Functional Analysis of Replacement Behavior: Assessing Concurrent Behavioral Excesses and Academic Deficits

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Functional Analysis of Replacement Behavior:
Assessing Concurrent Behavioral Excesses and Academic Deficits
by
Kristi L. Hofstadter-Duke

A DISSERTATION

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FUNCTIONAL ANALYSIS OF REPLACEMENT BEHAVIOR:
ASSESSING CONCURRENT BEHAVIORAL EXCESSES AND ACADEMIC DEFICITS

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This dissertation involved the application of functional analysis methodology to replacement behaviors (i.e., academic responding). Participants were exposed to the typical school-based functional analysis conditions – (a) teacher attention, (b) peer attention, and (c) escape – in addition to a control condition; yet, replacement behavior (i.e., academic responding) was reinforced across conditions instead of problem behaviors. Two functional analyses were conducted using identical contingencies while measuring condition impact on disruptive behavior, academic engagement, and academic performance (i.e., problems completed, digits correct). Unknown math problems were used during the first functional analysis, and a second functional analysis incorporated antecedent instructional sessions, resulting in the use of known materials. In an extended analysis, both versions of the single-most effective condition from the previous functional analyses (with and without prior instruction) were compared. A multi-element design was used to evaluate the relative effects of functional analysis conditions, with and without instruction on participant performance.

Conditions were implemented with a high degree of integrity, and results demonstrated that the functional analysis with unknown problems produced undifferentiated patterns of responding across participants; however, the functional
analysis with known problems resulted in differentiated patterns of responding, allowing for identification of controlling variables for all participants. Additionally, the extended analysis replicated the findings of the functional analyses using a novel mathematics operation for all participants. Results are discussed in terms of the conceptual underpinnings responsible for the findings obtained, as well as the need for future research to refine and extend the functional analysis of replacement behavior.
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CHAPTER 1

Introduction and Review of Literature

A growing body of literature documents the co-occurrence of behavioral and academic problems for students exhibiting disruptive behavior in classroom settings (Nelson, Benner, Lane, & Smith, 2004; Scruggs & Mastropieri, 1986; Walker & Severson, 2002). The forms behavioral and academic problems take vary widely both within and across individuals and environments, complicating efforts to examine their causes. There are several methods for categorizing and labeling behavior within school settings; however, the topography of behavior provides relatively little information about why behaviors occur or fail to occur, or how to effectively treat problematic behavior (Gresham, Watson, & Skinner, 2001). Although behavior problems take countless forms, behavior is labeled problematic for one of two reasons. In one case, too much behavior occurs (e.g., disruptions, aggression), so this group of behaviors can be collectively referred to as behavioral excesses (Rhode, Jenson, & Reavis, 1992). Alternatively, behavior may be problematic because it is occurring too infrequently (e.g., academic responding, rule following). These behaviors can be termed behavioral deficits (Rhode et al.), or when referring specifically to academic performance, academic deficits.

Behavioral excesses, such as disruptive behavior, constitute the majority of office discipline referrals in educational settings and present a significant challenge to teachers and other school personnel (Skiba, Peterson, & Williams, 1997). These behaviors are frequently the focus of educational intervention as well as research efforts, because they are aversive to teachers, may interrupt instruction, and potentially reduce instructional opportunities for both the target student and classroom peers (Sterling-Turner, Robinson,
& Wilczynski, 2001). Further, students exhibiting behavioral excesses are at risk for restrictive educational placement as a result of disruption of the learning environment (Arceneaux & Murdock, 1997). Due to the salience and associated outcomes of these behaviors in the school setting, it is not surprising that behavioral excesses are at the center of assessment and treatment research. In fact, federal legislation, such as the 1997 and 2004 reauthorizations of the Individuals with Disabilities Education Act, mandates the use of functional behavioral assessment for students exhibiting behavioral problems (Individuals with Disabilities Education Improvement Act, 2004).

Educators are faced with the task of imparting educational skills to all children, yet academic deficits remain a pressing concern in America’s schools. In the year 2005, only 31% of fourth grade students read at the “Proficient” level, and 36% of fourth graders were reading below the “Basic” level (National Center on Educational Statistics, 2005). In the same year (2005), in mathematics, only 36% of fourth grade students were performing at the “Proficient” level, and 20% of fourth grade students failed to perform at even the “Basic” level (National Center on Educational Statistics). Academic deficits in basic skills (e.g., reading, math, writing) are particularly detrimental to students, impeding progress throughout formal educational experiences and beyond. Further, when experienced in combination with behavioral excesses, academic deficits can often go unnoticed or underreported, creating a delay in provision of academic intervention and further intensifying the impact of behavioral and academic problems.

**Behavior and Controlling Variables: The Four-Term Contingency**

Independently, behavioral excesses and academic deficits each impede education across subject areas and grade levels (Talbott & Coe, 1997). Those experiencing
combined academic and behavioral problems are the most vulnerable to detrimental outcomes, such as retention and drop out (Cairns & Cairns, 1994; Ensminger & Slusarcick, 1992). Further, the risk of negative outcomes increases steadily over time, as interventions for both behavioral excesses and academic deficits become progressively less effective after the third grade (Walker & Severson, 2002). The decreasing effectiveness of intervention efforts across time provides the impetus for an improved understanding of the relevant variables associated with these concomitant problems. It is essential that assessment methodologies not only identify students at an early age, but that these assessment methods also inform effective treatments.

A closer examination of relevant variables impacting behavioral and academic problems is warranted, as these variables provide the foundation for all assessment and treatment technologies. Behavior analysis provides a conceptual, empirical framework for treatment of social problems like those created by behavior disorders (Skinner, 1953). From a behavior analytic standpoint, all behavior is a function of the interaction between an organism and the surrounding environment (Baer, Wolf, & Risley, 1968; Bijou & Baer, 1961). Thus, both behavioral excesses and academic deficits are impacted by and change in response to interaction with environmental events. The environmental variables that influence and maintain responding can be collectively described as behavioral function (Michael, 1982). Together, these factors culminate in the maintenance of individual patterns of maladaptive behavioral responses (e.g., behavioral excesses, academic deficits).

The measurement of problem behavior and events controlling it has produced highly useful technologies for treating academic and behavior problems (Miltenberger,
Although the distinction between behavioral excesses and deficits is the historical tradition for categorizing behavioral types, both types are responsive to the same types of controlling variables, usually depicted in the four-term contingency. The function of behavior can be conceptualized to encompass four events that occur sequentially and contingently: (a) motivating operations, (b) discriminative stimuli, (c) behavioral responses, and (d) consequent events (Michael, 1982). Table 1 provides an overview of each element of the four-term contingency and is followed by an in-depth exploration of the controlling variables of behavioral responses.

**Antecedents**

Antecedents, including motivating operations (MOs) and discriminative stimuli, are stimulus events that precede responding (Miltenberger, 2007). MOs impact behavior in one of two ways, by either momentarily increasing or decreasing the value of associated reinforcement. The effect of increasing reinforcer potency is termed the reinforcer-establishing effect, and the simultaneous increase in behavior is termed the evocative effect (Michael, 1993; O’Reilly et al., 2007). Although the term MO suggests an increase in reinforcing value, MOs can momentarily increase or decrease the strength of a particular reinforcer (Smith & Iwata, 1997). For example, prior instruction may decrease the strength of escape as a reinforcer, simultaneously diminishing behaviors reinforced by escape (e.g., disruption). This process is termed the reinforcer-abolishing effect, which has an abative effect on behavior (Michael; O’Reilly et al.).

There are similarities between MOs and discriminative stimuli, as both may increase responding via disparate pathways. Discriminative stimuli increase responding by indicating the availability of reinforcement, whereas MOs may alter responding by
making the consequence more or less reinforcing. Thus, the distinction lies within the primary property of each antecedent. Discriminative stimuli do not impact the reinforcing value of consequences, and MOs do not indicate the availability of reinforcement (Michael, 1993). For example, the presence of hunger, an MO, does not make it more likely that food will be available, and the presence of a restaurant sign, a discriminative stimulus, has no bearing on the reinforcing value of the available food at a given moment. The following antecedent variables are key examples of typical educational antecedents that impact behavioral excesses and/or academic deficits, either as discriminative stimuli or MOs.

**Task demands.** Academic task demands can have both an evocative and abative effect on problem behaviors (e.g., destructive or disruptive behaviors) and academic performance (Michael, 1993). Task demands can operate as aversive stimuli, thereby establishing escape as a reinforcer and increasing the probability of behaviors reinforced by escape (Smith & Iwata, 1997). By evoking escape-maintained behavior, task demands can simultaneously increase behavioral excesses and academic deficits. However, tasks matched to an individual’s skill level can simultaneously have an evocative effect on academic responding and an abative effect on problem behaviors. These effects are highly variable across individuals (Carr, Yarbrough, & Langdon, 1997). For instance, disparate features of task demands (e.g., difficulty, repetition) may be aversive across students (McComas, Hoch, Paone, & El-Roy, 2000). Additionally, the same task demands may occasion different behaviors across individuals, relative to student skills and preferences.
Altering task dimensions has been demonstrated to change both academic performance and disruptive behavior in school settings (Dunlap, Kern-Dunlap, Clarke, & Robbins, 1991; Gunter, Shores, Jack, & Denny, 1994). Dunlap et al. examined the effects of altering task dimensions on the disruptive and on-task behavior of a 12-year-old female student displaying behavioral and academic problems. Task dimensions (e.g., short versus long tasks, easy versus difficult tasks, chosen versus assigned tasks) contributing to disruptive behavior and on-task behavior were identified, and antecedent modifications were made. Results indicated that altering academic tasks by modifying task length, interspersing easy and difficult tasks, and providing choice increased the student’s rate of on-task behavior and nearly eliminated disruptive behavior. Thus, the same task dimensions that occasion behavioral excesses and academic deficits (e.g., difficulty, length) can be altered to evoke increased academic performance and decreased behavior problems. The most commonly manipulated task dimension is task difficulty, which will be explored in greater detail.

Exposure to difficult academic material has been consistently found to result in low rates of academic engagement and/or responding and high rates of disruptive behavior in academic settings (Center, Dietz, & Kaufman, 1982; DePaepe, Shores, & Jack, 1996; Gickling & Armstrong, 1978; Gilbertson, Duhon, Witt, & Dufrene, 2008). Gickling and Armstrong (1978) examined the impact of easy (i.e., more than 90% known elements), instructional level (i.e., known elements were 70%-85% and 93%-97% for seatwork and reading tasks, respectively), and difficult (i.e., less than 70% known elements for seatwork and less than 90% known elements for reading tasks) academic material on the task completion, comprehension, and on-task behavior of eight typically
developing first- and second-grade students. Findings suggested that tasks considered too
difficult resulted in low levels of task completion (i.e., 41%-53%), comprehension, and
on-task behavior (i.e., 30%-50%). Alternatively, tasks matched to student instructional
levels resulted in increases across all three areas, with task completion as high as 94%,
comprehension between 94% and 95%, and on-task behavior averaging 88%. In a
similar examination, Center et al. demonstrated that when difficulty of presented tasks
was not matched to student skill level, an increase in behavioral excesses was observed in
a class of 15 boys classified with behavior disorders.

DePaepe et al. (1996) reported that students identified with emotional and
behavioral disorders exhibited higher rates of disruptive behavior during a difficult task
condition than during an easy task condition. The authors suggested that exposure to
difficult material may have decreased students’ motivation to perform academic tasks and
increased escape-maintained behavioral excesses, such as disruptive behavior. McComas
et al. (2000) reported similar findings regarding the role of task difficulty in academic
performance and disruptive behavior.

As results from the previous studies suggest, difficult academic tasks may serve
as MOs for negatively reinforced behavioral excesses by momentarily increasing the
reinforcing value of escape, thus simultaneously increasing the rate of behaviors (e.g.,
disruptive behaviors) that have previously resulted in task termination (McComas et al.,
2000). Difficult tasks may simultaneously have a reinforcer-abolishing effect on
reinforcement associated with academic responding, thus reducing the probability of
behaviors associated with that reinforcement (e.g., task engagement). Response effort
should also be considered when examining the impact of task difficulty on behavioral
excesses and academic deficits, as altering the difficulty of a task also alters the associated response effort (Perry & Fisher, 2001). Reducing or increasing the response effort associated with academic tasks can make the task itself more or less reinforcing, respectively. Thus, instructional-level tasks may serve as an MO for academic responding in part by decreasing the response effort required and momentarily increasing the reinforcing value of responding.

**Stimulus control and instruction.** Although difficult tasks have been demonstrated to evoke behavioral problems and academic deficits, altering difficulty level is not the only approach used to impact these behaviors. Rather than modifying the task to match the student’s skill level, instruction can increase the student’s skill level to match a specific task. Effective classroom instruction, which consists of various components (e.g., modeling, prompting, differential reinforcement), is intended to strengthen academic skills through the development of stimulus control (Martens & Kelly, 1993). Stimulus control is the process by which the probability of responding in the presence of a specific antecedent stimulus (i.e., discriminative stimulus) is increased, because the response has been differentially reinforced in the presence of that particular stimulus (Miltenberger, 2007). Thus, reinforcement is received more frequently in the presence of the stimulus than in its absence (Michael, 1982).

Stimulus control is particularly relevant for academic skills, as desired behavior (e.g., academic responding) has an increased probability of occurring in the presence of the discriminative stimulus – the curricular assignment. When stimulus control has not been established, there is a decreased probability of the desired behavior being emitted (Martens & Kelly, 1993). Thus, without instructional procedures designed to establish
appropriate forms of stimulus control (e.g., presenting math worksheets occasions correct responses on the part of the learner), academic deficits are more likely to occur and persist. With effective academic instruction and intervention, the student’s responding to curricular tasks comes under stimulus control of the task stimuli (Daly, Martens, Barnett, Witt, & Olsen, 2007). For instance, if a student reliably and correctly answers multiplication problems, the student’s academic responding is said to be under control of the task stimuli (e.g., multiplication problems). Through a process of differential reinforcement, correct answers are reinforced and incorrect answers are corrected. Furthermore, when academic responding is under the control of task stimuli, behavioral excesses are less likely to occur in the presence of these task stimuli, because newly acquired skills are more probable. Thus, stimulus control via academic instruction may actually weaken behavioral excesses by creating alternative behavioral repertoires that compete more effectively with problem behaviors (Daly et al.).

Several studies have examined the impact of instruction on academic performance and behavioral excesses. Gunter et al. (1994) conducted a study examining the impact of instruction on disruptive behavior and compliance with academic demands exhibited by a 12-year-old male student classified with severe behavior disorder. The instructional strategy – modeling correct responding – reduced the rate of disruptive behavior while increasing the percentage of compliance with academic requests. In a similar vein, McComas et al. (2000) altered the instruction provided for three male students diagnosed with autism by providing a three-step prompt (i.e., verbal, gestural, and physical guidance), while maintaining consistent task difficulty levels and behavior-consequence
contingencies. Findings suggested that these instructional strategies increased academic responding and decreased disruptive behavior.

Behavioral excesses can also come under the control of classroom stimuli. For instance, if attention-maintained disruptive behavior results in teacher redirection or reprimands only in the presence of the teacher, the teacher may then become a discriminative stimulus signaling the availability of attention for disruptive behavior. In this case, instructional sessions directed by the teacher may fail to produce academic responding, because the teacher’s presence exerts stimulus control over the student’s disruptive rather than academic responding (Sutherland, Singh, Conroy, & Stichter, 2004).

In the classroom setting, the teacher often serves as a discriminative stimulus, maintaining stimulus control over student behavior, promoting desired or undesired behaviors (Knoff, 1984; Marholin & Steinman, 1977). Through continual differential reinforcement of appropriate behavior, the teacher can become a stimulus signaling availability of reinforcement, frequently in the form of praise or contingent access to other preferred school activities (e.g., being the line leader). However, behavior under stimulus control of the teacher’s presence would, by definition, be less likely to be emitted in the teacher’s absence (Marholin & Steinman).

Marholin and Steinman (1977) examined the impact of applying reinforcement contingencies to academic responding in the presence of academic materials on the disruptive behavior, on-task behavior, and rate and accuracy of academic responding of eight students with academic and behavioral problems. Three conditions – (a) baseline, (b) teacher reinforcement of on-task and appropriate behavior, and (c) teacher
reinforcement of rate and accuracy of academic performance – were examined using an ABCBC design. In the teacher’s presence, both reinforcement contingencies had similar effects on behavior. However, in the teacher’s absence, students exhibited less disruptive behavior and higher on-task behavior as well as academic completion and accuracy when reinforced for academic performance than when reinforced for on-task behavior. These findings suggest that responding in the teacher’s absence was under the stimulus control of academic materials. The authors suggest that transferring stimulus control to academic or task stimuli promotes lower rates of disruptive behavior and higher rates of academic completion and accuracy, independent of teacher presence. Thus, the stimulus control exerted by instructional material (and brought about through effective instruction) is not only instrumental in increasing academic responding (i.e., reducing academic deficits), but it may also contribute to a corresponding reduction in behavioral excesses.

**Consequent Events**

Although MOs and discriminative stimuli acquire functional relationships with behavior, they do not directly cause behavioral responses (Gresham et al., 2001). Rather, all behavior, whether problematic or desirable, occurs as a function of the consequences it produces (Iwata & Worsdell, 2005). However, antecedents affect behavior to the extent that they are consistently correlated with consequences (Gresham et al.). Although punishment undeniably influences behavior, it produces only behavioral decreases in behavior that comes under its contingent influence. Only reinforcement increases the probability of behavior, and although specific sources of reinforcement may vary considerably, there are only two types of consequences that increase behavior: positive
reinforcement and negative reinforcement (Gresham et al.; Iwata & Worsdell; Skinner, 1953).

**Positive reinforcement.** Positive reinforcement can be defined as the application of a stimulus contingent on behavior, which results in an increase in, or strengthening of, that behavior (Miltenberger, 2007). Thus, behavior maintained by positive reinforcement occurs to contact or increase the frequency and/or intensity of a stimulus that follows it. Positive reinforcement can be either socially mediated or occur as a direct or automatic result of behavior (Iwata & Worsdell, 2005). Within educational settings, positively reinforced behaviors are most frequently maintained by socially mediated positive reinforcement, which can include praise, sympathy, redirection, comforting, eye contact, smiles or frowns (Gresham et al., 2001; Iwata & Worsdell). Even access to preferred stimuli (e.g., a favorite toy) is generally socially mediated (O’Neill et al., 1997). In some circumstances, automatic or sensory reinforcement can also serve as positive reinforcement for individuals, often in cases of self-injury and stereotypic behaviors (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994); however, this is not typically explored as a function of frequent school-based concerns (e.g., disruptive behavior, academic deficits).

**Negative reinforcement.** Negative reinforcement is the removal, delay or reduction of a stimulus contingent on behavior, which results in the strengthening (i.e., future increase) of that behavior (Miltenberger, 2007). The function of negatively reinforced behavior is to escape, avoid, or reduce the intensity of an aversive stimulus. For example, students may engage in behaviors (e.g., tantrums, out of seat) that result in removal or delay of task demands that are considered aversive. Thus, antecedent events
MOs, discriminative stimuli) previously discussed may contribute to escape-motivated behaviors in situations in which an antecedent condition is considered aversive to the individual in question. Negative reinforcement (i.e., escape or avoidance) and socially mediated positive reinforcement are the most frequently identified functions of problematic behavior in school settings (Broussard & Northup, 1995).

**Behavioral Excesses and Academic Deficits: Their Interrelationship**

Examination of controlling variables provides a great deal of information about behavioral excesses and academic deficits as well as the relevant factors impacting each; however, an appreciation of these variables alone does not provide an explanation for the relationship that exists between these co-occurring problems. A long-standing body of literature documents a direct relationship between the exhibition of behavioral excesses and academic deficits (Barriga et al., 2002; Hinshaw, 1992; McEvoy & Welker, 2000; Sampson, 1966). The association between behavioral excesses and academic deficits has strong implications for educational practices, as an improved understanding of the relationship between these types of student difficulties can potentially increase the sophistication of current assessment and treatment techniques in school settings (Barriga et al.; Hinshaw). Although the literature strongly suggests that a direct, positive correlation exists between behavioral excesses and academic deficits (de Lught, 2007; Talbott & Coe, 1997), there is less agreement regarding the mechanisms responsible for this relationship.

Two potential explanations have been put forth. One model begins with pre-existing learning problems or skill deficits that are present before a child enters school and leads to behavioral excesses with the introduction of task demands (Huesmann, Eron,
& Yarmel, 1987). In this explanation, achievement deficits result in difficulty gaining reinforcement through academic responding, eventually making academic tasks aversive for the child. This, in turn, makes alternative behaviors (e.g., disruptions) that produce positive or negative reinforcement more appealing and more likely to occur due to relative rates of reinforcement (McEvoy & Welker, 2000). Conversely, Patterson, Reid, and Dishion (1992) suggested that behavioral excesses learned through the child’s reinforcement history lead to later academic deficits. In this model, the child has learned that disruptive behavior produces reinforcing consequences, and upon entering academic settings, the exhibition of these excesses interferes with engagement and corresponding acquisition of academic behaviors. Over time, the lack of engagement leads to skills deficits, which further enhance the reinforcing properties of disruptive behavior via relative rates of reinforcement (Patterson et al.). To date, there is no definite evidence favoring one explanation over another. Fortunately, the failure to resolve these differing viewpoints has not hindered the field from productively examining the interrelationship between these two types of behavior.

Response Covariation and Matching

Both explanations are equally plausible, and there may potentially be different pathways of development for various individuals. Regardless of the origin of concurrent behavioral excesses and academic deficits, the relationship between these concerns may be best understood through response covariation. Response covariation refers to a relationship between response alternatives, in which a change in the rate of one behavioral response results from a change in the rate of another response (Kazdin, 1982b; Lalli, Kates, & Casey, 1999). Therefore, any procedures designed to change one
behavior may impact other, nontargeted behaviors. The most commonly examined covarying relationship has been that of problematic behaviors and alternative, desired behaviors occurring under a variety of experimental conditions (Lalli et al.). For instance, the effects of functional communication training (FCT) on response covariation have been studied (Horner & Day, 1991; Lalli, Browder, Mace, & Brown, 1993; Sprague & Horner, 1992). The common feature across FCT studies consisted of teaching participants verbal responses that were functionally equivalent (i.e., obtained the same consequences) to problem behavior. A resulting inverse relationship between verbal responding and problem behavior was reported by the authors; as the former increased, the latter decreased. Thus, instruction in one area resulted in change across behavioral responses (i.e., verbal responding and problem behavior).

Wahler and colleagues have extensively studied response covariation and found that behavioral responses are organized into classes or groups consisting of various responses that systematically covary (Wahler, Berland, & Coe, 1979). These classes are composed of behaviors that are positively or negatively correlated with other responses within the class. For instance, Wahler (1975) observed the behaviors of children referred for disruptive behavior across home and school environments to identify correlations among different response classes. In the school setting, one child’s academic engagement was observed to positively correlate with self-stimulatory behavior and negatively correlate with disruptive and off-task behaviors. Furthermore, Kara and Wahler (1977) reported that positively correlated behaviors are likely to change in the same direction upon introduction of treatment, and negatively correlated behaviors are likely to change in opposing directions. Identification of clusters containing positively
and negatively correlated responses can predict the likely pattern of behavior change following treatment of one response (Kara & Wahler, 1977).

The relationship between behavioral excesses and academic deficits reported in school settings (Ayllon, Layman, & Kandel, 1975; Ayllon & Roberts, 1974) suggests that treatment of one response may lead to changes for both behaviors in opposing directions, with problem behavior decreasing while academic performance increases in response to effective instruction. Several studies have demonstrated findings consistent with this expectation (Kaufman & O’Leary, 1972; Lalli et al., 1999; Medland & Stachnik, 1972; Simon, Ayllon, & Milan, 1982; Witt, Hannafin, & Martens, 1983). Kaufman and O’Leary (1972) employed a token economy and response cost to decrease disruptive behavior and also found collateral increases in academic performance. Similarly, Medland and Stachnik delivered reinforcement contingent on decreases in class-wide disruptive behavior and found not only decreased problem behavior, but also increased levels of class-wide academic assignment completion.

Simon et al. (1982) identified a reciprocal relationship between disruptive behavior and low math performance among seven hearing-impaired middle school students. Upon implementation of a token program designed to increase academic responding, an increase in academic performance as well as a reciprocal decrease in classroom disruption was obtained. Witt et al. (1983) similarly targeted academic responding, providing home-based reinforcement for increases in academic performance. In addition to the reported increases in academic production, decreases in disruptive behavior were also noted. More recently, Lalli, Kates, and Casey (1999) examined the effects of spelling instruction on the academic responding and problem behavior of two
boys classified with mild mental retardation. Similar to the prior studies, results demonstrated that problem behavior decreased, covarying with academic improvements.

One explanation for this covariation draws from the matching law, which is derived from the field of behavioral economics. The matching law states that simultaneously available response alternatives within an environment will be emitted by an organism in the same proportion that reinforcement is allocated to those alternatives (Borrero & Vollmer, 2002). Herrnstein (1970) suggested that all behavior choices arise not only from reinforcement for a particular behavior, but also from reinforcement for available alternative responses. As reinforcement for one behavior increases, performance of alternative behaviors decreases.

Thus, students emitting an excess of one behavior (e.g., disruption, aggression) and a deficit of another (e.g., academic responding) are responding to concurrent rates of reinforcement that reflect this behavioral distribution. Based on the fact that disruptive and academic behaviors are concurrently available response alternatives, which are typically incompatible, the behavioral excesses consume time and are reinforced and strengthened, while the behavioral deficits are perpetuated by allocation of behavior to the alternate response and corresponding low rates of reinforcement (Borrero & Vollmer, 2002). In this process, students may fail to acquire academic skills necessary for academic responding, and without these academic behaviors in their repertoire of response, the proportion of reinforcement available for disruptive responses increases.

**Assessment of Behavioral Excesses and Academic Deficits**

The direct, functional relationship between behavioral excesses and academic deficits (Maguin & Loeber, 1996) is impacted by numerous variables across the four-
term contingency, many of which are inherent in the school setting (e.g., task demands, instruction). These naturally occurring and programmed environmental variables culminate in the maintenance of concomitant behavioral excesses and academic deficits (Michael, 1982). However, the effects of environmental events on behavior are largely idiosyncratic, making careful analysis of events and the manner in which they relate to individual patterns of behavior necessary (Holden, 2002). The importance of these variables is underscored by the fact that environmental conditions not only maintain problem behaviors, but they also maintain appropriate, desired behaviors, making these variables crucial treatment components (Witt, Daly, & Noell, 2000). It has been demonstrated that academic variables are related to problem behavior, but what was true in the early 1990’s (Repp, 1994) is still true today: there is no current assessment technology designed to simultaneously evaluate both problems. Functional behavioral assessments, particularly functional analysis and BEA, are the most prominent and promising methods for identifying environmental variables related to behavioral excesses and academic deficits (Iwata et al., 1982/1994; Martens, Witt, Daly, & Vollmer, 1999); however, significant improvements are necessary to bridge assessment methods and mutually inform treatment.

**Functional Behavioral Assessment**

Functional Behavioral Assessment (FBA) has emerged as a method of assessing variables associated with problem behaviors to identify behavioral function. The term FBA encompasses a range of procedures, from indirect to direct, designed to identify contingencies that maintain problem behavior by assessing the impact of environmental variables (Sterling-Turner et al., 2001). Given information regarding maintaining
variables, existing environmental contingencies can be manipulated to reduce problematic responses. Thus, FBA provides the essential link between assessment and treatment (Witt et al., 2000).

FBA incorporates a collection of methods, including indirect assessments, direct descriptive assessments, and experimental functional analyses (Gresham et al., 2001). Indirect assessments include information-gathering techniques that are temporally removed from occurrences of behavior, such as interviews, record reviews, and rating scales (Sterling-Turner et al., 2001). Alternatively, direct descriptive assessments involve the direct observation of behavior to identify environmental variables falling within the four-term contingency. Both indirect and direct descriptive assessments result in correlational information regarding the function of behavior. Although the entire range of FBA is applicable to the school setting in which behavioral excesses and deficits are present, only experimental analysis uses rigorous manipulations to provide causal, rather than correlational, data about behavior-consequence relationships (Lerman & Iwata, 1993). Thus, functional analysis may be more complex than indirect and descriptive methods, yet it is regarded as more valid for the identification of behavioral function (Sasso, Conroy, Stichter, & Fox, 2001).

**Functional Analysis**

Functional analysis is a specific type of FBA that entails systematic manipulation of environmental variables with corresponding measurement of behavior to reliably identify behavioral function (Gable, Hendrickson & Sasso, 1995; Sasso et al., 1992). Stimulus events are combined into experimental conditions designed to represent naturally occurring contingencies delivered on a continuous schedule, so that
measurements can be taken of behavior to infer function (Alter, Conroy, Mancil, & Haydon, 2008). Although specific conditions vary across cases, Iwata et al. (1982/1994) developed four general conditions: (a) attention, (b) escape, (c) alone, and (d) play. The attention, escape and alone conditions are meant to mimic distinct functions of behavior, whereas the play condition serves as a control condition to facilitate discrimination between undifferentiated and multiply controlled analysis outcomes (Hanley, Iwata, & McCord, 2003). These conditions allowed Iwata et al. to experimentally manipulate aspects of the four-term contingency to identify the function of self-injury. Table 2 provides a description of typical functional analysis conditions. Relative rates of problem behavior across conditions yield information regarding function, where high rates in one condition, relative to other conditions and the control, permit the identification of environmental events maintaining problem behavior (Iwata & Worsdell, 2005).

Although variations of these as well as other conditions have been manipulated to conduct functional analyses, models of analysis typically emphasize either antecedent variables (e.g., Carr & Durand, 1985) or consequence variables (e.g., Iwata et al., 1982/1994). Both types of analysis employ manipulation of various combinations of environmental variables in an attempt to identify the function of problem behavior(s) and facilitate function-based intervention development (Hanley et al., 2003).

Some analyses manipulate the antecedent variables hypothesized to impact problem behavior (e.g., task difficulty, demands, instruction) while measuring response across conditions. For instance, Carr and Durand (1985) examined the influence of two variables -- task difficulty (easy or difficult) and amount of antecedent teacher attention (33% or 100% of intervals) -- on the problem behaviors (i.e., aggression, tantrums, self-
injury, opposition, out-of-seat) of four children. Results demonstrated that participants displayed idiosyncratic responses across conditions, revealing individual differences in maintaining variables. Antecedent variables evoking problem behavior (e.g., task difficulty, attention deprivation) were used to identify appropriate replacement behaviors. For instance, if increased problem behavior was observed in the low teacher-attention condition (i.e., 33% of intervals), the student may be taught appropriate behaviors for obtaining teacher attention (e.g., raising hand). Identifying relevant antecedent variables and teaching corresponding replacement behaviors resulted in decreases in problem behavior across all participants. Meyer (1999) conducted a functional analysis emphasizing antecedent manipulation within the school setting. The findings were consistent with previous studies, suggesting that analysis of antecedent-behavior relationships can provide information that can be used to select functionally equivalent replacement behaviors.

Functional analyses that focus on antecedent manipulations demonstrate a functional relationship between one or more antecedent environmental events and behavior, identifying situations in which problem behavior is more probable. Although this type of analysis identifies or manipulates relevant antecedent variables, consequences (i.e., reinforcers) are not explicitly programmed, making it necessary to infer function based on the antecedent-behavior correlations only (Hanley et al., 2003). Inferring function based on antecedent events may lead to inaccurate conclusions. For instance, problem behavior may reliably occur after task presentation, leading one to infer that the behavior in question is maintained by escape from tasks, when in fact task presentation may actually serve as a discriminative stimulus, signaling the availability of positive
social attention for problem behavior (Vollmer, Iwata, Smith, & Rodgers, 1992). Thus, only analyses manipulating both antecedent and consequent variables experimentally examine the full range of environmental events maintaining behavior, making more rigorous demonstrations of causation. Additionally, information regarding both antecedents and consequences makes the analysis more useful, as each component in the contingency can potentially be manipulated to produce an effective intervention (Sasso et al., 2001).

A more comprehensive model of functional analysis incorporates all aspects of the four-term contingency (Iwata et al., 1982/1994). Analyses focusing on consequence manipulations typically use experimental conditions that each contain an MO, a discriminative stimulus and a source of reinforcement, with contingencies that are often reversed in the control condition for comparison purposes (Sasso et al., 2001). The analysis includes exposing individuals to the four conditions within a multielement design, in which conditions are counterbalanced and alternated across sessions (Sidman, 1960). Resulting levels of problem behavior are graphed, and the condition repeatedly and consistently producing the highest problem behavior level is considered to reflect the function of the behavior (Gresham et al., 2001).

The full functional analysis, described above, involves repeated assessment within each condition, increasing the confidence with which causal statements can be made regarding behavioral function (Northup et al., 1991). Functional analyses emphasizing consequence manipulation were initially designed to assess the environmental contingencies maintaining self-injurious behavior in children with developmental disabilities (Iwata et al., 1982/1994). A majority of early functional analysis research
focused on maladaptive behaviors (e.g., self-injury, aggression, and pica) exhibited by people with developmental disabilities, primarily in institutional settings (Iwata et al.; Mace & Lalli, 1991). The initial movement of functional analysis technology to classroom settings was focused primarily on students with profound cognitive disabilities (e.g., Cooper et al., 1992; Dunlap et al., 1991; Northup et al., 1994). According to Ervin et al. (2001), the majority (i.e., 70%) of all school-based functional assessments have focused on students with cognitive disabilities. Within the last 10 to 15 years, functional analysis methodology has been increasingly applied within the school setting to address the problem behaviors exhibited by both typical students and those identified with E/BD (Broussard & Northup, 1995; Ellis & Magee, 1999; Filter & Horner, 1999; Moore & Edwards, 2003; Wright-Gallo, Higbee, Reagon, & Davey, 2006). The most recent classroom-based analyses will be explored in greater detail.

**Classroom-Based Functional Analysis of Problem Behavior**

Broussard and Northup (1995) conducted abbreviated functional analyses with three students, examining the impact of experimental conditions on both disruptive behavior and academic work completion. One of the three functions most often related to classroom disruptive behavior – (a) teacher attention, (b) peer attention, and (c) escape from academic tasks – was selected as the hypothesized function for each student, based on FBA results. Two conditions, contingent and noncontingent reinforcement, were then conducted for each student, employing the hypothesized maintaining event as a reinforcer, followed by a contingency reversal. Results indicated that in each case the functional analysis validated the prior hypothesized function. Further, contingency reversals demonstrated the effectiveness of the maintaining variable as reinforcement for
alternative, appropriate behavior. Although not targeted directly, work completion was reported to covary with disruptive behavior across conditions. The noted covariation between behavioral excesses and deficits during the analysis was promising; however, treatment effects (i.e., contingency reversal) over an extended period were not examined. Thus, the link between analysis and treatment efficacy was not clearly demonstrated.

More recently, Ellis and Magee (1999) conducted analog and in-class functional analyses with three students classified with emotional and behavioral disorders. Using a multielement design, five conditions -- (a) peer attention, (b) peer competition for teacher attention, (c) play, (d) escape, and (e) alone -- were implemented, and the impact on problem behavior was measured. The condition resulting in the highest levels of problem behavior was incorporated into an intervention, which was then evaluated using an A/B design. Findings suggested that implementation of function-based interventions corresponded with reductions in problem behavior for all three students. The treatment effects were presented as an indicator of accurate identification of contingencies maintaining problem behavior. Although the extended treatment implementation represents an attempt to validate the function-based treatment, the lack of experimental control during this phase of the experiment prevents definitive statements regarding the effects of the analysis-derived interventions.

In another application of functional analysis methodology to the classroom environment, Moore and Edwards (2003) examined the effects of teacher-implemented conditions on the problem behavior of four students classified with emotional disturbance. The functional analysis results indicated that all four students’ problem behaviors were maintained by escape, and an A/B functional analysis was subsequently
conducted to identify antecedent variables associated with escape-motivated behaviors. The additional manipulations identified aspects of the instructional context differentially impacting student problem behavior, yet treatments based on analysis results were not reported or examined in the study.

Wright-Gallo et al. (2006) provided further evidence for the utility of classroom-based functional analyses by implementing traditional functional analysis conditions in a self-contained special education classroom and measuring the impact on the disruptive behavior of two students classified with emotional disorders. Using procedures outlined by Iwata et al. (1982/1994), the students’ disruptive behavior was identified as a function of both escape and attention. A function-based treatment, using differential reinforcement of alternative behaviors (DRA), was implemented and evaluated using a single-case B/A/B design. Findings indicated that the function-based intervention decreased disruptive behavior for both students and effects were replicated, providing the most rigorous evidence of treatment utility of the examined research.

Filter and Horner (2009) examined the impact of escape, attention, and control conditions on the problem behavior of two fourth-grade students. Functional analysis results indicated that both students’ problem behaviors were maintained by escape. A function-based intervention, consisting of antecedent task modification, was compared to a non-function-based intervention using an A/B/C/B design. Results indicated that the function-based intervention produced lower rates of problem behavior and higher rates of task engagement compared to the non-function-based intervention.

Although the school-based functional analyses demonstrated that the function of problem behavior could be reliably determined, no empirical evidence was presented to
support function-based treatments derived from the analyses. Filter and Horner (2009) provided the seemingly strongest evidence of function-based intervention effectiveness by comparing function-based and non-function-based interventions. However, the non-function-based interventions resembled additional analysis conditions, rather than treatments. For both students, the non-function-based interventions consisted of reinforcement provided contingent upon problem behavior, representing a contingency reversal compared to the function-based intervention. Consequently, the comparison between function-based and non-function-based interventions was a misnomer, as only the function-based treatment could be termed intervention.

Thus far, the functional analysis literature has focused solely on contingencies maintaining problem behavior. In fact, Hanley et al. (2003) define functional analysis as a method for identifying environment-behavior interactions that maintain “problem behavior,” and the term *functional analysis of problem behavior* is synonymous with functional analysis. Of the previous studies, only Broussard and Northup (1995) and Filter and Horner (2009) measured both problem behavior and academic behavior; however, the functional analysis conditions targeted only problem behavior, revealing a lack of attention to the analysis of academic performance. A primary limitation of functional analysis is the focus on behavioral excesses, with little regard to academic deficits. There are few studies implementing full functional analyses that measure response covariation between academic and behavioral problems across conditions. Further, conditions targeting academic performance have been largely excluded from functional analysis research.
**Functional Analysis and Academic Deficits**

The field of behavior analysis has long focused on ameliorating or reducing behavioral excesses (Carr & Durand, 1985); however, there is also a general consensus that problem behaviors should be replaced with appropriate or desired behaviors (i.e., replacement behaviors; Carr & Durand; Goldiamond, 1974). In the school setting, desired behavior often consists of academic engagement or responding contingent on the presentation of a curricular task, yet there is little inclusion of these variables as dependent variables in current functional analysis literature. Academic deficits have traditionally been assessed using standardized, norm-referenced achievement measures that provide little information regarding appropriate treatments (Martens, Steele, Massie, & Diskin, 1995). Within the last 15 years, new methods for assessing and developing treatments for academic deficits have emerged. Based on functional analysis procedures, brief experimental analysis examines the impact of relevant environmental variables on academic performance across content areas (Daly, Witt, Martens, & Dool, 1997).

**Brief experimental analysis of academic performance.** Brief Experimental Analysis (BEA) is an abbreviated assessment of academic behavior that involves systematic manipulation of environmental variables (i.e., instructional strategies) and measurement of corresponding academic behavior. Relative rates of academic behavior in response to instructional variables yield information regarding the instructional strategies functionally related to academic performance (Martens et al., 1999). Thus, the BEA is designed to identify variables related to academic deficits. Additionally, conditions are treatment-based, as each instructional strategy is designed to increase academic responding. Thus, there is an inherent link between BEA and treatment,
because the condition producing the greatest academic response is also the identified treatment, with no need for the contingency reversals employed in functional analyses of problem behavior.

While the vast majority of BEA research has focused on reading fluency (e.g., Daly, Andersen, Gortmaker, & Turner, 2006; Daly, Bonfiglio, Mattson, Persampieri, & Foreman-Yates, 2005; Daly, Martens, Hamler, Dool, & Eckert, 1999; Daly, Murdoch, Lillenstein, Webber, & Lentz, 2002; Eckert, Ardoin, Daisey, & Scarola, 2000; Eckert, Ardoin, Daly, & Martens, 2002), this assessment method has also been applied to a variety of academic areas, including reading comprehension, math, and writing (Carson & Eckert, 2003; Duhon et al., 2004; McComas et al., 1996). Across targeted academic areas, a series of skill- and performance-based treatments are tested, providing information on effective interventions as well as hypothesized functions of academic deficits (Bonfiglio, Daly, Martens, Lin, & Corsaut, 2004). Although both types of academic deficit may potentially contribute to problem behavior, distinct treatment components are intended to address skill deficits (i.e., instruction) and performance deficits (i.e., contingency management and feedback). However, there may be complex interactions between skill and performance-based components that complicate identification of the function of academic deficits (Bonfiglio et al.).

BEA technology contributes to the identification and application of effective academic treatment components (Daly et al., 2002). BEA makes a substantial contribution to the experimental analysis literature by including variables designed to strengthen academic skills (Daly et al., 1999), which are notably absent from functional analyses of problem behavior. However, similar to functional analysis research, the
existing BEA literature has failed to examine the impact of experimental conditions on concurrent behavioral and academic concerns (i.e., response covariation). Thus, there are two forms of analysis grounded in behavior analytic theory that separately address behavioral excesses and academic deficits, although these problems frequently co-occur, as noted earlier. The assessment processes for behavioral excesses and academic deficits have been and remain isolated, which may fragment intervention efforts, despite evidence of a functional relationship between these problems (Filter & Horner, 2009).

**Limitations to Existing Functional Analysis Technologies**

The primary limitations of functional analysis are related to the contingencies applied in functional analysis experimental conditions. Functional analysis conditions are designed to increase problem behavior, which presents several disadvantages. First, increases in problem behavior may be dangerous (e.g., aggression) or unacceptable for consumers or change agents, making functional analysis impractical (Iwata & Worsdell, 2005). Additionally, increases in problem behavior do not provide information regarding academic deficits. Despite this weakness, functional analyses have been implemented to develop function-based academic interventions (Filter & Horner, 2009). This practice currently consists of identifying the function of problem behavior and applying the identified contingencies to increase replacement behavior (e.g., academic performance). However, there is no guarantee that variables maintaining problem behavior will also maintain alternative, replacement behaviors (Holden, 2002).

Consider a situation in which a functional analysis indicates that teacher reprimands maintain disruptive classroom behavior. The function-based treatment may consist of providing teacher praise contingent on academic engagement (i.e., replacement...
behavior) and discontinuing responding for behavioral excesses. However, there are two fundamental problems with this approach. First, the contingencies for problem behavior and academic engagement are not matched. Both consequences are forms of teacher attention, but the reinforcing value of praise is unknown. Teacher reprimands have been established as a reinforcer for problem behavior, but praise (which has a different topography) has not been established as a reinforcer for academic engagement. Second, the functional analysis has confirmed that attention maintains disruptive behavior, but it does not necessarily follow that attention will also maintain academic engagement, which could operate under separate contingencies. The practice of applying a function-based intervention to a behavior for which no functional information is known amounts to rearranging contingencies in a post hoc manner that fails to provide an empirical basis for the newly targeted stimulus-response relationship and which also fails to account for any possible existing contingencies for the covarying response classes.

Functional analysis is effective in performing its original purpose, which was to identify treatments to decrease problem behavior (Iwata et al., 1982/1994). However, the current state of functional analysis does not provide relevant information for development of interventions designed to increase appropriate replacement behaviors. There is an analysis-to-treatment gap in the functional analysis of problem behavior. To remedy this gap, the function of relevant replacement behaviors (e.g., academic behaviors) should be directly identified through functional analysis methodology.

Prior research has focused on experimental manipulation of treatment packages designed to increase appropriate behaviors (Harding, Wacker, Cooper, Millard, Jensen-Kovalan, 1994; Millard et al., 1993); however, the treatments in this research do not
correspond to behavioral functions and provide limited information or hypotheses regarding function. Although functional analysis researchers have employed contingency reversals to validate identified functions (Broussard & Northup, 1995), few attempts have been made to advance a full functional analysis of replacement behaviors.

A functional analysis technology has not yet been developed for concurrent examination of behavioral and instructional variables. Functional analysis conditions were designed to increase problem behavior within session to provide information about function; thus, it is not possible within the confines of current methods to examine the impact of instructional or other academic-based strategies that may be necessary for a comprehensive treatment. Academic treatments, such as instruction involving modeling, prompting and feedback, are designed to increase academic skills and weaken problem behavior, which would directly interfere with the contingencies that a functional analysis of problem behavior is designed to detect. Therefore, instructional strategies are procedurally incompatible with current functional analysis technology, which precludes a complete examination of variables relevant to treatment of academic deficits and behavioral excesses.

Existing functional analysis methods neglect very important behavior-environment relationships that are directly relevant to academic performance and covarying behavioral excesses. Thus far, no functional analyses of problem behavior incorporate instruction or other variables designed to establish stimulus control over replacement behaviors (e.g., academic responding). Alternatively, BEAs incorporate these instructional variables, yet do not explicitly include typical functional analysis contingencies designed to identify behavioral function. Finally, neither form of analysis
examines the impact of experimental conditions on the response covariation between academic responding and behavioral excesses. To date, there exists no comprehensive assessment strategy that incorporates relevant behavioral and academic variables and informs intervention to address both academic deficits and behavioral excesses. A functional analysis designed to identify the function of desired replacement behaviors would not only remedy the limitations mentioned, but it would also represent an analysis through which instructional strategies could be jointly examined.

**Purpose of the Current Study**

Based on the limitations of current analysis procedures for academic and behavioral problems, the purpose of the current study was twofold. First, an alternative method for conducting functional analyses was examined. This revised methodology included an examination of replacement behaviors (academic responding), in that the contingencies within experimental conditions were applied to replacement behaviors rather than solely to behavioral excesses. Performing a functional analysis in this manner directly tests conditions intended to strengthen replacement behaviors and weaken problematic responding, thereby providing a direct link to effective intervention. Including conditions designed to increase replacement behaviors (i.e., academic responding) and reduce behavioral excesses also allows for concurrent examination of instructional strategies designed to establish stimulus control, based on the shared direction of intended behavior change. Thus, the second purpose of the study was to examine the effects of antecedent instruction on functional analysis outcomes. This examination was expected to provide information about the procedural compatibility of functional analysis and instruction and the extent to which instruction contributes to an
assessment methodology for examining concurrent academic deficits and behavioral excesses.

Corresponding to the purposes of the study, two research questions were addressed. First, what is the effect of applying functional analysis methodology to alternative academic behaviors in terms of producing consistent results regarding function? By conducting a functional analysis of replacement behavior with students experiencing a combination of behavioral and academic problems, the current study directly examined the utility of functional analysis for identifying conditions that not only maintain high rates of replacement behavior, but also result in low rates of problem behavior (i.e., response covariation). Specifically, students were exposed to the typical school-based functional analysis conditions – (a) teacher attention, (b) peer attention, and (c) escape; however, the replacement behavior (i.e., academic responding) was reinforced across conditions instead of problem behaviors. A control condition was also included to distinguish between multiply controlled replacement behavior and undifferentiated results. Students were presented with unknown math problems across all four conditions and provided with condition-specific consequences (e.g., teacher attention, peer attention) contingent on academic responding, while measuring their relative impact on disruptive behavior, academic engagement, and academic performance (i.e., rate of math computation problems completed, rate of digits correct). Outcomes of the functional analysis of replacement behavior allowed for examination of response covariation between behavioral excesses and academic deficits, which could potentially improve treatment selection. It was hypothesized that participants would produce similar academic and behavioral responses within conditions; however, differentiation of
responding between conditions was expected to occur, allowing the function of replacement behavior (i.e., academic responding) to be identified.

The second research question to be addressed was related to the incorporation of antecedent instruction in functional analysis procedures. What is the effect of establishing stimulus control for academic responding on the outcomes of functional analysis? Specifically, do the outcomes remain consistent or does stimulus control for academic responding alter functional analysis outcomes by producing different patterns of behavior? To examine the impact of antecedent instruction on functional analysis of replacement behavior outcomes, a second functional analysis incorporated antecedent instructional sessions. Before the functional analysis was carried out, students received instruction in previously unknown math facts, using an instructional program that included modeling, prompting, practice, feedback, and differential reinforcement. Instruction occurred before the second analysis, rather than throughout the analysis, to isolate the effects of stimulus control. Known problems were used in the experimenter attention, peer attention, and escape conditions; unknown problems were used in the control condition. With instruction occurring prior to experimental sessions, the conditions remained identical to the previous functional analysis, and the only systematic change was the prior establishment of stimulus control of instructional materials over student academic responding.

Incorporating instruction to further strengthen academic skills associated with responding was hypothesized to impact the relative outcomes of functional analysis conditions in three ways. First, instruction was predicted to reduce task difficulty associated with unknown math facts, which would be evident in increased response levels
(especially for accurate completion of math problems) relative to the results of the first functional analysis. Second, by increasing the probability of a response during functional analysis conditions by using known math problems, the probability of reinforcement would also increase and therefore was expected to allow for the detection of behavioral function through differential response patterns across conditions. For this reason, differentiation across conditions was expected, with higher response levels in conditions containing effective consequences relative to conditions containing ineffective consequences within the second functional analysis. Finally, based on research substantiating the likelihood of response covariation, it was expected that co-varying response patterns would be established for those functional analysis conditions which contained effective consequences for behavior. In other words, for those conditions which elevated academic responding and academic engagement in the second functional analysis, a concurrent reduction in disruptive behavior was expected.

The condition producing both the highest rates of academic responding and lowest rates of disruptive behavior was selected for further examination. An extended analysis was conducted after the functional analyses to directly compare like conditions, using the condition that produced the most desirable level of responding across the two functional analyses, with and without prior instruction. The extended analysis allowed for replication of results with a different computation skill, providing evidence of generalizability (or a lack thereof).
CHAPTER 2

Method

Participants and Setting

The participants in the study included 3 students enrolled in a private elementary school in the Midwest. Patty was an 8-year-old, White female with no previous diagnoses or special education services. Jennifer was a 9-year-old, White female, who was previously diagnosed with Attention-Deficit Hyperactivity Disorder (AD/HD). Jennifer was prescribed Adderall, which she took during school hours throughout the study. Erin was an 11-year-old, White female with no previous diagnoses or special education services. (All names provided are pseudonyms.) Medication status was held constant throughout the study for all participants. Approval was obtained from the Human Subjects Institutional Review Board (IRB), and participants were covered under IRB number 20100310409EP.

Recruitment procedures consisted of a two-tiered process. First, the education coordinator referred students for concurrent behavioral and academic concerns. Second, participants were selected from the referral group based on the following criteria: (a) The student exhibited a high rate of externalizing behavior (i.e., total score greater than 18 out of 23), according to teacher ratings on the Behavior Screening Form (see Appendix A), and (b) the student received a score of 25% or more unknown math facts in one or more operations on an initial mathematics screening of all addition and multiplication problems 1 through 12. (Screening procedures are described in the Procedures section.) Additionally, students were selected based on the receptiveness of teachers, parents and students to participate. (See Table 3 for participant information.)
All assessment and intervention activities were conducted in empty office spaces and classrooms during class-wide mathematics activities. The author was responsible for implementation of all functional analysis procedures in addition to all screening and instructional sessions. Two trained advanced school psychology doctoral students were responsible for observation of student behavior during functional analysis conditions via video recording. Their training is described below in the Procedures section.

Materials

Math Fact Index Cards. All screening and instructional sessions were conducted using blank, white 3x5-inch index cards with skill-specific (i.e., addition, subtraction, multiplication, division) math computation problems printed on one side. Addition and multiplication cards contained all problems 1-12, and multiplication and division cards contained all problems resulting in a positive, whole number.

All functional analysis sessions were conducted using laminated, colored 3x5-inch index cards. Individualized math computation cards were created based on student math performance during initial screening. Problems included were those that were not answered or were answered incorrectly within 3 s. Thus, initial probes included 100% unknown math facts. Each unknown math fact was printed on a 3x5-inch index card to facilitate a stable rate of stimulus presentation. Four different color note cards were used, with each color assigned to a functional analysis condition to facilitate discrimination between conditions (i.e., pink cards for experimenter attention, green cards for peer attention, yellow cards for escape, orange cards for control).

Video camera. All screening, instruction, and functional analysis sessions were videotaped using the author’s built-in laptop computer camera. The laptop was placed on
the table throughout each session to capture examiner and participant behavior, and observations for academic engagement, disruptive behavior, and procedural integrity were conducted via video after completion of the study. Two advanced school psychology doctoral students served as observers, using video recordings of all conditions.

**Incentives.** Incentives used in conjunction with instruction were structured so that participants earned one sticker for each card added to the instructional pile. Participants were told that they could redeem each sticker earned for 1 minute of a preferred activity. Participants were presented with reward options including free time, game play, drawing time, or time to play with modeling clay. Cards with pictures of each reward option were presented to the participant, and the selected activity was provided at the end of the instructional session for a time period corresponding to the number of earned stickers (i.e., 10 stickers = 10 minutes).

**Measurement of Dependent Variables**

Three student behaviors – academic engagement, disruptive behavior, and mathematics computation rate – were measured throughout the study.

**Academic engagement.** Academic engagement was defined as active academic responding, including reading problems aloud, writing on note cards, and overt calculation of problems (e.g., counting on fingers, counting aloud, counting in a whisper or silently moving one’s mouth). Academic engagement was recorded using a 10-s momentary time sampling procedure during each 5-min videotaped session. Academic engagement was calculated for each session by dividing the number of intervals in which
academic engagement occurred by the total number of observed intervals, and multiplying that figure by 100 to produce a percentage occurrence.

**Disruptive behavior.** Disruptive behavior included both motor and verbal disruptions. Specifically, motor and verbal disruptions collectively included the following behaviors: Marker/pencil tapping; drawing or writing on self, table or other non-paper surface; making faces and/or gestures; talking not categorized as academic engagement (e.g., reading problems, performing problem steps aloud); laughing, singing, humming, and whistling. Disruptive behavior data were recorded using a 9-s partial-interval recording procedure during the same 5-min videotaped sessions. Thus, one data recording form (see Appendix B) was used to record disruptive data for 9 s, followed by 1 s, in which the presence or absence of academic engagement was recorded. Disruptive behavior was calculated by dividing the number of intervals in which disruptive behavior occurred by the total number of observed intervals, and multiplying that number by 100 to produce a percentage occurrence.

**Rate of math computation.** In each experimental session, participants wrote answers to math problems on math computation cards for 5 minutes per condition. Mathematics computation performance was measured as rate of completed problems and rate of digits correct. Completed problems included those for which participants placed at least one identifiable number under the equals line on the math computation card. Digits correct (DC) included the number of correct digits according to place value. For example, when given the problem 3x4, a student answering 22 would receive a score of 1 DC for the 2 placed in the ones column, although the 2 in the tens column is incorrect. Using a stopwatch, the exact number of seconds was recorded for each session, and the
time provided on each video recording was used to confirm the exact number of seconds elapsed for each session. To calculate rate of completed problems, the number of completed problems per session was divided by the time (in seconds) and multiplied by 60 to determine the number of completed problems per min (a rate measure). The same formula was applied to DC. For the escape condition, the calculations had to be adjusted to account for the 15-s breaks that were provided contingent on the target behavior. As such, 15-s was subtracted from the time for every break provided before results were calculated. The number of problems completed per min and the number of DC per min were calculated across each condition as measures of mathematics computation rate.

**Interobserver agreement.** Two observers independently coded academic engagement and disruptive behavior for 33% of sessions (randomly selected) using video recordings of each 5-minute session. Agreements and disagreements across observers were compiled. An agreement was defined as identical scoring across both observers for the same interval (e.g., both participants agree that target behavior occurred in interval 10). A disagreement was defined as any discrepancy across observers within the same interval. For each videotaped session, percentage agreement between observers was calculated using a point-by-point agreement ratio (Kazdin, 1982a). Kappa coefficients were not calculated due to the influence of base rates of behavior (Thompson & Walter, 1988; Feinstein & Cicchetti, 1990). In the current study, the base rates of dependent variables are largely varied, so that the kappa coefficients would not be comparable across dependent variables. Additionally, the base rate of disruptive behavior was very low and the base rate of academic engagement was very high, and these extremes often result in smaller kappa values (Simon, 2006). Agreement was calculated on an interval-
by-interval basis by dividing the total number of agreements by the total number of intervals and multiplying by 100. An overall percentage of agreement across sessions represented the average percentage of intervals during which both observers agreed on the occurrence or non-occurrence of disruptive behavior and academic engagement, respectively. The mean interobserver agreement across sessions was 87% (range, 67% to 100%) for academic engagement and 96% (range, 73% to 100%) for disruptive behavior.

Interrater agreement was also calculated for mathematics computation performance. The researcher scored all mathematics computation responses for every session, and a school psychology doctoral student independently scored 34% of sessions (randomly selected) across participants in each condition. Agreements and disagreements for both completed problems and DC were compiled either on a problem-by-problem basis (completed problems) or on a digit-by-digit basis (DC). An agreement was identified as identical scoring across observers for the same math computation problem (e.g., both agree that the problem was complete and a digit in the tens place was correct). A disagreement was defined as any discrepancy between observers regarding the same math computation problem (e.g., one observer scores a digit correct in the ones column and the other observer scores a digit correct in the tens column). For both variables, the total number of agreements was divided either by the total number of problems (completed problems) or digits (DC) and multiplying by 100. The mean interrater agreement was 100% for problems completed and 99.9% (range, 99% to 100%) for DC.

**Experimental Conditions**

Four of the experimental conditions – experimenter attention, peer attention, escape and control – were used in both functional analyses (which are described below in
the Experimental Design and Procedures sections). The Instruction condition was delivered between the first and second functional analyses. Each condition is described here in turn.

**Experimenter attention.** During the experimenter attention condition, the participants were instructed to remain seated and work quietly on individually presented mathematics computation cards. Specifically, participants were told:

When we use the pink cards, I will pay special attention to you to help you stay seated and work quietly on your math problems. If you complete a problem while staying seated and working quietly, I will tell you what a good job you are doing! If you do anything other than work quietly, I will turn away like this (demonstration).

The experimenter sat at the table with the participant, presenting pink math computation cards at fixed, 10-s intervals or upon completion of each problem. Pink math computation cards were used across all experimenter attention conditions as an additional stimulus to make contingencies more salient and to facilitate condition discrimination. The experimenter also provided attention (e.g., praise, smile, high five) contingent upon problem completion, using a continuous schedule of reinforcement. All other responses were actively ignored by averting eye contact and physically turning away from the student, while continuing to present math problems at regular intervals.

**Peer attention.** A peer confederate was identified by each teacher prior to conducting the functional analysis. Each confederate was asked to work with the experimenter and the participant to assist with completion of math problems. After peers
were selected by classroom teachers, the experimenter met individually with each peer, providing the following information:

_______ (participant’s name) and I will be working together on math facts over the next few weeks. If you want to, you can join us. If you decide to work with us, you can help ______ (the participant) to complete some math problems by telling them what a good job they are doing. This will take about five minutes, and you would probably work with us two or three times a week. At any time, if you decide you would like to return to your classroom, you can tell me and I will walk you back to your room. Do you have any questions? Would you like to join us?

If the selected peer agreed to participate, they were given the following instructions immediately prior to each session:

_____ (the participant) is going to be working on some math problems. Every time she finishes a problem, tell her what a good job she is doing. Say whatever you can think of, but do not tell _____ (the participant) the answer or whether or not the answer is correct. If _____ (the participant) does anything other than work, do not say anything.

The peer was provided with sample comments (e.g., “You are working very hard,” “Wow, you got another one done!”) to be used within the session, and the experimenter modeled contingent ignoring. Participants were told that a peer would help them to remain seated and work quietly on individually presented math problems.

Specifically, each participant was told:

When we use the green cards, ______ (the peer) will help you stay seated and
work quietly on your math problems. If you complete problems, ______ (the peer) will tell you what a good job you are doing. ______ (the peer) will not pay attention to anything other than working quietly on math facts.

The peer was then seated at the table beside or across from the participant. The peer was prompted by the examiner to present green math computation cards at fixed, 10-s intervals or upon completion of each problem. Green math computation cards were used across all peer attention conditions to make contingencies more salient and facilitate discrimination between conditions. Throughout each peer attention condition, the examiner maintained a proximity of approximately 5 ft from the peer, but all student behavior was ignored.

**Escape.** During the escape condition, the participants were instructed to remain seated and work quietly. They were told that they would be given a 15-s break from working for each problem completed. Specifically, the experimenter told the participant:

> When we use the yellow cards, you will get breaks to help you stay seated and work quietly on your math problems. Each time you complete a problem, you will be given a 15-s break from working.

The experimenter was seated at the table beside the student, and yellow math computation cards were presented at fixed 10-s intervals or after each 15-s escape period. During the 15-s escape period, the completed math card was physically removed and the experimenter turned away from the student. After each break, the experimenter continued to present yellow math computation fact cards at fixed 10-s intervals or after each escape period. Yellow math computation cards were used across all escape
conditions to increase the salience of contingencies and to facilitate condition discrimination.

**Control.** During the control condition, each participant was instructed to stay seated and work quietly at his or her own pace. Participants were told:

When we use the orange cards, you will complete problems on your own. Stay seated and work quietly at your own pace. Do as much or as little as you want.

I’ll be working over here while you complete problems.

The participants were then provided with a stack of orange, unknown math computation cards, and all behavioral responses were ignored. Orange math computation cards were used across all control conditions to make contingencies more salient and to facilitate condition discrimination. The participant controlled the rate of stimulus presentation, and the examiner remained approximately 4 to 6 feet away from the participant with averted eye gaze throughout the control condition.

**Instruction.** After the initial functional analysis, but prior to the second analysis, instruction was delivered to create a set of “known” math problems for the second functional analysis. This condition allowed the functional analysis to examine stimulus function with instructional items that had stimulus control over academic responding. Unknown math problems, which were identified during screening, were taught using a modified version of the Strategic Incremental Rehearsal (SIR) intervention procedures (Kupzyk, Daly & Andersen, in press; see Appendix C) in combination with programmed incentives. Prior to implementing the intervention procedures, each participant was presented with all unknown math facts on white note cards and prompted to provide the answer. Problems answered correctly within 3 s were removed from inclusion in the
functional analysis with known problems. The exclusion of problems learned during the functional analysis with unknown facts was essential to distinguish between the impact of instruction and practice during the functional analysis with unknown problems.

During the first instructional session, the first unknown problem (U1) was modeled (e.g., “Three times two equals six.”) and the participant was prompted to repeat the answer. For incorrect responses, the experimenter provided corrective feedback by repeating the problem and answer and prompting the student to say the correct answer aloud (“No, three times two equals six. What is the answer?”). The same procedures were used to introduce the second unknown problem (U2), and the above steps were repeated for U1 and U2 before implementing a prompt delay. With subsequent presentations of U1 and U2, the examiner modeled the correct answer if the student answered incorrectly or failed to respond within 3 s (prompt delay procedure). If the student provided the correct answer within 3 s, the next stimulus item was presented. After students provided correct answers to both problems (U1 and U2) without a prompt, a new unknown problem was presented (U3). The procedures above for modeling, prompting and corrective feedback were employed when U3 was presented for the first time, then U1 and U2 were presented in random order, using the prompt delay and corrective feedback procedures. All three problems (U1, U2, U3) were then shuffled and presented using a prompt delay and corrective feedback. This process continued until all three problems were answered correctly within 3 s without prompting. Once all instructional items were answered correctly, a new unknown problem (U4) was introduced. These procedures were repeated until conclusion of each instructional session.
During subsequent instructional sessions, all previously instructed items were shuffled and presented with a prompt delay and corrective feedback. Math fact index cards were shuffled between each presentation and prior to adding a new unknown problem. Modeling was used to introduce each new unknown problem, and a prompt delay was used with all subsequent problem presentations. These instructional procedures continued until 80% of all unknown problems were answered correctly within 3 s without prompting (i.e., known).

**Experimental Design**

Two successive functional analyses were conducted. Within each analysis, a multielement design (Sidman, 1960) was used to evaluate the relative effects of functional analysis conditions, with and without instruction, on academic engagement, disruptive behavior, and mathematics performance. Functional analysis conditions were rapidly alternated in a pre-determined, semi-random presentation order. Each participant was exposed to all four conditions across several series, and the order of presentation for each series of four conditions was randomized before the next series of conditions was delivered. Additionally, the relative impact of the most effective condition was examined with and without antecedent instruction, using a multielement design within an extended analysis. Experimental control was evidenced by systematic differentiation in responding across experimental conditions, visible in clearly differentiated data series between conditions (Kazdin, 1982a).

A multielement design was utilized to address both research questions. Rapid alternation between all functional analysis conditions allowed for examination of patterns of differentiation, which were used to determine whether the functional analysis of
replacement behavior produced consistent results within conditions to identify a potential treatment (first research question). Use of a multielement design with the second functional analysis allowed for a comparison of response patterns across analyses (second research question), as the conditions and design remained consistent and the only systematic change was related to the stimulus control acquired by curricular materials over student responding during instruction which proceeded the second functional analysis. Further, the extended analysis permitted for comparison of the single most effective condition, with and without instruction (i.e., known and unknown problems). Use of a multielement design in the extended analysis provided a more direct comparison of conditions with and without the impact of stimulus control, as well as evidence of generalization of effects to other skill areas.

Procedures

Prior to experimental sessions, the experimenter met teachers of the referred students to describe the project. Teachers interested in having their students participate were provided with a teacher consent form (see Appendix D). Additionally, the parents of referred students were contacted initially by the classroom teacher, who provided parents with an approved IRB project overview document (see Appendix E), which described the project and provided experimenter contact information. Parents were then contacted via telephone by the experimenter to ascertain the level of interest and willingness to participate. During this telephone contact, a more detailed description of the project and the child’s involvement was provided, and all questions were answered. Parents who verbally expressed interest in having their child participate were sent an informed consent form (see Appendix F) via the classroom teacher. The experimenter
then met individually with students from whom signed informed consent forms were received. Students were provided with an age-appropriate description of the project, and assent forms (see Appendix G) were presented and explained. Participants only included students from whom signed teacher and parent informed consent and assent forms were obtained.

**Training.** All observers and experimenters had prior coursework and practicum experience using behavioral observation measures as well as academic and behavioral intervention strategies. Additionally, prior to conducting classroom observations, all observers received a minimum of two 1-hour training sessions provided by the author. Each observer was trained to use the data recording form in Appendix B. Training included a description and rationale for observation procedures, a demonstration of appropriate observational coding, and practice coding of a training videotape combined with immediate feedback (e.g., praise, error correction). Practice included repeated simultaneous coding for three observation sessions on the training videotape. Training continued until each observer reached 90% agreement for disruptive behavior and 90% agreement for academic engagement with a pre-scored protocol.

**Screening.** Each student was assessed for math computational skills using mathematics fact cards until reaching a criterion of 25% unknown facts within one skill area, either addition or multiplication. The reason for establishing a criterion for unknown facts was to identify a skill area in which the student displayed an academic deficit. During the screening session, each participant was presented with all possible digit combinations of addition and multiplication facts 1 to 12, printed on white note cards. Correct responses provided within 3 s were counted as correct. Errors were
scored for omissions, incorrect answers, and responses occurring after 3 s. The percentage of unknown problems was calculated by dividing the number of errors by the total number of problems and multiplying by 100. The mathematics operation (i.e., addition or multiplication) resulting in the highest percentage of unknown problems was selected as the target skill.

The screening process also included the structured use of incentives to maintain acceptable levels of task engagement. Specifically, during the screening session, both stacks of 144-math-fact flashcards were shuffled and divided into four stacks of 36 cards each. The participants were told that for each stack they completed, they would earn a sticker. It was then explained that they would be allowed to select a reward when they earned eight stickers (i.e., addition and multiplication facts complete). Reward options included 5 min of free time, 5 min of game play, a positive note home, or 5 min of drawing time. Cards with pictures of each reward option were presented to the participant (see Appendix H), and the selected reward was immediately provided. Participants selected game play, drawing time and time to play with modeling clay (a free time option).

**Functional analysis with unknown facts.** This analysis examined the relative impact of functional analysis conditions on participant replacement behaviors -- academic engagement, math computation performance and disruptive behavior. Using 100% unknown facts derived from screening in one skill area (addition or multiplication), all four functional analysis conditions (teacher attention, peer attention, escape, and control) were randomly presented to each participant in several series. Analog conditions were conducted in open office and classroom spaces during the regularly scheduled math
period. All office and classroom spaces were free from distractions, with enough room for the laptop (used for videotaping) to be set up and remain unobtrusive. Each condition was presented for several 5-min sessions, and two to three sessions were conducted each day. All conditions were videotaped using the experimenter’s laptop computer. Videotaping was conducted to minimize potential participant discomfort caused by having multiple observers present. Condition presentation continued until stability was observed in the level or trend of academic performance.

**Instruction.** After completion of the functional analysis with unknown facts, instruction (i.e., SIR) was conducted with each participant until 80% of math facts were answered correctly (i.e., 20% unknown problems retained for the control condition). Instructional sessions lasted approximately 20 min and were conducted one to two times per week across participants.

**Functional analysis with known facts.** The functional analysis with known facts was conducted for each participant after all instructional sessions were completed. This analysis examined the combined effect of antecedent instruction and functional analysis conditions on participant replacement behaviors -- academic engagement, math computation performance, and disruptive behavior. The functional analysis with known facts was conducted using the same procedures as the functional analysis with unknown facts, with one exception: known facts which were learned during the preceding instructional sessions were used across the functional analysis conditions -- experimenter attention, peer attention, and escape -- to examine the impact of stimulus control on patterns of behavioral and academic responding. The control condition was held constant across analyses, and only unknown math computation problems were presented.
**Extended analysis.** The most effective condition from the functional analyses was further examined in the extended analysis. Specifically, both versions of the single-most effective condition from the previous functional analyses (with and without prior instruction) were compared using a multielement design to determine whether results from separate functional analyses would be replicated. Replication within the same phase would permit comparisons of like conditions across known and unknown stimulus materials, which may strengthen conclusions regarding possible effects of antecedent instruction on functional analysis outcomes.

The following decision process was applied to select the single-most effective condition for the extended analysis. Because math computation skill was the most critical outcome and the keystone variable that presumably influenced the other dependent variables, results for the rate of completed problems and rate of digits correct were examined. All conditions across both functional analyses were compared to select the condition that produced the most consistent improvement in level of responding across functional analyses. The condition that met the most criteria for effectiveness was chosen for the extended analysis. Those criteria for effectiveness included: (a) a condition that was visibly higher than two or more of the other conditions (i.e., differentiation within and across functional analyses); (b) a condition whose mean exceeded the other condition means by at least 1 standard deviation; and (c) a condition whose standard deviation was at least 1 standard deviation smaller than the other condition means, or if two or more conditions meet the above criteria, the condition with the smallest standard deviation. This decision process identified an effective condition
for each of the participants (experimenter attention for Patty, experimenter attention for Jennifer, and escape for Erin).

Once the most effective condition was selected using the above decision-making process, the condition was presented both with and without antecedent instruction (i.e., known and unknown problems) during each session using a previously unexamined mathematics skill. The order of presentation was semi-random and determined prior to implementation. One purpose of the extended analysis was to test the generality of results to a second skill area. Therefore, when addition was used during the functional analyses, subtraction was selected for use in the extended analysis (Jennifer). Similarly, when multiplication was used during the functional analyses, division was selected for use in the extended analysis (Patty and Erin). The fact cards were divided equally, and half of the unknown cards were randomly assigned to the most effective functional analysis condition with unknown facts, and half were randomly assigned to the most effective functional analysis condition with known facts. Prior to the experimental sessions constituting the extended analysis, instruction (SIR) was delivered exclusively using the math facts assigned to the condition with known facts. Thus, the most effective functional analysis condition was implemented using unknown math facts versus instructed facts (i.e., known facts).

**Procedural Integrity**

Procedural integrity for functional analyses was calculated via video recording. Procedural integrity checks were conducted to ensure that functional analysis condition procedures were carried out as they were designed and to quantify the degree to which procedures were followed. After completion of the study, 33% of videotaped sessions for
each condition within each analysis were randomly selected to determine procedural adherence across participants.

A trained observer recorded both student behaviors (e.g., academic responding, target behaviors) as well as experimenter and peer responses to calculate the percentage of responses correctly conseuated for each condition. It was necessary to calculate condition-specific procedural adherence not only to demonstrate adherence to procedures, but also to ensure that contamination across conditions did not occur. Academic and behavioral responses exhibited by the participant were recorded continuously across all conditions. Experimenter and peer responses (i.e., experimenter attention, peer attention, task removal) were also recorded continuously. If a condition-appropriate response (i.e., experimenter attention during the experimenter attention condition, escape during the escape condition, peer attention during the peer attention condition, or no action/response during the control condition) occurred within 5-s of student academic responding, it was coded as a correct consequence. When a student response was not followed by a condition-appropriate consequence, no consequence was coded. Finally, when condition-inappropriate responses (e.g., experimenter attention during the escape condition, experimenter attention in response to disruptive behavior) occurred, they were coded as incorrect consequences.

To calculate procedural integrity, the number of appropriate consequences (i.e., correct responses) was divided by the total number of consequences provided (i.e., correct consequences plus no consequences plus incorrect consequences) and multiplied by 100. Using this formula, procedural integrity was calculated by participant, condition and analysis. See Table 4 for procedural adherence results.
All instructional sessions were videotaped, and a procedural checklist was completed by an independent observer for 50% of sessions (randomly selected). The percentage of procedural adherence was calculated for each session by dividing the number of steps completed by the total number of intervention steps and multiplying by 100. The percentage of procedural integrity was 100% for all instructional sessions.
CHAPTER 3

Results

Functional Analysis with Unknown Problems

The functional analysis with unknown problems was designed to determine whether applying functional analysis methodology to academic replacement behavior using unknown problems would yield consistent results regarding function. Figures 1 through 3 display the participant results across analyses and dependent variables (i.e., rate of completed problems, rate of correct digits, percentage of disruptive behavior, percentage of academic engagement). Examination of the results for the functional analysis with unknown problems (left panel of each figure) reveals largely undifferentiated patterns of responding across participants.

Patty. Figure 1 (left panel) displays the results of Patty’s functional analysis with unknown problems. Visual inspection of Patty’s rate of completed problems reveals a largely undifferentiated pattern of responding. Increasing trends are evident in experimenter attention and control conditions; however, the results are inconclusive due to significant overlap across conditions. A similar pattern of undifferentiated responding is also apparent for Patty’s rate of digits correct, precluding identification of controlling variables. Some differentiation is visible in Patty’s disruptive behavior (i.e., percentage of intervals with disruptive behavior) across conditions. The peer attention condition produced a higher level of disruptive behavior compared to other conditions, and an increasing trend is evident in the escape condition. A high degree of overlap is discernible in Patty’s academic engagement across conditions. Patty’s academic
engagement also appears to be characterized by a high degree of variability for all conditions, particularly compared to other dependent variables.

Visual analysis results are corroborated by summary statistics (Table 5) for Patty’s responding across dependent variables in the functional analysis with unknown problems. All condition means for rate of completed problems, rate of digits correct and percentage of academic engagement fall within 1 standard deviation of the total analysis mean for each respective variable (Completed problems: M = 9.0, SD = 4.8; Digits correct: M = 8.4, SD = 2.9; Academic engagement: M = 76.5, SD = 19.6). Mean percentages of disruptive behavior for most conditions fall within 1 standard deviation of the overall disruptive behavior mean (M = 9.0, SD = 4.8); however, the peer attention condition produced a mean percentage of disruptive behavior (M = 28.3, SD = 6.9) that exceeded 1 standard deviation of the total disruptive behavior mean. Thus, a higher percentage of disruptive behavior was exhibited in the peer attention condition relative to other conditions in the functional analysis with unknown problems. Overall, the functional analysis with unknown problems produced mostly undifferentiated responding across dependent variables with the exception of disruptive behavior, suggesting that either responding is multiply controlled or the method was unable to reliably identify one or more stimulus functions governing academic responding for Patty.

**Jennifer.** Figure 2 (left panel) depicts the results of Jennifer’s functional analysis with unknown problems. Examination of Jennifer’s rate of completed problems shows an undifferentiated pattern of responding across conditions. The control and peer attention conditions produced increasing trends in Jennifer’s rate of completed problems; however, the lack of differentiation prevents identification of potential controlling
variables. A similar pattern emerged in Jennifer’s rate of digits correct. Although increasing trends are visible in the control and peer attention conditions, a high degree of overlap is present across conditions. Jennifer exhibited low, near-zero levels of disruptive behavior across conditions, producing undifferentiated results. Conversely, Jennifer’s academic engagement remained at high rates across all conditions with a similarly high degree of overlap across conditions.

Visual analysis results are substantiated by summary statistics (Table 6) for Jennifer’s responding across dependent variables in the functional analysis with unknown problems. Condition means for all dependent variables fall within 1 standard deviation of the total analysis mean for each respective variable. Overall, the functional analysis with unknown problems produced undifferentiated responding across dependent variables, indicating that either Jennifer’s responding is multiply controlled or the method was unable to reliably identify one or more stimulus functions governing academic responding.

**Erin.** Figure 3 (left panel) displays the results of Erin’s functional analysis with unknown problems. Visual inspection of Erin’s rate of completed problems reveals a primarily undifferentiated pattern of responding. Increasing trends are visible across all conditions, and Jennifer produced a somewhat lower rate of completed problems in the control condition; however, the proximity of condition series as well as the marked overlap of other conditions (i.e., experimenter attention, peer attention, escape) contribute to inconclusive findings. An undifferentiated pattern of responding is also evident for Erin’s rate of digits correct. Additionally, the experimenter attention, peer attention, and control conditions produced a great deal of variability in Erin’s rate of digits correct.
Erin exhibited low, near-zero levels of disruptive behavior across conditions, creating a high degree of overlap (i.e., undifferentiated results). Erin appeared to produce a somewhat lower level of academic engagement in the control condition relative to other conditions; yet, a slight increasing trend is visible across sessions in the control condition. Significant overlap is present across all other conditions (i.e., experimenter attention, peer attention, escape) for academic engagement.

Visual analysis results are corroborated by summary statistics (Table 7) for Erin’s responding across dependent variables in the functional analysis with unknown problems. All condition means for rate of completed problems, rate of digits correct and percentage of disruptive behavior fall within 1 standard deviation of the total analysis mean for each respective variable (Completed problems: M = 12.3, SD = 4.6; Digits correct: M = 9.5, SD = 2.7; Disruptive behavior: M = 1.4, SD = 4.3). Mean percentages of academic engagement for most conditions fall within 1 standard deviation of the overall academic engagement mean (M = 93.3, SD = 11.7); however, the mean percentage of academic engagement in the control condition (M = 78.3, SD = 15.8) was greater than 1 standard deviation below total academic engagement mean. Thus, a lower percentage of academic engagement was exhibited in the control condition relative to other conditions in the functional analysis with unknown problems. Overall, the functional analysis with unknown problems produced largely undifferentiated responding across dependent variables with the exception of academic engagement, suggesting that either the method was unable to reliably identify one or more stimulus functions governing Erin’s academic responding or her responding was multiply controlled.
Summary. The three participants demonstrated mostly undifferentiated patterns of responding across conditions and dependent variables. The consistently undifferentiated patterns across participants suggest that the current procedures did not produce consistent results regarding function when unknown or uninstructed academic material was used. The undifferentiated results across participants indicate that experimental control was not achieved. In a multielement design, experimental control is achieved through visible differentiation between conditions (Kazdin, 1982), which did not occur, with the possible exception of Patty’s disruptive behavior.

Functional Analysis with Known Problems

The functional analysis with known problems was intended to examine whether functional analysis results might be affected by bringing stimulus items (i.e., math computation problems) under appropriate stimulus control, which was lacking in the first functional analysis (i.e., responding was not under stimulus control of stimulus items). Given that the current method for conducting functional analysis failed to produce differentiated results with unknown math problems, a critical question is whether use of known math computation problems might produce differentiated effects and thereby be useful for detecting stimulus functions controlling academic responding and disruptive behavior. The results for the functional analysis with known stimulus items reveal two primary findings. First, visible differentiation of conditions for some dependent variables across participants was achieved. Second, controlling variables differed across all participants.

Patty. Figure 1 (middle panel) depicts Patty’s responding across dependent variables in the functional analysis with known problems. Experimenter attention
appears to have produced the highest rate of completed problems relative to other conditions. Additionally, a high degree of variability in the escape condition produced overlap between escape and all other conditions except control for rate of completed problems. Similarly, Patty’s rate of digits correct across sessions was higher in the experimenter attention condition relative to other conditions. The control condition produced a visibly lower rate of digits correct compared to other conditions, and escape was characterized by a high degree of variability. Patty exhibited high, yet variable rates of disruptive behavior in the escape and peer attention conditions. The experimenter attention condition, however, reveals a low, stable level of disruptive behavior across sessions, and no disruptive behavior was exhibited in the control condition. Patty displayed high and stable rates of academic engagement in the experimenter attention and peer attention conditions, whereas she displayed lower and highly variable academic engagement across sessions in the escape and control conditions.

Summary statistics (Table 5) confirm the visual inspection findings for the functional analysis with known problems. The experimenter attention condition produced the highest mean rate of completed problems (M = 18.3, SD = 2.8), which clearly exceeded the overall mean rate of completed problems (M = 14.5, SD = 3.9). Similarly, the experimenter attention condition produced the highest mean rate of digits correct (M = 39, SD = 7.6), which also exceeded the overall mean rate of digits correct (M = 27.8, 11.3). All other conditions fell within 1 standard deviation of the overall mean rates for completed problems and digits correct. Corresponding to the visual inspection results, the mean percentage of disruptive behavior exhibited in the escape condition (M = 58.3, SD = 23.2) and the peer attention condition (M = 37.8, SD = 43.2)
substantially exceed the percentage of disruptive behavior displayed in the experimenter attention (M = 10.9, SD = 7.3) and control conditions (M = 0, SD = 0). Additionally, the mean percentage of disruptive behavior exhibited during the escape condition was approximately 1 standard deviation above the overall analysis mean percentage of disruptive behavior across conditions (M = 26.7, SD = 32.4). The mean percentage of academic engagement in the experimenter (M = 100, SD = 0) and peer attention conditions (M = 98.5, SD = 3.0) clearly exceeded the mean percentage of academic engagement in the escape (M = 71, SD = 25.3) and control conditions (M = 73.1, SD = 11.8); however, all condition means fell within 1 standard deviation of the overall academic engagement mean for the analysis (M = 85.7, SD = 18.9).

Across dependent variables, experimenter attention produced more desirable outcomes for Patty, relative to other conditions. The experimenter attention condition produced the highest rates of completed problems, digits correct and academic engagement, while maintaining low, stable rates of disruptive behavior. This pattern of responding across conditions reveals response covariation between Patty’s disruptive behavior and her rates of completed problems, digits correct and academic engagement.

**Jennifer.** Figure 2 (middle panel) depicts Jennifer’s responding across dependent variables in the functional analysis with known problems. Experimenter attention and peer attention produce visibly higher rates of completed problems relative to other conditions. Additionally, a decreasing trend in the escape condition produced differentiation between the escape and control conditions, so that Jennifer exhibited the lowest overall rate of completed problems in the escape condition. Examination of Jennifer’s rate of digits correct across conditions reveals a pattern of responding, which
mirrors that of her rate of completed problems. The highest rates of digits correct were produced by the experimenter and peer attention conditions, and the escape condition produced the overall lowest rate of correct digits. Overlap is visible for the experimenter and peer attention conditions, and a decreasing trend is visible in the escape condition. Jennifer exhibited no disruptive behavior across conditions, with the exception of the escape condition. An increasing trend in disruptive behavior is evident in the escape condition, yet the overall rate of disruptive behavior remained fairly low across sessions. Jennifer displayed high rates of academic engagement across conditions, and the escape and control conditions were characterized by a high degree of variability.

Summary statistics (Table 6) confirm the visual inspection findings for the functional analysis with known problems. The experimenter attention condition (M = 20.1, SD = 0.3) and peer attention condition (M = 19.5, SD = 0.9) produced the highest mean rates of completed problems compared to the control (M = 15.7, SD = 0.6) and escape (M = 11.4, SD = 3.7) conditions. All condition means were within 1 standard deviation of the total mean rate of completed problems, with the exception of the escape condition mean, which was greater than 1 standard deviation below the total variable mean. However, the mean rates of completed problems for examiner and peer attention exceeded both the escape and control condition means by more than 1 standard deviation. Similarly, the experimenter attention condition (M = 36.6, SD = 0.7) and peer attention condition (M = 35.2, SD = 1.8) produced higher mean rates of digits correct compared to the control (M = 29.0, SD = 1.4) and escape (M = 21.7, SD = 6.7) conditions. Condition means fell within 1 standard deviation of the overall mean rate of digits correct (M = 30.6, 6.9), with the exception of the escape condition mean. The experimenter attention
and peer attention conditions means exceeded the mean rate of digits correct for both escape and control conditions. The mean percentage of disruptive behavior exhibited in the escape condition (M = 9.2, SD = 5.7) was greater than 1 standard deviation higher than the total mean percentage of disruptive behavior for the analysis (M = 2.3, SD = 4.8). Jennifer’s disruptive behavior for all other conditions fell within 1 standard deviation of the total disruptive behavior mean. Additionally, all condition means fell within 1 standard deviation of the overall academic engagement mean for the analysis (M = 95.8, SD = 5.5).

Across academic variables, experimenter attention and peer attention produced higher rates of responding for Jennifer relative to other conditions. The experimenter attention condition produced the highest rates of completed problems and digits correct, while maintaining stable (i.e., least variable) responding. Additionally, the escape condition produced the lowest rates of completed problems and digits correct and the highest rate of disruptive behavior. This pattern of responding across conditions reveals response covariation between Jennifer’s disruptive behavior and her rates of completed problems and digits correct.

**Erin.** Figure 3 (middle panel) displays Erin’s results in the functional analysis with known problems. Visual inspection of Erin’s rate of completed problems reveals a largely undifferentiated pattern of responding. Although increasing trends are visible in the escape and peer attention conditions, no controlling variables can be identified due to a high degree of overlap. Examination of Erin’s rate of digits correct across conditions reveals clear differentiation, with escape producing the highest rate of digits correct relative to other conditions. The control condition also produced a distinctly lower rate
of digits correct compared to other conditions. Erin exhibited low, near-zero rates of disruptive behavior across conditions, producing an undifferentiated pattern of response. Erin displayed high rates of academic engagement across the experimenter attention, peer attention, and escape conditions. A somewhat lower level of academic engagement is visible in the control condition.

Summary statistics (Table 7) support the visual inspection findings for the functional analysis with known problems. All condition means fell within 1 standard deviation of the total mean rate of completed problems ($M = 18.9$, $SD = 2.3$). The escape condition ($M = 26.9$, $SD = 6.9$) produced a significantly higher rate of digits correct than the experimenter attention ($M = 14.9$, $SD = 3.1$), peer attention ($M = 13.2$, $SD = 1.9$), and control ($M = 4.4$, $SD = 0.8$). Further, the mean rate of digits correct in the escape condition exceeded the overall mean rate of digits correct ($M = 14.8$, $8.8$) by greater than 1 standard deviation, and the mean rate of digits correct in the control condition fell more than 1 standard deviation below the total mean rate of digits correct. Erin’s disruptive behavior for all conditions fell within 1 standard deviation of the total disruptive behavior mean ($M = 1.5$, $SD = 2.4$). Additionally, all condition means fell within 1 standard deviation of the overall academic engagement mean for the analysis ($M = 95.8$, $SD = 5.5$), with the exception of the control condition ($M = 88.0$, $SD = 5.5$), which produced an overall mean percentage of academic engagement greater than 1 standard deviation below the total academic engagement mean.

The escape condition produced an overall higher rate of digits correct for Erin relative to other conditions; however, clear differentiation was not present across the other dependent variables.
Summary. Experimental control was established for all participants when known items were used in the functional analyses. Experimental control was clearer for some dependent variables than for others. Specifically, the clearest differentiation was present for rate of digits correct across all participants, suggesting that it may be the most sensitive variable for detecting changes in responding. For Patty, clear differentiation was also present for completed problems and academic engagement, and Jennifer also exhibited a clearly differentiated rate of completed problems. Across all participants, disruptive behavior produced the greatest amount of overlap across conditions in the functional analysis with known problems.

Functional Analysis Summary

Table 8 summarizes the results for all three participants across the functional analysis with unknown problems and the functional analysis with known problems. The functional analysis with unknown problems produced undifferentiated results for all three participants, precluding identification of controlling variables. However, the functional analysis using known problems produced differentiated responding for all three participants for at least one dependent variable. Patty produced clearly differentiated responding for both rate of completed problems and rate of digits correct after antecedent instruction. Experimenter attention produced significantly higher (i.e., more than 1 standard deviation) mean rates of completed problems and digits correct relative to other conditions and was selected as the effective condition for the extended analysis.

Clear differentiation was also visible in Jennifer’s results for both rate of completed problems and rate of digits correct. The mean rates of completed problems and digits correct in the experimenter attention and peer attention conditions exceeded
means for other conditions (i.e., escape, control) by more than 1 standard deviation. Both conditions were considered effective, yet the experimenter attention condition produced the least variable responding for completed problems and digits correct. Thus, the experimenter attention condition was selected as Jennifer’s effective condition for the extended analysis. Erin produced a clearly differentiated pattern of responding for rate of digits correct. The escape condition produced mean rates of responding that exceeded all other conditions (i.e., experimenter attention, peer attention, control) by more than 1 standard deviation. Therefore, escape was selected as Erin’s effective condition for the extended analysis.

**Extended Analysis**

The extended analysis was designed to replicate two like conditions (with and without prior instruction) using the condition producing the most desirable effects (i.e., effective condition) from the previous analyses. This analysis allowed for further examination of the impact of antecedent instruction in a new mathematics operation (i.e., division or subtraction). Overall, visual inspection of the extended analysis results reveal that conditions in which antecedent instruction was delivered consistently produced higher rates of responding compared to the same contingencies without antecedent instruction for all three of the participants. These findings are consistent with the previous two analyses, suggesting that not only does antecedent instruction produce higher levels of academic responding (through stimulus control), but also that antecedent instruction may have established the contingencies as being more reinforcing.

**Patty.** Patty’s extended analysis (Figure 1, right panel) reveals that the experimenter attention with known problems condition produced a visibly higher rate of
completed problems, rate of digits correct and percentage of academic engagement relative to the experimenter attention with unknown problems condition. Although both conditions produced increasing trends in Patty’s rates of completed division problems and digits correct, the experimenter attention condition using known problems resulted in a higher mean rate of completed problems (M = 40.0, SD = 6.9) and digits correct (M = 32.3, SD = 7.6) compared to the experimenter attention condition using unknown problems (M = 21.6, SD = 5.7 and M = 20.3, SD = 5.4, respectively). Specifically, the mean rates of completed problems and digits correct in the experimenter attention condition with known problems exceeded that of the experimenter attention condition using unknown problems by more than 1 standard deviation. Additionally, the experimenter attention condition using known problems produced higher academic engagement (100%) across all sessions, compared to the experimenter attention condition using unknown problems (M = 80.5, SD = 8.2). Further, Patty exhibited comparably low levels of disruptive behavior across both conditions, suggesting that both experimenter attention conditions (with and without antecedent instruction) produced low rates of disruption.

**Jennifer.** Jennifer’s extended analysis (Figure 2, right panel) reveals that the experimenter attention with known problems condition produced a visibly higher rate of completed problems and rate of digits correct relative to the experimenter attention with unknown problems condition. Although both conditions produced increasing trends in Jennifer’s rates of completed subtraction problems and digits correct, the experimenter attention condition using known problems produced a mean rate of completed problems (M = 19.4, SD = 1.9) and digits correct (M = 19.8, SD = 1.9) that exceeded the
experimenter attention condition using unknown problems (M = 13.1, SD = 1.5 and M = 13.2, SD = 1.5, respectively) by greater than 1 standard deviation. Additionally, the experimenter attention condition using known problems produced a higher mean rate of academic engagement (M = 98.8, SD = 2.4) compared to the experimenter attention condition using unknown problems (M = 93.7, SD = 7.7); however, both condition means fell within 1 standard deviation of one another. Further, Jennifer exhibited no disruptive behavior in both experimenter attention conditions (with and without antecedent instruction).

**Erin.** Erin’s extended analysis (Figure 3, right panel) reveals a visibly higher rate of completed problems and rate of digits correct in the escape condition with known problems relative to the escape condition with unknown problems. The escape condition using known problems produced a mean rate of completed problems (M = 38, SD = 0) and digits correct (M = 39, SD = 2) that exceeds the escape condition using unknown problems (M = 11.0, SD = 2.6 and M = 11.0, SD = 2.6, respectively) by greater than 1 standard deviation. Additionally, the escape condition using known problems produced higher academic engagement (100%) across all sessions, compared to the escape condition using unknown problems (M = 79.8, SD = 21.2); however, both condition means fell within 1 standard deviation of one another due to highly variable responding in the escape with unknown problems condition. Finally, Erin exhibited low rates of disruptive behavior across both escape conditions (with and without antecedent instruction).

**Summary.** The data demonstrate that differentiation was obtained in the extended analysis for all participants across academic variables. All three participants
produced visibly higher rates of responding for rate of completed problems and rate of digits correct in the condition using known problems. The extended analysis replicated the overall outcomes across analyses by producing results consistent with the previous phases using a distinct operation (i.e., division, subtraction).

**Summary of Results Across Analyses**

Overall, although the functional analysis using unknown problems produced a great deal of overlap across conditions, the functional analysis using known problems produced consistent results regarding the function of alternative academic behaviors. Additionally, antecedent instruction (provided between the functional analysis with unknown and functional analysis with known problems) produced distinctly different and differentiated patterns of responding across conditions for all participants. Furthermore, substantially higher levels of accuracy and academic engagement were exhibited across conditions after antecedent instruction (functional analysis with known problems). Moreover, the gains achieved following antecedent instruction were demonstrated across mathematics operations (i.e., multiplication and division, addition and subtraction).

Thus, inclusion of antecedent instruction in the functional analysis was not only necessary to discriminate between effects of treatment conditions, but the instruction also produced improvements in mathematics performance across computation problem type.
CHAPTER 4

Discussion

The purpose of this study was to investigate methods for conducting functional analyses with replacement behaviors. Specifically, the study was designed to answer two research questions. First, what is the effect of applying functional analysis methodology to alternative academic behaviors in terms of producing consistent results regarding function? Second, what is the effect (if any) of establishing stimulus control through antecedent instruction for academic responding on the outcomes of functional analysis applied to alternative academic behaviors? In particular, do functional analysis outcomes remain consistent or does antecedent instruction alter functional analysis results by producing different patterns of behavior?

To answer both research questions, two functional analyses were conducted with three participants in which math problems were presented as the instructional task and differential consequences were delivered contingent on problem completion. The difference between them was that the first functional analysis included unknown math problems as stimulus items and the second functional analysis included known math problems as stimulus items. To assure instructional items were known in the second functional analysis, instruction was carried out. Overall, the results of the study suggest that functional analyses using unknown problems (first method) produced largely undifferentiated results across participants and function was not identified. However, the functional analysis using known problems (second method) produced differentiated results across participants, and a different function was identified both within and across participants. Additionally, these findings were replicated in the extended analysis, and
higher rates of academic responding were consistently obtained in the conditions with antecedent instruction for all participants.

**Research Question 1: What is the Effect of Applying Functional Analysis Methodology to Alternative Academic Behaviors in Terms of Producing Consistent Results Regarding Function?**

Very few functional analysis studies have been conducted using replacement behaviors. Most functional analysis research has focused on identification of variables maintaining problem behavior (Gable et al., 1995). Although this literature has yielded essential information regarding problem behavior, functional analysis of problem behavior has limited treatment utility for increasing alternative or incompatible replacement behaviors for two reasons. Recent research has revealed that the topography of reinforcement (e.g., type of attention) differentially impacts behavior (Kodak, Northup & Kelley, 2007), and the topography of typical functional analysis conditions varies when applied to problem or replacement behavior (i.e., reprimand v. praise). Second, the variables maintaining problem behavior may not maintain replacement behavior (Holden, 2002). Therefore, the application of functional analysis methodology to replacement behaviors was intended to identify controlling variables directly maintaining the desired behavior, bypassing the inference necessary when selecting a treatment intended to increase a replacement behavior based on functional analysis results that targeted problem behavior only.

It was hypothesized that the participants would exhibit similar rates of responding within conditions; yet, differentiated responding across conditions was predicted to occur, allowing for identification of controlling variables. Findings similar to those produced by
research in the area of functional analysis of problem behavior (e.g., Iwata et al., 1982/1994) were expected with application of functional analysis to replacement behavior. However, the functional analysis with unknown problems produced largely ambiguous or undifferentiated response patterns across dependent measures for all participants. Thus, applying functional analysis methodology to replacement behavior (i.e., academic responding) in this study did not allow for identification of controlling variables when unknown stimulus items were used.

In reviews of the literature on functional analysis, Hanley et al. (2003) and Iwata et al. (1994) report that controlling variables are identified for the vast majority of cases, leaving only 5% to 6% of cases undifferentiated (Hanley et al., 2003; Iwata et al., 1994). In the current study, all of the functional analyses conducted with unknown problems (first method) produced undifferentiated results, which is highly discrepant from what one would expect based on the research literature and therefore raises serious concerns about the validity and utility of the method. The second method of functional analysis (using known problems) produced differentiated results both within and across participants, making it a much more promising approach. However, the failure of the first method coupled with the success of the second method may be quite instructive for future functional analysis studies targeting academic performance.

Previous research on functional analysis of problem behavior examining strategies for clarifying behavioral function when initial analysis results are ambiguous (e.g., Roane, Lerman, Kelley, & Van Camp, 1994; Tiger, Fisher, Toussaint, & Kodak 2009) is helpful for clarifying what may have occurred in the present study. In previous studies, researchers have resolved inconclusive functional analyses by (a) incorporating
idiosyncratic reinforcement conditions (Hagopian, Wilson, & Wilder, 2001; Tiger et al., 2009), (b) manipulating the presence of particular stimuli (Carr et al., 1997), and (c) arranging motivating operations to evoke problem behavior under certain conditions (Roane et al., 1999). Tiger et al. (2009) delineated three possible explanations for ambiguous or undifferentiated functional analysis results. First, it is possible that the analysis was missing a critical condition, and the behavior is maintained by consequences not included in the analysis. Second, it is possible that the correct conditions were included in the analysis, but the behavior is under stimulus control of an environmental event not included in the analysis. Lastly, it is possible that the conditions were appropriate, but a motivating operation was not present to potentiate the functional reinforcer. This body of research suggests that undifferentiated analyses do not necessarily indicate that the controlling variables related to the target behavior cannot be identified (i.e., failed analysis). Rather, it appears that initial ambiguous analyses are probably missing one or more components (e.g., discriminative stimuli, MOs, reinforcers) necessary for identification of behavioral function (Tiger et al., 2009).

In the current study, the critical difference between both methods of functional analysis was the type of instructional items that were used. Although the consequences remained the same (in terms of the types of reinforcement and the schedule of reinforcement) in both functional analyses, an antecedent variable—the presentation of known versus unknown stimulus items—differed across analyses. It would appear, therefore, that functional analysis targeting academic responding using known stimulus items is a more productive method for application and future investigation. The first method used in this study provided differential consequences for a behavioral deficit that
was not under appropriate stimulus control (stimulus items were unknown), which is quite different from a functional analysis conducted with a behavioral excess which capitalizes on already existing forms of stimulus control and provides high doses of various types of putative reinforcers to identify behavioral function. The lack of stimulus control characteristic of the first functional analysis reduced the likelihood that the target behavior would occur in the first place and impacted the frequency of reinforcement, making it virtually impossible to detect behavioral function.

The absence of relevant discriminative stimuli in functional analysis conditions are likely to produce negative outcomes, potentially leading to the faulty conclusion that the reinforcers present do not influence the target behavior (Carr et al., 1997). In other words, the consequences may be theoretically effective (assuming the appropriate motivating operations are also present), but the signaling function of the discriminative stimuli (e.g., presentation of an instructional item) is not operating when response strength is low. In the current study, the first functional analysis failed to detect behavioral functions that were clearly present for participants as revealed in the second functional analyses (experimenter attention for Patty and Jennifer and escape for Erin). Although relevant discriminative stimuli are at times omitted from functional analyses of problem behavior, this is much more likely to occur in an analysis targeting behavioral deficits (i.e., replacement behaviors). In the case of a behavioral excess (e.g., problem behavior), it is simply a matter of identifying and including the appropriate discriminative stimulus; however, when an appropriate level of stimulus control has not yet been established for a behavioral deficit, there is nothing to evoke the appropriate response.
The problem presented by absence of stimulus control was perhaps further exacerbated by its impact on the overall amount of reinforcement delivered across sessions. The math problems in the current study had not yet become associated with the reinforcers present across conditions, resulting in low rates of academic performance. Although a continuous schedule of reinforcement was employed across conditions, the low frequency of behavior resulted in a low frequency of reinforcement, probably due to the absence of antecedent instructional strategies (modeling and prompting), which would evoke correct responses that could then be reinforced. For academic performance and other behavioral deficits, it appears that establishing some level of stimulus control for the instructional task that brings the participant into contact with the contingencies for instructional items may be necessary to obtain accurate and differentiated functional analysis results.

Comprehensive functional analyses include manipulations of antecedents and consequences to identify functional relationships (Hanley et al., 2003). In the functional analysis with unknown problems, key controlling variables were not directly programmed into the analysis. Although other relevant antecedent variables may have been present in the functional analysis with unknown problems (e.g., motivating operations), instructional items that had discriminative control over the replacement behavior were not systematically included in the analysis. The functional analysis with known problems produced distinct outcomes compared to the analysis with unknown problems, and it appears as though the second functional analysis method (i.e., using known items) remedied the problems inherent in the initial analysis. Using items with appropriate discriminative control over academic responding allowed for identification of
a function of replacement behavior (i.e., academic responding) for all participants. The functional analysis with known problems produced consistent within-subject variability across (but not within) conditions, so that discernible and consistent patterns of responding across conditions were identified for each participant. Additionally, idiosyncratic responding was observed across participants: responding varied across participants, both in level and in patterns of responding across conditions. Thus, the data provide individualized information regarding reinforcers that may promote academic responding. As such, the current findings suggest that applying functional analysis methodology to alternative academic behaviors is a viable method for producing consistent results regarding function when instructional items exert antecedent control over responding. The results of the functional analysis with known problems produced results consistent with those observed for functional analyses of problem behavior, in which sources of influence are identified for up to 96% of cases (Iwata et al., 1994).

The positive impact of incorporating relevant stimulus items for which discriminative control had been established through instruction was further demonstrated in the extended analysis. The extended analysis compared conditions which produced the same consequences, but which varied in terms of the types of instructional stimuli that were presented. In one case, student responding was not under appropriate stimulus control (unknowns) and in the other case, student responding was under appropriate stimulus control (knowns). In all cases, the conditions including known items produced visibly higher rates of responding across participants. More importantly however, the rates of behavior were consistent with observed patterns in the prior functional analyses. This finding rules out the possibility of a mere sequence effect accounting for prior
differences across functional analyses. The specific effects of developing stimulus control on functional analysis outcomes will be discussed further in the following section (Research Question 2). The important point here is that the results were replicated in a separate phase using an entirely different type of computation problem for each participant, attesting to the generality of results across problem types for each participant.

The results of the functional analysis with known problems extends both functional analysis (e.g., Iwata et al., 1982/1994) and treatment-based analysis research (e.g., Harding et al., 1994; Millard et al., 1993) by demonstrating that behavioral function can be identified for replacement behaviors (i.e., academic responding). This type of analysis may be more feasible for educators who do not have to evoke problem behaviors (as is the case in traditional functional analyses) and who can design functional analysis conditions that more accurately reflect the types of instructional events that are going on in the classroom using variables that can potentially affect both behavioral excesses as well as academic deficits. A further advantage is that educators can bypass the inference necessary with a functional analysis of problem behavior, meaning that analyses can directly target relevant motivational and instructional variables simultaneously. The result is that empirically derived interventions can be more easily extended to the classroom. Therefore, the results of a functional analysis of replacement behavior may have greater ecological validity when all the necessary controlling variables are present (i.e., motivating operations, discriminative stimuli, and consequences).

These findings may also be relevant to classrooms in which similar types of reinforcers may be available to children (e.g., contingent teacher attention for correct answers, contingent breaks for completing assignments). For a child exhibiting
behavioral excesses and deficits, teachers may be more likely to design interventions to address the behavioral excesses, as these are the most salient behaviors (Sterling-Turner et al., 2001). This approach may reduce the behavioral excesses observed, but those interventions are likely to be missing critical variables that are needed to establish appropriate forms of academic responding. The current findings suggest that effective instruction brings academic responding into contact with sources of reinforcement that are common in classrooms, and that those reinforcers may be idiosyncratic across children. Nonetheless, those forms of reinforcement will not be effective if instruction is not appropriately configured to make correct responding possible (Heward, 1994). For this reason, for children exhibiting both behavioral excesses and academic deficits, exclusive emphasis on behavioral interventions may be neglecting the development of academic skills and may be less efficient than strengthening skills through differential reinforcement.

Although the findings of the current study are directly relevant to classroom-based intervention, implementation of identified conditions in the natural setting was not examined as part of the current project. Additional research is necessary to determine whether the results of functional analyses of replacement behavior yield effective treatments when implemented in classrooms. The methodology used in the functional analysis with known problems appears to be promising for identifying the conditions under which optimal academic responding can be achieved. In the future, researchers should examine the impact of interventions derived from functional analyses of replacement behavior to ensure that the conditions identified generalize to the classroom and other relevant settings. For example, interventions derived from functional analyses
for academic performance could be compared to interventions derived from functional analyses of disruptive behavior to determine which interventions are more efficient and efficacious. It would also be beneficial to conduct a comparison of conditions in the natural setting to compare outcomes across settings and examine the impact of setting on the relative effectiveness of conditions. Finally, future research could examine just how accurate responding needs to be during the functional analysis to produce accurate identification of controlling variables. In the current study, instructional items were either unknown or known. In the classroom, the teacher is generally adding new instructional items over time. It may be productive in the future to conduct parametric evaluations of ratios of known to unknown stimulus items to determine optimal ratios that achieve the most valid and generalizable identification of controlling variables.

**Research Question #2: What is the Effect of Establishing Stimulus Control for Academic responding on the Outcomes of Functional Analysis?**

It was hypothesized that bringing student responding under stimulus control of the instructional items (math computation problems) using antecedent instruction would have three primary effects on functional analysis outcomes. First, it was predicted that altering task difficulty through antecedent instruction would change functional analysis outcomes. Specifically, one would expect higher rates of responding when conditions were preceded by instruction. Second, it was hypothesized that using instructional items that had stimulus control over responding would increase the probability of reinforcement, which would elevate academic responding and academic engagement in conditions with effective consequences relative to conditions with ineffective consequences in the second functional analysis. Third, it was expected that academic responding and academic
engagement would covary with disruptive behavior in conditions containing effective consequences for behavior. Therefore, development of stimulus control was expected to change functional analysis results when compared to the functional analysis with unknown facts.

The functional analysis results following antecedent instruction are substantially different compared to the results obtained using unknown or uninstructed problems. A clear pattern of differentiation emerged only after antecedent instruction, suggesting that when instructional items are brought under stimulus control, differentiated patterns of responding across conditions are more likely. Two primary differences can be seen in the present data when comparing response patterns in the functional analysis with unknown problems and the functional analysis with known problems. First, the overall level of responding is higher for facts complete and digits correct in the second functional analysis, which is not at all surprising in light of the fact that the sessions now included known items. The overall higher levels of academic responding during the second analysis provide evidence that instruction altered (i.e., reduced) task difficulty, as initially predicted.

The second difference between functional analyses is much more interesting. Specifically, a clear pattern of differentiation across conditions emerged after antecedent instruction for each participant, whereas results were undifferentiated for all participants when unknown items were used. Antecedents that exert control over behavior can be one of two types: they can exert discriminative control (discriminative stimuli) or they can exert motivational control (motivating operations; Michael, 2004; Smith & Iwata, 1997). Smith and Iwata clarify the distinction in the following way. Antecedents are categorized
as discriminative stimuli when behavior is systematically altered by antecedents that are differentially correlated with consequent events. In other words, the contingent relationship between the presence of the antecedent and occurrence of reinforcement for a response should produce variability in response levels across conditions such that behavior occurs in the presence of the discriminative stimulus and does not occur in its absence. Behavior varies differently as a function of MOs, however. To demonstrate an MO effect, one must be able to rule out that variable behavior across antecedent manipulations is due to contingency correlations between discriminative stimuli and consequences. In other words, the behavior-consequence contingencies must be held constant while behavior varies across antecedent manipulations. The critical question is whether differences in results across functional analyses can be accounted for through discriminative control or motivational control when those functional analyses maintained the same consequences for responding.

The discrepancy between functional analyses speaks to the importance of having stimulus materials that can evoke correct responses for a behavioral deficit. If responses are not evoked, potentially effective consequences cannot affect behavior. In the initial analysis (with unknown problems), it would appear that the condition-specific consequences were contacted infrequently due to the lack of discriminative control exerted by the math problems over responding. The effectiveness of the consequences in the second functional analysis for at least one condition and the replication in the final phase of the experiment suggest that the appropriate MOs were likely present for at least one type of reinforcement (e.g., social attention for Patty and escape for Erin) throughout the analyses; however, these consequences were not adequately contacted in the absence
of discriminative stimuli (i.e., first functional analysis). Indeed, the final phase directly compared the effective condition with and without instruction. The only difference between conditions was whether the stimulus items could evoke a correct response (second functional analysis) or not (first functional analysis). In the absence of stimulus control, the function of a behavioral deficit (i.e., academic responding) may be “latent.” It is only when discriminative stimuli are developed for a behavioral deficit that responding can be evoked to contact contingencies and reveal the function of behavior. Behavior will then vary as a function of prior satiation or deprivation conditions (MOs) and according to which reinforcement contingencies are effective for the learner being examined.

The findings of the current study raise important questions about the validity of functional analysis results across different proficiency levels with the instructional tasks. In the current study, stimulus items were either “known” or “unknown.” However, response strength for behavioral deficits grows over time as responding first becomes accurate, then fluent, and then generalizes across stimulus conditions (Haring & Eaton, 1978; Wolery, Bailey, & Sugai, 1988). Thus, the optimal ratio of known to unknown items used in a functional analysis of replacement behavior has not yet been determined. However, the results of the current study demonstrate that use of known items (those that have stimulus control over responding) allows for the detection of behavioral function. This behavioral function may then be applied as an effective consequence for future instructional targets as part of the acquisition, fluency-building, or generalization processes. Presumably, one or more consequences (e.g., attention, escape, tangibles) is an effective reinforcer prior to instruction, but the reinforcer cannot be adequately
accessed until instructional strategies (e.g., response prompting, practice) are present to evoke responding. Using known items in the functional analysis would appear to allow for identification of these existing functional relations, which may be applicable to upcoming instructional targets when appropriate instructional strategies are implemented.

The initial functional analysis did not include response-prompting or other acquisition strategies, resulting in low rates of accurate responding across conditions. Yet, in classrooms, teachers use instructional strategies including modeling, practice and error correction to strengthen responding. Therefore, it is likely that the classroom application of functional reinforcers, identified through functional analyses with known problems, will serve as effective consequences across various levels of proficiency. The extended analysis provides further support for the effectiveness of identified functional reinforcers. The functions identified for participants in the functional analysis with known problems were subsequently applied to a novel mathematics operation. These identified reinforcers resulted in higher rates of responding with instruction than without instruction, not only replicating the findings of the functional analyses, but also demonstrating the applicability of identified function to future target areas. However, future research is necessary to determine the extent to which these results generalize to other academic skills (e.g., reading). Future studies could also investigate the emergence of functional relations for new instructional tasks as response strength grows (accuracy, fluency, generalization). It would be particularly interesting to determine whether functional analyses using known stimulus items predict which reinforcers would be more effective during instruction which alternated types of reinforcement across instructional items that have yet to be learned.
Although it was expected that response covariation would occur for effective consequences in the second functional analysis, the results did not support this hypothesis. In fact, the rate of disruptive behavior remained fairly low for all participants across conditions, revealing little covariation with rate of completed problems, rate of digits correct, or academic engagement across conditions. Although the participants were rated by teachers to have high rates of disruptive behavior in the classroom, the one-on-one setting used across analyses may have resulted in low rates of disruptive behavior, despite manipulation of relevant contingencies. It is also possible that simply making reinforcement available contingent on replacement behavior produced overall lower rates of disruptive behavior. In the current study, the levels of disruptive behavior across participants were low and stable, precluding the variability necessary to establish the predicted response covariation. Therefore, this question could not be adequately addressed by the results. In the future, researchers may want to select participants with more severe behavior problems or include conditions that reinforce inappropriate behavior (as one does in a traditional functional analysis) to more adequately examine the possibility of response covariation.

Limitations

A number of limitations should be considered when interpreting the findings of the current study. It is possible that a sequence effect may be present in the data. It may be the case that stimulus control alone was not responsible for the changes observed across analyses. Rather, it may be the sessions delivering instruction between sessions that accounted for the observed results. However, this limitation may be more apparent than real due to the fact that the replication present in the extended analysis significantly
reduces the likelihood of a sequence effect. The extended analysis included conditions with and without antecedent instruction simultaneously and the overall findings in the initial analyses are replicated, suggesting that stimulus control is likely the key variable contributing to the observed changes from unknown to known analyses.

The behavioral screening form, which was used to identify students with high rates of externalizing behavior, is not a research-based screening tool. Thus, the scores obtained from this form may be influenced by subjective interpretations of those completing the screener. In other words, the current participants’ high scores based on classroom teacher report may reflect relative ratings of externalizing behavior compared to classroom peers, rather than rates compared to a normative sample. This suggests that the overall rates of externalizing behavior in the classroom may have influenced the inclusion or exclusion of students in the study. The current participants had very low rates of disruptive behavior during the study sessions; however, no information regarding classroom rates of externalizing behavior is available. To resolve this potential selection problem, future studies should use more rigorous screening methods (e.g., Systematic Screening for Behavior Disorders; Walker & Severson, 1992).

This being the initial attempt at applying functional analysis methodology to replacement behaviors, ongoing alteration of conditions may be necessary to fine tune the analysis procedures. There may be idiosyncratic discriminative stimuli for problem behavior present as part of analysis conditions. For instance, Patty exhibited high rates of disruptive behavior in the peer attention condition. For Patty, peer presence may signal the availability of reinforcement (i.e., attention) for disruptive behavior. Additionally, withholding peer attention for disruptive behavior, as in the current study, may actually
create a deprivation state that could make peer attention more reinforcing. If
discriminative stimuli for problem behavior are detected during the analysis, extended
sessions designed to establish peers and teachers as discriminative stimuli for academic
responding may be helpful for producing differentiation.

The escape condition may present problems for a functional analysis of
replacement behavior. It is possible to access escape by leaving the table, terminating the
session, and a number of behaviors other than academic responding. This was not a
concern for the current participants, as they were repeatedly presented with stimuli until
they provided an academic response; however, this could be problematic for other
students for whom problem behavior has consistently produced escape in the past. Future
research should target non-aversive ways to restrict access to escape, so that escape can
be provided contingent on identified replacement behaviors.

Lastly, continuous reinforcement was used across conditions in the current
analyses, maintaining consistency with functional analysis of problem behavior
methodology. However, continuous reinforcement may not be ecologically valid, as
there are few teachers or clinicians who could regularly reinforce each instance of
appropriate behavior. In the future, researchers should examine various schedules of
reinforcement to determine whether thinner, more ecologically valid reinforcement
schedules are adequate to produce differentiation in functional analyses of replacement
behavior.

**Conclusion**

The purpose of this study was to apply functional analysis methodology to
replacement behavior (i.e., academic responding) and examine the impact of instruction
on the resulting analysis. Using typical school-based functional analysis conditions (i.e., experimenter/teacher attention, peer attention, escape, control) in which contingencies were applied to academic responding, an analysis was conducted using unknown problems, followed by an analysis using known problems. An extended analysis using the most effective condition from the previous analyses (with and without instruction) was conducted for replication purposes. The results demonstrated that 1) applying functional analysis methodology to replacement behavior produced consistent results regarding function when antecedent instruction was incorporated, and 2) establishing stimulus control for academic responding changed the functional analysis outcomes. Specifically, it appears as though bringing student responding under stimulus control of stimulus items (i.e., math fact cards) brought participants into contact with otherwise effective contingencies for behavior. Thus, instruction was a critical variable in producing meaningful differentiation for all participants, and has important implications for future functional analysis research on academic performance.
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Appendix A

Behavior Screening Form

Externalizing refers to all behavior problems that are directed outwardly, by the child, toward the external social environment. Externalizing behavior problems usually involve behavioral excesses, (i.e., too much behavior) and are considered inappropriate by teachers and other school personnel. Non-examples of externalizing behavior problems would include all forms of adaptive child behavior that are considered appropriate to the school setting.

Examples include:
- displaying aggression toward objects or persons,
- arguing,
- forcing the submission of others,
- defying the teacher,
- being out of seat,
- not complying with teacher instructions or directives,
- stealing,
- not following teacher or school imposed rules.
- having tantrums,
- being hyperactive and
- disturbing others

Non-Examples include:
- cooperating, sharing
- working on assigned tasks
- making assistance requested in an appropriate manner,
- listening to the teacher,
- interacting in an appropriate manner with peers
- complying with teacher requests
- following directions and
- attending to task

Please rate the following three items for only students identified from your class as exhibiting externalizing behavior AND academic problems to the greatest degree.

Student Initials/numeric code

<table>
<thead>
<tr>
<th>1. The severity of externalizing behaviors.</th>
<th>Very Mild</th>
<th>Somewhat Mild</th>
<th>Moderate</th>
<th>Somewhat Severe</th>
<th>Very Severe</th>
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<tr>
<th>2. The frequency of externalizing behaviors.</th>
<th>Very Infrequent</th>
<th>Somewhat Infrequent</th>
<th>Moderate</th>
<th>Somewhat Frequent</th>
<th>Very Frequent</th>
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Student Initials/numeric code

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Appendix B

Functional Analysis of Replacement Behavior Observation Form

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Total TB: _______TB/ _______ #intervals = _______ %
Total AE: _______AE/ _______ #intervals = _______ %

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Total circled / + T: __________
Circled / + T + total / + T: __________
(Circled / + T - X) ÷ total / + T: __________
Behavior Codes:
Academic Engagement  Active academic responding, including reading problems aloud, writing on note cards, and overt calculation of problems (e.g., counting on fingers, counting aloud, in a whisper or silently moving one’s mouth). Record whether or not the student is engaged at 10-second intervals, using momentary time sampling.

Disruptive Behavior  Record target behaviors using 9-second partial interval recording. Indicate any instance of the following by circling the corresponding code (TB).

Disruptive behavior: Marker/pencil tapping; drawing or writing on self, table, or other non-paper surface; making faces or gestures; talking not categorized as academic engagement (e.g., reading problems, performing problem steps aloud); laughing, singing, humming or whistling.

Record condition fidelity by doing the following:
After performing the behavioral observations, watch the video again to score condition fidelity. Record both student behaviors (academic responding and target behaviors) as well as experimenter/peer behaviors using frequency recording. Mark a / for each instance of academic responding (i.e., completion of a math fact card). If the behavior (academic responding) is followed by the condition-specific response (i.e., experimenter attention during the experimenter attention condition, peer attention during the peer attention condition, demand removal during the escape condition, or no action/response during the control condition), circle the / . Use the following definitions to determine whether the appropriate response occurred for each condition. If any other response is provided (e.g., teacher attention provided during escape condition), turn the / into an X (error). Across all conditions, record a T for target behaviors. If the target behavior is ignored, circle the T. If the target behavior is followed by a response, leave the T uncircled.

Definitions:
Teacher Attention  Any physical contact, facial expression, gesture, or verbal comment directed toward the participant by the teacher.

Peer Attention  Any physical contact, facial expression, gesture, or verbal comment directed toward the participant by the peer.

Escape/Demand Removal  Removing a task or demand: Physically removing a note card/providing a break following academic performance (i.e., completion of one math problem).
Appendix C

Incremental Rehearsal

**Preparation**
- Organize instructional flashcards into two piles—those that have already been instructed in previous sessions (instructional pile) and those that are unknown or have not yet been instructed (reserve pile). If this is the first session, take 2 unknown cards from the reserve pile to make up the instructional pile.
- You will begin by reviewing items from the known/instructional pile and only add items from the reserve pile at step 5.

**Practicing Instructional Items with a Prompt Delay Procedure (Modeling Prompt)**
- 1. Shuffle all items from the instructional pile.
- 2. **Present all instructional items** one at a time and prompt the student to give the correct response.
   - If the student does not provide the correct answer in 3 seconds, **model** the correct response and **have the student repeat** it.
- 3. After the instructional cards have been presented once, shuffle the flashcards and **keep** them in one instructional pile.
- 4. Repeat these steps until the student responds correctly to all items without the delayed prompt (i.e., within 3 seconds and no model provided) on any item.
   - When the student responds correctly to all items from the instructional pile without the delayed prompt, begin folding in new instructional items (see next steps).

**Folding New Instructional Items into Acquired Items**
- 5. Put a **new instructional item** (from the reserve pile) at the beginning of the instructional pile.
- 6. **Present** the **new instructional item**, **Model** the correct response. **Prompt** the correct response.
   - If the student repeats correctly, praise the student.
   - If the student makes an error, say, “No, the correct response is ______. Say it!” Repeat as necessary.
- 7. **Present** the **remaining instructional items** one at a time and **prompt** the student to give the correct responses.
   - If the student does not provide a correct answer in 3 seconds, **model** the correct response and **have the student repeat** it.
- 8. Shuffle all the instructional items presented up to this point and **put** them into one instructional pile.
- 9. **Present all instructional items** from the instructional pile one at a time and **prompt** the student to give the correct responses.
   - If the student does not provide a correct answer in 3 seconds, **model** the correct response and **have the student repeat** it.
- 10. Repeat steps 8 and 9 until the student responds correctly to all items without the delayed prompt (i.e., within 3 seconds and no model provided) on any item.

Steps 5 – 10 can be repeated for new instructional items during the instructional session by adding them according to step 5 and following steps 6 to 10 until time has run out.
Appendix D

INFORMED CONSENT FORM
FOR THE TEACHER
Functional Analysis of Replacement Behavior Project
Kristi Hofstadter, Ed.S.
Edward Daly, Ph.D.

Your student is invited to participate in research being conducted by faculty and students of the School Psychology program at the University of Nebraska – Lincoln. The goal of the project is to study methods of assessment for improving students academic and behavioral performance. We believe that your student may benefit from the information provided from the information provided by these assessments and any instructionally relevant information that may result. We also believe that there is little risk involved, as we will be using methods that have been shown to be effective in prior research. The greatest apparent source of risk is any frustration your student might experience while being assessed. Your student is one of a number of children being invited to participate. If your student participates in the study, a school-technologist-in-training and perhaps undergraduate students will work with your student and you.

The study will be conducted in three parts and will be carried out as part of the school psychology student’s dissertation requirements. The first part should take approximately three weeks. During this time, your student will complete basic math problems for brief periods of time (1 to 5 minutes) during several sessions, while receiving one of three rewards (experimenter attention, peer attention, break from work). During the second part of the study, we will provide math fact fluency instruction and your student will then continue to complete basic math fact problems for brief periods of time during several sessions while continuing to receive one of three rewards. The third and final part of the study will involve a comparison of the methods used within the first and second portions. This will allow us to determine whether a behavioral strategy alone or a combined instructional and behavioral strategy works best to improve the academic and behavioral performance of your student. Finally, we will describe the most effective technique to you and assist in the development of an intervention plan if necessary. Specifically, we will consult with you to develop a plan that might help improve your student’s academic and behavioral performance. We will assess the effects of this intervention plan. For ease of observation and to make sure that the researcher is conducting the procedures correctly, we will videotape the sessions. The assessment sessions will be brief, lasting approximately 15 minutes. The sessions will be done between three and five times a week, and the complete study will take approximately two to three months to complete. We will consult with you about the best times to work with or observe your student and when it is appropriate to take the student out of the classroom. We will make every attempt not to take the student during instructional time. Information regarding behavioral severity and frequency will be gathered from you to identify students who may be appropriate for the project; however, you will not be responsible for providing any additional data (e.g., outcome data).

Your permission is required for us to be able to gather information about your student who is participating in the study or from you. The voluntary nature of participation and the procedures will be explained to the student, and he or she will be given the opportunity to choose whether or not he or she will participate. The parent permission form explains that the information may be useful to school personnel to plan more effective instruction for your student. Therefore, we are willing to share results with you if they can help you to instruct your student better. Videotapes and observation forms on which your student’s performance is recorded will be kept in Dr. Daly’s locked cabinet for three years and then

114 Teachers College Hall / P.O. Box 88345 / Lincoln, NE 68588-0345
destroyed. Also, if the results are published in a research journal or presented at a conference, pseudonyms will be used so that no one can tell that the data are your student’s data.

There may be alternative services for the kinds of educational practice and instruction your student would receive through his or her participation in this study. If you suspect that your student may have a disability, we suggest that you contact the school psychologist who will take appropriate action. Also, psychoeducational assessment and tutoring are offered through various agencies throughout the region. However, these services are usually for a fee and it would be the parents’ responsibility to pay for any such services.

You may ask any questions concerning this research and have those questions answered before agreeing to participate in or during the study. Or you may call the investigator at any time, office phone, (402) 472-5923, or after hours (402) 429-0896. Please contact the investigator:

- If you want to voice concerns or complaints about the research, and/or
- In the event of a research related injury.

Please contact the University of Nebraska-Lincoln Institutional Review Board at (402) 472-6965 for the following reasons:

- You wish to talk to someone other than the research staff to obtain answers to questions about your rights as a research participant;
- To voice concerns or complaints about the research;
- To provide input concerning the research process; and/or
- In the event the study staff could not be reached.

You are free to decide not to participate in this study or to withdraw at any time without adversely affecting your relationship with the investigators, the University of Nebraska, or the school. You are voluntarily making a decision whether or not to let your student participate in this research study. Your signature certifies that you have decided to participate having read and understood the information presented. You will be given a copy of this consent form to keep.

Signature of Teacher __________________________ Date ________

Name and phone number of investigator(s)

Edward Daily Office: (402) 472-5923
Kristi Hofstadter Office: (402) 471-2471
Functional Analysis of Replacement Behavior

What is Functional Analysis of Replacement Behavior?
- An assessment intended to help students by identifying the situations in which they demonstrate appropriate behavior and increased mathematics performance.
- Several intervention components, including structured consequences for appropriate behavior and math instructional strategies, will be tested across time to tailor behavioral and academic interventions to student needs.

Assessment Conditions:
- Experimenter attention: Math computation cards will be presented to the student, one at a time, and the experimenter will provide attention (e.g., praise, high five) for each problem completed.
- Peer attention: Peer selected by classroom teacher. The process will be modeled for peers, who will also receive instructions, sample praise comments, and practice. Peers will present computation cards and provide attention for each problem completed.
- Escape/Break: Math computation cards will be presented, and a 15-second break will be provided for each problem completed.
- Control: A stack of computation cards will be given to the student, and the experimenter will remind the student to “get back to work” after each instance of disruptive behavior.

Project Overview:
- Screening: Unknown math facts will be identified for use in the first assessment series.
- Assessment series 1: Assessment conditions are randomly presented in 5-minute sessions using unknown math computation cards.
- Instruction: All unknown math facts will be instructed until each student answers 100% of facts correctly.
- Assessment series 2: Assessment will be repeated using known math facts.
- Each session will be videotaped to reduce potential student discomfort caused by multiple observers. The videotapes will be used to collect data on both disruptive behavior and academic engagement across all sessions. All videotapes will be given codes corresponding to participants, and research assistants who collect data using the videos will use the participant codes on all corresponding paperwork.
- The strategies (conditions with or without instruction) that produce the greatest increase in academic engagement and corresponding decrease in disruptive behavior will be incorporated into specific intervention recommendations.
Who would be involved?
• 3 to 6 students in 2nd through 5th grade identified by teachers as having both disruptive behavior and problems with math performance.
• Students would participate in approximately four 5-minute sessions (approximately 20-30 minutes) three to five times per week.
• All assessment sessions will be conducted by Kristi Hofstadter, the primary investigator.
• Screening and instruction will be conducted by Kristi Hofstadter and/or research assistants.

What are the benefits of this project?
• Students will be receiving state-of-the-art, research-based services that will lead to concrete recommendations for how to improve their educational programming.
• Students will learn all math facts 1-12 across two operations (e.g., addition, subtraction).
• The resulting recommendations will be beneficial for both classroom teachers as well as parents, and recommendations for individualized intervention will be provided across settings.

If you have any questions or would like additional information, please contact Kristi Hofstadter (402) 472-2471 (khofstadter2@unl.edu), Edward J. Daly (402) 472-5923 (edaly2@unl.edu)
INFORMED CONSENT FORM
Functional Analysis of Replacement Behavior Project
Kris Hofstadter, Ed.S.
Edward Daly, Ph.D.

Your child is invited to participate in research being conducted by faculty and students of the School Psychology program at the University of Nebraska-Lincoln. Your child’s teacher suggested that your child might be appropriate for this study, because it will help them learn math facts and decrease distracting behaviors. The goal of the project is to study methods for identifying effective strategies for improving children’s academic and behavioral performance. We believe that your child may benefit from the information provided by these assessments and any instructional changes that may result. We also believe that there is little risk involved, as we will be using methods that have been shown to be effective in prior research. The greatest apparent source of risk is any frustration your child might experience while being assessed. Your child is one of a number of children being invited to participate. If your child participates in the study, a school psychologist-in-training and perhaps undergraduate students will work with your child and his or her teacher.

The study will be conducted in three parts and will be carried out as part of the school psychology student’s dissertation requirements. The first part should take approximately three weeks. During this time, your child will complete basic math problems for brief periods of time (1 to 5 minutes) during several sessions, while receiving one of three rewards (experimenter attention, peer attention, breaks from work). During the second part of the study, we will provide math fact fluency instruction and your child will then continue to complete basic math fact problems for brief periods of time during several sessions while continuing to receive one of three rewards. The third and final part of the study will involve a comparison of the methods used within the first and second portions. This will allow us to determine whether a behavioral strategy alone or a combined instructional and behavioral strategy works best to improve the academic and behavioral performance of your child. Finally, we will describe the most effective technique to you and assist in the development of an intervention plan if necessary. Specifically, we will consult with your child’s teacher to develop a plan that might help improve your child’s academic and behavioral performance. We will assess the effects of this intervention plan. For ease of observation and to make sure that the researcher is conducting the procedures correctly, we will videotape the sessions. The assessment sessions will be brief, lasting approximately 15 minutes. The sessions will be done between three and five times a week, and the complete study will take approximately two to three months to complete. We will consult with the teacher about the best times to work with or observe your child and when it is appropriate to take your child out of the classroom. We will make every attempt not to take your child during instructional time.

Your permission is required for your child to participate in the study. Also, your child’s assent for participation will be sought. The voluntary nature of participation and the procedures will be explained to your child, and he or she will be given the opportunity to choose whether or not he or she will participate. The information may be used by school personnel to plan more effective instruction for your child. Therefore, results may be shared with your child’s teacher or other school personnel including the building administrator if they can be beneficial to your child’s educational progress. The information will not be shared with any educational personnel or other individuals who are not directly involved in your child’s educational programming without your explicit, written permission. Videotapes and observation forms on which your child’s performance is recorded will be kept in Dr. Daly’s locked cabinet for three
years and then destroyed. Also, if the results are published in a research journal or presented at a conference, pseudonyms will be used so that no one can tell that the data are your child’s data. Further, videotape portions will not, under any circumstances, be used in any publications or presentations.

The alternative services for the kinds of educational practice and instruction your child would receive through his or her participation in this study include the support services provided regularly through your child’s school. Your child will continue to receive any available services through the school whether or not they participate in this project. If you want additional recommendations for external support services, you may contact Dr. Daly or Kristi Hofstadler.

You may ask any questions concerning this research and have those questions answered before agreeing to participate in or during the study. Or you may call the investigator at any time, office phone, (402) 472-5923, or after hours (402) 429-0866. Please contact the investigator:

if you want to voice concerns or complaints about the research, and/or
in the event of a research related injury.

Please contact the University of Nebraska-Lincoln Institutional Review Board at (402) 472-6965 for the following reasons:
you wish to talk to someone other than the research staff to obtain answers to questions about your rights as a research participant;
to voice concerns or complaints about the research;
to provide input concerning the research process; and/or
in the event the study staff could not be reached.

You are free to decide not to participate in this study or to withdraw at any time without adversely affecting your relationship with the investigators, the University of Nebraska, or the school. You are voluntarily making a decision whether or not to let your child participate in this research study. Your signature certifies that you have decided to participate having read and understood the information presented. You will be given a copy of this consent form to keep.

Research Subject’s Name: _______________________

Signature of Parent/Guardian _____________________ Date __________

Name and phone number of investigator(s)
Edward Daly Office: (402) 472-5923
Kristi Hofstadler Office: (412) 472-2471
Appendix G

CHILD ASSENT FORM
Functional Analysis of Replacement Behavior Project
Kristi Hofstadter, Ed.S.
Edward Daly, Ph.D.
University of Nebraska-Lincoln

We are inviting you to take part in this study of ways to help students like you do better in school. We are asking you because your teacher thought that you might benefit from some more help in school work.

In this study we will ask you to do math problems, like in your classroom. We will try different things like telling you when you’re doing a good job, showing you, having you practice, and having a friend help you to figure out the best way for you to learn. We will work together for about 15 to 20 minutes several times a week. A video recording will be made each time we work together so someone else can check to make sure I am doing everything correctly.

If you get upset or frustrated in any way, tell me or the person working with you and we will help you. If you want to stop working together and return to your classroom activities, you can do so at any time.

Your parents will also be asked to give their permission for you to take part in this study. Please talk this over with your parents before you decide whether or not to participate.

You do not have to be in this study if you do not want to. If you decide to participate in the study, you can stop at any time.

If you have any questions at any time, please ask one of the researchers.

IF YOU SIGN THIS FORM IT MEANS THAT YOU HAVE DECIDED TO PARTICIPATE AND HAVE READ EVERYTHING THAT IS ON THE FORM. YOU AND YOUR PARENTS WILL BE GIVEN A COPY OF THIS FORM TO KEEP.

Signature of Subject_______________Date___________

Signature of Investigator_______________Date___________

INVESTIGATORS
Dr. Edward Daly Office: 472-5923
Kristi Hofstadter Office: 472-2471
Table 1

*The Four-Term Contingency*

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
<th>Example</th>
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<tr>
<td><strong>Motivating Operations</strong></td>
<td>Given a behavior-consequence contingency, motivating operations (MOs) are environmental changes or stimuli that momentarily alter the value of available reinforcement, simultaneously increasing or decreasing the probability of responses maintained by that reinforcement without altering the probability of reinforcement (Michael, 1982).</td>
<td>Task difficulty may serve as an MO, momentarily increasing a response class (e.g., disruption) by momentarily increasing the value of the reinforcer (e.g., escape).</td>
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<td><strong>Discriminative Stimuli</strong></td>
<td>Discriminative stimuli increase the frequency of a particular response by signaling the availability of reinforcement, due to a prior association of the stimulus with an increased frequency of reinforcement following behavior (Michael, 1982).</td>
<td>Presentation of a specific type of academic task (e.g., addition probe) may serve as a discriminative stimulus, increasing academic responding by signaling the availability of reinforcement (e.g., contingent teacher praise).</td>
</tr>
<tr>
<td><strong>Contingent Behavioral Responses</strong></td>
<td>Contingent behavioral responses refer to any behavior occurring as a function of the relevant antecedents and consequences as part of a four-term contingency.</td>
<td>Academic responding may be a contingent behavioral response, preceded by a discriminative stimulus (e.g., task, teacher prompt) and contingently reinforced (e.g., praise, grades).</td>
</tr>
<tr>
<td><strong>Consequent Events</strong></td>
<td>Consequent events, punishment and reinforcement, are environmental events that produce a change in behavioral responding. Punishment is defined as the contingent application or removal of a</td>
<td>Praise often serves as a form of social reinforcement in school settings, as students are often provided with praise contingent on appropriate behavior (e.g., academic)</td>
</tr>
</tbody>
</table>
stimulus, which results in a future decrease in responding over time (Michael, 2004). Conversely, reinforcement is the contingent application or removal of a stimulus, which results in a future increase in behavior (Miltenberger, 2007).
Table 2

*Typical Functional Analysis Conditions*

<table>
<thead>
<tr>
<th>Condition</th>
<th>Tests for</th>
<th>Programmed Stimuli</th>
<th>Data patterns and conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attention</td>
<td>Socially mediated positive reinforcement function</td>
<td>Consists of a trained teacher or therapist providing attention contingent on occurrences of problem behavior. In the initial study conducted by Iwata et al. (1982/1994), the experimenter made statements indicating social disapproval (e.g., “Don’t do that.”) contingent on self-injury.</td>
<td>An increase in self-injurious behavior during this condition, relative to the other conditions, would indicate that the behavior functions to obtain social attention (e.g., disapproving statements).</td>
</tr>
<tr>
<td>Escape</td>
<td>Serves as a test for the negative reinforcement function</td>
<td>Includes task presentation, with task removal provided contingent on problem behavior. The tasks provided by Iwata et al. (1982/1994) were those not completed independently by participants prior to functional analysis conditions. When the individual exhibited self-injury, the task was terminated and the experimenter turned away for 30 s.</td>
<td>If problem behavior (e.g., self-injury) was high in this condition, relative to the other conditions, it would be determined that self-injury functioned to obtain escape from task demands.</td>
</tr>
<tr>
<td>Alone</td>
<td>Automatic positive reinforcement</td>
<td>Consists of placing the individual alone in an environment devoid of all external sources of reinforcement (e.g., toys).</td>
<td>Self-injurious behavior occurring at a heightened rate in the alone condition, relative to the other conditions, would suggest that the behavior was maintained by automatic or</td>
</tr>
</tbody>
</table>
The individual has access to play items and social attention. In the seminal work by Iwata et al. (1982/1994), no task demands were presented and the participant was placed in an enriched environment. Social attention, in the form of praise and touch, was provided contingent on the absence of self-injury every 30 s, and the participant had noncontingent access to toys.

Play was designed to serve as a control condition, in which lower rates of self-injury were expected to occur.

<table>
<thead>
<tr>
<th>Play</th>
<th>Control condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>The individual has access to play items and social attention. In the seminal work by Iwata et al. (1982/1994), no task demands were presented and the participant was placed in an enriched environment. Social attention, in the form of praise and touch, was provided contingent on the absence of self-injury every 30 s, and the participant had noncontingent access to toys.</td>
<td></td>
</tr>
</tbody>
</table>

sensory reinforcement.
Table 3

Participant Information

<table>
<thead>
<tr>
<th>Student</th>
<th>Gender</th>
<th>Ethnicity</th>
<th>Age</th>
<th>Grade</th>
<th>Behavior Rating Score</th>
<th>Addition Percent</th>
<th>Multiplication Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patty*</td>
<td>Female</td>
<td>White</td>
<td>8</td>
<td>3rd</td>
<td>21 of 23</td>
<td>31%</td>
<td>36%</td>
</tr>
<tr>
<td>Jennifer*</td>
<td>Female</td>
<td>White</td>
<td>9</td>
<td>4th</td>
<td>18 of 23</td>
<td>30%</td>
<td>18%</td>
</tr>
<tr>
<td>Erin*</td>
<td>Female</td>
<td>White</td>
<td>11</td>
<td>5th</td>
<td>21 of 23</td>
<td>22%</td>
<td>39%</td>
</tr>
</tbody>
</table>

*All names provided are pseudonyms
Table 4

*Procedural Integrity*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Functional Analysis with Unknown Facts</th>
<th>Functional Analysis with Known Facts</th>
<th>Extended Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent Integrity</td>
<td>Percent Integrity</td>
<td>Percent Integrity</td>
</tr>
<tr>
<td></td>
<td>Experimenter Attention</td>
<td>Peer Attention</td>
<td>Escape</td>
</tr>
<tr>
<td>Patty</td>
<td>100%</td>
<td>80%</td>
<td>100%</td>
</tr>
<tr>
<td>Jennifer</td>
<td>100%</td>
<td>96%</td>
<td>100%</td>
</tr>
<tr>
<td>Erin</td>
<td>100%</td>
<td>92%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Table 5

Means and Standard Deviations for Patty’s Performance Across Functional Analysis Phases and Conditions

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Functional Analysis with Unknown Problems</th>
<th>Functional Analysis with Known Problems</th>
<th>Extended Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>EA</td>
<td>PA</td>
</tr>
<tr>
<td>Mean Facts Complete Per Minute</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>4.8</td>
<td>6.6</td>
<td>2.4</td>
</tr>
<tr>
<td>Mean Digits Correct Per Minute</td>
<td>8.4</td>
<td>9.1</td>
<td>5.9</td>
</tr>
<tr>
<td>SD</td>
<td>2.9</td>
<td>2.9</td>
<td>1.3</td>
</tr>
<tr>
<td>Mean % Disruptive Behavior</td>
<td>11.8</td>
<td>0.8</td>
<td>28.3</td>
</tr>
<tr>
<td>SD</td>
<td>15.0</td>
<td>1.7</td>
<td>6.9</td>
</tr>
<tr>
<td>Mean % Academic Engagement</td>
<td>76.5</td>
<td>82.5</td>
<td>62.3</td>
</tr>
<tr>
<td>SD</td>
<td>19.6</td>
<td>20.1</td>
<td>22.8</td>
</tr>
</tbody>
</table>

Note. EA = Experimenter Attention; PA = Peer Attention; ESC = Escape; CON = Control; EA-K = Experimenter Attention-Known; EA-U = Experimenter Attention-Unknown; SD = Standard Deviation
Table 6

Means and Standard Deviations for Jennifer’s Performance Across Functional Analysis Phases and Conditions

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Functional Analysis with Unknown Problems</th>
<th>Functional Analysis with Known Problems</th>
<th>Extended Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>EA</td>
<td>PA</td>
</tr>
<tr>
<td>Mean Rate of Completed Problems</td>
<td>13.7</td>
<td>14.2</td>
<td>13.3</td>
</tr>
<tr>
<td>SD</td>
<td>2.3</td>
<td>1.6</td>
<td>3.9</td>
</tr>
<tr>
<td>Mean Rate of Digits Correct</td>
<td>24.6</td>
<td>25.7</td>
<td>23.2</td>
</tr>
<tr>
<td>SD</td>
<td>3.9</td>
<td>2.6</td>
<td>5.2</td>
</tr>
<tr>
<td>Mean % Disruptive Behavior</td>
<td>0.6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>SD</td>
<td>1.9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mean % Academic Engagement</td>
<td>98.3</td>
<td>96.7</td>
<td>100</td>
</tr>
<tr>
<td>SD</td>
<td>2.6</td>
<td>2.9</td>
<td>0</td>
</tr>
</tbody>
</table>

Note. EA = Experimenter Attention; PA = Peer Attention; ESC = Escape; CON = Control; EA-K = Experimenter Attention-Known; EA-U = Experimenter Attention-Unknown; SD = Standard Deviation
Table 7

*Means and Standard Deviations for Erin’s Performance Across Functional Analysis Phases and Conditions*

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Functional Analysis with Unknown Problems</th>
<th>Functional Analysis with Known Problems</th>
<th>Extended Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>EA</td>
<td>PA</td>
</tr>
<tr>
<td>Mean Rate of Completed Problems</td>
<td>12.3</td>
<td>12.8</td>
<td>13.6</td>
</tr>
<tr>
<td>SD</td>
<td>4.6</td>
<td>5.0</td>
<td>4.7</td>
</tr>
<tr>
<td>Mean Rate of Digits Correct</td>
<td>9.5</td>
<td>11.0</td>
<td>9.7</td>
</tr>
<tr>
<td>SD</td>
<td>2.7</td>
<td>3.0</td>
<td>1.8</td>
</tr>
<tr>
<td>Mean % Disruptive Behavior</td>
<td>1.4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>SD</td>
<td>4.3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mean % Academic Engagement</td>
<td>93.3</td>
<td>98.5</td>
<td>96.3</td>
</tr>
<tr>
<td>SD</td>
<td>11.7</td>
<td>3.0</td>
<td>4.5</td>
</tr>
</tbody>
</table>

*Note.* EA = Experimenter Attention; PA = Peer Attention; ESC = Escape; CON = Control; ESC-K = Escape-Known; ESC-U = Escape-Unknown; SD = Standard Deviation
Table 8

*Effective condition selection across participants and functional analyses*

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Patty</th>
<th>Jennifer</th>
<th>Erin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FA-Unknown</td>
<td>FA-Known</td>
<td>FA-Known</td>
</tr>
<tr>
<td>A. A condition that was visibly higher than two or more of the other conditions.</td>
<td>None</td>
<td>Experimenter Attention</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>B. A condition whose mean exceeded other condition means by at least 1 standard deviation.</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>C. A condition whose standard deviation was at least 1 standard deviation smaller than the other condition means, or if two or more conditions meet the above criteria, the condition with the smallest standard deviation.</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Effective Condition Selected</td>
<td>Experiment Attention</td>
<td>Experiment Attention</td>
<td>Escape</td>
</tr>
</tbody>
</table>
Figure 1. Patty’s performance (rate of completed problems, rate of digits correct, percentage of disruptive behavior, percentage of academic engagement) across functional analysis phases and conditions.
Figure 2. Jennifer’s performance (rate of completed problems, rate of digits correct, percentage of disruptive behavior, percentage of academic engagement) across functional analysis phases and conditions.
Figure 3. Erin’s performance (rate of completed problems, rate of digits correct, percentage of disruptive behavior, percentage of academic engagement) across functional analysis phases and conditions.