the skip-counting procedure with a number-line for a specific set of multiplication facts. Students' performance on the multiplication facts involving the skip-counting numbers increased; however, they did not generalize this skill to numbers that had not been explicitly taught as part of the skip-counting procedure. Other researchers have examined the effects of the pre-training skill of skip counting on directly taught facts and the amount of generalization to untaught numbers (Carnine, 1980; McIntyre et al., 1991). The research established skip-counting as an effective training strategy for teaching multiplication facts, however the results were unclear as to the amount of generalization that occurs to novel facts. (Carnine, 1980; McIntyre et al., 1991). More research is needed to determine if students generalize strategies, such as skip-counting, from sets of taught facts to other sets of untaught facts.

The Current Study

In 1977, Stoke and Baer wrote an article that was intended to spark research on the functional aspects of generalization (Kirby & Bickel, 1988; Stokes, 1992). However, the majority of the generalization research that has been produced has focused on the effectiveness of specific generalization techniques instead of the functional nature of these techniques. The current study is intended to extend the generalization literature by examining the functional nature of generalization through the use of BFA. Specifically, the study examined the utility of skill versus performance deficit assessment to determine the function of potentially effective generalization strategies and develop hypotheses about the most effective generalization procedures for individual students. Furthermore, the study extended the academic intervention literature by examining skip-counting with a hundred's chart as an effective strategy for teaching multiplication facts.

Research Questions:

1. Is skip-counting with a highlighted number-chart an effective intervention for teaching single-fact multiplication skills?

2. Does teaching one set of multiplication facts with a number-grid skip-counting strategy spontaneously generalize to similar multiplication facts? If spontaneous generalization does occur, what is the proportion of spontaneous generalization during the treatment phase for each generalization skill?

3. Can a BFA be used to determine if an antecedent-based or a consequence-based procedure will produce the greatest generalization effect to untrained multiplication facts?

4. What is the proportion of generalization when the generalization strategies are applied to the generalization skills in the extended analysis following the BFA?

CHAPTER III

METHODOLOGY

Research Design

The overall design utilized in this study was a small-N alternating treatment design nested within a multiple baseline across students. A multiple baseline across students was utilized to demonstrate experimental control of the treatment condition and repetition of the treatment effect for all three students. The alternating treatment design provided an extended analysis of the two conditions presented during the BFA.

Establishing experimental control within generalization research can be difficult due to the possibility of spontaneous generalization between the treatment skill and the generalization skill. Generalization is considered to be spontaneous when it occurs naturally without explicit programming (Stokes & Baer, 1977). However, the spontaneous occurrence of generalization is likely due to a lack of experimental control of the variables responsible for the generalization rather than a natural phenomenon (Kirby & Bickel, 1988; Stokes & Baer, 1977). A potential variable that may impact spontaneous generalization is the students' prior learning experiences with the target skills and generalization procedures. The first two phases of this research design attempted to control for these variables by establishing a stable baseline of both the treatment and generalization skills and a baseline of the student's pre-treatment performance in the presence of the generalization stimuli. Furthermore, to determine if spontaneous generalization occurred during this study, the generalization skills were intermittently probed during the treatment phase. If the students showed significant gains on the generalization skills during the treatment phase, it was determined that spontaneous generalization had occurred due to uncontrolled functional variables. Furthermore, generalization of skills was examined for both accuracy and fluency to determine if students generalized at one level but not the other.

The next two phases of this study included a BFA and an extended analysis alternating treatment design. The BFA of the two generalization procedures was used to hypothesize which procedure would work best for that particular student, and the alternating treatment design was used to determine the accuracy of the hypotheses about the generalization procedures. During the BFA and the extended analysis, each of the two generalization procedures was applied to a different set of multiplication facts to control for carryover between the procedures (Sindelar, Rosenberg, & Wilson, 1985). During the alternating treatment design, the target skill was intermittently probed to measure maintenance of performance. A final phase of the study was conducted in which the most effective generalization strategy for a particular student was applied to contraindicated skill to verify the effects of the generalization strategy across skill.

Participants and Setting

Participants were selected from a second grade classroom in a school district in the Midwest, USA. Twelve students were referred by their teachers as potential candidates for the study. Six of these students were included in the study. Five of the referred students were not included due to levels of accuracy over 25% on the initial pre-assessment of multiplication skills, and one student was dismissed due to emotional frustration expressed during the pre-assessments. All six participants were Caucasian, and four of the participants were male. Ryan, Matt, Kristin, and Beth were all 7 years old at the start of the study, while John and Travis were 8 years old at the start of the study. All six students were classified as general education students and had not been retained for any grades in school. All phases of the treatment were implemented by trained School Psychology doctoral level graduate students and occurred in a quiet hallway with tables and chairs outside the students' classrooms.

Materials

Throughout the phases of the study, students were given multiplication probe sets each having a single common factor of 6, 7, or 8, with repeated factors eliminated. For example, 6x8 and 8x7 were not included in any of the sets. The probes were created using an Excel® spread sheet, which were specifically configured to generate random numbers for the factors of 6's, 7's or 8's for a given problem so that multiple, equivalent probes could be created. A number chart was included at the top of every probe presented to the students throughout the study (see Appendix). The number chart consisted of a 10x10 grid with numbers 1-100 on it. During the treatment phase and the cueing procedures, the number chart was highlighted with the appropriate skip-counting numbers. For example, on the 6's facts probes for the treatment phase, multiples of 6's (i.e. 6, 12, 18, etc.) were highlighted. During the pre-assessment and BFA phases, colorful pencils and stickers were utilized as contingencies for beating individual goals. During the reinforcement generalization sessions, a blank graph was utilized for students to record their daily progress toward their overall goal. On the X axis of the graph, the dates of sessions were recorded and the Y axis contained intervals of 5 for numbers 0 – 40. The students' individual goals were also marked on the graph with a dotted line. Also, a sticker goal sheet was utilized during the reinforcement generalization sessions, in which students were able to put a sticker next to their daily goal if they beat it.

Independent Variables

Two independent variables utilized during this study were the skip-counting treatment and the two generalization procedures. During the treatment phase, a skip-counting strategy with a number chart was used for the treatment target skill. For this treatment, students were shown a problem and then taught how to solve the problem by counting the common factors on the number chart.

During the BFA and alternating treatment phases of the study, the independent variables were the two generalization strategies. The first generalization strategy was an antecedent-based strategy in which the students were given a copy of the number chart with the appropriate skip-counting numbers highlighted on it as a cue to use the skip-counting strategy. The second was a consequent-based strategy in which the student were given a goal and performance feedback after administration of the study. Students marked their progress on a graph and received a sticker for beating their goal.

Dependent Variable

The dependent variables in this study were the students' accuracy and fluency of single-digit multiplication problems. The students' level of response and spontaneous generalization was utilized to determine if accuracy or fluency was the most appropriate measure for each particular student. For students who demonstrated spontaneous generalization of accurate responding during the treatment phase, fluency was used as the primary dependent variable. For students who did not demonstrate spontaneous generalization of accurate or fluent responses, accuracy was utilized as the primary dependent variable. For each probe given, the amount of digits correct (DC) was counted. Accuracy was determined by dividing the amount of DC over the total number of problems attempted to obtain a percentage of accurate problems. Fluency was determined by calculating amount of DC in 2 minutes and dividing this number by 2 for the digits correct per minute (DCPM).

Procedures

Initial inclusionary procedures. All twelve students who were referred by their teacher's as potential participants in the study were given one single-fact probe of each of the experimental facts (6, 7, and 8). The number chart was present at the top of each probe, but no explanation was given for it. Students were instructed to attempt all of the problems and mark X's through any problems they could not complete, and they were given 2 minutes to complete each probe. Students who were more than 25% accurate and less than 10 DCPM on the probe were excluded from the study.

Baseline of reinforcement and cueing procedures. A baseline measure of both the reinforcement and cueing procedures was obtained for each student to rule out performance deficits and prior exposure to the cueing strategy. Students were told if they could beat their score from the previous day's single-fact multiplication probes (the initial assessment probes), they would receive a pencil from the pencil bag, during this procedure the non-highlighted number chart was presented at the top of the paper. If students increased their scores with the reinforcement above 25% accuracy or 10 DCPM, then it would have been determined they had a performance deficit of the single-digit multiplication skills and they would have been removed from the study. None of the students displayed this increase with the reinforcement, so they were presented with probes that included highlighted number-charts at the top. Instructions on how to use the number chart were not given. If the students increased their performance with the highlighted cue above 25% accuracy or 10 DCPM, then it would have been determined that they had prior learning experience with the highlighted number chart and would have been removed from the study. None of the students increased their performance with the highlighting of the number chart.

Baseline (Phase 1). Once the six participants had been identified from the initial assessments, each student was randomly assigned a different combination of the multiplication facts for the treatment and generalization skills. Ryan and John were assigned 6's as their treatment skill, 7's as the cue generalization skill and 8's at the reinforcement generalization skill. Kristin and Matt were assigned 7's as the treatment skill, 8's as the cue skill, and 6's as the reinforcement skill. Finally, Travis and Beth were assigned 8's as the treatment skill, 6's as the cue skill and 7's as the reinforcement skill. During the pre-treatment baseline phase, students were given single-fact multiplication probes of the treatment and generalization skills. Students were presented with the probes and told do their best on the problems. They had 2 minutes to complete each probe. The non-highlighted number chart was present at the top of each probe; however, no explanation was given of the number chart.

Skip counting treatment (Phase 2). On the first day of treatment, students were presented with the single-fact multiplication probe of their treatment target skill with a highlighted number chart at the top of the probe. The research assistant gave students instructions on how to use the highlighted number chart to skip count and find the answers to the problems on the multiplication probe. The instructor modeled the process to students on the first problem by showing the students how to count on the number chart to obtain the correct answer. For example, if the problem was 6 x 5, 6-factors were highlighted on the number chart, and the instructor counted five highlighted numbers, which was the number 30. The instructor circled this number and wrote it down as the answer to the problem. The instructor used guided practice on the next two problems by reading the problems and then asking the students how they could use the number chart to solve it and counted with the students on the number chart. If the students stated that they did not know how to use the number chart to solve the problem, the instructor gave the students specific instructions to count the numbers on the number chart. After the students correctly did two problems with guided practice, they were given the opportunity to do the next three problems on their own. If the students missed any of these three problems, they were given corrective feedback about the correct number to count on the number chart. This process continued until the students correctly answered three problems without corrective feedback. Once the students accurately completed three consecutive problems, they were given a 2-minute multiplication probe of the same target facts with the highlighted chart. Each successive day of treatment, the student was reminded about how to use the number chart with the prompt "Remember you can use the number chart to help you figure out the answers to these problems by counting the highlighted boxes." For these probes, the students were given 2-minute probes of the target skills with a goal written at the top of each page that was based on their median performance from the previous three day's probes. The students were instructed that if they beat their goal they would get to put a sticker on the sticker chart, and mark their progress on the graph. The students were also reminded that once they reached their overall goal on the graph they would get either lunch in the classroom or extra computer time.

Furthermore, during the treatment phase, probes of the single-fact generalization skills with a non-highlighted number chart were administered intermittently throughout the treatment phase with the baseline procedures to determine if spontaneous generalization occurred between the skills.

Brief Functional Analysis (Phase 3). The BFA of skill versus performance deficit was conducted to develop a hypothesis about which generalization procedure would produce the greatest results. First, students were given a single-fact multiplication probe of the reinforcement generalization skill with the non-highlighted number chart present. Students were informed of a goal for performance, based on their average baseline performance of the reinforcement skill. If students beat their goal, they were given a pencil from the pencil bag. Then the students were given another single-skill multiplication sheet of the cue generalization skill with a highlighted number chart. The students were asked to complete the worksheet without any explanation of the number chart or the highlights. If students were able to increase their performance with the presentation of the goal with reinforcement, then it was hypothesized that their deficits in baseline were due to a performance deficit in generalization and that the consequent-based procedure would produce greater effects in the alternating treatment phase. Whereas if the student increased their performance over baseline with the presence of the highlighted number chart, it was hypothesized that their deficits in baseline were due to a skill deficit in generalization and that the antecedent-based procedure would produce the greatest gains in the alternating treatment phase.

If students did not show clear differentiation of performance between the skills, the BFA was repeated two more times, and the skill with the higher level of performance on at least two of the trials was hypothesized to be most appropriate generalization treatment for that student. If the students did not increase performance on either skill for three trials of the BFA, a verbal prompt of "use the number chart to help you solve these problems" was added to the cueing procedure instructions.

Extended analysis of generalization procedures (Phase 4). The consequent-based reinforcement procedure and the antecedent-based cueing procedures were carried out in an alternating treatment design with a day separating treatment sessions. The order of the cue and reinforcement days was counterbalanced across students. On the reinforcement day, students were given single-fact multiplication probes of their first generalization skill with a non-highlighted number chart. The goal was written at the top of each page, and the same sticker chart and self-graphing procedures from the treatment phase were utilized. The probes were scored in front of the students after completion and the students were given feedback on their performance, and they marked their score on the graph. On the cueing days, students were given a single-fact multiplication probe of their cueing generalization skill with a highlighted number chart. The students were explicitly told they did not have a goal to beat on these days, but they needed to do their best. The cueing probes were not scored in front of the students, and the students were not given feedback about their performance. Also, during the extended analysis, the original target skill was intermittently probed w/ a highlighted number chart present to ensure maintenance of this skill.

Verification of effective generalization strategy (Phase 5). To replicate the effectiveness of the generalization strategies a final phase was conducted in which the most effective generalization strategy was applied to the contraindicated skill set. For example, if the antecedent-based cue strategy was more effective than the reinforcement strategy, then the cue strategy was applied to the reinforcement skill and the opportunity for reinforcement was removed.

Procedural Integrity and Inter-Scorer Agreement

Procedural integrity data were collected for 32% of all intervention sessions by an independent observer. For each of these phases, an independent observer watched the intervention session and checked off steps on an intervention protocol as the instructor completed each step. Based on step-by-step agreement the procedural integrity was 98% for the intervention sessions. Furthermore, inter-scorer agreement was calculated. An independent scorer re-scored 39% of the math probes, and there was 98% agreement on the scores.

Data Analyses

Visual analysis and calculation of accurate or fluent responding were used to answer the first and third questions of this study. Furthermore, a generalization ratio was used to answer the second and fourth questions concerning the proportion of generalization that occurred. The generalization ratio is the average performance of the last three data points for the generalization skill over the average performance of the last three data points for the treatment skill in each phase (House, Duhon, Hastings & Linden, 2009).

The first question of the effectiveness of the skip-counting procedure was analyzed through visual analysis of the amount of change between baseline performance of the treatment skill and the performance of the treatment skill for each student. Furthermore the average DCPM or percentage of accuracy in baseline and treatment phases was compared to determine if the skip-counting procedure was an effective intervention for teaching single-fact multiplication. Also, the students' performance in relation to the goal criteria was examined. For the students with accuracy goal, the criterion was 85% accuracy, and for the students with fluency goals, the criterion was 20 DCPM.

The second question of spontaneous generalization was analyzed through visual analysis comparing the student's performance on the treatment skill to the generalization skills. The difference in the generalization skills from baseline was examined to determine if spontaneous generalization had occurred. Furthermore, the proportion of spontaneous generalization was analyzed with the generalization ratio by dividing the average performance of each generalization skill in the treatment phase by the average performance of the last three data points for the treatment skill in the treatment phase. If the student displays less than 0.50 generalization on generalization skills, it was determined they have not spontaneously generalized across skills.

The third question of the use of developing an accurate hypothesis about the best generalization procedure based on the results of the BFA was analyzed through visual analysis of the student's performance on the reinforcement and cueing procedures in the alternating treatment phase. A hypothesis for the most effective generalization strategy was developed for each student based on the skill that was highest in the BFA. During the alternating treatment phase, visual analysis was used to confirm the results of the BFA to determine that the hypothesized most effective strategy produced the highest level of performance for each student.

Finally, a generalization ratio was used to answer the fourth question of the proportion of generalization that occurred during the alternating treatment extended analysis phase. The generalization ratio was calculated by dividing the average performance of the last three data points of each generalization skill by the average performance of the data points for the treatment skill in the alternating treatment phase. For the final question, the generalization ratio was used as a comparison measure for the two generalization skills. This allowed direct comparisons of the two skills in relation to the student's performance on the treatment skill. In addition, the criterion of 0.50 generalization was used as a cut-off for determining that a significant amount of generalization had occurred.

CHAPTER IV

RESULTS

Data for all six participants are presented in Figures 1-4 and Tables 1-4. Originally, the students were randomly assigned to one of two multiple baseline sets for the initial skip-counting treatment phase (Table 1; Figures 1 & 2). After the skip counting treatment, students were regrouped in multiple baselines according to their level of spontaneous generalization during the treatment phase. Figure 3 is the multiple baseline across the four participants who did not display spontaneous generalization of accuracy or fluency during the treatment phase. For these four participants, the accuracy scores were utilized for interpretation; the mean accuracy scores of each phase for each student are displayed in Table 2. Figure 4 includes the multiple baseline of the two students who did display spontaneous generalization of accuracy but not fluency during the treatment phase. For these two students the fluency scores were utilized for interpretation; the mean DCPM scores of each phase for each subject are displayed in Table 3.

Results for the skip counting treatment will be discussed first (see Table 1 and Figures 1 & 2). All six students displayed a level of 0% accuracy during the baseline phase, and they all displayed immediate gains in accurate responding on the first two-minute probe of the treatment skill after teaching the skip counting strategy. In the first multiple baseline set (figure 1), Ryan began the treatment after three baseline sessions. He immediately increased his performance to 100% accuracy and maintained this level of performance throughout the skip counting phase. Kristin began the skip counting treatment next after five baseline sessions and immediately increased her performance to 88% accuracy and maintained a high level of response with a mean of 99% accuracy throughout the phase. Finally, Beth began the skip-counting treatment after seven baseline sessions and immediately increased her performance to 100% accuracy on the skip-counting skill.

For the second multiple baseline set (Figure 2), Matt initiated the skip counting treatment after three baselines sessions and scored 50% accuracy on the first probe. Matt's performance continued to increase throughout the skip-counting treatment phase with a mean of 83% accuracy. John began the skip-counting treatment after five baseline sessions; he scored 52% on the first probe after being taught the skip counting strategy and continued to increase performance with a mean of 82% accuracy during the skip-counting phase. Finally, Travis began the skip-counting phase after seven baseline sessions. He scored 100% on the first skip counting probe after treatment and maintained this level of response with a mean of 98% accuracy during throughout phase 2.

Next the results of the generalization scores for the accuracy and fluency students will be discussed. The results of the accuracy students who did not display spontaneous generalization (Figure 3 and Table 2) will be discussed along with the proportion of generalization for each phase (Table 4). During the skip counting treatment, Travis, John, Ryan and Matt all displayed a level of 0% accuracy on the intermittent probes of the cue and reinforcement generalization skills, and their proportion of spontaneous generalization was 0 for both generalization skills.

As a result of the stable performance on both the treatment and generalization skills, the BFA and extended analysis was initiated first for Travis. Initially, in response to the cue and reinforcement procedures, Travis continued to display 0% accuracy on both the cue and reinforcement skills. After two trials of 0% accuracy, a verbal cue to use the highlighted number chart was added to Travis's cueing procedure. Upon initiation of the verbal cue, Travis displayed 62% accuracy on the cue skill and 0% accuracy on the reinforcement skill. This pattern of the antecedent-based procedure being more effective was confirmed in the extended analysis phase. Travis consistently displayed higher levels of accurate performance for the verbal cue condition, with a mean of 83% accuracy. For the reinforcement skill, Travis had a mean of 19% accuracy. Furthermore, Travis maintained a level of 100% accuracy on intermittent probes of the treatment skill during the generalization phase. In the last phase of the study, the verbal cue was added to the reinforcement skill and the opportunity for reinforcement was removed. During this phase, Travis increased his performance on the reinforcement skill to a mean of 93% accuracy and maintained 90% accuracy for the cue skill and 100% accuracy for the treatment skill. The results of the last phase verify that the antecedent-based strategy was effective for both generalization skills. Furthermore, the proportion of generalization was calculated using the generalization ratio. Travis displayed 0.84 generalization of the cue skill and 0.20 of the reinforcement skill during the alternating treatment phase. In the last phase of the study, Travis displayed 0.93 generalization of the cue skill and 1.00 generalization of the reinforcement skill.

John was the next student to begin the BFA and alternating treatment phases. During the BFA, John's performance on the cue skill immediately increased to 44% accuracy with the visual cue of the highlighted number chart, and his performance on the reinforcement skill was 0% accuracy. During the alternating treatment extended analysis phase, John maintained a high level of performance on the cue skill with a mean level of 86% accuracy and a low level of performance on the reinforcement skill with a mean level of 19% accuracy, which confirmed the antecedent-based strategy of the cue was most effective for John. Furthermore, John maintained a level of 95% accuracy on intermittent probes of the treatment skill during the alternating treatment phase. In the last phase of the study, when the cue was applied to the reinforcement skill John increased his performance to 77% accuracy on the reinforcement skill and maintained 93% accuracy on a treatment skill probe. The generalization ratio was used to calculate the proportion of generalization for each skill. John displayed 0.95 generalization of the cue skill and 0.20 generalization of the reinforcement skill during the alternating treatment phase. In the last phase, John displayed 0.85 generalization of the reinforcement skill. The cue skill was not re-administered for John during this phase.

Ryan began the BFA and alternating treatment phase after John. During the BFA, Ryan's performance on the cue skill increased to 50% accuracy with the visual cue of the highlighted number chart, and his performance on the reinforcement skill remained 0% accurate. During the alternating treatment extended analysis phase, Ryan maintained a high level of performance on the cue skill with 100% accuracy and a low level of performance on the reinforcement skill with 0% accurate, which confirmed the results of the BFA that the antecedent-based cueing strategy was most effective for Ryan.

Furthermore, Ryan maintained a level of 100% accuracy on intermittent probes of the treatment skill during the generalization alternating treatment phase. The generalization ratio was used to calculate the proportion of generalization for each skill during this phase. Ryan displayed 1.00 generalization of the cue skill and 0.00 generalization of the reinforcement skill. During the alternating treatment phase, Ryan became frustrated with the intervention procedures and refused to complete the math probes. Therefore, Ryan was removed from the study and did not complete the final phase of verifying the cue as the most effective strategy.

Matt was the last accuracy student to enter the BFA and alternating treatment phases. During the BFA, Matt's performance on the cue skill increased to 78% accuracy with the visual cue of the highlighted number chart, and his performance on the reinforcement skill remained 0% accurate. The effectiveness of the cueing strategy was confirmed in the alternating treatment extended analysis phase; Matt maintained a high level of performance on the cue skill with a mean level of 97% accuracy and a low level of performance on the reinforcement skill with 0% accurate. Furthermore, his performance on the intermittent treatment skill probes was a mean of 96% accuracy. In the last phase of the study when the cue was applied to the reinforcement skill Matt increased his performance on the reinforcement skill to a mean of 96% accuracy and maintained 100% accuracy for the cue and treatment skills, which confirmed the effectiveness of the cueing strategy for both the generalization skills. The generalization ratio was used to calculate the proportion of generalization for each skill. Matt displayed 1.04 generalization of the cue skill and 0.12 generalization of the reinforcement skill during the alternating treatment phase. In the verification phase, Matt displayed 1.00 generalization of the cue skill and 0.96 generalization of the reinforcement skill.

The fluency multiple baseline (Figure 4) consisted of the two students, Beth and Kristin, who displayed spontaneous generalization of accurate responding during the treatment phase. During the treatment phase, Beth's proportion of spontaneous generalization for accuracy was 0.89 for the cue skill and 0.93 for the reinforcement skill. Kristin's proportion of spontaneous generalization during the treatment phase was 0.69 for the cue skill and 0.82 for the reinforcement skill. Therefore, both students displayed a significant level of spontaneous generalization on accurate responses for both generalization skills during the treatment phase. Due to this level of spontaneous generalization, the fluency scores (Table 3), which did not have the same level of generalization (see Table 4), were utilized to interpret the results of the generalization procedure.

During the baseline phase Beth had a level of 0 DCPM on the cue skill and reinforcement skill, and on the treatment skill she had a mean score of 2 DCPM. Kristin's mean scores during baseline were 0 DCPM for the treatment and reinforcement skill and 1 DCPM for the cue skill.

On the first treatment probe after teaching the skip-counting strategy, Beth increased her performance on the treatment skill to 17.5 DCPM, and maintained a mean level of 21.06 DCMP during the treatment sessions. On the intermittent probes of the generalization skills during the treatment phase Beth's performance was a mean of 6 DCPM for the cue skill and 6.63 DCPM for the reinforcement skill. Beth's proportion of spontaneous generalization was 0.26 for the cue skill and 0.28 for reinforcement skill during the treatment phase.

Kristin's performance on the treatment skill increased to 7.5 DCPM on the first treatment probe after teaching the skip-counting strategy and she continue to increase her performance and maintained a mean level of 18.23 DCPM during the treatment phase. Kristin's performance on the intermittent probes of the generalization skills was a mean level of 7.33 DCPM for the cue skill and 8.72 DCPM for the reinforcement skill. Kristin's proportion of spontaneous generalization was 0.36 for the cue skill and 0.43 for reinforcement skill during the treatment phase.

As a result of the stable performance on both the treatment and generalization skills, the BFA and extended analysis was initiated first for Beth. During the BFA, Beth's performance on the cue skill immediately increased to 17 DCPM with the visual cue of the highlighted number chart and her performance on the reinforcement skill was 6.5 DCPM. During the alternating treatment phase, Beth maintained a high level of performance for the cue skill with a mean level of 21.61 DCPM and a lower level of performance for the reinforcement skill with a mean level of 11.5 DCPM, which confirmed the results of the BFA that the cue was a more effective procedure for Beth. The generalization ratio was used to calculate the proportion of generalization for each skill during the alternating treatment phase. Beth displayed 1.14 generalization of the cue skill and 0.66 of the reinforcement skill. Due to the initiation of winter break towards end of the study, the verification phase was not implemented for Beth.

Although Kristin's performance on the generalization skills continued to increase during the treatment phase, the BFA and alternating treatment phase was initiated to determine if the added cue or reinforcement would result in differentiated effects and produce greater increases in her performance. On the first administration of the BFA Kristin's performance was 18 DCPM for the cue skill and 14 DCPM for the reinforcement skill. Due to the small difference in performance on these two skills, the BFA was conducted two more times. On the second administration of the cue and reinforcement strategy, Kristin scored 13.5 DCPM for the cue skill and 16.5 DCPM for the reinforcement skill; on the final implementation of the BFA, Kristin scored 13.5 DCPM for the cue skill and 12 DCPM for the reinforcement skill. On two of the three administrations of the BFA, Kristin performed slightly higher with the cue strategy than the reinforcement strategy; therefore, it was hypothesized that the antecedent-based cue strategy would be most effective for Kristin during the extended analysis. During the extended analysis alternating treatment phase, Kristin's performance on the cue skill was a mean of 20.88 DCPM and on the reinforcement skill her performance was a mean of 15.13 DCPM. Furthermore, Kristin maintained a high level of performance on the intermittent treatment skill probes with a mean of 20 DCPM. During the final phase of the study when the cue strategy was implemented for the reinforcement skill, Kristin's performance on the reinforcement skill increased to a mean of 20.00 DCPM, and she maintained a mean of 20.5 DCPM on the cue skill and 22.00 DCPM on the treatment skill. Furthermore, the generalization ratio was used to calculate the proportion of generalization for each skill. Kristin displayed 1.04 generalization of the cue skill and 0.78 of the reinforcement skill during the alternating treatment phase. In the last phase of the study, Kristin displayed 0.93 generalization of the cue skill and 0.91 generalization of the reinforcement skill.

CHAPTER V

DISCUSSION

The primary purpose of this study was to examine the utility of a BFA to identify effective generalization procedures for individual students. Through conceptualizing generalization as a behavior and a lack of generalization as a behavioral deficit the results of the current study extend the generalization literature. Specifically, this study built on the proposal that generalization is under stimulus control and therefore affected by antecedent and consequent manipulations (Kirby & Bickel, 1988). Furthermore, these different types of manipulations can be tested to determine the most effective strategy for an individual student.

Initially, students were taught how to solve a set of multiplication facts using a skip counting strategy and spontaneous generalization to other sets of facts was measured. Next, a BFA procedure was utilized in which an antecedent- and a consequent- based generalization procedure were administered to increase generalization across multiplication skills. Based on the results of the BFA, hypotheses were developed about the most effective generalization procedures and tested in an extended analysis alternating treatment phase. Overall, the results of this study provide answers to the four research questions concerning the effectiveness of the initial treatment, the level of spontaneous generalization and the utility of using the BFA to identify effective generalization procedures. Furthermore, there are practical implications of this study for researchers and practitioners who utilize academic and behavioral interventions.

Research Question 1

The first research question addressed the effectiveness of skip-counting as a strategy for solving multiplication facts. Prior to initiation of the study, it was established that all six students had not been exposed to a skip-counting strategy using the hundred's chart to solve multiplication facts. Furthermore, all six students had a level of 0% accuracy during the baseline phase on all three sets of multiplication facts. Upon initiation of the skip counting treatment, the six students immediately increased their level of accuracy and fluency on the treatment skills and continued to make progress throughout the treatment phase. Visual analysis of the students' performance (Figures 1 and 2) reveals replication of the treatment effect across all the students.

This first question was not the primary focus of the study. However, effectiveness of the skip-counting treatment needed to be established prior to answering the other research questions. If the skip-counting strategy had not been effective, then generalization of the strategy could not be examined. Although the skip-counting strategy was not the primary focus of this study, the results do add to the limited literature base on the subject and confirm that skip-counting is an effective strategy for teaching small sets of multiplication facts (Sherin & Fuson, 2005).

Research Questions 2

The second question addresses generalization of the skip counting strategy. When generalization occurs without explicit programming, it is considered spontaneous (Stokes & Baer, 1977). In this study, spontaneous generalization was examined and measured during the treatment phase to determine if students increased their performance on the untaught multiplication facts without explicit programming. The four accuracy students did not demonstrate spontaneous generalization to the untaught skills during the treatment phase, and maintained a level of 0% accuracy on all generalization skills during this phase.

The other two students spontaneously generalized accurate responses to the untaught skills and demonstrated small amounts of generalization for fluent responses. Beth displayed 26% generalization on the untaught cue skill and 28% generalization on the untaught reinforcement skill. Kristin displayed 36% generalization on the cue skill and 43% generalization on the reinforcement skill. Although this indicates a level of generalized responses, neither student reached the pre-established criteria of 50% generalization. Therefore, neither student displayed significant levels of generalization during the treatment phase for fluent response. Furthermore, it was hypothesized that the students would increase their fluency performance with an explicit generalization procedure.

The literature on generalization posits that spontaneous generalization is unlikely to occur without explicit programming (e.g., Stokes & Baer, 1977; Stokes & Osnes, 1989). In addition, research on generalization of skip-counting procedures demonstrated that students did not generalize the strategy to untaught skills without explicit programming (Lloyd et al., 1981). Four of the students in this study did not generalize to untaught facts during the treatment phase, which is consistent with the previous research on generalization. However, two students did generalize without explicit programming for the untaught facts. Research has shown that pre-skills training in skip-counting may facilitate generalization to untaught facts (Carnine, 1980; McIntyre et al., 1991). Although the current study attempted to control for pre-skills training with pre-assessments of the students' experience with a 100's number chart for multiplication, it is possible that the students had prior experience with the basic skip-counting procedure which served as pre-skill for generalization to the untaught multiplication facts.

Research Questions 3

The primary purpose of this study was addressed with questions three and four, which examine the utility of selecting generalization procedures based on the functional variables associated with the generalization deficits. Specifically, two different hypotheses were tested for each student to determine which generalization strategy would be most effective for the individual student. It was hypothesized that the deficits in generalization were due to either a skill deficit of not knowing when to use the skip-counting strategy or a performance deficit indicating a lack of reinforcement for using the strategy. For a skill deficit, the antecedent-based instructional procedure would be more effective and for a performance deficit the consequent-based procedure that cued reinforcement for higher level of performance would be more effective.

For five of the six students the results of the BFA clearly indicated that the antecedent-based strategy would be the most effective for the students, and this was confirmed in the extended analysis for all five students. Therefore, the BFA was an effective procedure for identifying which strategy would be the most beneficial for the students.

For the other student, Kristin, there was not clear differentiation between her performance on the cueing procedure and the reinforcement procedure during the initial BFA. The BFA was conducted two additional times to determine which strategy had the most potential for being effective during the extended analysis. The cueing procedure was slightly higher for Kristin on two of the three BFA trails; therefore, it was hypothesized that this would be the most effective procedure. This hypothesis was confirmed during the extended analysis with Kristin displaying greater levels of fluency with the cueing strategy than the reinforcement strategy.

The literature has proposed that generalization should be conceptualized as a behavior that can be changed with antecedent and consequent manipulations (e.g. Kirby & Bickel, 1988; Stokes & Osnes, 1989). Furthermore, both antecedent and consequent manipulations have been shown to be effective procedures for producing generalization (e.g., Ayllon et al., 1982; Mesmer et al., 2007; Noell et al., 2000; Rhode et al., 1983). However, there are often differences in the individual responses to these procedures and a structure for selecting the most effective generalization procedure has not been examined.

The structure presented in this study conceptualized generalization deficits as occurring due to either a skill deficit or a performance deficit and a BFA procedure was developed to determine which type of generalization procedure would be most effective for the individual students. The results from the four accuracy students indicate that generalization may occur due to skill deficits in which the students do not know when to use the previously learned behavior. For these four students, the antecedent-based instructional procedure provided a cue to perform the skip-counting strategy. These results add to the previous literature as they confirm the functional nature of generalization and introduce a systematic process for determining effective generalization procedures.

Research Question 4

The proportion of generalization that occurred during the extended analysis was calculated using the generalization ratio. On the cue procedure, all six students displayed at least 0.84 generalization of the treatment skill. Furthermore, the four accuracy students displayed less than 0.20 generalization of the treatment skill on the reinforcement procedure during the extended analysis. Therefore, the proportion of generalization clearly indicates that the cue strategy was the most beneficial generalization procedure for the four students who did not spontaneously generalize during the treatment phase.

The results are less clear for Beth and Kristin, the two fluency students who did display spontaneous generalization during the treatment phase. Beth and Kristin both displayed higher levels of generalization with the cue procedure than with the reinforcement procedure during the extended analysis. For the cue procedure, Beth had a level of 1.14 generalization of the treatment skill, and for the reinforcement procedure she had a level of 0.66 generalization of the treatment skill. Kristin had a level of 1.04

generalization of the treatment skill for the cue procedure and for the reinforcement procedure a level of 0.78 generalization of the treatment skill during the extended analysis. Although both students had higher levels of generalization with the cue procedure, they still displayed significant levels of generalization with the reinforcement procedure. The difference in the level of performance may be due to the difference of effort required for each task. For the cue procedure, the numbers on the chart were already highlighted, and therefore the students simply had to count out the number of highlighted numbers. For the reinforcement procedure the numbers were not highlighted, therefore the students had to count out the appropriate skip-counting numbers, which took more time and response effort.

In the literature, generalization is presented as a discrete phenomenon that either occurs or does not occur (e.g., Ayllon et al. 1982; Lloyd et al., 1981; Noell et al., 2000; Rhode et al., 1983; Weinstein & Cooke, 1992). The current study utilized a generalization ratio to measure the amount of generalization that occurs in relation to the initial training of the behavior. Use of this ratio allowed for estimates to be made about the amount of generalization that occurred during each phase to determine when a generalization procedure was needed. Also, the ratio calculations provided estimates about the effectiveness of the generalization procedures. Visual analysis of the paths and levels for each skill in the extended analysis clearly showed that the antecedent-based procedure was most effective for the four students who did not generalize during the treatment phase. However, for Kristin and Beth, who did generalize during the treatment phase, gains were made with both generalization procedures. By using the generalization ratio the amount of generalization that occurred for each procedure can be directly compared as it relates to the student's performance on the initial treatment skill, and measured against the pre-established criteria for significant amounts of generalization.

Implications

It has been proposed that generalization is a behavior under stimulus control that can be changed with the manipulation of antecedents or consequences (Kirby & Bickel, 1988). The current study adds to this theory through conceptualizing a lack of generalization as a behavior deficit that occurs either due to a skill deficit or a performance deficit. Skill deficits are typically remediated through an instructional antecedent procedure, whereas performance deficits typically require consequent-based reinforcement (Gresham, 1981; Lentz, 1988). The four students who had clear generalization deficits during the treatment phase responded best to the antecedent-based instructional procedure that cued the generalized response. Therefore, stimulus control of generalization was established through manipulation of antecedent cues for each of these students. Furthermore, based on skill versus performance deficit theory, it was hypothesized that if the students knew how and when to use the skip-counting strategy (i.e. no skill deficit), then reinforcement should have be an effective strategy because the reinforcement would provide motivation for performing the behavior. Although the consequent-based reinforcement procedure was not more effective than the cue procedure, it was still an effective procedure for producing generalization for the two fluency students. This finding has implications for the generalization research because it explicitly defines the generalization procedures in terms of the type of stimulus control based on the type of deficit. Furthermore, these results provide a practical implication for practitioners developing academic interventions. The results of the current study provide a potential structure for assessing generalization deficits and developing a procedure based on the assessment data to remediate the deficits.

Another interesting implication from these results is the match of the generalization procedures with the instructional hierarchy and intervention selection (Skinner, 1998). Students with inaccurate responses typically require an antecedent-based instructional cue to provide them with the needed skills to develop accurate responding (Haring & Eaton, 1978). For example, modeling of correct responses is often used to increase accuracy of reading, spelling, writing, and math (Hendrickson & Gable, 1981). Whereas, students who have influent but accurate responses typically require more reinforcement for increasing the speed at which they produce accurate responses (Skinner, 1998). Therefore, it follows the theoretical framework of the instructional hierarchy that the accuracy students performed best with the cueing procedure because they had a deficit in knowing when to use the previously learned strategy, and the highlighting provided an antecedent-based instructional cue for these students which helped to increase their accurate responding.

Furthermore, the fluency students displayed gains with both procedures which is consistent with the instructional hierarchy for fluency building. Although these two students did not require the same amount of stimulus control to produce generalization as the other students, the generalized behavior followed the typical learning pattern for behavior. The students first developed accuracy of the generalized behavior and then fluency. This pattern of developing accuracy before fluency is again consistent with the instructional hierarchy of learning behaviors (Haring & Eaton, 1978). Generalization has been conceptualized as behavior that is under stimulus control but the pattern of generalization development has not been considered. These results suggest that researchers and practitioners should examine both accurate and fluent responses when determining if generalization has occurred.

In summary, generalization is a behavior and should be treated as such when programming is developed. As with all behaviors, individuals will differ in the amount of stimulus control needed to produce the behavior. However, the amount and type of stimulus control can be identified through assessment procedures used to identify any effective behavioral intervention, such as BFA.

Limitations

There are several limitations that should be considered with this study. The first limitation concerns the differences in response efforts for the two generalization procedures. This is a mainly concern for the results from Beth and Kristin who displayed generalization of both skills. It is possible that the antecedent manipulation was more effective due to the response efforts required for the procedures and not due the functional nature of the deficits. The antecedent-based procedure required less response effort since the skip-counting numbers were already highlighted. If the two procedures were equal in the amount of effort required differences in the extended analysis may not have been present, specifically for Kristin who displayed mixed results during the BFA. However, for the other students who displayed zero levels of generalization during the treatment procedure, it seems clear that the cue procedure was more effective because of the instructional nature of the antecedent-based cue.

Another limitation of this study is the lack of differentiation between students for the most effective procedures. The BFA was utilized as an assessment strategy to identify the most effective generalization procedure. Although the results of the BFA did accurately predict the most effective procedure for each student, without differentiation between students it cannot be said that this is an effective tool for assessing two different generalization procedures. As stated above, the antecedent-procedure may have been more effective for each student due to other variables, such as ease of response effort, instead of functional variables associated with the deficits.

Another aspect of this study that should be examined with caution is the use of the generalization ratio for measuring the amount of generalization that occurred. Although this formula has potential to be utilized as a generalization measurement, it has not been firmly established in the literature. Furthermore, it is not a standardized measure and cannot be used to directly compare amounts of generalization across studies.

The final limitation is the use of the small-N design. A small-N design was chosen for this study to examine the individual responses to the treatment conditions and maintain a high level of internal validity. However, there is a lack of external validity and the results can only be generalized to the specific populations and behaviors that were examined in this study.

Recommendations for Future Research

Future research on generalization should focus on examining the functional variables associated with the production of generalization and strategies for identifying effective generalization procedures. This study provided one method for potentially identifying effective generalization techniques; however the lack of differentiation between subjects indicates that more information is needed about this assessment procedure. It is possible that other antecedent and consequent based procedures would produce greater differentiation between subjects. Furthermore, this strategy needs to be examined with other behaviors.

Another area for future researchers is examination of the generalization learning process. Since generalization is a behavior, it should follow the same learning principles as all other behaviors. In this study a pattern emerged of accurate responding developing prior to fluent responses of the generalized behavior. However, more research is needed to determine if this is a consistent pattern with across generalized behavior.

Finally, research is needed on the generalization ratio as a potential tool for measuring and comparing generalized behavior. The reliability and validity of this ratio needs to be established as well as criteria for differing levels of generalization. This study used the arbitrary number of 0.50 as the criterion for considering a significant amount of generalization has occurred. However more rigorous criteria should be developed based on large samples of responses to generalization procedures.

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APPPENDICES

Oklahoma State University Institutional Review Board

Date:	Wednesday, August 12, 2009
IRB Application No	ED0997
Proposal Title:	Using Brief Functional Analysis to Determine Generalization Strategies
Reviewed and Processed as:	Expedited (Spec Pop)

Status Recommended by Reviewer(s): Approved Protocol Expires: 8/11/2010

Principal Investigator(s):

Sara House
1114 W. Newman
Stillwater, OK 74075

Gary J Duhon
423 Willard
Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Sheila Kennison, Chair
Institutional Review Board

Example Multiplication Probe

Name:________________ Date:

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

7 x 4	2 x 7	3 x 7	7 x 9	5 x 7	7 x 3	5 x 7				
7 x 4	9 x 7	3 x 7	1 x 7	7 x 3	2 x 7	7 x 1				
2 x 7	5 x 7	7 x 3	9 x 7	7 x 2	3 x 7	3 x 7	7 x 1	1 x 7	2 x 7	7 x 3
1 x 7	7 x 1	3 x 7	3 x 7	2 x 7	7 x 5	4 x 7	7 x 1	1 x 7	2 x 7	7 x 5
5 x 7	7 x 1	7 x 1	7 x 3	4 x 7	7 x 2	5 x 7	7 x 4	9 x 7	7 x 2	4 x 7
2 x 7	2 x 7	7 x 9	5 x 7	7 x 3	7 x 1	2 x 7	7 x 2	7 x 4	3 x 7	7 x 2
7 x 3	7 x 3	7 x 5	4 x 7	7 x 4	2 x 7	7 x 5	7 x 9	3 x 7	7 x 2	2 x 7
5 x 7	9 x 7	7 x 3	7 x 4	4 x 7	7 x 3	3 x 7	7 x 2	5 x 7	7 x 4	7 x 4
7 x 1	1 x 7	7 x 1	7 x 3	7 x 3	3 x 7	7 x 2	9 x 7	3 x 7	7 x 2	3 x 7

Table 1

Mean Percentage Correct for all students Skip Counting Treatment

	Baseline Phase 1	Skip Counting Treatment Phase 2
Ryan	0%	100%
Kristin	0%	99%
Beth	0%	100%
Matt	0%	83%
John	0%	82%
Travis	0%	98%

Table 2

Mean Percentage Correct for Accuracy Students Across Phases

	Baseline Phase 1	Treatment Phase 2	BFA Phase 3	Alternating Treatments Phase 4	Verification of Effective Gen Strategy Phase 5
Travis					
Tx	0%	98%		100%	100%
Cue	0%	0%	62%	83%	90%
Rf	0%	0%	0%	19%	93%
John					
Tx	0%	82%		95%	93%
Cue	0%	0%	44%	86%	--
Rf	0%	0%	0%	19%	77%
Ryan					
Tx	0%	100%		100%	--
Cue	0%	0%	50%	100%	--
Rf	0%	0%	0%	0%	--
Matt					
Tx	0%	83%		96%	100%
Cue	0%	0%	78%	97%	100%
Rf	0%	0%	0%	11%	96%

Note. Cue data was not obtained for John during the final phase, and Ryan did not participate in the final phase.

Table 3

Mean Digits Correct per Minute for Fluency Students Across Phases

	Baseline Phase 1	Treatment Phase 2	BFA Phase 3	Alternating Treatments Phase 4	Verification of Effective Gen Strategy Phase 5
Beth					
Tx	2	21		20	--
Cue	0	6	17	22	--
Rf	0	7	7	12	--
Kristin					
Tx	0	18		20	22
Cue	1	7	15	21	21
Rf	0	8	14	15	20

Note. Beth did not participate in the final phase.

Table 4

Generalization Ratios of Generalization Skills/Treatment Skill

	Treatment Phase 2	Alternating Treatments Phase 4	Verification of Effective Gen Strategy Phase 5
Travis			
Cue	0.00	0.84	0.93
Rf	0.00	0.20	1.00
John			
Cue	0.00	0.95	--
Rf	0.00	0.20	0.85
Ryan			
Cue	0.00	1.00	--
Rf	0.00	0.00	--
Matt			
Rf	0.00	1.04	1.00
Cue	0.00	0.12	0.96
Beth			
Cue	0.26	1.14	--
Rf	0.28	0.66	--
Kristin			
Cue	0.36	1.04	0.93
Rf	0.43	0.78	0.91

Note. Cue data was not obtained for John during the final phase, and Ryan and Beth did not participate in the final phase.

Figure 1. Set 1 for Multiple Baseline of **Treatment Skill**

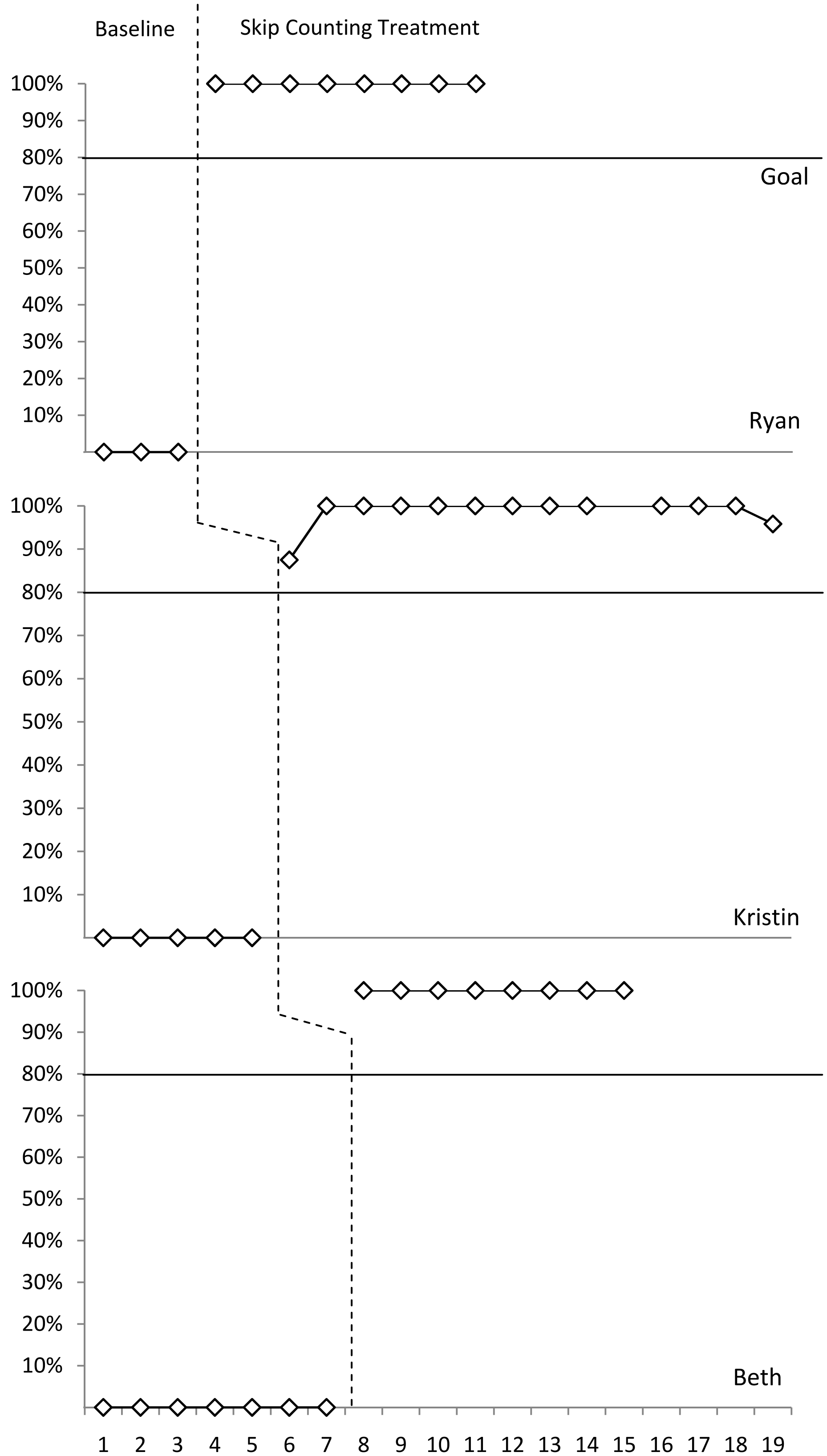


Figure 2. Set 2 of Multiple Baseline for **Treatment Skill**

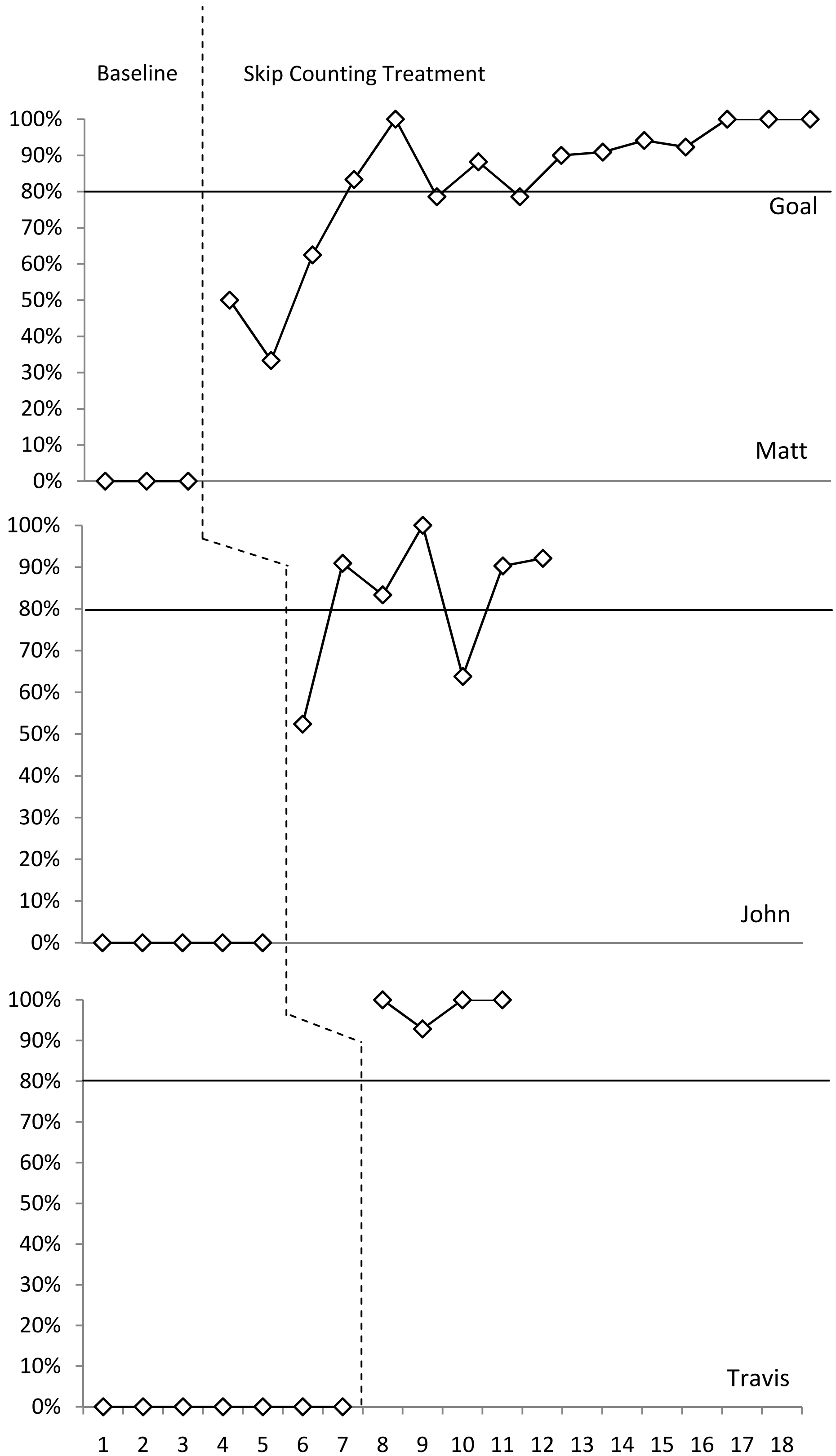


Figure 3. Multiple Baseline for Accuracy Students

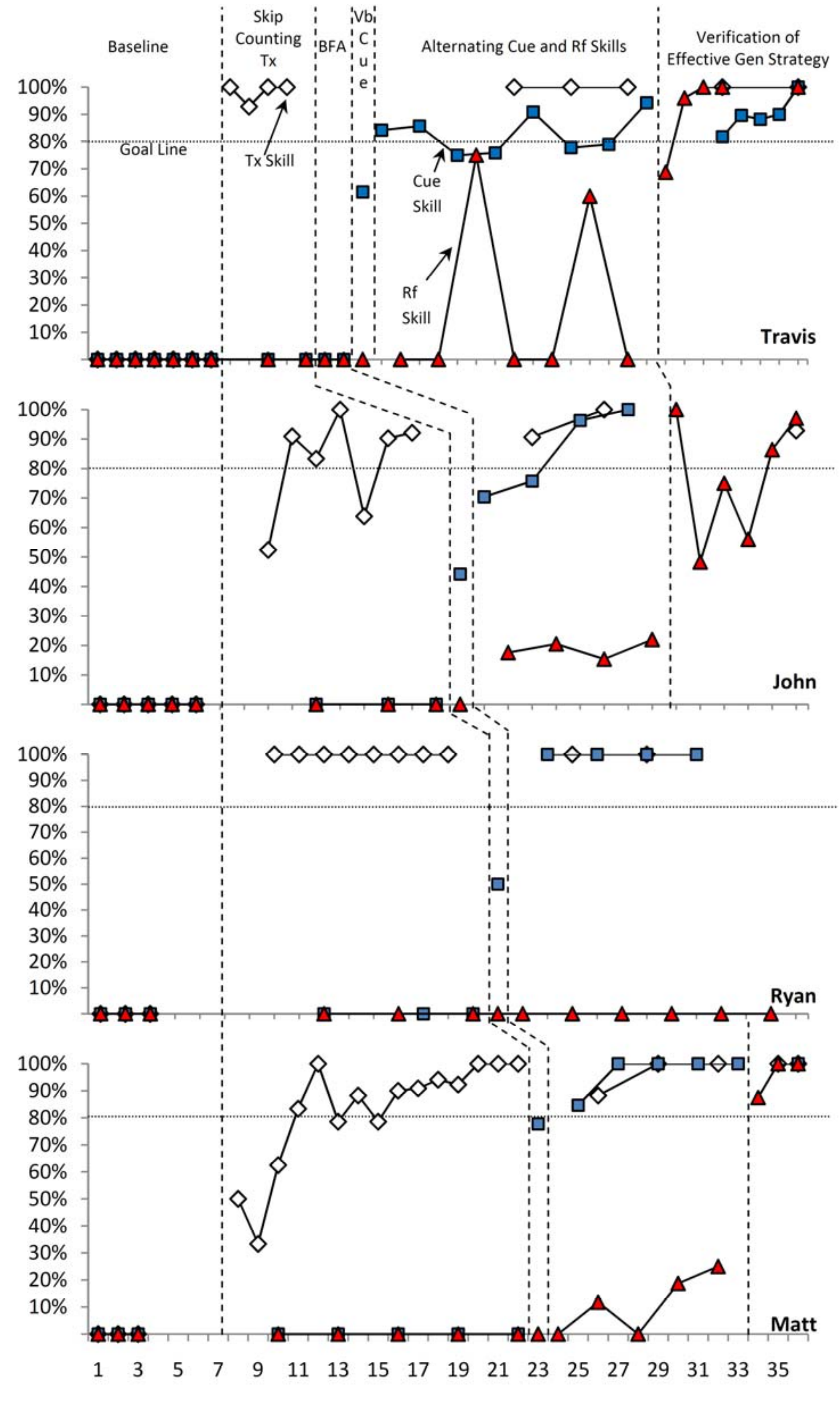
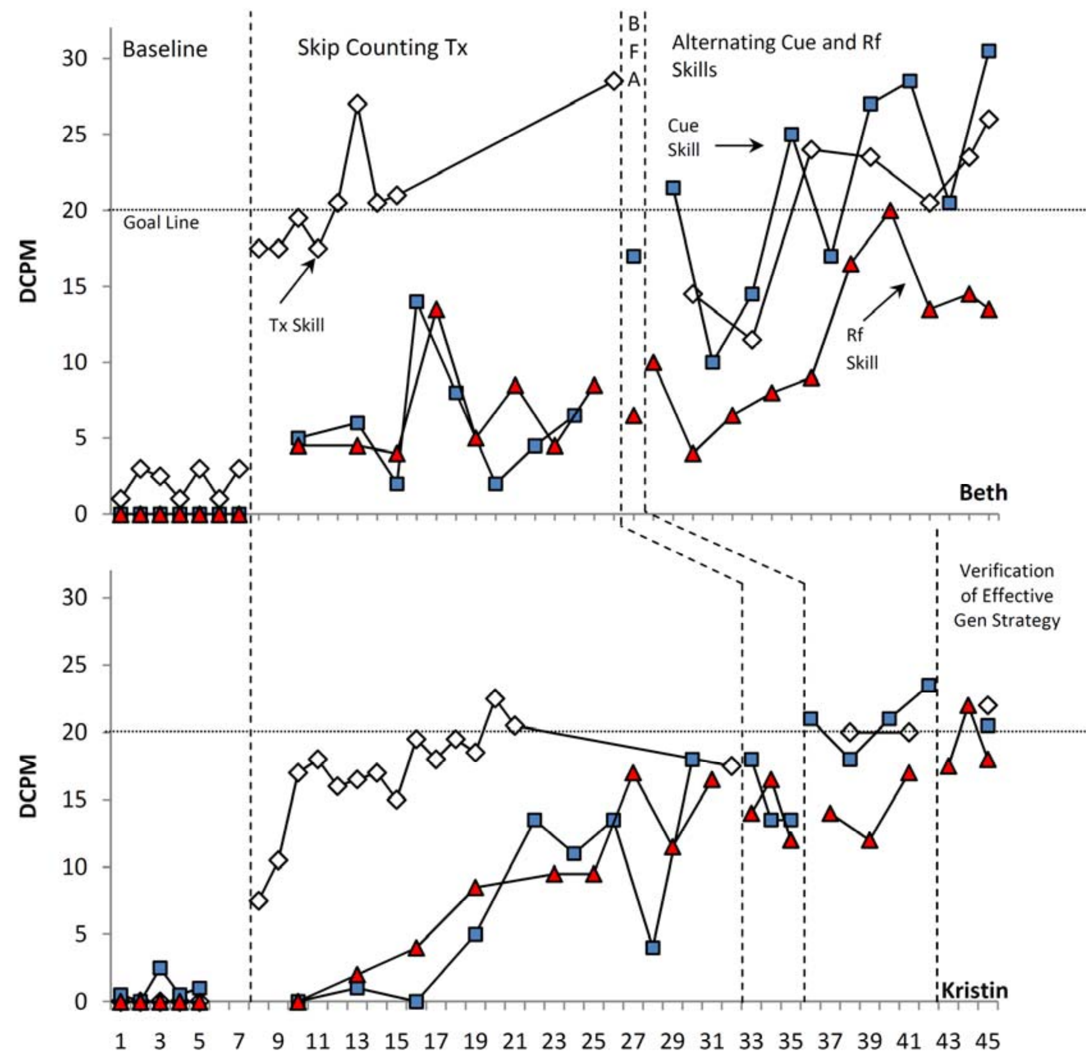


Figure 4. Multiple Baseline for Fluency Students



VITA

Sara E. House

Candidate for the Degree of

Doctorate of Philosophy

Thesis: USING BRIEF FUNCTIONAL ANALYSIS TO DETERMINE GENERALIZATION STRATEGIES

Major Field: Educational Psychology: School Psychology

Biographical:

Education:

Harding University. Searcy, AR. Bachelor Degree in Psychology with a minor in Social Services received May 7, 2005.

Oklahoma State University, Stillwater, OK. Masters of Science for Educational Psychology with specialization in Applied Psychometrics received May, 2007.

Experience:

- Data Manager for NSF grant funded research project examining gender in science and engineering. Fall 2009 – Summer 2010.
- Clinic Assistant at Oklahoma State University School Psychology Center. Fall 2008 – Spring 2010.
- Graduate Teaching Assistant at Oklahoma State University in the School of Applied Health and Educational Psychology in the College of Education. Fall 2006 – Spring 2008
- 600 Hour School Based Practicum at Highland Park Elementary Fall 2008 - Spring2009
- 400 Hour Clinic Based Practicum at the Oklahoma State University School Psychology Center, Summer 2009 - Spring 2010

<u>Professional Memberships:</u>

American Psychological Association (Fall 2005-current)
Student Affiliates in School Psychology (Fall 2006 – current)
National Association of School Psychologists (Fall 2006 – current)
School Psychology Graduate Organization (Fall 2006 – current)

Name: Sara E. House Date of Degree: July 2011

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: USING BRIEF FUNCTIONAL ANALYSIS TO DETERMINE GENERALIZATION STRATEGIES

Pages in Study: 88 Candidate for the Degree of Doctor of Philosophy

Major Field: Educational Psychology

Scope and Method of Study: The primary purpose of this study was to examine the utility of a BFA to identify effective generalization procedures for individual students. Through conceptualizing generalization as a behavior and a lack of generalization as a behavioral deficit the results of the current study extend the generalization literature. Specifically, this study built on the proposal that generalization is under stimulus control and therefore affected by antecedent and consequent manipulations. Furthermore, these different types of manipulations can be tested out to determine the most effective strategy for an individual student. A Small-N design with six students was utilized with two multiple baselines of 4 and 2 students. Initially, students were taught how to solve a set of multiplication facts using a skip counting strategy and spontaneous generalization to other sets of facts was measured. Next a BFA procedure was utilized in which an antecedent- and a consequent- based generalization procedure were administered to increase generalization across multiplication skills. Based on the results of the BFA, hypotheses were developed about the most effective generalization procedures and tested out in an extended analysis alternating treatment phase.

Findings and Conclusions: All six students displayed immediate gains with the skip counting strategy, and two of the students displayed levels of spontaneous generalization on accurate but not fluent responses of the generalization skill. Two multiple baselines were formed based on the level of spontaneous generalization, one for accuracy students and one for fluency students. For five of the six students, the antecedent cue was the most effective strategy in the BFA, and this was confirmed in the extended analysis. For the other student, a clear differentiation as not found in the BFA, but the antecedent-based procedure was more effective in extended analysis. Overall the results of this study confirm that generalization is a behavior and should be treated as such when programming is developed. As with all behaviors, individuals will differ in the amount of stimulus control needed to produce the behavior. However, the results of this study indicate that the amount and type of stimulus control can be identified through assessment procedures used to identify any effective behavioral intervention, such as BFA.

ADVISER'S APPROVAL: Gary J. Duhon, Ph.D.