Reinforcement magnitude: an evaluation of preference and reinforcer potency

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REINFORCEMENT MAGNITUDE: AN EVALUATION OF PREFERENCE AND REINFORCER POTENCY

A Thesis

Submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College in partial fulfillment of the requirements for the degree of Master of Arts

in

The Department of Psychology

by
Nicole M. Trosclair
B.S., Louisiana State University, 2001
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Reinforcers that maintain problem behavior often are an integral part of treatment with differential reinforcement. Basic research suggests that various parameters of reinforcement (e.g., rate, quality, delay, and magnitude) may influence treatment outcomes. Germene to the current study, the voluminous basic literature on reinforcement magnitude indicates that this parameter may influence responding, especially in choice situations or when response requirements are systematically increased over time. Although consideration of reinforcer magnitude may be important for maximizing treatment effectiveness, relatively little is known about children’s preference for different magnitudes of reinforcement or the extent to which relative preference would be related to differences in reinforcer potency. The purpose of this study was to evaluate the basic relation between reinforcer magnitude, preference, and potency by drawing on the procedures and results of basic research in this area. Participants were two children who engaged in problem behavior maintained by access to tangible items, attention, or escape from demands. Results of a concurrent operants preference assessment indicated that one participant preferred a larger magnitude of reinforcement across multiple reinforcers. Next, a progressive ratio reinforcer assessment indicated a positive relationship between preference and reinforcer potency for two out of three positive reinforcer evaluations and no clear relationship for negative reinforcement. In general, results for positive reinforcement supported the hypothesis that individuals would show a preference for different magnitudes of reinforcement and that preference would predict relative reinforcer potency. Collectively, the preference and reinforcer assessments provide preliminary evidence regarding the relationship between preference and potency of
different magnitudes of reinforcement and suggest that for positive reinforcement, preferred magnitudes of reinforcement may yield stronger reinforcement effects.
INTRODUCTION

Assessment and Treatment of Problem Behavior

Children with developmental delays often engage in a variety of problem behaviors (e.g., aggression, self-injury). For example, Johnson and Day (1992) reported that for individuals with severe to profound mental retardation, the prevalence of self-injurious behavior (SIB) was 14% to 59%. Within the past 20 years, the use of analogue functional analysis procedures to identify environmental variables maintaining problem behavior has become standard practice in the assessment and treatment of problem behavior (e.g., Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994). The utility of analogue functional analyses in developing effective treatments for a variety of problem behaviors has been extensively documented in the applied literature. Prior to such methodology, researchers and clinicians relied on the efficacy of applying reinforcement and/or punishment contingencies on top of existing contingencies in order to treat problem behavior (Mace, 1994). The functional analysis is used to identify the reinforcer maintaining the behavior (i.e., the functional reinforcer) so that it can be withheld following problem behavior and provided at other times as part of treatment.

Two common treatments are differential reinforcement and noncontingent reinforcement (NCR). During differential reinforcement, problem behavior no longer produces reinforcement (i.e., is placed on extinction). Instead, the functional reinforcer is provided for an alternative behavior (differential reinforcement of alternative behavior, DRA), the absence of behavior (differential reinforcement of other behavior, DRO), or low rates of behavior (differential reinforcement of low rates of behavior, DRL). NCR procedures are similar in that reinforcement is withheld for problem behavior and
delivered on some predetermined schedule (e.g., every 30 s), but independently of behavior.

**Stimulus Preference and Reinforcer Assessments**

While identification of functional reinforcers is an important aspect of treatment of problem behavior, the development of stimulus preference assessments (e.g., DeLeon & Iwata, 1996; Fisher et al., 1992) has also improved clinical intervention. The purpose of a preference assessment is to evaluate an individual’s preference for different stimuli that could serve as potential reinforcers for that individual. Research has demonstrated the utility of using arbitrary reinforcers (i.e., those that are unrelated to maintenance of the problem behavior) as part of treatment and suggests that, in some instances, arbitrary reinforcers can be substituted for functional reinforcers in programs to decrease problem behavior (e.g., Fischer, Iwata, & Mazaleski, 1997). These findings are important because teachers or caregivers sometimes are unable or unwilling to deliver functional reinforcers, such as attention or escape from tasks. In addition, identifying a variety of potent arbitrary reinforcers is useful for teaching and maintaining adaptive behavior in individuals with developmental disabilities (e.g., Bowman, Piazza, Fisher, Hagopian, & Kogan, 1997).

Preference is typically assessed by presenting items singly or in pairs and measuring an individual’s approach toward or interaction with each item (e.g., Fisher et al., 1992; Pace, Ivancic, Edwards, Iwata, & Page, 1985). However, relative preference is not necessarily indicative of relative reinforcer potency (e.g., Roscoe, Iwata, & Kahng, 1999). Some type of reinforcer assessment typically is conducted to evaluate whether preferred stimuli identified during a preference assessment function as reinforcers (e.g.,
Fisher et al.; Roane, Lerman, & Vorndran, 2001; Tustin, 1994). For example, Roane, Lerman, and Vorndran evaluated the reinforcer potency of preferred arbitrary stimuli within the context of increasing schedule requirements (i.e., progressive ratio schedules) with four individuals with developmental disabilities. The effectiveness of two stimuli with similar preference rankings was compared in a multielement design. Each participant was required to emit a certain number of responses to access the preferred item. Within each session, the number of responses required to access the stimuli increased until specified termination criteria were met. Reinforcer potency was indicated by the highest schedule requirement completed (i.e., a higher schedule requirement completed for one stimulus relative to the other indicated a more potent reinforcer). For each participant, one stimulus functioned as a more potent reinforcer than the other stimulus even though the items were similarly preferred. These results highlight the importance of considering not only preference for reinforcers but also the relative value of reinforcers. Preference and reinforcer assessments, when used in combination, provide a methodology for identifying effective reinforcers to be used as part of behavioral interventions (Fisher & Mazur, 1997).

Parameters of Reinforcement

The development of analogue functional analysis procedures identified an important parameter of reinforcement that may influence treatment efficacy, namely, the type of reinforcer used (i.e., functional versus arbitrary reinforcers; e.g., Durand & Carr, 1987). In addition to the type of reinforcer (i.e., functional versus arbitrary), other parameters of reinforcement (e.g., rate, quality, delay, and magnitude) may influence treatment outcomes. For example, several studies have evaluated the influence of
different dimensions of reinforcement on responding under concurrent operants arrangements. This arrangement involves two or more response alternatives – each associated with a separate source of reinforcement – that are available simultaneously (Catania, 1998). Research findings have demonstrated more responding (i.e., a preference) for the response alternative that produces a higher rate of reinforcement (e.g., Mace, Neef, Shade, & Mauro, 1994), higher quality reinforcers (e.g., Neef, Mace, Shea, & Shade, 1992), and more immediate reinforcers (e.g., Neef, Mace, & Shade, 1993) under such an arrangement.

For example, Mace et al. examined response allocation across academic tasks that were associated with different variable interval (VI) schedules for three students with behavior disorders and learning difficulties. Different rates of reinforcement were associated with different color index cards on which math problems were printed. Identical math problems were presented on different colored index cards, and one of three different concurrent VI VI schedules was in place (reinforcement ratios were 2:1, 6:1, 12:1). The dependent measure was time allocated to completing problems in each stack of cards. Results indicated that participants allocated more time to the stack producing the higher rate of reinforcement and that higher rates of reinforcement yielded stronger reinforcement effects.

Collectively, this line of research indicates that the various dimensions of reinforcement may have an important role in reinforcer effectiveness (i.e., more preferred dimensions may function as more effective reinforcers). However, few studies have examined the effects of these reinforcement variables on treatment outcomes.
One parameter of reinforcement that has begun to receive some attention in the applied literature is reinforcement magnitude. Magnitude refers to the number, intensity, or duration of reinforcement (Hoch, McComas, Johnson, Faranda, & Guenther, 2002). Basic research suggests that reinforcement magnitude can influence responding (see further discussion below). Thus, this reinforcement parameter may be important to consider when establishing behavior programs for individuals with developmental disabilities. Although this parameter is often discussed in applied texts, few guidelines are available for determining how much reinforcement to deliver in order to maximize the effectiveness of reinforcement-based procedures. A small but growing number of applied studies have evaluated the effects of reinforcement magnitude on responding, and the results have been somewhat inconsistent (e.g., Carr, Bailey, Ecott, Lucker & Weil, 1998; Ecott, Foate, Taylor, & Critchfield, 1999; Hoch et al., 2002; Lerman, Kelley, Van Camp, & Roane, 1999; Lerman, Kelley, Vorndran, Kuhn, & LaRue, 2002; Lovitt & Curtiss, 1969; Peck et al., 1996; Roscoe, Iwata, & Rand, 2003).

In the majority of applied studies on reinforcement magnitude, the effects of magnitude on responding have been evaluated within the context of NCR rather than contingent reinforcement (e.g., Carr et al., 1998, Ecott et al., 1999, Roscoe et al., 2003). Analogue procedures were used to study the effects of magnitude on response suppression under NCR in lieu of manipulating magnitude during treatment of problem behavior. For example, in Carr et al., five participants with severe to profound mental retardation received food reinforcers for inserting poker chips into a plastic cylinder. A multielement or combination reversal and multielement design was used to evaluate the
effects of different amounts of noncontingent food on levels of responding. Three reinforcer magnitudes (large, medium, and small) were evaluated for three participants and two (medium and low) were evaluated for two participants. The large reinforcer magnitude was two times larger than the medium magnitude, and the medium reinforcer magnitude was three times larger than the small magnitude. During baseline, participants received a small magnitude of reinforcement on a variable ratio (VR) 3 schedule for engaging in the response. During NCR conditions, reinforcement was no longer delivered contingent on responding. A small, medium, or large amount of the reinforcer was delivered on a noncontingent fixed time (FT) schedule. Larger magnitudes of reinforcement produced the greatest reductions in responding relative to baseline. In addition, the smallest magnitude of reinforcement either did not reduce responding or increased responding. These results are relevant to treatment of problem behavior using NCR procedures in that larger reinforcer magnitudes may produce larger reductions in problem behavior.

One study has directly examined the relation between the magnitude of contingent reinforcement and levels of problem behavior during functional analysis. Volkert, Lerman, and Vorndran (2005) evaluated the effects of three different magnitudes of reinforcement on the occurrence of problem behavior. Six children with developmental delays and/or autism participated. Functional analysis procedures were based on those described by Iwata et al. (1982/1994). Three functional analyses were conducted for each participant in a reversal design to examine magnitude effects. During the large magnitude functional analysis, problem behavior was reinforced on a fixed ratio (FR) 1 schedule and resulted in 120-s access to either attention, escape from demands, or access to tangibles.
Procedures were identical during the medium and small magnitude functional analyses; however, problem behavior resulted in 20-s or 3-s access to reinforcement respectively. Although the same function was identified across all reinforcement magnitudes, rates of problem behavior were much lower under the large magnitude for the majority of participants.

Fewer studies have directly examined the relationship between the magnitude of contingent reinforcement and responding as part of treatment for problem behavior. Lerman, Kelley, Vorndran, Kuhn, and LaRue (2002) compared the effects of several reinforcement magnitudes during treatment with DRA. Three children diagnosed with moderate to profound mental retardation or autism participated. For all participants, the alternative response was touching a communication card. During baseline, the functional reinforcer (i.e., escape from demands or access to tangibles) was delivered for 20-s contingent on the occurrence of problem behavior. There were no programmed contingencies in place for the occurrence of the alternative response (card touches). During the reinforcement phase, three reinforcer magnitudes (i.e., 20-s, 60-s, and 300-s access to the functional reinforcer) were provided on a VI schedule for the occurrence of the alternative response. A reversal design was used to compare levels of responding under the different magnitudes. For one participant, higher levels of responding were observed under the large reinforcer magnitude; however, no differences in response rates were shown for the other two participants.

In another study, conducted by Lerman, Kelley, Van Camp, and Roane (1999), the effects of two different reinforcement magnitudes were evaluated while treating screaming that was maintained by access to tangible items. During baseline, 20-s access
to tangible items was provided for screaming, and engagement in an alternative response (hand clapping) was ignored. During treatment (functional communication,) the contingencies were reversed. Hand clapping produced either 10-s or 60-s access to tangible items on a FR 1 schedule, and occurrences of screaming were ignored. Levels of hand clapping were similar under the two different reinforcer magnitudes although lower levels of screaming were observed when the large magnitude (60 s) of reinforcement was in place relative to the small magnitude of reinforcement (10 s).

Finally, Hoch et al. (2002) evaluated the effects of reinforcement magnitude on response allocation for one individual with autism while targeting peer interactions. The participant could choose between two play areas (no peer and peer present). During equal magnitude sessions, choosing to play in either area resulted in 50-s access to the stimuli (toys) in that area. In the unequal magnitude sessions, choosing to play in the area with the peer resulted in 90-s access to the toys, whereas choosing to play in the area without the peer resulted in 10-s access to the toys. The participant spent more time in the area that produced the greatest magnitude of reinforcement (i.e., the longest access to the toys).

Collectively, results from applied studies evaluating the effects of reinforcement magnitude have been inconsistent. Results of most studies on the magnitude of contingent reinforcement indicate that this parameter does not substantially influence responding. It should be noted, however, that the studies contained a number of procedural variations. One noteworthy difference among the studies was the use of single versus concurrent operants arrangements. It is possible that magnitude does reliably influence responding when a concurrent operants arrangement is used (e.g., Hoch et al,
2002). This possibility is supported by the voluminous basic literature on magnitude, as discussed in more detail below. In addition, among most of the studies using a single operant arrangement, reinforcement was delivered on a continuous schedule. It is possible that the schedule of reinforcement might interact with reinforcement magnitude; another finding that has been reported in basic research (e.g., Reed, 1991). The results of basic research on reinforcement magnitude will be discussed next.

Magnitude—Basic Research

Magnitude effects have been examined more extensively in the basic laboratory under a variety of procedural arrangements, including both single operant and concurrent operants. Results of this research have begun to identify some of the conditions under which magnitude influences responding. Results have been inconsistent when a single-operant arrangement was used. Collectively, reinforcer magnitude was found to be positively related (e.g., Hutt, 1954; Jenkins & Clayton, 1949; Reed & Wright, 1988; Stebbins, Mead, & Martin, 1959), negatively related (e.g., Belke, 1997; Lowe, Davey, & Harzem, 1974; Staddon, 1970), or unrelated (e.g., Catania, 1963; Keesey & Kling, 1961) to rates of responding under a single-operant arrangement (see Bonem & Crossman, 1988 for a review). For example, Stebbins et al. evaluated the effects of different amounts of reinforcement (i.e., different percentages of a sucrose solution) on the rate of bar pressing for two naïve male albino rats. Four concentrations of the solution (5.0%, 12.7%, 32.0%, and 50% by weight) were evaluated under a fixed-interval (FI) 2-min schedule of reinforcement. As amount of reinforcement increased, rate of bar pressing increased for both subjects. Similar results were obtained by Reed and Wright, who examined the effects of four different amounts of food reinforcement (1, 2, 3, and 4 food pellets) on
response running rates under a VR 30 schedule. In contrast, Staddon (1970) reported a negative relation between magnitude and response rates. The effect of different durations of reinforcement (i.e., access to grain) on key pecking was evaluated with three pigeons. Five different durations of reinforcement (1.3 s, 2.4 s, 3.5 s, 5.7 s, and 9.0 s) were evaluated in randomized blocks of five for 12 sessions under a FI 60-s schedule of reinforcement. Rate of key pecking decreased for all subjects as the reinforcer duration increased. Lowe et al. (1974) obtained similar results with rats when examining four condensed milk concentrations (10%, 30%, 50%, and 70%) on responding under a FI 60-s schedule of reinforcement.

Results of other research have identified alternative arrangements that appear to provide a more consistent, sensitive measure of magnitude effects. In particular, studies using concurrent-operants arrangements have generally reported a positive relationship between reinforcer magnitude and responding (e.g., Catania, 1963; Reed, 1991; see Bonem & Crossman, 1988 for a review). For example, Catania evaluated different durations of reinforcement on rate of key pecking under a concurrent VI 2-min schedule with three pigeons. Rate of key pecking on the key associated with the larger magnitude of reinforcement increased. Reed (1991) reported similar results when two reinforcement amounts (i.e., 1 and 4 pellets) were evaluated on a concurrent VI 60-s VI 60-s schedule of reinforcement with four male rats. A reversal design was used to compare equal reinforcement for both responses (i.e., 1 food pellet versus 1 food pellet) to unequal reinforcement across responses (i.e., 1 food pellet versus 4 food pellets). An increase in reinforcement magnitude was associated with an increase in response rates for all
subjects. Results of the aforementioned studies suggest that responding under concurrent
operants arrangements is more sensitive to the differential effects of magnitude.

The schedule of reinforcement for responding also appears to interact with
reinforcement magnitude under single-operant arrangements, which would account for
the inconsistent findings described above. In a review of this literature, Reed (1991)
noted that a positive relation between response rates and reinforcement magnitude has
been found under schedules that tend to increase responding (e.g., thin ratio schedules);
conversely, a negative relationship has been observed under schedules that decrease
responding (e.g., DRL). For example, studies using progressive ratio (PR) schedules have
consistently shown a positive relationship between magnitude and responding. Under PR
schedules, the number of responses that must be emitted to obtain reinforcement
systematically increases within each session. Sessions are typically terminated when no
responses have occurred for a pre-specified duration of time. Greater response persistence
is considered an indicator of more potent reinforcement effects (Hodos, 1961). PR
schedules are considered a valid and efficient method of studying response patterns under
increasing schedule requirements in both basic (e.g., Baron, Mikorski, & Schlund, 1992)
and applied (e.g., Roane et al., 2001) literatures.

For example, Hodos (1961) examined the effects of different reinforcer
magnitudes (i.e., sweetened condensed milk diluted with various amounts of water) on
PR schedule completion. As reinforcer magnitude decreased (i.e., as more water was
added to the milk), the final PR schedule completed decreased, suggesting a positive
relationship between magnitude and reinforcer potency. In addition, a number of basic
studies have demonstrated similarities in responding under PR and FR schedules of
reinforcement (e.g., Baron & Derenne, 2000; Baron et al., 1992; Findley, 1958; Stafford & Branch, 1998; Thomas, 1974).
PURPOSE

Basic findings suggest that reinforcement magnitude may influence responding, especially in choice situations or when response requirements are systematically increased over time. This is important because individuals are often faced with a choice between two behaviors (e.g., problem or appropriate behavior) during treatment. Results of basic research indicate that the allocation of responding to certain alternatives can be increased by providing larger magnitudes of reinforcement for those alternatives. When treating problem behavior that will continue to produce reinforcement, for example, a larger magnitude of reinforcement could be provided for appropriate behavior relative to that for problem behavior to bias responding towards the appropriate response.

Basic research findings on the interaction between reinforcement magnitude and reinforcement schedule also are clinically relevant because schedule thinning is a common component of reinforcement-based programs. For example, a teacher may require students to complete an increasing amount of work prior to reinforcement delivery (e.g., Hanley, Iwata, & Thompson, 2001; Kahng, Iwata, DeLeon, & Wallace, 2000; Roane, Fisher, Sgro, Falcomata, & Pabico, 2004). Basic research findings suggest that treatment will be more successful if the magnitude of the reinforcer is increased as the schedule is thinned, a recommendation that has appeared in applied texts (e.g., Cooper, Heron, & Heward, 1987). Nevertheless, this potential interaction has not been examined in clinical studies, and no guidelines exist for selecting the most appropriate magnitude. Thus, although consideration of reinforcer magnitude may be important for maximizing treatment effectiveness, the magnitude of the reinforcer delivered in treatment has varied widely and often seemed to be chosen arbitrarily in most studies.
(e.g., 20 s access to attention, [Roane et al., 2004] versus brief attention [Worsdell et al., 2000]).

In fact, relatively little is known about children’s preference for different magnitudes of reinforcement or the extent to which relative preference would be related to differences in reinforcer potency. The small body of applied research suggests that magnitude is relatively unimportant; however, reinforcement magnitude typically was evaluated using a single-operant arrangement (rather than a concurrent operants arrangement) and a fixed reinforcement schedule (typically continuous). The generality of basic findings on magnitude needs to be established with clinical populations and problems and with the types of reinforcers that are typically used in application. Moreover, if interactions between reinforcement schedules and magnitudes are demonstrated in further research, clinicians will need efficient assessment tools for determining the most effective magnitude for a given individual.

The purpose of this study was to evaluate the basic relation between reinforcer magnitude, preference, and potency by drawing on the procedures and results of basic research in this area. Participants were two children who engaged in problem behavior maintained by access to tangible items, attention, or escape from demands, which are common variables found to maintain problem behavior in individuals with developmental disabilities (Hanley, Iwata, & McCord, 2003).

A concurrent operants assessment was conducted to determine if participants chose specific magnitudes of these functional reinforcers (access to tangible items, attention, or escape from demands) over other magnitudes. Allocation of choice to one option versus another indicated relative preference for that value. A subsequent reinforcer
assessment was conducted to further assess the potency of the different magnitude values under increasing schedule requirements (Roane et al., 2001). Basic findings indicate that PR schedules provide a valid and efficient method for evaluating variables that may interact with reinforcement schedules to influence responding and for comparing the potency of different reinforcers (e.g., Baron & Derenne, 2000; Baron et al., 1992; Findley, 1958; Stafford & Branch, 1998; Thomas, 1974). In addition, the utility of using increasing schedule requirements to evaluate reinforcer potency has been demonstrated in applied research (e.g., DeLeon, Iwata, Goh, & Worsdell, 1997; Roane et al., 2001; Tustin, 1994). In Roane et al. (2001), for example, differences in the potency of similarly preferred toys were evaluated by comparing relative response persistence under PR schedules among 3 individuals who engaged in problem behavior maintained by automatic reinforcement. The effectiveness of the toys in reducing problem behavior as part of treatment with three reinforcement-based procedures (NCR, DRA, and DRO) was then examined for each participant. Overall, differences in responding under PR schedules predicted the relative effectiveness of the treatments. Thus, another purpose of the current study was to determine if a concurrent operants preference assessment and a reinforcer assessment with PR schedules provide clinicians with efficient assessment tools for determining the most effective magnitude for a given individual.

The relation between preference and potency was also examined to determine if relative preference was a reliable predictor of relative reinforcer potency. If so, results would provide insight into how reinforcer magnitudes should be determined, as well as demonstrate an efficient, empirical methodology for identifying reinforcer magnitudes to be utilized during treatment. A clear preference for certain reinforcement magnitudes
over others would have important implications for treatment development, especially in situations when reinforcers are concurrently available (e.g., DRA without extinction). In addition, if reinforcers were more potent under certain reinforcement magnitudes as response requirements increased, it may be possible to develop efficient guidelines for selecting and/or increasing reinforcer magnitude during schedule thinning. Finally, if magnitude preference predicted reinforcer potency, a simple preference assessment could be conducted to identify the most potent reinforcement magnitude to be utilized during treatment.
METHOD

Participants and Settings

Two children participated in the study. Seth was a 5-year-old male diagnosed with autism. He communicated via vocal speech and demonstrated good receptive and expressive language skills. For example, Seth followed three-step instructions and spoke in complete sentences. Cal was a 9-year-old male diagnosed with severe language delay and autism. He did not communicate via vocal speech; his communication was limited to a few signs (e.g., eat, music, more), and he followed one-step instructions. Neither participant demonstrated any sensory or motor impairments, nor were they taking any medications at the time of the study. Participants were selected from children referred to the Louisiana State University School Psychology Program for the functional analysis and treatment of problem behavior (i.e., self-injury, aggression, or disruptive behavior). The first two children whose problem behavior was found to be maintained by social positive reinforcement in the form of access to tangibles or attention or social negative reinforcement in the form of escape from tasks participated in the study. These reinforcers were selected because they are commonly found to maintain problem behavior in individuals with developmental disabilities (Hanley, Iwata, & McCord, 2003).

Doctoral students from the school psychology program conducted sessions during each participant’s functional analysis, magnitude preference assessment, and reinforcer assessment. Sessions were conducted at Seth’s daycare and at Cal’s school in rooms other than his classroom (e.g., testing room) or at Louisiana State University in rooms designated for a summer program for children with autism. Each session room was
equipped with materials necessary for sessions and included a table, chairs, and stimuli used during the assessments (e.g., color cards, demand materials, toys). In addition, other objects (e.g., trash can, text books) stored in the room by the school (Cal) or daycare (Seth) were present; however, participants were blocked from engaging with these items when necessary.

Response Measurement, Reliability, and Procedural Integrity

Trained graduate and undergraduate students used laptop computers to collect frequency and/or duration data on targeted behaviors during all assessments. During functional analysis sessions, data were collected on targeted problem behaviors identified by caregiver report and direct observations of participants in their classrooms. Seth’s problem behavior included aggression, defined as hitting, scratching, grabbing, hair pulling, biting, or head butting another person; and disruption, defined as throwing objects, knocking objects off of furniture, property destruction, turning over furniture, or saying no. Cal’s problem behavior included self-injury, defined as hand biting; and aggression, defined as hitting or head butting another person. Frequency data were converted to a rate measure by dividing the total number of occurrences by the total number of minutes in the session.

During the magnitude preference assessment, data were collected on the number of times a particular magnitude was selected by the participant (defined as the participant touching the stimulus associated with a particular magnitude). Data were converted to the percentage of trials each magnitude was selected by dividing the number of times it was chosen by the total number of trials the magnitude was presented and multiplying that number by 100%. A preference for a particular magnitude of reinforcement was defined
as participants choosing that magnitude a higher percentage of times relative to the comparison magnitude or no-reinforcement for at least three consecutive sessions.

In addition, data were collected on the duration of reinforcer delivery, which was defined as the total amount of time the therapist provided participants with access to the relevant reinforcer (i.e., access to tangible items, attention, or escape from demands) in order to check procedural integrity. Integrity was defined as the delivery of the functional reinforcer within 5 s above or below the corresponding magnitude of reinforcement. For example, if the 120-s magnitude was chosen, integrity was scored if the therapist delivered between 115 s and 125 s of reinforcement. Each reinforcer delivery was scored for integrity for at least 77% of sessions. Final integrity scores for each session were converted to percentage of trials by dividing the number of reinforcer deliveries with integrity by the total number of reinforcer deliveries and multiplying by 100%.

During the reinforcer assessment, data were collected on the frequency of the targeted response. The targeted response for Seth was a button press, defined as pressing a button with the finger or hand until an audible click was emitted. Cal’s response was a card touch, defined as touching a gray card with the finger or hand. Data were converted to cumulative number of responses emitted across sessions by adding the total number of responses emitted during each session to the total number of responses emitted during previous sessions. In addition, data were collected on the duration of reinforcer delivery to check for procedural integrity as defined above.

Interobserver agreement data were collected for 58% of functional analysis sessions, 49% of preference assessment sessions, and 53.7% of reinforcer assessment sessions by having a second observer simultaneously but independently record
occurrences of the targeted behaviors. Agreement was calculated by dividing each session into 10-s intervals and comparing the data of the two observers. Agreements were defined as the same number of responses (or duration in seconds) scored within a 10-s interval. Agreement coefficients were calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100%. Mean agreement coefficients for targeted responses for each assessment are presented in Table 1 below.

Table 1
Mean Agreement Coefficients for each Assessment

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Mean Agreement</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Functional Analysis</td>
<td>92%</td>
<td>0% - 100%</td>
</tr>
<tr>
<td>Preference Assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100%</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Attention</td>
<td>98.5%</td>
<td>66.7% - 100%</td>
</tr>
<tr>
<td>Escape</td>
<td>97.1%</td>
<td>0% - 100%</td>
</tr>
<tr>
<td>Reinforcer Assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tangible</td>
<td>98.2%</td>
<td>89.3% - 100%</td>
</tr>
<tr>
<td>Attention</td>
<td>98.9%</td>
<td>95% - 100%</td>
</tr>
<tr>
<td>Escape</td>
<td>92.1%</td>
<td>50% - 100%</td>
</tr>
<tr>
<td>Cal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Functional Analysis</td>
<td>92%</td>
<td>50% - 100%</td>
</tr>
<tr>
<td>Preference Assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attention</td>
<td>95.3%</td>
<td>14.3% - 100%</td>
</tr>
<tr>
<td>Reinforcer Assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attention</td>
<td>94.3%</td>
<td>66% - 100%</td>
</tr>
</tbody>
</table>

Note. Mean agreement coefficients are collapsed across targeted behaviors.

Procedural integrity data were collected for 100% of preference and reinforcer assessment sessions for Seth and 77.2% and 100% of preference and reinforcer assessments, respectively, for Cal for each magnitude of reinforcement as previously described. Mean integrity scores for each participant for preference and reinforcer assessments are presented in Table 2.
### Table 2

Mean Integrity Scores for Preference and Reinforcer Assessments

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Mean Integrity</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Seth</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preference Assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tangible</td>
<td>98.2%</td>
<td>33.3% - 100%</td>
</tr>
<tr>
<td>Attention</td>
<td>98%</td>
<td>50% - 100%</td>
</tr>
<tr>
<td>Escape</td>
<td>94.7%</td>
<td>50% - 100%</td>
</tr>
<tr>
<td>Reinforcer Assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tangible</td>
<td>94.7%</td>
<td>75% - 100%</td>
</tr>
<tr>
<td>Attention</td>
<td>93.9%</td>
<td>53% - 100%</td>
</tr>
<tr>
<td>Escape</td>
<td>98.5%</td>
<td>88% - 100%</td>
</tr>
<tr>
<td><strong>Cal</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preference Assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attention</td>
<td>85.5%</td>
<td>0% - 100%</td>
</tr>
<tr>
<td>Reinforcer Assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attention</td>
<td>87.5%</td>
<td>50% - 100%</td>
</tr>
</tbody>
</table>

**Note.** Mean integrity scores for preference and reinforcer assessments are collapsed across reinforcement magnitudes.

### Procedures

Each participant was exposed to three assessments. First, a functional analysis was conducted to identify the variables maintaining the participants’ problem behavior. Second, a magnitude preference assessment was conducted to identify preference for a particular magnitude (i.e., large or small) of reinforcement and to identify a magnitude value for which no preference was shown. Finally, a magnitude reinforcer assessment was conducted to evaluate the reinforcer potency of each magnitude value. Seth was exposed to the preference and reinforcement assessments for each functional reinforcer (i.e., access to tangible items, attention, and escape) separately.

### Functional Analysis

A multielement (Iwata et al., 1982/1994) or pairwise functional analysis (Iwata, Duncan, Zarcone, Lerman, and Shore, 1994) was initially conducted to identify the
variables maintaining problem behavior for each participant. Results of the functional analysis served as a screening method for inclusion in the remainder of the study. Only children whose problem behavior was maintained by access to social reinforcement (i.e., access to tangible items, attention, or escape from demands) were included in the subsequent phases of the study. Seth’s multielement functional analysis consisted of three test conditions (attention, demand, and tangible) and a control condition (toy play). Consequences were provided for aggression only. An additional pairwise analysis was conducted for Seth to further evaluate a possible demand function after no problem behavior was observed during the demand condition of the multielement functional analysis. Information provided by his parents and teacher indicated that problem behavior also might be maintained by escape from demands. The pairwise analysis consisted of a demand test condition and toy play control condition. In addition, consequences were provided for aggression and disruption during the pairwise analysis.

Cal’s pairwise functional analysis consisted of an attention test condition and a no interaction control condition. Consequences were provided for self-injury and aggression. A pairwise analysis was used for Cal because potential carryover effects between conditions were observed during a previous multielement functional analysis. The no interaction condition rather than the play condition was used as the control to further reduce the likelihood of interaction effects (i.e., to remove the discriminative stimulus for social reinforcement). All sessions were 10 min. Sessions continued until clear results were obtained (determined by visual inspection of the data).

During the attention condition (Seth and Cal), participants had access to low preference toys. The therapist pretended to engage in an activity (e.g., reading a
magazine) and did not interact with participants. Contingent on the occurrence of targeted problem behavior, the therapist delivered 20-s access to verbal and physical attention in the form of reprimands, concerning statements, and/or hugs. Upon the termination of the 20-s reinforcement interval, the therapist withdrew all attention and resumed the pretend activity. There were no programmed consequences for the occurrence of nontargeted behaviors. The purpose of this condition was to determine if problem behavior was maintained by attention from others.

During the tangible condition (Seth), the therapist allowed the participant approximately 2-min access to preferred stimuli prior to the start of session. Upon the termination of the 2-min interval, the therapist restricted access to the stimuli. Contingent on the occurrence of a targeted problem behavior, the therapist delivered 20-s access to preferred stimuli. The therapist did not provide any attention to the participant during tangible sessions. Upon the termination of the 20-s reinforcement interval, the therapist once again restricted access to the preferred stimuli. There were no programmed consequences for the occurrence of nontargeted behaviors. The purpose of this condition was to determine if problem behavior was maintained by access to tangible items.

During the demand condition (Seth), the therapist and participant were seated at a table. The therapist provided continuous instructions to the participant utilizing a graduated prompting procedure (i.e., verbal, model, and physical prompts). If the participant complied with the instruction following the verbal or model prompt, the therapist delivered brief verbal praise (e.g., “Good job.”). If the participant did not comply, the therapist used hand-over-hand physical guidance to have him complete the instruction. Contingent on the occurrence of a targeted problem behavior during any
point in the prompting procedure, the therapist delivered a 20-s break from the task(s) (i.e., the therapist removed the materials and turned away from the participant for 20 s). Upon the termination of the 20-s escape interval, the therapist resumed instructions. There were no programmed consequences for the occurrence of nontargeted behaviors. The purpose of this condition was to determine if problem behavior was maintained by escape from tasks.

During the no interaction condition (Cal), the participant did not have access to any stimuli (preferred or nonpreferred) or attention. There were no programmed consequences for the occurrence of targeted or nontargeted behaviors. The purpose of this condition was to determine if problem behavior was maintained by automatic reinforcement. In addition, this condition served as a control condition for comparison with the attention condition for Cal.

During the toy play condition (Seth), the participant had continuous, noncontingent access to preferred stimuli and therapist attention. In addition, no instructions were delivered to the participant. There were no programmed consequences for the occurrence of targeted or nontargeted behaviors. The purpose of this condition was to serve as a control condition for comparison with the attention, tangible, and demand conditions for Seth.

Magnitude Preference Assessment

Prior to the preference assessments, sessions were conducted to teach each participant to discriminate among three stimuli that would be correlated with different magnitudes of reinforcement. Different colored cards were used for Seth and different items of different colors were used for Cal. The large magnitude of reinforcement was
120-s access to the functional reinforcer and the small magnitude was 10-s access to the functional reinforcer. These values were chosen because they represent a range that is commonly used in applied research during assessment and treatment of problem behavior. Procedures used for each type of reinforcer are discussed separately in the following sections.

**Discrimination Training—Attention (Seth and Cal).** A small magnitude (10 s), a large magnitude (120 s), and no-reinforcement were paired with different stimuli (pink card, orange card, and white card, respectively for Seth; purple peg, blue cylinder, and wooden block, respectively for Cal). The stimuli were presented to participants by placing the stimuli on a piece of cardboard (Seth) or on a movable cart (Cal) an equal distance from each other and from the participant. For all phases of discrimination training, the therapist did not restrict the movement of participants (i.e., participants were free to move about the room). There were no programmed consequences for the occurrence of problem behavior. Sessions continued until the criteria for each phase of discrimination training were met or 1 hour elapsed, whichever came first (see further description below).

First, each magnitude was paired with the corresponding stimulus five (Seth) or ten times (Cal). The therapist presented the three stimuli correlated with the different magnitudes of reinforcement in a forced-choice, concurrent-operants arrangement. In other words, the therapist prompted participants to pick a particular stimulus until each stimulus was picked five or ten times. To force a choice, the therapist delivered a verbal prompt (i.e., “pick this one”) combined with hand-over-hand guidance to touch the stimulus. The therapist delivered attention to participants for the corresponding duration.
associated with the stimulus participants were forced to choose. During the reinforcement interval, the stimuli correlated with different magnitudes of reinforcement were removed (i.e., participants did not have access to the stimuli). For no-reinforcement, the therapist removed the stimuli and turned away from participants for 10 s.

Following these pairings, the stimulus correlated with the large magnitude of reinforcement was presented simultaneously with the stimulus correlated with no-reinforcement in a free-choice, concurrent-operants arrangement. The therapist instructed participants to pick a stimulus by providing a verbal prompt (i.e., “pick one”). If participants did not make a choice, the therapist provided the verbal prompt every 30 s until a choice was made. Reinforcement was delivered as described above. This phase of discrimination training was terminated contingent on five consecutive trials in which participants picked the large magnitude of reinforcement relative to no-reinforcement. A similar training phase was then conducted with the small magnitude of reinforcement. If participants did not meet criteria to advance to the final phase of discrimination training following 20 trials with either the large magnitude or the small magnitude, the forced-choice phase of discrimination training was reinitiated. If either participant failed to meet the criteria after five instances in which the forced-choice phase was reinitiated, he would have been excluded from the remainder of the study. However, this did not occur.

During the final phase of discrimination training, all three reinforcement stimuli were presented to participants in a free-choice, concurrent-operants arrangement. Sessions were identical to those described above for the second phase of discrimination training with the exception that all three stimuli were presented concurrently. This phase was terminated contingent on five consecutive trials in which participants did not pick the
no-reinforcement stimulus. If participants did not meet criteria for this final phase, discrimination training was repeated as described above until participants met the criteria. If either participant had repeated the discrimination training five times without meeting the criteria, he would have been excluded from the study. However, this did not occur.

**Discrimination Training—Tangible (Seth).** Sessions were conducted as described above with the following exceptions. Prior to each session, a multiple stimulus without replacement (MSWO) preference assessment (Deleon & Iwata, 1996) was conducted using the five highest ranked items from a paired-stimulus (PS) preference assessment (Fisher et al., 1992). The top two items from the MSWO were used as reinforcers during each subsequent session. The therapist delivered access to the tangible items to the participant for the corresponding duration associated with the stimulus chosen. In addition, if the no-reinforcement stimulus was selected at any time, the therapist did not turn away from the participant but continued to restrict access to the tangible items for 10 s.

**Discrimination Training—Escape (Seth).** Sessions were conducted as described above with the following exceptions. The therapist required the participant to complete 10 trials of a work task (i.e., receptive letter sound identification) in order to access the stimuli correlated with the different magnitudes of reinforcement. The procedures utilized during the 10 trials of the work task were identical to those described above for the escape condition of the functional analysis, except that problem behavior no longer produced escape from the task. The therapist delivered escape from the task to the participant for the corresponding duration associated with the stimulus the participant chose (i.e., 10 s or 120 s). For the no-reinforcement stimulus, the therapist removed the
stimulus and resumed the work trials. During the concurrent-operants phases of discrimination training, the therapist prompted the participant to make a choice every 30 s and continued the work task until a choice was made. During the 30-s interval between therapist prompts, the stimuli remained available to the participant so that a choice could be made at anytime during the work task.

Preference Assessment. Preference for the three magnitude values (i.e., small, large, and no-reinforcement) was evaluated utilizing a concurrent-operants arrangement. The no-reinforcement stimulus was included to serve as an additional control because preference for a particular magnitude was not shown during some phases of the assessment. Each session consisted of five trials of a choice between reinforcer magnitude values. Procedures were identical to those described above for the final phase of discrimination training. One deviation from these procedures is that the verbal prompt was changed from an instruction (i.e., “Pick one.”) to “Here, you can pick one if you want,” which indicated that a choice was available. Attempts to select more than one stimulus were blocked, and the therapist reissued the verbal prompt to pick just one. If participants touched the stimulus associated with either the small or large magnitude of reinforcement, the functional reinforcer being evaluated (i.e., access to tangible items, attention, or escape) was delivered for the duration of the corresponding magnitude as described above. If participants chose the no-reinforcement stimulus, the therapist continued item restriction (tangible), turned away (attention), or continued the work task (escape) for 10 s as described above. Upon the termination of the reinforcement interval, item restriction (tangible), ignore (attention), or continued demand (escape) intervals were reinitiated, and the therapist presented the stimuli and the verbal prompt as
described above. If participants did not make a choice, the therapist prompted a choice every 30 s until one was made.

As noted above, preference for a particular magnitude was defined as participants choosing that magnitude a higher percentage of times relative to the comparison magnitude and no-reinforcement for at least three consecutive sessions. Sessions continued until this criterion was met or at least five sessions were conducted, whichever came first. If no preference had been observed during the initial choice of 10 s versus 120 s, the reinforcer assessment (described below) would have been initiated. When preference was shown for the large magnitude (Seth – attention, tangible, and escape; Cal – initial phases of the preference assessment), the small magnitude was systematically increased by half (i.e., 60 s, 90 s, 105 s) until a value was identified at which no preference was observed. When preference was shown for the small magnitude (Cal – latter phases of the preference assessment), the large magnitude was decreased by half (i.e., 60 s) to identify a value at which no preference was observed. In other words, when a preference was established (either for the large or small value), the nonpreferred value was manipulated until a value was identified at which no preference was observed. A nonpreferred value was identified for use in the subsequent assessment of reinforcer potency (see further explanation below). A different stimulus was associated with each new value, and discrimination training was conducted as described above prior to conducting additional preference assessment sessions.

Magnitude Reinforcer Assessment

It was hypothesized that when a clear preference for a given magnitude was shown, the reinforcer delivered for that magnitude would function as a more potent
reinforcer than a reinforcer delivered for the less preferred magnitude. When a clear preference was not shown, the reinforcing potency of the different magnitudes would be similar. To test this hypothesis, a reinforcer assessment was conducted based on the procedures described by Roane, Lerman, and Vorndran (2001). The reinforcer potency of two (Cal) or three (Seth) different magnitudes of reinforcement were compared in a multielement design. Two magnitudes of reinforcement (10 s and 120 s) were compared to no-reinforcement for Cal because a clear preference for either 10 s or 120 s was not observed or replicated in the magnitude preference assessment. Three magnitude values were compared for Seth because he showed a preference for 120 s over 10 s but no preference when 120 s was concurrently available with 60 s.

Preferred and nonpreferred values were compared using a single-operant arrangement by examining responding under a PR schedule. For example, because the results of Seth’s tangible magnitude preference assessment demonstrated an initial preference for 120 s over 10 s, but no preference for 120 s over 60 s, the reinforcer potency of 10 s, 60 s, and 120 s was compared by examining responding under PR schedules in a single-operant, multielement design. As noted above, the primary dependent measure for the reinforcer assessment was the cumulative number of responses emitted by participants under a given magnitude value. In other words, the number of responses emitted within each session was added to the total number of responses emitted for all previous sessions under each magnitude value. In addition, the stimulus used during the preference assessment (e.g., color card) to represent each magnitude was present during corresponding sessions of the reinforcer assessment to assist participants.
with discrimination. Procedures used for the two types of reinforcers are discussed separately in the following sections.

Reinforcer Assessment—Attention (Seth and Cal). Prior to baseline, participants were taught to engage in a simple, free-operant response (i.e., button pressing for Seth and card touching for Cal) to gain access to the functional reinforcer. Training was conducted using a three-step graduated guidance procedure in which a more intrusive prompt was delivered if participants did not respond within 5 s of a prompt. Participants received 20-s access to attention contingent on each occurrence of the targeted response. Initially, reinforcement was delivered for all prompted and unprompted responses. As participants began to respond independently, reinforcement was withheld for prompted responses. Training was terminated when participants emitted the targeted response independently on 10 consecutive trials.

Prior to each baseline and reinforcement session, the therapist physically guided participants to engage in the targeted response once so that participants experienced the contingencies in place during that session. During baseline, no programmed contingencies were provided for the targeted response or any other behavior. Each baseline session continued until participants did not engage in the target response for 5 min or the session duration reached 60 min, whichever came first. A session duration cap was used due to the time constraints of participants’ availability. During the reinforcement phase, a single-operant arrangement was used during all sessions, and the different magnitude values were alternated within a multielement design. Attention was presented for the corresponding length of time being evaluated during that session contingent upon the completion of an increasing number of responses (e.g., button
pressing) within each session. There were no programmed contingencies for problem behavior.

A PR schedule of reinforcement was used in which the number of responses required to access the functional reinforcer systematically increased within each session following the completion of the previous schedule requirement. As in baseline, each session continued until participants did not engage in the target response for 5 min (Roane, Lerman, & Vorndran, 2001; Tustin, 1994). An additional termination criterion based on the total amount of time available to engage in the target response was used for Seth’s attention and escape sessions because of the high rate of responding observed during the initial series of sessions. Based on the rate of responding, the absolute number of reinforcers that could be earned within 60 min was calculated. The absolute duration of reinforcement was then calculated by multiplying 120 s by the absolute number of reinforcers that could be earned. The additional termination criterion was then determined by subtracting the absolute duration of reinforcement from 60 min to yield the maximum amount of time Seth could have access to the response apparatus. This was done to hold this variable constant across the different magnitudes of reinforcement. The additional termination criteria for Seth’s attention and escape reinforcer assessments were 27-min and 36-min access to the button, respectively. It should be noted that this termination criterion was only met two times during Seth’s attention reinforcer assessment and never met during Seth’s escape reinforcer assessment.

Upon the completion of each session, the schedule requirement was reset to the lowest response requirement (i.e., PR 1) for each new session. For each participant, the following PR schedule was utilized: PR 1, PR 1, PR 2, PR 2, PR 5, PR 5, PR 10, PR 10,
PR 20, PR 20, PR 30, PR 30, PR 40, PR 40. This was similar to the PR schedules used in previous applied research (e.g., Roane et al., 2001). If participants reached the final PR schedule and the session duration cap had not been met, the schedule was increased by increments of ten until the session cap was reached. The PR schedule involved two exposures to each requirement in order to prevent rapid ratio strain (i.e., to increase the likelihood that the procedures were sensitive enough to show any potential differences in resistance across the different reinforcement magnitudes). The same procedures were used for all magnitudes of reinforcement. The reinforcer assessment continued until clear differences in responding were obtained (defined as no overlapping data points across the conditions for three consecutive sessions) or until no differences in responding were apparent for at least four sessions with each magnitude of reinforcement.

Reinforcer Assessment—Tangible (Seth). Sessions were identical to those described above with the following exceptions. Prior to each session, a MSWO preference assessment (Deleon & Iwata, 1996) was conducted using the five highest ranked items from a PS preference assessment (Fisher et al., 1992). The top two items from the MSWO were used as reinforcers during each subsequent session. The therapist delivered access to the tangible items for the corresponding duration being evaluated contingent on the completion of the schedule requirement. In addition, prior to the participant completing the schedule requirement, the therapist did not turn away from the participant but continued to restrict access to the tangible items until the schedule requirement or session termination criteria were met, whichever came first.

Reinforcer Assessment—Escape (Seth). Sessions were identical to those described above with the following exceptions. During escape sessions, the participant
was required to complete a work task (e.g., receptive letter sound identification), as described above, in order to gain access to the response apparatus. The work task consisted of ten trials. Once the schedule requirement for button presses was completed, the participant received a break from the work task for the specified duration of reinforcement. It should be noted that Seth was required to continue work trials while pressing the button so that the break only occurred contingent on the completion of the schedule requirement.

**Reinforcer Assessment – Data Analysis.** The major dependent variable during the reinforcer assessment was the cumulative number of responses across sessions in each condition, which provided an overall summary of the total number of responses for each magnitude. Secondary analyses were conducted for the reinforcer assessment, which permitted the exploration of potential interactions between the schedule of reinforcement and magnitude. In general, these secondary analyses provide additional information about the value of the reinforcer by examining: (a) break point, (b) the work-rate function, and (c) the reinforcer-demand function. More importantly, these analyses provide a more fine-grain analysis of possible interactions between schedule and magnitude by examining the number of responses emitted and number of reinforcers earned at each schedule requirement.

Break points were determined by the final schedule requirement completed in each session. Higher break points indicated a more potent reinforcer because participants engaged in progressively more amounts of work (e.g., button presses) in order to access the reinforcer being evaluated. The work-rate function was defined as the number of responses across each session at each schedule requirement. This was calculated by
adding the total number of responses emitted at each completed schedule requirement across sessions. Finally, the reinforcer-demand function was defined as the number of reinforcers earned across each session at each schedule requirement. The reinforcer-demand function was determined by adding the total number of reinforcers earned at each schedule requirement across each session of the assessment.

**Experimental Design**

During the magnitude preference assessment, sessions were conducted in a combined free-choice, concurrent-operants, and ABAB reversal design. During the reinforcer assessment, a reversal design with an embedded multielement component was utilized to compare the different magnitude values under PR schedules of reinforcement.
RESULTS

The top panel of Figure 1 depicts data from Seth’s multielement and pairwise functional analyses. During the multielement functional analysis, elevated levels of aggression were observed during the tangible ($M = 1.1$ responses per minute) and attention ($M = 1.1$ responses per minute) conditions relative to the toy play condition ($M = 0.2$ responses per minute). Due to the severity of Seth’s aggression during the attention and tangible conditions, sessions were discontinued and a possible demand function was further evaluated. During the pairwise functional analysis, levels of aggression and disruption were higher during the demand condition ($M = 0.9$ responses per minute) relative to the toy play condition ($M = 0.1$ responses per minute). Together, these findings indicated that Seth’s problem behavior was maintained by positive reinforcement in the form of access to attention and tangible items and negative reinforcement in the form of escape from demands. The data from Cal’s pairwise functional analysis are depicted in the bottom panel of Figure 1. Higher rates of problem behavior were observed during the attention condition ($M = 2.78$ responses per minute) relative to the no interaction condition ($M = 0.4$ responses per minute), indicating that Cal’s problem behavior was maintained by attention.

Results of Seth’s magnitude preference assessment using tangible reinforcers are presented in the top panel of Figure 2. Seth allocated more responses to the 120-s magnitude ($M = 70\%$) than to the 10-s magnitude ($M = 23\%$) and no-reinforcement ($M = 7\%$) during the first phase. When the small value was increased, choice became variable, with response allocation alternating between 60 s ($M = 52\%$) and 120 s ($M = 48\%$). These
Figure 1. Responses per minute aggression and aggression plus disruption for Seth (top panel) and responses per minute aggression and biting for Cal (bottom panel).
results indicated that 120-s access to tangibles was preferred over 10-s access but not over 60-s access.

Results of Seth’s reinforcer assessment (cumulative number of responses) using tangible reinforcers are presented in the bottom panel of Figure 2. Button presses decreased across baseline. During reinforcement, more responses were observed under the 120-s magnitude relative to the 10-s and 60-s magnitudes, indicating that 120 s was a more potent magnitude of reinforcement than either 10 s or 60 s.

Secondary analyses also were conducted for Seth’s reinforcer assessment. The upper panel of Figure 3 depicts the break point for each session. Higher break points were reached under 120 s ($M = PR \ 20$; range, PR 5 to PR 30) relative to 10 s and 60 s ($M = PR \ 5$; range, PR 2 to PR 10; $M = PR \ 2$; range, no responding to PR 5, respectively). It should be noted that the average break points that appear in the preceding parentheses were calculated by adding the break points from each session, dividing that number by the total number of sessions, and rounding to the nearest PR schedule evaluated. The middle panel depicts the work-rate function. Higher levels of responding were observed across increasing schedule requirements for 120 s relative to 10 s and 60 s. More specifically, under the richer schedules of reinforcement (i.e., PR 1 and PR 2) similar levels of responding were observed for 120 s and 60 s relative to 10 s. Differences in responding were not observed until the schedule requirement reached PR 5. Differences in responding were also observed between 10 s and 60 s, with more responses occurring for 60 s relative to 10 s of reinforcement under each schedule of reinforcement reached during the assessment. The bottom panel depicts the reinforcer-demand function. More reinforcers were earned across the increasing schedule requirements for 120 s relative to
Figure 2. Percentage of trials in which magnitude values were selected during the tangible preference assessment (top panel) and cumulative number of responses across sessions of the tangible reinforcer assessment (bottom panel) for Seth.
Figure 3. Breaking point for each session (top panel), work-rate function (middle panel), and reinforcer-demand function (bottom panel) during Seth’s tangible reinforcer assessment.
10 s and 60 s beginning at PR 5. In addition, higher numbers of reinforcers were earned for 60 s than 10 s, even at the smallest schedule requirement (i.e., PR 1).

Collectively, the primary and secondary analyses indicate that 120 s, which was identified as the preferred value from the preference assessment, was a more potent magnitude of reinforcement relative to 10 s and 60 s when access to preferred tangible items was used as a reinforcer. This is indicated by the higher total number of responses observed across sessions (cumulative number of responses), the higher break points reached in each session, and the higher levels of responding (work-rate) and higher number of reinforcers earned (reinforcer-demand) across increasing schedule requirements under the 120-s magnitude. There also appears to be an interaction between magnitude and the schedule of reinforcement in that higher levels of responding occurred and more reinforcers were earned for larger amounts of reinforcement as the schedule requirement increased. This interaction effect is supported by the greater differences under the thinner schedules of reinforcement observed.

Figure 4 depicts the results of Seth’s assessments with attention as the reinforcer. During the preference assessment (top panel) more responses were allocated to the 120-s magnitude ($M = 78\%$) relative to the 10-s magnitude ($M = 20\%$) and to no-reinforcement ($M = 2\%$) during the first phase. When the small value was increased to 60 s, Seth’s choice responding became variable, alternating between 60 s ($M = 51\%$) and 120 s ($M = 49\%$); no responses were allocated to no-reinforcement. These data indicate a preference for 120 s of attention over 10 s but not over 60 s.

The cumulative number of responses during Seth’s reinforcer assessment is depicted in the bottom panel of Figure 4. Decreases in responding were observed during
Figure 4. Percentage of trials in which magnitude values were selected during the attention preference assessment (top panel) and cumulative number of responses across sessions of the attention reinforcer assessment (bottom panel) for Seth.
baseline. During reinforcement, higher levels of responding were observed under the 120-s magnitude than under the 10-s magnitude. Responding also was slightly higher under 120 s than under 60 s. Secondary analyses for the reinforcer assessment are depicted in Figure 5. Higher break points (top panel) were generally reached under the 120-s magnitude ($M = \text{PR 40}$; range, PR 20 to PR 50) than under the 10-s magnitude ($M = \text{PR 20}$; range, PR 10 to PR 30); however, break points were similar for 120 s and 60 s ($M = \text{PR 40}$; range, PR 20 to PR 70). The work-rate function is depicted in the middle panel. For the 120-s magnitude, higher levels of responding were observed across the increasing schedule requirements relative to 10 s, and slightly higher levels of responding were observed across increasing schedule requirements relative to 60 s. More responding was also observed for 60 s than 10 s across the increasing schedule requirements. Interestingly, there was no difference between the conditions until the schedule exceeded PR 10, demonstrating an interaction between schedule and magnitude. Moreover, slight differences between 120 s and 60 s emerged at PR 20 through PR 50, yet more responding was observed for 60 s than for 120 s at values higher than PR 50. Figure 5 (bottom panel) depicts the reinforcer-demand function. More reinforcers were earned across the increasing schedule requirements for the 120-s magnitude relative to 10 s and for the 60-s magnitude relative to 10 s. Slightly more reinforcers were earned across increasing schedule requirements for the 120-s magnitude relative to 60 s (up to PR 50).

Taken together, results of the secondary analyses of the attention reinforcer assessment indicate no differences in the potency of the three magnitudes under rich schedules of reinforcement. However, both 120 s and 60 s appeared to be more potent than 10 s as the schedule requirements increased. Results of the comparison between 60 s
Figure 5. Breaking point for each session (top panel), work-rate function (middle panel), and demand-reinforcer function (bottom panel) during Seth’s attention reinforcer assessment.
and 120 s were more complex. The primary analysis indicated that 60 s and 120 s were more potent magnitudes of reinforcement compared to 10 s. In addition, the data suggest that these magnitudes were of similar value. The analysis of break points, however, suggests that 120 s was a more potent magnitude than both 10 s and 60 s. The work-rate and reinforcer-demand functions analyses provide a more in depth evaluation of these effects. These data supported the conclusions from both the primary analysis and the evaluation of break points under certain schedules. It appeared that 120 s functioned as a more potent reinforcer than 60 s when the schedule was greater than PR 10 but less than PR 60. In fact, the data suggested that 60 s was of greater value than 120 s beyond PR 50.

Figure 6 shows the data from the evaluation of escape as the reinforcer for Seth’s responding. Seth allocated more responses to the 120-s magnitude ($M = 92\%$) than to the 10-s magnitude ($M = 8\%$) and to no-reinforcement ($M = 0\%$) when these values were compared. When the small value was increased, choice alternated between 60 s ($M = 50\%$) and 120 s ($M = 41\%$). A slight increase in responding for no-reinforcement ($M = 9\%$) was also observed. These results indicated that a 120-s break was preferred over a 10-s break from the work task and that there was no preference between a 60-s break and 120-s break when they were concurrently available.

Data (cumulative number of responses) from Seth’s escape reinforcer assessment are presented in the bottom panel. During baseline, decreases in button presses were observed. Similar rates of responding were observed across all reinforcement magnitudes during the reinforcement condition, although it appears that responding for 120 s was beginning to decline toward the end of the assessment. Secondary analyses of the reinforcer assessment data are presented in Figure 7. Break points were similar and quite
Figure 6. Percentage of trials in which magnitude values were selected during the escape preference assessment (top panel) and cumulative number of responses across sessions of the escape reinforcer assessment (bottom panel) for Seth.
variable across the 10-s, 60-s, and 120-s magnitudes ($M = PR 20$; range, PR 10 to PR 40; $M = PR 20$; range, PR 1 to PR 40; $M = PR 20$; range, PR 2 to PR 40; respectively).

Work-rate function and demand-reinforcer data are depicted in the middle and bottom panels of Figure 7, respectively. Similar results were initially observed through PR 10 for all magnitudes in both analyses. A slight decrease in responding and number of reinforcers earned was observed at PR 20 for 120 s and continued for the remaining schedule requirements.

Together, the primary and secondary analyses showed no significant differences in reinforcer potency across the three magnitudes of negative reinforcement, although the 120-s magnitude was associated with slightly lower rates of responding and number of reinforcers earned than the other magnitudes. Again, this difference was not evident until higher schedule requirements were reached (i.e., PR 20).

Results for Cal are presented in Figure 8. During the preference assessment (top panel), Cal initially allocated more responses towards the 120-s magnitude ($M = 94\%, 97\%, \text{and } 91\%$) than towards the 10-s magnitude ($M = 6\%$), 60s magnitude ($M = 3\%$), and 90-s magnitude ($M = 6\%$). Across these three comparisons, response allocation to no-reinforcement was at or near zero. Choices became much more variable when 120 s ($M = 41\%$) was available concurrently with 105 s ($M = 34\%$). During the replication phase of 10 s versus 120 s, a shift in preference to the 10-s magnitude was observed with more responses allocated to 10 s ($M = 72\%$) than to 120 s ($M = 20\%$) and no-reinforcement ($M = 8\%$). Following a return to 105 s versus 120 s, Cal’s preference for 10 s over 120 s was replicated. Thus, the large value was decreased to 60 s in order to identify a magnitude at which preference would no longer be observed. During the comparison of 10 s and 60 s,
Figure 7. Breaking point for each session (top panel), work-rate function (middle panel), and reinforcer-demand function (bottom panel) during Seth’s escape reinforcer assessment.
responding was variable with no clear difference between 10 s ($M = 37\%$), 60 s ($M = 29\%$), and no-reinforcement ($M = 34\%$). A return to the 10 s versus 120 s comparison failed to replicate a preference for either the 10-s ($M = 47\%$) or 120-s ($M = 22\%$) magnitudes. In addition, increases in responding for no-reinforcement ($M = 31\%$) were observed. Across the assessment, Cal began to choose smaller amounts of attention and sometimes no attention with increasing frequency. Therefore, it was hypothesized that attention was no longer a reinforcer and had possibly become aversive.

Cal’s reinforcer assessment data are depicted in the bottom panel of Figure 8. Decreases in responding were observed during baseline and across the 10-s and 120-s magnitudes of reinforcement. These data indicate that attention did not function as a reinforcer for responding, regardless of the magnitude. This confirmed the conclusion that attention no longer functioned as a reinforcer and had possibly become aversive. Due to the decrease in responding during reinforcement, secondary analyses were not conducted for Cal’s attention reinforcer assessment.
Figure 8. Percentage of trials in which magnitude values were selected during the attention preference assessment (top panel) and cumulative number of responses across sessions of the attention reinforcer assessment (bottom panel) for Cal.
DISCUSSION

In general, results of the preference assessments suggested that children with developmental disabilities may show a preference for larger magnitudes of functional reinforcers, such as attention and escape, and that larger magnitudes of reinforcement may influence responding under concurrent-operants arrangements. Furthermore, increases in responding for larger magnitudes of positive reinforcement were observed under PR schedules of reinforcement. Therefore, it appears that preference for different magnitudes of a positive reinforcer may predict the relative reinforcer potency of the preferred magnitude.

The demonstration of magnitude effects using concurrent-operants arrangements and PR schedules is consistent with findings that have been reported in the basic literature (e.g., Catania, 1963; Hodos, 1961). Prior to this study, the majority of applied studies evaluating magnitude used single-operant arrangements and continuous schedules of reinforcement. These results support the hypothesis that the inconsistent results observed in the applied literature may be related to the methods used to evaluate reinforcement magnitude. In addition, results indicate that preference for a particular magnitude of positive reinforcement may predict the relative reinforcing potency of that value. If this finding is replicated in future studies, clinicians should be able to use preference or reinforcer assessments to determine the most effective magnitude of positive reinforcement to use during reinforcement-based procedures in lieu of selecting magnitude values arbitrarily.

For one participant (Cal), consistent preference for one magnitude of positive reinforcement relative to another was not observed. Furthermore, responding was not
differentiated across two reinforcement magnitude values and no-reinforcement during the reinforcer assessment. In fact, Cal had ceased responding in all conditions by the end of the reinforcer assessment. Based on these results, it is difficult to determine what effects, if any, differences in magnitude had on his responding. The lack of responding during the reinforcer assessment indicates that attention lost its reinforcing value or potency during the course of the study. This finding is interesting because results of the functional analysis identified attention as a reinforcer for his problem behavior. This discrepancy in the findings could be due to differences in the quality of attention delivered during the functional analysis versus during the preference and reinforcer assessments (Fisher, Ninness, Piazza, and Owen-DeSchryver, 1996). Attention was delivered in the form of reprimands and concerning statements during the functional analysis but in the form of praise, hugs, and songs during the preference and reinforcer assessments. In addition, the behavior being reinforced across the assessments was qualitatively different (i.e., problem behavior versus object selection), which may also account for the lack of responding during the reinforcer assessment. Therefore, it is possible that attention in the form of reprimands and concerning statements functioned as a reinforcer for Cal’s problem behavior, but attention in the form of praise, hugs, and songs did not function as a reinforcer for an alternative behavior.

It should be noted, however, that a reinforcement effect was observed during Cal’s preference assessment. He initially selected some magnitude of reinforcement over no-reinforcement during the first phases of the preference assessment. In fact, over the course of the preference assessment, preference switched from the large value to the small value, and Cal even began to select no-reinforcement more often toward the end of
the assessment. This also suggests that attention may have lost its value over the course of the assessment. The results of the reinforcer assessment confirmed that attention no longer functioned as a reinforcer.

This study also demonstrates the efficacy of using PR schedules of reinforcement to evaluate magnitude effects related to positive reinforcement. As demonstrated in the reinforcer assessment, Seth generally responded more for larger amounts of positive reinforcement. More specifically, the results indicate a positive relationship between the amount of response persistence under increasing schedule requirements and reinforcement magnitude. Similar levels of responding were observed under lower schedules of reinforcement. Differences in responding across the different magnitudes of positive reinforcement were evident only as the schedule requirement increased. It is also interesting to note that, under the PR schedules, the large magnitude value produced more responding than the value at which no preference was identified during the tangible preference assessment. So, while the concurrent-operants preference assessment identified a point where responding was not influenced by differences in magnitude, the reinforcer assessment, or PR schedule, did identify a difference between the two. This suggests that magnitude effects may be observed more readily under certain schedule arrangements; however, more research is needed to evaluate this hypothesis.

In contrast, results of the preference and reinforcer assessments corresponded perfectly when attention was the reinforcer evaluated. That is, results of the reinforcer assessment replicated the results of the preference assessment in that a difference was observed between 10 s and 120 s of attention, yet no difference was observed between 60 s and 120 s. This indicates that the methodologies may be similarly sensitive to
magnitude effects. Future research should address any potential differences between concurrent-operants arrangements and PR schedules (single-operant arrangement) for identifying magnitude effects. Both may provide a good measure of these effects, yet one method may be more desirable from a clinical perspective (e.g., ease, efficiency). In addition, future research should evaluate the efficacy of combining the two methodologies (i.e., a concurrent-operants arrangement with increasing schedule requirements for each component) to evaluate magnitude effects. This arrangement would be similar to procedures used previously to evaluate different parameters of reinforcement (Neef, Mace, Shea, & Shade, 1992). A combined arrangement may also provide a more efficient evaluation of magnitude effects.

Results also have some important clinical implications for the selection of different amounts of reinforcement to use during reinforcement-based procedures. First, results suggest that reinforcement magnitude can influence responding in choice situations. This indicates that clinicians may be able to bias responding during treatment when two behaviors are concurrently available by providing larger amounts of reinforcement for a desired response (e.g., sign language) relative to one that is undesired (e.g., aggression), especially when caregivers are unable to withhold reinforcement for problem behavior. Second, for certain types of reinforcers (i.e., positive reinforcers), increasing the magnitude of reinforcement may enhance treatment effectiveness. This may be especially relevant at higher schedule requirements. These findings also support the results of basic research and the recommendation that treatment will be more successful as the schedule requirement is thinned if the magnitude of the reinforcer is increased (e.g., Cooper, Heron, & Heward, 1987). Therefore, clinicians should consider
using larger magnitudes of reinforcement during schedule thinning in order to maintain response persistence under these conditions. Future research, however, should directly examine this recommendation.

These results also suggest that clinicians should consider the type of reinforcer (i.e., positive versus negative) when determining the most effective amount of reinforcement to use during reinforcement-based procedures. More responding was observed for larger amounts of positive reinforcement, yet similar levels of responding were generally observed across all magnitudes of negative reinforcement. For negative reinforcement-based procedures, clinicians may be able to select magnitude based on other factors, such as ease of implementation.

One possible explanation of the results obtained with negative reinforcement is that larger magnitudes of escape functioned as an abolishing operation (AO), decreasing the motivation to respond for the reinforcer. The large magnitude condition was necessarily associated with a lower rate of demands, which may have reduced the aversiveness of the demand situation (e.g., Smith, Iwata, Goh, & Shore, 1995). In turn, this would decrease the motivation to respond for breaks from the task. This seems likely given the reduced response persistence for the largest value.

One procedural nuance during the reinforcer assessment, however, may explain differences in the findings for positive versus negative reinforcement. During the evaluation of positive reinforcement, the establishing (EO) remained present (i.e., therapist attention and preferred tangible items were not available) once a session ended. In contrast, the EO was no longer present (i.e., the work task was discontinued) after the session ended during the evaluation of negative reinforcement. As such, the contingency
for completing a schedule requirement was short breaks from the work task, whereas the contingency for not engaging in the alternative response was the termination of the task altogether (i.e., sessions ended contingent on a 5-min period of no responding). This procedural nuance may have decreased the likelihood that Seth’s responding would persist as the schedule of negative reinforcement was thinned. Nonetheless, responding should have decreased across the assessment for all magnitudes if this procedural component influenced the results. In fact, the opposite occurred. Increases in responding were observed across some of the magnitudes. Additional research should address this potential limitation by using a different session termination criterion (i.e., one not based on the absence of responding). To do so, an alternative to within-session PR schedules would be needed to examine the interaction between magnitude of negative reinforcement and schedule. For example, this problem may be rectified by using a trial-based termination criterion and schedules that increase across sessions rather than within session.

There are some additional limitations to the current investigation. First, the procedures were evaluated with just two participants. Future research should evaluate these procedures with more participants and multiple sources of social reinforcement. Additional direct comparisons of positive and negative reinforcement are needed to clarify any potential differences that exist between these forms of reinforcement.

Another limitation is that single- and concurrent-operants arrangements were not directly compared during the preference or reinforcer assessments. For example, the strength of the concurrent-operants arrangement for detecting magnitude effects would have been enhanced by comparing the results to those of a single-operant preference.
assessment. However, it should be noted that previous studies have directly evaluated differences in reinforcement effects under concurrent and single-operants arrangements (e.g., Roscoe, Iwata, & Kahng, 1999). Results of Roscoe et al. for example, showed that concurrent-operants arrangements provide a better measure of relative preference. The interaction between magnitude and reinforcement schedule also could have been examined more directly by comparing responding under FR 1 to responding under the PR schedule.

Although PR schedules provide a relatively quick evaluation of responding under increasing schedule requirements, they may not exemplify schedules typically used in applied settings (Roane, Call, & Falcomata, 2005). Typically, reinforcement schedules are increased more gradually across time once some criterion is met (see Hanley, Iwata, & Thompson, 2001, for a discussion of reinforcement schedule thinning). In addition, increases usually involve smaller schedule increments (e.g., FR 1 to FR 2). Therefore, evaluations of magnitude effects under schedules of reinforcement that are more commonly used in the natural environment are warranted. For example, future research could use a gradual fading procedure (as described above) to evaluate magnitude.

In addition, some of the magnitudes evaluated during the reinforcer assessment were never directly compared during the preference assessment. For example, 10 s of reinforcement was never directly compared to 60 s during each of Seth’s preference assessments. This makes it difficult to draw conclusions about responding under these magnitudes across the preference and reinforcer assessments. Finally, reinforcement magnitude was not evaluated within the context of treatment for problem behavior. As a result, it remains unclear what effects magnitude preference or potency would have on
decreasing problem behavior. Further evaluation is needed within the context of
treatment (e.g., functional communication training). Despite these limitations, this study
began to identify conditions under which magnitude effects may be observed in
application and provided preliminary evidence for the use of preference and reinforcer
assessments for determining effective magnitudes of reinforcement.
REFERENCES


VITA

Nicole M. Trosclair received a Bachelor of Science degree at Louisiana State University (LSU) in 2001. Her degree was awarded through the College of Arts and Sciences and her major was psychology. As an undergraduate, Nicole was a member of a number of organizations (e.g., Psi Chi) and received various acknowledgements (e.g., Dean’s List). During her four years of undergraduate study, she gained experience within the area of applied behavior analysis by enrolling in classes in this area taught by Dr. Dorothea Lerman. Through her experience as a research assistant in Dr. Lerman’s lab, she developed an interest in applied behavior analysis. Upon graduating from LSU, she began working full-time at the Marcus Institute in Atlanta in an entry-level position (Behavior Data Specialist) and was shortly promoted to the Clinical Specialist I position. She worked as an apprentice to Dr. Wayne Fisher, Dr. Cathleen Piazza, Dr. Henry Roane, and Dr. Meeta Patel and learned to provide clinical services to children with various diagnoses who engaged in severe destructive behavior or had feeding disorders. While working at the Marcus Institute, she gained experience conducting functional analyses of problem behavior and developing and conducting function-based treatments to treat problem behavior, increase appropriate behavior, and to increase the oral consumption of children with feeding disorders. Her experience at the Marcus Institute reinforced her interest in utilizing behavior analytic procedures to treat problem behavior associated with various diagnoses and thus decided to further her knowledge and education in this area. She is currently pursuing her doctoral degree in school psychology at Louisiana State University.