Using a Behavioral Economic Assessment to Evaluate Stimulus Preferences and to Predict Treatment Outcomes for Aberrant Behavior.

Henry Stanley Roane
Louisiana State University and Agricultural & Mechanical College

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USING A BEHAVIORAL ECONOMIC ASSESSMENT TO EVALUATE STIMULUS PREFERENCES AND TO PREDICT TREATMENT OUTCOMES FOR ABERRANT BEHAVIOR

A Dissertation

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 Doctor of Philosophy

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Henry S. Roane
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ABSTRACT

Problem behavior (e.g., self-injury, aggression, and disruption) may impede the development of many individuals with disabilities. These behaviors may occur for many reasons (Iwata et al., 1994). Most problem behaviors are controlled by social stimuli; however, for some individuals, problem behavior occurs independent of the social environment (i.e., by automatic reinforcement). That is, an individual may engage in these behaviors regardless of what is occurring around them. Presumably the behavior persists because the behavior produces (or alleviates) some type of stimulation. As such, the reinforcer for the behavior can not be controlled directly, making behaviors maintained by automatic reinforcement difficult to treat. One treatment for automatically reinforced behavior involves the presentation of alternative stimuli (e.g., preferred toys). Preferred items are typically determined using one of several different preference assessment procedures in which participants select (i.e., orient toward) the items that they prefer. However, recent research has suggested that existing preference assessments may not be the optimal method for identifying stimuli to be incorporated into behavioral interventions.

In this investigation, individuals with developmental disabilities were presented with one of two preferred items (as identified in a commonly used preference assessment) contingent upon completion of a predetermined number of responses. The number of responses required to access the preferred items progressively increased within the course of each session, such that the total response requirement increased as the session progressed. The stimulus that resulted in more responding was deemed the high preference stimulus, whereas the stimulus that resulted in fewer responses was deemed
the low preference stimulus. Subsequent treatment evaluations were conducted to
compare the treatment efficacy of these two stimuli as components of various
reinforcement-based interventions for problem behavior maintained by automatic
reinforcement. Results showed that when an effective treatment was identified, the high
preference stimulus was associated with greater treatment success. Results are discussed
in terms of the application of these procedures to the further treatment of problem
behavior maintained by automatic reinforcement, and directions for future research are
presented.
REVIEW OF THE LITERATURE

Prevalence of Self-injurious Behavior

Self-injurious behavior (SIB) is defined as behavior that produces physical damage to an individual’s own body (Tate & Baroff, 1966). Self-injury is one form of problem behavior exhibited by individuals with developmental disabilities; however, other problem behaviors (e.g., aggression, property destruction, and pica) also frequently occur. The occurrence of problem behavior in individuals with developmental disabilities is a significant issue facing practitioners who work with these individuals. In general, the prevalence of SIB has been widely estimated to occur among 7% to 50% of individuals with developmental disabilities (Schroeder, 1991). For example, Schroeder, Schroeder, Smith, and Dalldorf (1978) interviewed staff in residential facilities and found that approximately 10% of institutionalized individuals engaged in chronic SIB. Using a similar method, Oliver, Murphy, and Corbett (1987) found that approximately 19% of individuals with developmental disabilities engaged in SIB. Furthermore, the prevalence of problem behavior has been noted to be higher among individuals with more severe disabilities (Johnson & Day, 1992) and lower among individuals in non-institutional settings (Schroeder, 1991). Thus, the occurrence of problem behavior presents a difficulty in the training and education of individuals with developmental disabilities.

Empirical Support for Operant Functions of SIB

Several hypotheses regarding the development and maintenance of SIB have been proposed. A psychoanalytic hypothesis posits that SIB is related to unconscious feelings or improper development of the self (Spitz & Wolfe, 1949); however, little empirical support exists for a psychodynamic model of SIB (Carr, 1977). An organic hypothesis
suggests that SIB is due to genetic abnormality (e.g., Lesch-Nyhan disorder) or variations in certain neurotransmitters (Cataldo & Harris, 1982). Although some evidence exists for an organic role in the development of SIB, incidences of this problem cannot be attributed entirely to organic aberrations.

In addition to the hypotheses listed above, Carr (1977) posited an operant account for the etiology of SIB. Carr presented three operant mechanisms that may be associated with the occurrence of SIB. A positive reinforcement hypothesis suggests that SIB is maintained by the contingent presentation of a stimulus following the behavior. For example, a child may receive social attention (e.g., verbal reprimands, hugs) contingent on maladaptive behavior. Although this response may be intended to “calm” the child, the attention may function as a reinforcer by increasing the future likelihood of the response that immediately preceded its delivery (i.e., SIB). The second operant mechanism described by Carr involves the contingent removal of an aversive stimulus. In this negative reinforcement hypothesis, maladaptive behavior results in the avoidance or cessation of an aversive event (e.g., instructional activities). Removal of the aversive event functions to strengthen the future occurrence of the maladaptive response. The final operant mechanism described by Carr was the “self-stimulation” hypothesis. This hypothesis purports that automatic reinforcement (i.e., reinforcement directly produced by the maladaptive response, independent of the social environment; Vaughn & Michael, 1982) may function in the development and maintenance of SIB. The term “social stimulation” implies that the behavior produces access to stimuli (i.e., automatic positive reinforcement). Conversely, an aversive stimulus (e.g., a toothache) also may be terminated by engaging in the behavior (i.e., automatic negative reinforcement).
Numerous research findings support Carr's (1977) hypotheses regarding an operant basis to SIB. Lovaas and Simmons (1969), for example, showed that rates of SIB increased when attention (i.e., statements of concern) was provided contingently (i.e., positive reinforcement). Carr, Newsome, and Binkoff (1980) showed that high rates of aggression occurred when a participant was allowed to escape academic demand situations contingent on aggression (i.e., negative reinforcement). Also, rates of aggression dropped to low levels when aggression no longer produced escape. Berkson and Mason (1964) showed that high rates of SIB occurred when participants were devoid of stimulation. Further, low rates of SIB occurred when alternative stimulation (e.g., toys) was provided continuously (i.e., automatic positive reinforcement). De Lissovoy (1963) noted that some cases of SIB occurred only in the presence of ear infections, presumably to alleviate painful stimulation (i.e., automatic negative reinforcement). These findings suggest that specific operant functions may be idiosyncratic across individuals.

Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994) presented a methodology designed to assess potential operant mechanisms responsible for the maintenance of SIB in individual cases. In three test conditions, relevant antecedent (i.e., presence or absence of social attention, aversive stimulation, or activities) and consequent events (i.e., delivery of attention, escape from tasks, or nothing) varied. Each condition was developed to test a particular operant hypothesis. In the social disapproval condition, a therapist was in the room with a participant. The therapist did not interact with the participant but sat nearby and was engaged in another activity. The participant had continuous access to toys but was ignored otherwise. Contingent on the occurrence of SIB, the therapist immediately ceased his or her activity and provided the participant with
attention in the form of disapproving comments (e.g., “Stop that”, “Don’t do that”). This condition was designed to test whether behavior was maintained by positive reinforcement. The second test condition was the academic demand condition. In this condition, a therapist was present in the room with the participant. Instructional activities were presented to the participant once every 30 seconds. Contingent on the occurrence of SIB, instructional items were removed, the therapist turned away from the participant, and the participant was given a 30-second break from instructions. This condition was designed to test the negative reinforcement hypothesis. In the final test condition, the participant was observed alone in a therapy room. No toys were present, and no social consequences were provided for SIB. The purpose of this condition was to determine if SIB would occur in the absence of social stimulation, which would suggest an automatic reinforcement function. A control condition (unstructured play) also was conducted in which participants had continuous access to preferred stimuli and received noncontingent attention on a fixed-time (FT) 30-second schedule of reinforcement. All four conditions were alternated randomly within a multielement design, and eight sessions were conducted daily. The analysis continued until (a) stable responding occurred in one of the test conditions, (b) unstable responding persisted for 5 days, or (c) 12 days of sessions were completed. Results indicated that higher levels of SIB were associated with one test condition for 6 of the 9 participants. Furthermore, response patterns differed among these 6 participants, suggesting that the operant function of SIB varied across individuals. Thus, the data presented by Iwata et al. provided evidence for an operant account of SIB. Furthermore, the authors demonstrated an efficient methodology for studying the relationship between problem behavior and specific antecedent and consequent events.
Since its development, the functional analysis methodology has become a
standard approach for identifying the variables that maintain aberrant behavior, including
aggression (Carr et al. 1980), disruption (Fisher, Adelinis, Thompson, Worsdell, &
Zarcone, 1998), pica (Piazza, Hanley, & Fisher, 1996), and vocalizations (Mace & Lalli,
1991). Functional analyses also are effective prescriptive tools because specific variables
that maintain problem behavior can be manipulated as part of treatment (Mace, 1994).
For example, Day, Rea, Schussler, Larsen, and Johnson (1988) used functional analysis-
based treatments for three individuals who engaged in SIB. Two participants’ behavior
was maintained by positive reinforcement in the form of access to leisure items or toys.
Treatment consisted of teaching an alternative method of accessing stimuli (i.e., teaching
participants to request materials) while no longer providing items contingent on SIB. For
a third participant, the functional analysis revealed that SIB was maintained by automatic
reinforcement. Treatment consisted of blocking SIB (via restraints) and providing
alternative stimulation (i.e., music via headphones). Steege et al. (1990) demonstrated
that two participants’ SIB was maintained by escape from tasks. Treatment consisted of
teaching the participants to engage in an alternative response (i.e., pressing a
microswitch) to escape tasks (i.e., self-grooming). These studies provide examples of
how functional analyses can lead to treatment development. In both studies, functional
analysis results were used to determine what type of reinforcement to present contingent
on an alternative response (differential reinforcement) and to withhold contingent on the
inappropriate behavior (extinction).
Automatic Reinforcement

As mentioned above, automatic reinforcement refers to behavior that is maintained by the consequences it produces (Vaughn & Michael, 1982). These consequences are presumably produced internally and are not controlled by the social environment. For example, self-scratching may occur because it alleviates a skin irritant. In this example, scratching is maintained by attenuation of aversive stimulation (i.e., an itch) rather than by the presentation of a social reinforcer (e.g., attention). Effective treatments for behavior maintained by automatic reinforcement may be difficult to identify due to a lack of control over the maintaining reinforcer. Treatment of automatically reinforced SIB has focused on three broad areas: (a) eliminating the relationship between the response and the reinforcer (Dorsey, Iwata, Reid, & Davis, 1982; Reid, Parsons, Phillips, & Green, 1993; Rincover, 1978), (b) providing alternative sources of stimulation (Berkson & Mason, 1964; Favell et al., 1982; Goh et al., 1995; Horner, 1980; Piazza et al., 1998; Vollmer, Marcus, & LeBlanc, 1994), and (c) providing alternative reinforcement contingent on an alternative response (Cowdery, Iwata, & Pace, 1990; Lockwood & Bourland, 1982; Piazza, Fisher, Hanley, et al., 1996; Shore et al., 1997; Wacker et al., 1990). These treatments are described in the next section.

Treatments for Behavior Maintained by Automatic Reinforcement

Extinction

In some cases, the reinforcing properties of automatically reinforced behavior can be identified (e.g., Goh et al., 1995). In such cases, operant extinction (withholding reinforcement for a previously reinforced response; Lerman & Iwata, 1996a) can be used to decrease levels of SIB. Rincover (1978) provided one example of using extinction to
decrease stereotypic behavior. First, direct observation was used to develop hypotheses about the sensory consequences produced by stereotypic behavior (e.g., object twirling, object spinning, finger flapping) displayed by 3 individuals. The putative consequences were then withheld contingent on the occurrence of the behavior. For example, it was hypothesized that one participant’s plate spinning was maintained by the auditory stimulation produced when the plate was spun on a table. In treatment, a piece of carpet was placed on the table, which eliminated auditory stimulation produced by spinning the plate. As a result, decreases in plate spinning were observed, presumably because the target behavior no longer produced the hypothesized reinforcer. However, this study was limited in that no experimental analysis was conducted to identify automatic reinforcement as the maintaining consequence for stereotypy or to demonstrate the specific stimulus properties reinforcing the behavior. Finally, the interventions used by Rincover could have influenced behavior via a number of mechanisms in addition to extinction. For example, one participant’s hand flapping was treated by applying a vibrator to the back of the hand, which could have functioned as a punisher (Mazaleski et al., 1994).

Response blocking also has been used to treat automatically reinforced SIB via extinction. Reid et al. (1993) used response blocking to decrease the self-injurious hand mouthing of two participants. Contingent on participants bringing their hands to their mouths, an experimenter blocked hand-to-mouth contact by placing his or her hand in front of the participant’s mouth. Hand mouthing decreased for both participants, and the authors concluded that the behavior no longer produced reinforcement. However, Reid et al. did not conduct a pre-treatment functional analysis to determine that automatic
reinforcement maintained hand mouthing. Thus, conclusions regarding the behavioral mechanism responsible for reductions in hand mouthing are tentative. Results of Lerman and Iwata (1996b) suggested that, in some cases, blocking might function as punishment. The authors varied the proportion of responses that were blocked to evaluate the mechanisms responsible for the effectiveness of blocking. If punishment were the effective component of response blocking, responding would decrease as more responses were blocked. Conversely, if extinction was the effective component, responding would increase as more responses were blocked (i.e., as the reinforcement schedule was thinned). Results showed that SIB dropped to near-zero rates when response blocking was initiated. Further, rates of SIB stayed low as the blocking schedule was thinned, indicating that punishment was the component responsible for the decreases in behavior.

Another variation of sensory extinction involves the use of protective equipment. Dorsey et al. (1982) evaluated the effects of noncontingent and contingent protective equipment on levels of SIB. Initially, protective equipment (i.e., gloves and helmet) was applied continuously throughout 20-minute sessions, resulting in decreases in SIB. Next, protective equipment was applied for 2 minutes contingent on each occurrence of SIB. Participants also received access to preferred items while protective equipment was in place. Rates of SIB remained low, and the time with equipment decreased in this condition. Presumably, low rates of SIB were observed in both conditions due to the disruption of the relationship between the response (SIB) and delivery of the automatic reinforcer. However, results of Mazaleski et al. (1994) suggested that behavior reductions obtained with protective equipment (or competing stimulation; i.e., Rincover, 1978) may be due to other properties (i.e., punishment) instead of extinction. Mazaleski et al.
observed decreases in SIB when protective equipment was provided either contingently or noncontingently. This study differed from the study conducted by Dorsey et al. in that contingent application of protective equipment did not follow a period of noncontingent application for one participant, and results showed that SIB decreased for this participant. Mazaleski et al. concluded that contingent presentation of equipment functioned as punishment rather than extinction because SIB could still occur, and the participant presumably could continue to access the maintaining reinforcer prior to equipment application.

The use of extinction procedures as treatment for behavior maintained by automatic reinforcement has some limitations. First, it may be extremely difficult to identify the reinforcing properties of the target behavior (Vollmer, 1994). Second, some extinction-based procedures (e.g., blocking) require continuous monitoring of behavior and thus, may be impractical. Third, the mechanisms underlying the effectiveness of extinction-based treatments are poorly understood. That is, although the procedures appear to involve withholding reinforcement for the target response, recent research indicates that other variables may account for treatment success.

Environmental enrichment (EE)

Horner (1980) demonstrated a procedure for decreasing inappropriate behavior and increasing appropriate behavior in 5 individuals with developmental disabilities by manipulating the environmental setting of an institutional ward. An austere environment (i.e., containing unit furnishings only) was compared to an enriched environment (i.e., containing alternative stimuli plus unit furnishings) in a reversal (ABAB) design. Initial results indicated that enriching the environment with alternative stimuli produced
increases in adaptive behavior (e.g., object manipulation) while generating moderate decreases in SIB. However, this study is limited in that no pre-treatment functional analysis was conducted to confirm that automatic reinforcement was responsible for behavioral maintenance.

An extension of environmental enrichment has involved the presentation of items that provide stimulation similar to the hypothesized stimulation produced by SIB. For example, Favell et al. (1982) hypothesized that two participants’ eye poking was maintained by the visual stimulation it produced. Treatment, consisting of noncontingent presentation of visual stimuli (e.g., mirrors, brightly colored toys), resulted in significant decreases in eye poking relative to baseline levels. One participant’s hand mouthing was hypothesized to be maintained by the oral stimulation it produced. Continuous, noncontingent presentation of toys that could be mouthed (e.g., a soft ball) resulted in decreases in hand mouthing. Finally, three participants engaged in high baseline levels of pica that was hypothesized to be maintained by oral stimulation. Treatment consisted of providing alternative oral stimulation (i.e., access to popcorn) noncontingently. Thus, Favell et al. demonstrated an inverse relationship between SIB and item consumption. These data indicated that stimuli that provide forms of sensory stimulation similar to that produced by SIB might be effective in reducing automatically reinforced SIB. However, this study is limited in that no pre-treatment functional analysis was conducted to identify automatic reinforcement as the maintaining variable for SIB.

Goh et al. (1995) extended the research of Favell et al. (1982) by using functional analyses to examine the variables maintaining 12 participants’ hand mouthing. Functional analysis results indicated that hand mouthing was maintained by automatic reinforcement...
for 10 participants. Following this assessment, a second study was conducted to identify the reinforcing properties of the participants’ hand mouthing. Preferred stimuli (identified through informal observations) were presented noncontingently throughout 10-minute sessions. Observers recorded the percentage of 10-second intervals in which hand mouthing, hand-to-toy contact, and mouth-to-toy contact occurred. For all 4 participants, higher levels of hand-to-toy contact were observed. These data suggested that hand stimulation was the reinforcer responsible for maintaining hand mouthing. However, Goh et al. noted that higher levels of hand-to-toy contact might have been due to a preference for the individual toys. Thus, a third study was conducted in which multiple stimuli were presented to the participants. In this study, each stimulus was presented singly, and observers recorded the percentage of 10-second intervals in which hand mouthing, hand-to-toy contact, and toy-to-mouth contact occurred. All 5 participants showed higher levels of hand-to-toy contact, relative to the other dependent measures. Thus, Goh et al. concluded that hand-to-toy contact occurred because of the stimulation provided to the hand by the toys. These data suggested that hand stimulation was the reinforcer responsible for the maintenance of hand mouthing. These findings extend those of Favell et al. in two ways. First, pre-treatment functional analyses were conducted to identify the variables maintaining the participant’s target behavior. Second, assessments were conducted to identify the components of hand mouthing that functioned as a reinforcer for that behavior. Despite these findings, Goh et al. did not assess the effectiveness of treatment with noncontingent stimuli over extended periods of time.

Previous investigations have shown that continuous, noncontingent presentation of alternative stimuli may result in reductions in aberrant behavior. Several mechanisms
may be responsible for these effects. First, it is possible that the presentation of alternative stimuli alters the establishing operation (EO) for SIB (Vollmer, 1994). An establishing operation is defined as an event that momentarily alters the effectiveness of a stimulus as a reinforcer and alters the probability of responses that have previously been reinforced by that stimulus (Michael, 1982). For example, reinforcer satiation functions as an establishing operation by decreasing the effectiveness of the reinforcer and decreasing the probability of responses associated with the reinforcer. Thus, if responding occurs to access sensory stimulation, one method of treatment may involve providing additional sources of stimulation (e.g., toys) noncontingently. A potential EO for automatically reinforced SIB is deprivation of stimulation (Horner, 1980). Thus, the presence of alternative stimuli may reduce the probability of behavior that directly produces sensory stimulation. Berkson & Mason (1964), for example, observed high rates of SIB when no alternative stimuli were available. Conversely, reductions in SIB were observed when alternative stimulation was provided. A second possibility for the effectiveness of EE concerns choice among concurrently available reinforcers. That is, noncontingent presentation of alternative stimuli presents a choice paradigm in which individuals can allocate responding to either item manipulation (i.e., consumption of the alternative stimulation) or SIB. It should be noted that during EE, participants’ can engage in both behaviors simultaneously; however, relative response rates for each behavior will be determined by the quality of reinforcement produced by these alternatives. If alternative stimuli are more preferred than the stimulation produced by SIB, responding should be allocated toward the alternative activities (Herrnstein, 1970). Ringdahl, Vollmer, Marcus, and Roane (1997), for example, showed that some stimuli
were more preferred than SIB (using percentage of 10-second intervals of interaction as the dependent measure) and that participants engaged in higher rates of appropriate item interaction relative to SIB when both alternatives were presented concurrently. Thus, it appeared that the quality of reinforcement derived from the alternative stimuli was higher than that derived from SIB, resulting in decreased levels of SIB.

Environmental enrichment procedures have some limitations. First, it may be difficult or impractical to provide alternative stimuli in some settings (e.g., during school activities). Also, identifying preferred stimuli may be time consuming (Cowdery et al., 1990; DeLeon & Iwata, 1996), and continuous presentation of stimuli eventually may produce satiation (i.e., stimuli do not function as effective reinforcers due to repeated presentation; Egel, 1981). Finally, noncontingent presentation of stimuli may result in adventitious reinforcement of aberrant behavior (i.e., reinforcement may inadvertently follow SIB).

Differential Reinforcement

A third treatment used for behavior maintained by automatic reinforcement is differential reinforcement. Differential reinforcement refers to a variety of interventions in which reinforcement is delivered contingent on the occurrence (or non-occurrence) of a target response. Differential reinforcement of other behavior (DRO) involves the presentation of reinforcement contingent on the omission of SIB (or other maladaptive response) for a pre-determined period of time. Differential reinforcement of alternative behavior (DRA) involves the presentation of reinforcement contingent on the occurrence of an alternative response (e.g., clapping). Typically, the behavior targeted for reduction (e.g., SIB) is placed on extinction. For behavior maintained by automatic reinforcement,
differential reinforcement may prove difficult because the reinforcer maintaining the behavior usually cannot be identified or controlled. In this case, differential reinforcement can be conceptualized as a choice paradigm in which two different reinforcers are concurrently available. Engaging in alternative behavior (or refraining from problem behavior) results in the presentation of one reinforcer, whereas engaging in SIB produces another reinforcer. As with EE, response allocation depends on the quality of reinforcement associated with each response (Herrnstein, 1970). In addition, responding under differential reinforcement procedures may be influenced by the effort required to obtain the different reinforcers (Shore et al., 1997).

Given the inherent difficulties in using differential reinforcement to treat automatically reinforced SIB, it is not surprising that previous research findings on its effectiveness have been mixed. Cowdery et al. (1990) used DRO to decrease one participant’s SIB. The participant had to refrain from engaging in SIB for a predetermined amount of time (initially 2 minutes) to receive a token that could be exchanged for backup reinforcers (e.g., video games). If SIB occurred during the DRO interval, the participant did not receive the token. Results demonstrated that the DRO procedure resulted in decreases in SIB. However, Cowdery et al. (1990) reported some negative side effects (e.g., crying) when reinforcement was not delivered (due to the occurrence of SIB).

Other studies have shown less effective results using DRO for behavior maintained by automatic reinforcement. Piazza, Fisher, Hanley et al. (1996) implemented a DRO procedure in which preferred stimuli were presented contingent on the absence of SIB. First, preference assessments were conducted to identify stimuli associated with
high levels of item interaction and low levels of SIB. These stimuli were used in subsequent DRO evaluations. In DRO, alternative stimuli were presented contingent on the omission of SIB for short time periods (e.g., 10 seconds). Results indicated that this treatment did not suppress SIB below baseline levels. In contrast, SIB increased in some cases. The authors noted that the participants’ high baseline rates of SIB resulted in relatively short DRO intervals (e.g., 5 seconds). As a result, participants may have had difficulty discriminating that SIB resulted in the non-delivery of reinforcement.

Shore et al. (1997) also used DRO to treat SIB maintained by automatic reinforcement. Stimuli identified as preferred in a stimulus preference assessment were presented contingent on the absence of SIB for brief periods of time. Both the DRO interval and reinforcer access times were systematically manipulated; however, no decreases in SIB were observed. That is, high levels of SIB continued even when participants were required to refrain from SIB for a small interval of time (e.g., 5 seconds). Shore et al. suggested that treatment failed due to competition between reinforcement obtained from SIB and that obtained from omission of SIB (i.e., access to preferred stimuli). Reinforcement obtained from SIB could be accessed immediately, whereas reinforcement obtained for the omission of SIB was delayed (by the length of the DRO interval). Although initial evaluations indicated that preferred stimuli resulted in low levels of SIB when both were presented continuously, a minor change in the immediacy of reinforcement for the omission of SIB was sufficient to diminish treatment effects. Subsequent analyses (described below) were conducted, demonstrating that changes in response effort also diminished preferences for preferred stimuli relative to...
SIB. Based on these findings, Shore et al. concluded that delay to reinforcement in a DRO could reduce the effectiveness of alternative stimuli as competing stimuli.

In addition to DRO, DRA has also been used to treat behavior maintained by automatic reinforcement. Lockwood and Bourland (1982) evaluated the effects of DRA on one participant’s SIB that was presumably maintained by automatic reinforcement. An alternative response (i.e., toy play) resulted in presentation of social praise and physical attention, while SIB resulted in no programmed consequences. Results showed that low levels of SIB were observed when an alternative response was reinforced. Horner (1980) increased the effectiveness of enriched environment procedures by providing social praise contingent on toy play and ignoring maladaptive behavior. However, both studies were limited because no pre-treatment analyses were conducted to identify preferred stimuli or to determine the function of SIB. Wacker et al. (1990) used DRA to treat stereotypic body rocking after results of a functional analysis indicated that the behavior occurred independent of social consequences. The participant was taught to emit an alternative communicative response (e.g., pressing a microswitch), and no programmed consequences were provided for body rocking. Contingent on the communicative response, the participant was given access to a rocking chair. Results showed that alternative behavior (appropriate communication) was established and maintained while SIB decreased.

Differential reinforcement has several advantages relative to other treatments. For example, differential reinforcement may be more applicable in settings where continuous access to preferred items (e.g., EE) is inappropriate (Cowdery et al., 1990). Also, differential reinforcement is used to develop adaptive behavior (e.g., communication, toy
play; Horner, 1980; Ringdahl et al., 1997). Finally, DRA may allow individuals to have more control over reinforcement delivery (Carr & Durand, 1985). Differential reinforcement procedures also have some limitations. Primary among these is the choice paradigm inherent in these procedures. Due to the lack of control over automatic reinforcers, extinction components observed in treatments of socially-mediated behaviors are not present in the treatment of behavior maintained by automatic reinforcement (Vollmer, 1994). In addition, the maintaining consequence can not be used as part of the differential reinforcement procedure. Thus, a competition between two different reinforcers exists when applying differential reinforcement procedures to behavior maintained by automatic reinforcement. Reinforcement for inappropriate behavior may be more immediate or more potent than that provided for appropriate behavior. Therefore, successful treatment with differential reinforcement depends on the extent to which alternative reinforcers are preferred over the maintaining reinforcers. This is especially important because the effort required to obtain alternative reinforcers may be greater than that to obtain automatic reinforcers (Shore et al., 1997; Vollmer, 1994). The effectiveness of differential reinforcement procedures also may depend on the amount of reinforcement delivered for the alternative response. That is, if participants engage in high rates of aberrant behavior (in DRO) or low rates of alternative behavior (in DRA), alternative reinforcers are withheld (Vollmer & Iwata, 1992). In this situation, the amount of alternative reinforcement delivered may not be sufficient to compete with the reinforcement produced by SIB. Finally, some differential reinforcement procedures may be difficult to implement. For example, DRO requires constant monitoring of behavior during the DRO interval, whereas DRA requires monitoring of alternative behavior.
Application of Stimulus Preference Assessments in Treatment

Although many of the treatments discussed so far have involved the delivery of alternative reinforcers, previous studies have rarely based treatment on data derived from stimulus preference assessments. Instead, preferred stimuli were identified via the verbal report of care providers. Although the stimuli used in previous studies appeared to be preferred, previous research has shown that items identified by caregivers may not function as reinforcers (Green et al., 1988). Although preferences may be identified verbally by some individuals (Northup, George, Jones, Broussard, & Vollmer, 1996), identifying preferences of individuals with developmental disabilities typically requires more direct assessments (Pace, Ivancic, Edwards, Iwata, & Page, 1985). Multiple preference assessment methodologies have been presented in the extant literature; however, most preference assessments involve two common components. First, items are presented to the individual in some manner (either verbally, pictorially, or physically). Second, the individual selects items by making an approach response (e.g., DeLeon & Iwata, 1996; Fisher et al., 1992; Pace et al., 1985) or by manipulating the item (Piazza, Fisher, Hanley et al., 1996; Ringdahl et al., 1997).

Pace et al. (1985) developed a single presentation preference assessment. In this procedure, an array of 16 stimuli was identified prior to the assessment. Next, each stimulus was presented individually 10 times each in a counterbalanced order. Each item was presented for 5 seconds. Observers scored participant approaches (e.g., reaches) toward each item. When an item was approached, participants received access to the item for 5 seconds. At the end of that time period, the chosen stimulus was removed, and a new stimulus was presented. Preferences were determined by calculating the number of
times each item was approached divided by the number of times each item was presented.

Results indicated differences in preference across the items.

Fisher et al. (1992) extended the procedures of Pace et al. (1985) by developing a stimulus-choice preference assessment. In this assessment, two stimuli were presented concurrently, and participants were verbally prompted to choose one stimulus (through a reach response). When an item was chosen, participants were given access to that item for approximately 5 seconds. At the end of that time period, the chosen stimulus was removed, and two new stimuli were presented. If both stimuli were approached simultaneously, the response was blocked, the stimuli were withdrawn, and the pair was re-presented after 5 seconds. Each stimulus was paired with all other stimuli twice. At the end of the assessment, preference for each item was determined by dividing the number of times the item was chosen by the number of times it was presented. Stimuli identified as highly preferred (i.e., chosen on at least 80% of presentations) were evaluated as reinforcers in a concurrent-operants design. Results indicated that all participants allocated more responding towards highly preferred stimuli.

Piazza, Fisher, Hanley et al. (1996) also extended the procedure developed by Pace et al. (1985). Stimuli were presented singly, and observers scored the duration of item interaction. In addition, data were collected on the occurrence of SIB while each item was available. Thus, the assessment yielded data on stimulus preference (high or low) and the occurrence of aberrant behavior (high or low). Results demonstrated that stimuli could be classified across three dimensions, high preference/high SIB (long duration of interaction and relatively high rates of SIB), high preference/low SIB (long duration of interaction and low rates of SIB), and low preference/low SIB (short duration
of interaction and low rates of SIB). High preference items were subsequently shown to function as reinforcers for a simple operant response (i.e., head turning). Thus, Piazza, Fisher, Hanley et al. developed a method for identifying stimuli that functioned as preferred reinforcers and for measuring the amount of SIB associated with each item, which indicated the ability of each stimulus to compete with SIB.

The utility of these preference assessments in identifying stimuli for use in the treatment of behavior maintained by automatic reinforcement has been examined in recent research. Vollmer et al. (1994) extended the work of Homer (1980) by using pre-treatment assessments to develop interventions for 3 participants’ SIB. First, a choice preference assessment was conducted to identify participants’ preferred and nonpreferred stimuli. Next, analogue functional analyses were conducted for two participants to identify the variables that maintained their SIB. A single condition in which no social stimulation was available (alone) was conducted for the third participant. Functional analysis results were inconclusive for two subjects and high rates of SIB were observed in the alone condition for the third participant. Combined, these results indicated that the participant’s target behaviors were maintained by automatic reinforcement. Results of the choice preference assessments were used to select alternative stimuli to present in subsequent treatment analyses. In treatment, the participants were alone in a therapy room but had continuous access to preferred or nonpreferred stimuli. Results showed decreases in SIB for all participants in the treatment associated with preferred stimuli (i.e., environmental enrichment) and no change in SIB in the treatment associated with nonpreferred stimuli. Thus, Vollmer et al. demonstrated the importance of first
conducting preference assessments when treating behavior maintained by automatic reinforcement.

Piazza et al. (1998) evaluated the utility of the preference assessment described by Piazza, Fisher, Hanley, et al. (1996) to identify stimuli that would compete with pica maintained by automatic reinforcement. In their assessment, stimuli designed to produce various forms of stimulation (e.g., oral, visual, tactile) were presented singly. Observers recorded the duration of interaction with each item and the duration of pica. Preference assessment results were used to identify stimuli associated with high levels of item interaction and low levels of pica. Preferred stimuli were then grouped into categories depending on the type of stimulation they produced. Items that produced oral stimulation were designated “matched” stimuli (i.e., stimuli that produced stimulation similar to that produced by pica), and items that produced other sensory consequences were designated “unmatched” stimuli. In treatment, participants had continuous access to either matched or unmatched stimuli. Results indicated that stimuli hypothesized to provide stimulation similar to that produced by pica (i.e., oral stimulation) were most effective at reducing the occurrence of pica.

Ringdahl et al. (1997) incorporated multiple preference assessments into the treatment of SIB maintained by automatic reinforcement. First, the authors conducted a stimulus-choice assessment (Fisher et al., 1992). The three most preferred items from the choice assessment were then presented concurrently for 10 minutes. Observers recorded the amount of time in which participants interacted with each item, as well as the total amount of SIB that occurred. The researchers then compared the amount of time spent with each item to that spent engaging in SIB. Results indicated that some stimuli were
more preferred (i.e., produced higher interaction percentages) than SIB. These data were used to predict the effectiveness of environmental enrichment procedures, during which a preferred stimulus was presented noncontingently for each participant. Results demonstrated that stimuli previously associated with high levels of interaction and low levels of SIB were effective in decreasing SIB during treatment.

In summary, recent research findings have demonstrated that the addition of data derived from stimulus preference assessments increased the efficacy of reinforcement-based interventions (e.g., Piazza et al., 1998; Ringdahl et al., 1997; Vollmer et al., 1994). However, results of other studies have shown that stimulus preference assessments did not lead to effective interventions for problem behavior (e.g., Piazza et al., 1996; Shore et al., 1997). As discussed above, Piazza, Fisher, Hanley et al. and Shore et al. failed to demonstrate decreases in SIB using DRO as treatment even though the stimuli used as alternative reinforcers had been previously identified as highly preferred via stimulus preference assessments. One possibility for these disparate findings may be that preference can change as a function of manipulation in response effort (i.e., requirement to obtain a reinforcer).

Shore et al. (1997) found that leisure items were more preferred than aberrant behavior when response effort was low (i.e., when items were available noncontingently). In a subsequent experiment, however, preference for alternative forms of stimulation relative to that produced by SIB was easily influenced by the effort required to access the alternative reinforcement. Response effort was manipulated by changing the distance between the participant and the reinforcer. Distance was altered by varying the length of a piece of string that attached the reinforcer to a tray on each participant’s wheelchair.
Thus, as the distance between the participant and the reinforcer increased, the degree of effort needed to grasp and manipulate the preferred item increased. All participants showed clear preferences for item manipulation over SIB when the reinforcer was near (low effort condition). However, small changes in reinforcer distance (i.e., increase in effort) resulted in fluctuations in these preferences, such that preferences for item manipulation were abolished. Shore et al. concluded that their DRO treatment failed because preference for alternative items relative to SIB was eliminated by the effort required to obtain the reinforcer in the DRO (i.e., refraining from SIB).

Implications of Behavioral Economics in Reinforcer Identification

The concept of behavioral economics provides one account for changes in preference associated with variations in response requirements. Hursh (1980) described behavioral experiments as economic systems. That is, in a behavioral experiment, a relationship exists between the amount of reinforcement delivered and the schedule requirements associated with reinforcement. In traditional economic systems, consumption is dependent on price. Similarly, in experimentation, the amount of reinforcement consumed (i.e., response rates) depends on the response requirement. A reinforcer that is highly preferred will produce high response rates even as the requirement (i.e., “price”) increases. Conversely, reinforcers that are less preferred will not maintain response rates as response requirements increase. Thus, preference for various reinforcers is shown by the amount of responding exhibited under varying reinforcement schedules (i.e., varying “prices”; Hursh, 1980). Behavioral economic theory predicts that response rates will be high, or responding will persist, under increasing response requirements if responding produces highly preferred stimuli.
Two recent investigations have examined the relationship between response requirement and reinforcer preference. Tustin (1994) exposed one individual with moderate mental retardation to increasing fixed-ratio (FR) schedules of reinforcement for two qualitatively different reinforcers (i.e., visual stimulation produced by a computer and adult attention). In this assessment, each item was presented in a single operant format. Data were collected on the number of responses emitted (i.e., pressing a button on a joystick) and number of reinforcers obtained. Schedule requirements increased across days in the following order: FR 1, FR 2, FR 5, FR 10, and FR 20. Once FR 20 was reached, the schedule requirements were reduced across days in the opposite order. Finally, response requirements were increased across days in the original order. Results showed clear changes in reinforcer preference. Response rates were identical under the FR 1 schedule of reinforcement for both reinforcers. However, as the schedule was thinned, higher response rates were generated for one stimulus (visual) than for the other stimulus (attention). Tustin concluded that current reinforcer assessment methodologies, which involve low response requirements (e.g., a reach response on an FR 1 schedule), may not be efficient for identifying reinforcers to be used in more effortful situations (e.g., skills training). Despite these outcomes, the Tustin study has some limitations. First, the results must be interpreted cautiously in that only one subject participated in the analysis. In addition, each schedule requirement was evaluated briefly. Consequently, Tustin’s findings may not generalize to other situations in which repeated sessions are conducted.

DeLeon et al. (1997) extended the findings of Tustin (1994) by further evaluating the relationship between reinforcer preference and response effort. Preferences for
qualitatively similar reinforcers (i.e., edible items) were compared in a concurrent operant arrangement while thinning the schedule of reinforcement from FR 1 to FR 10. Participants received the reinforcers for pressing a microswitch. Unlike the study conducted by Tustin, multiple sessions were conducted under each schedule requirement. Under low schedule requirements, a similar number of responses were allocated toward each item (indicating similar preferences). However, as schedule requirements increased, participants shifted more of their responding toward one reinforcer. Thus, DeLeon et al. replicated the findings of Tustin by demonstrating changes in preference for two concurrently available reinforcers as response requirements increased. Furthermore, the shifts in preferences occurred with relatively small increases in the requirement (i.e., from FR 1 to FR 2 for one subject; from FR 1 to FR 5 for the other subject). It should be noted that DeLeon et al. employed a concurrent operants paradigm in their experimental procedures, whereas Tustin employed a single operant paradigm. The use of concurrent operants may limit the understanding of the absolute preference for stimuli. That is, a concurrent operant paradigm reveals relative preference for one stimulus versus another, in that an individual may be willing to forgo responding for a slightly less preferred stimulus because a slightly more preferred stimulus is equally available. By contrast, when stimuli are presented singly, absolute preference for a stimulus can be determined. Total response levels emitted under varying requirements will denote stimulus preferences independent of the influences of other stimuli.

The findings of Tustin (1994) and DeLeon et al. (1997) have important implications for the identification of reinforcers. Current reinforcer identification methods use participant approach as the primary dependent measure when determining...
preference. An approach response is then reinforced by presenting the stimulus for a brief amount of time (e.g., 5 seconds). As such, a low effort response (i.e., reaching for an item) is reinforced on a rich (i.e., FR 1) schedule. In contrast, behavioral interventions often have more laborious response requirements (e.g., DRO intervals, engagement in alternative responses). To the extent that behavioral interventions can be conceptualized as choice paradigms (i.e., allocation towards item consumption or problem behavior), increased effort for one reinforcer may shift response allocation toward the other (less effortful) reinforcer.

Purpose

Previous research led to the principle research questions of the current study. First, reinforcement-based treatments have been shown to be effective in reducing SIB maintained by automatic reinforcement (Favell et al., 1982; Horner, 1980). In addition, these treatments have been augmented by the inclusion of data derived from stimulus preference assessments (Piazza et al., 1998; Ringdahl et al., 1997; Vollmer et al., 1994). However, some studies have shown that treatment efficacy may vary when participants are required to engage in relatively more effortful responses to produce alternative reinforcers (e.g., Piazza, Fisher, Hanley et al., 1996; Shore et al., 1997). Furthermore, recent research (e.g., Tustin, 1994) has demonstrated that current methods of identifying stimulus preferences (e.g., Fisher et al., 1992) may not accurately reflect stimulus preferences when response requirements vary. For example, preferences for reinforcers may change as a function of reinforcement schedule (DeLeon et al., 1997; Tustin, 1994) or response effort (Shore et al., 1997).
Given that behavioral treatments may involve varying levels of response effort, reinforcer assessments that account for changes in preference with increased response requirements are needed. Although Tustin (1994) and DeLeon et al. (1998) demonstrated effective methods for identifying shifts in preference that may have implications for treatment development, these methods were limited by time expenditures making them impractical in some situations. Thus, a method is needed that will require relatively brief exposure to the requirements necessary to demonstrate changes in preference. The purpose of the current investigation was to evaluate an alternative method for identifying reinforcer preferences under varying response requirements. In addition, data derived from these reinforcer assessments were used to develop treatments that varied in the response requirement for reinforcement. The treatment of problem behavior maintained by automatic reinforcement was examined. This particular operant mechanism was chosen because treatments for behavior maintained by automatic reinforcement typically involve the presentation of alternative stimuli (Favell et al., 1982; Horner, 1980), rather than maintaining reinforcers. The treatment of behavior maintained by automatic reinforcement allows for a comparison of two different stimuli in order to determine which is more effective in competing with the automatic reinforcement derived from problem behavior. Furthermore, given that different behavioral interventions may require individuals to emit more effortful responses in order to access alternative reinforcers, the ability of stimuli to function as reinforcers across varying levels of effort may be an important consideration in developing an intervention. Therefore, this study attempted to evaluate the effectiveness of stimuli as reinforcers under varying response requirements that occur as a function of different treatments. It was expected that differentiation
observed under varying response requirements would predict the differential
effectiveness of the components of behavioral treatments.

The primary research questions were: (a) Do preferences demonstrated at low
schedule requirements change as response requirements are rapidly increased in a
relatively brief amount of time, and (b) Do changes in preference affect the efficacy of
reinforcement-based treatments for behavior maintained by automatic reinforcement?
Two principle hypotheses were addressed. First, it was hypothesized that the changes in
preference observed by Tustin (1994) and DeLeon et al. (1997) could be replicated within
the context of progressively increasing changes in response requirements. Second, it was
hypothesized that the items that were more preferred would be more effective
components of reinforcement-based treatments.
EXPERIMENT 1: IDENTIFICATION OF PREFERRED REINFORCERS

Method

Participants and Settings

Six individuals diagnosed with developmental disabilities participated. Participants were chosen based on referral for treatment of problem behavior. Bucky was an 18-year-old man diagnosed with moderate mental retardation who was referred for treatment of SIB in the form of hand scratching. Bucky attended a pre-vocational preparatory school for individuals with developmental disabilities. Sandy, a 13-year-old girl diagnosed with Sanfilippo syndrome and severe mental retardation, was referred for the assessment and treatment of pica and hand mouthing. Throughout the study, Sandy was hospitalized on a unit specializing in the assessment and treatment of severe behavior disorders. Dave was an 8-year-old boy diagnosed with severe mental retardation who was referred for assessment and treatment of multiple topographies of SIB (i.e., face slapping, head banging). Dave attended a self-contained classroom for children with developmental disabilities. Joel was a 13-year-old boy with a diagnosis of unspecified mental retardation and autism. At the time of the study, Joel was a patient on a hospital unit specializing in the assessment and treatment of severe behavior disorders. Although admitted for the treatment of multiple behavior problems, Joel exhibited very few occurrences of aberrant behavior and was discharged within three weeks of his admission. Beth was an 8-year-old girl with a diagnosis of moderate mental retardation and oppositional defiant disorder. She was admitted to an inpatient hospital unit for the assessment and treatment of multiple behavior problems including pica, aggression, and SIB (skin picking). Sue was a 15-year-old girl who was admitted to an inpatient hospital unit for the assessment and
treatment of pica, multiple topographies of SIB (face slapping, pinching, and head banging), and screaming. Sue was functioning in the severe range of mental retardation and carried additional diagnoses of bipolar disorder and attention deficit/hyperactivity disorder.

Sessions were conducted in empty rooms at the individuals' schools (Bucky and Dave) or hospital units (Sandy, Joel, Sue, and Beth). Rooms at the participants' schools contained at least one table and several chairs. Sessions conducted on the hospital unit took place in fully padded treatment rooms (3 m by 3 m) consisting of at least one table and several chairs.

Response Measurement and Reliability

Observers previously trained in behavioral observation collected data via lap-top computers and were seated either in unobtrusive positions within the therapy rooms or behind one-way observation mirrors (on the hospital unit). For the choice preference assessment, observers collected data on the number of times each stimulus was presented and the number of times each stimulus was selected. Item presentation was defined as the therapist holding two stimuli in front of the participant. Item selection was defined as the participant touching one item with his or her hand (i.e., a reach response). During the behavioral economic assessment, data were collected on the frequency of an alternative response (defined individually), duration of item manipulation (in seconds), and frequency of reinforcer delivery. The alternative responses differed for each participant. For Bucky and Dave, the alternative response was pressing a 1 cm by 1 cm button; for Sandy, moving an unconnected light switch from left to right or right to left; for Joel, touching a 10 cm by 10 cm piece of paper taped to a table; for Beth, pressing a “big mac”
switch; and for Sue, touching a 12 cm by 12 cm piece of paper taped to a table. Data from the behavioral economic assessment were analyzed by adding the total number of responses that occurred with either stimulus across all sessions to yield the cumulative number of responses for each stimulus.

Interobserver agreement (IOA) coefficients were calculated for all dependent and independent measures. Exact agreement was defined as the number of 10-second intervals in which observers scored exactly the same frequency of responses or the same duration of responses (EA) divided by the number of intervals with agreement plus the number of intervals with disagreement (D). Thus, the formula for computing interobserver agreement was \( \frac{EA}{EA + D} \). The coefficient was multiplied by 100% to yield a total percentage of agreement. Interobserver agreement was collected on 100% of all stimulus choice assessments and on 64.3% of all behavioral economic assessment sessions. Exact IOA for each stimulus choice during the choice preference assessment was as follows: Bucky, 100%; Sandy, 94% (range, 88% to 100%); Dave, 100%; Joel, 96.9% (range, 84% to 100%); Sue, 96.9% (range, 84% to 100%); Beth, 100%. For each participant, exact IOA coefficients for the alternative response in the behavioral economic assessment were as follows: Bucky, 92.9% (range, 84.8% to 98.2%); Sandy, 97.9% (range, 90.8% to 100%); Dave 88.3% (range, 72% to 100%), Joel, 99.3% (range, 96.9% to 100%); Sue, 96.9% (range, 84.8% to 100%); and Beth, 83.3% (range, 52.7% to 100%).

Procedure

Each participant progressed through Experiment 1 in the same manner. First, a choice preference assessment (Fisher et al., 1992) was conducted to identify highly
preferred stimuli. Two stimuli that were similarly preferred (i.e., chosen on a similar number of presentations) were selected for subsequent comparison in the behavioral economic assessment. Session length varied depending on the condition (described below). Sessions were conducted in blocks of time ranging from one to two hours, based on the participants' schedules. One to five sessions were conducted during each block of sessions, three to five days per week.

**Choice preference assessment.** A choice preference assessment (Fisher et al., 1992) was conducted to identify an array of preferred stimuli for each participant. Stimuli were included in the assessment based on caregiver and/or teacher report of preferred stimuli, and an attempt was made to include stimuli from multiple sensory domains (e.g., tactile, auditory, and gustatory stimuli). Multiple stimuli were assessed for each participant; however, the number of stimuli included in each assessment varied (from 10 to 16 items) across participants. In the preference assessment, each stimulus was paired with every other stimulus twice, and stimulus pairs were presented in a random order. At the beginning of each presentation, the therapist held one pair of stimuli in front of the participant and prompted him or her to make a choice (e.g., saying, “Pick one of these”). Stimuli were selected through a reach response. When a stimulus was chosen, participants had access to the item for approximately 20 seconds. When the 20-second interval elapsed, the chosen stimulus was withdrawn, and two different stimuli were presented in the same manner. Attempts to approach both stimuli were blocked. If no stimulus was chosen or if both stimuli were approached, the stimuli were withdrawn and re-presented approximately 5 seconds later. The number of times each item was chosen was divided by the number of trials in which it was presented. This number was
converted to a percentage to indicate the relative preference for each stimulus. Two stimuli that were chosen on more than 50% of trials and were chosen on an equivalent number of presentations were used in ensuing experimental conditions.

Behavioral economic assessment. Following the choice assessment, an additional assessment was conducted to determine preferences for different stimuli under increasing schedules of reinforcement (DeLeon et al., 1997; Tustin, 1994). The assessment was conceptualized as a behavioral economic assessment in that the cumulative number of responses exhibited under varying reinforcement schedules was the primary dependent measure (Hursh, 1980). That is, two stimuli that were identified as similarly preferred in the choice assessment (i.e., chosen on an equivalent number of trials) were compared because responding in the choice assessment is similar to responding under low schedule requirements (i.e., selection responses are reinforced on a FR 1 schedule of reinforcement). The comparison was conducted using an alternating treatments design with an initial baseline phase. During baseline, the participant was seated either at a table or on the floor, and the therapist sat across from the participant. No consequences were provided for the emission of target responses (described above), and all instances of aberrant behavior were ignored. During the reinforcement phase, the participant was seated across from the therapist as in baseline; however, each stimulus was presented contingent on the target response using a progressive ratio (PR) schedule of reinforcement (Findley, 1958). In the PR schedule, the number of responses required to access the stimulus increased by some factor after the completion of each previous requirement. For example, each successive requirement was one more than the previous requirement (e.g., PR 1, PR 2, PR 3, PR 4, PR 5) for some participants. The factor by
which response requirements increased was determined individually for each participant but was consistent across stimuli (i.e., the same schedule was in effect for both stimuli). The progressive ratio schedule for each participant was determined based on the amount of responding exhibited in baseline. An attempt was made to ensure that response requirements did not progress too rapidly or too slowly for each participant. Specific schedule requirements for each participant are shown in Table 1. Each session began with the response requirement reset to the lowest level (e.g., PR 1).

Table 1: Schedule requirements during the Behavioral Economic Assessment

(PR = Progressive Ratio)

<table>
<thead>
<tr>
<th>Participant</th>
<th>Schedule Requirement*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bucky</td>
<td>PR 1, PR 1, PR 2, PR 2, PR 5, PR 5, PR 10, PR 10, PR 20, PR 20</td>
</tr>
<tr>
<td>Sandy</td>
<td>PR 1, PR 1, PR 2, PR 2, PR 3, PR 3</td>
</tr>
<tr>
<td>Dave</td>
<td>PR 1, PR 1, PR 2, PR 2, PR 4, PR 4, PR 8, PR 8, PR 16, PR 16, PR 32, PR 32, PR 64, PR 64</td>
</tr>
<tr>
<td>Joel</td>
<td>PR 1, PR 2, PR 3, PR 4, PR 5, PR 6, PR 7, PR 8, PR 9, PR 10</td>
</tr>
<tr>
<td>Sue</td>
<td>PR 1, PR 1, PR 2, PR 2, PR 3, PR 3, PR 4, PR 4, PR 5, PR 5, PR 6, PR 6, PR 7, PR 7, PR 8, PR 8</td>
</tr>
<tr>
<td>Beth</td>
<td>PR 1, PR 1, PR 2, PR 2, PR 4, PR 4, PR 6, PR 6, PR 8, PR 8, PR 10, PR 10, PR 12, PR 12, PR 14, PR 14, PR 16, PR 16, PR 18, PR 18, PR 20, PR 20, PR 22, PR 22</td>
</tr>
</tbody>
</table>

*NOTE: The final schedule requirement reflects the highest schedule completed by the participant in at least one session.
Across baseline and reinforcement sessions, the response requirement progressed until no responses were emitted for 5 minutes, or until 30 minutes had elapsed (Tustin, 1994). For Beth, session termination criteria were 5 minutes with no responses or 15 minutes of total session time (these criteria differed from those of the other participants because the medical staff at the place of Beth's hospital admission determined that the risk of injury associated with her SIB prohibited her from being in a single session for more than 15 minutes). Thus, for all participants, session length varied as a function of response persistence. Only one of the two items was available in each session (i.e., single operant presentation). Two to three sessions were conducted during each session block, and the order of sessions altered across days. The assessment continued until clear separation or no separation in responding occurred for at least three sessions with each stimulus. The stimulus associated with more cumulative responding and a steeper response slope was referred to as the high-preference stimulus, whereas the stimulus associated with less cumulative responding and a flatter response slope was referred to as the low-preference stimulus. The effectiveness of these stimuli in treatments for SIB was compared in subsequent analyses (see Experiment 2).

Results and Discussion

Figure 1 shows the outcome of each participant's choice preference assessment. Stimuli are plotted on the x-axes, and the percentages of presentations in which each item was chosen are plotted on the y-axes. For all participants, at least one item was identified as the most preferred. Furthermore, each outcome yielded at least two stimuli (among the top five) that were similarly preferred (i.e., chosen on a similar or identical number of trials). For each participant, two similarly preferred stimuli were used in subsequent
analyses (indicated by the arrows). The items used for each participant were a microphone and musical toy (Bucky); teether and musical toy (Sandy); MegaMouth ® and noise strip (Dave); fire truck and hand-pin toy (Joel); hairbrush and hair dryer (Beth); and radio and keyboard (Sue).

Figure 2 shows the outcome of each participant's behavioral economic assessment. The x-axes show the number of sessions, and the y-axes show the cumulative number of responses emitted for each stimulus. The reinforcing efficacy of the stimuli evaluated in the behavioral economic assessment was compared by examining the cumulative number of responses emitted to obtain each item under the progressive ratio schedule of reinforcement. For all but one participant (Dave), one item resulted in more responding and a steeper response slope than the other item. The items that produced more responding were the microphone (Bucky), the teether (Sandy), the hand-pin toy (Joel), the hairbrush (Beth), and the radio (Sue). These were designated high preference stimuli. The other items were designated low preference stimuli. Conversely, for Dave, the two stimuli produced similar levels of responding as requirements increased. Thus, for 5 of the 6 participants, it appeared that the behavioral economic assessment identified changes in preferences when the response requirement increased.

Results of Experiment 1 demonstrated that the choice assessment identified two stimuli as similarly preferred under relatively low response requirements. The response requirement in the stimulus-choice assessment was considered low in that “choosing” (i.e., reaching for) a stimulus was reinforced on an FR1 schedule of reinforcement (i.e., one reach resulted in immediate access to the stimulus). By contrast, results of the behavioral economic assessment showed that, when schedule requirements increased, the
Figure 1: Percentage of trials in which each item was approached in the choice preference assessment.
Figure 2: Cumulative number of responses in the behavioral economic assessment.
majority of the participants responded more for one stimulus than the other. These results replicated those of DeLeon et al. (1997) and Tustin (1994) by demonstrating that stimulus preferences may shift as a function of response requirements. Furthermore, changes in preferences were revealed in less time than in previous studies because schedule requirements increased during the course of each session. The results for Dave showed no differences in responding in the economic assessment. These data may indicate that preferences observed under low schedule requirements remained relatively consistent even as response requirements increased.

The data from Experiment 1 suggested that items associated with higher levels of responding in the behavioral economic assessment would be more effective reinforcers for some responses, particularly as response requirements increased. However, an additional question remained regarding the efficacy of these stimuli as components of reinforcement-based interventions for problem behavior maintained by automatic reinforcement. That is, the treatment of automatically reinforced problem behavior often consists of providing access to alternative stimuli either continuously (e.g., EE) or contingent upon some criterion (e.g., DRO and DRA). Based on the requirements of a specific treatment, the efficacy of alternative stimuli in treatment may be impacted by their effectiveness as reinforcers under varying response requirements (Shore et al., 1997). As demonstrated by Shore et al., two stimuli may be equally effective as treatment components when little effort is required to access reinforcement (as in EE) relative to treatments that require more effort (as in DRA). As such, it was hypothesized that any differences observed between stimuli in the behavioral economic assessment might also
be reflected across other factors that occur in treatment (e.g., response requirements, 
duration of the reinforcement interval). Thus, the purpose of Experiment 2 was to 
compare the effectiveness of the stimuli assessed in the behavioral economic assessment 
as components of reinforcement-based treatments.
EXPERIMENT 2: TREATMENT ANALYSES

Method

Participants and Settings

Four individuals (Bucky, Sandy, Dave, and Sue) who participated in Experiment 1 also participated in Experiment 2 (Joel did not participate because he exhibited very few occurrences of aberrant behavior during his admission, and Beth's behavior was maintained by socially mediated reinforcers). These individuals participated because the severity of their problem behavior warranted intervention. That is, all participants' behavior had resulted in significant tissue damage (e.g., formation of skin lesions, hematomas, or callusing) and had impacted negatively on the participants' health (e.g., caused infections) and social well-being (e.g., affected school or residential placement). In addition, these individuals participated because the results of their functional analyses (described below) indicated their behavior was maintained by automatic reinforcement. It should be noted that the other problem behaviors exhibited by Sandy, Sue, and Beth were treated within the course of their admission. Sessions were conducted in the same rooms described before.

Response Measurement and Reliability

Problem behavior was defined individually for all participants. Hand scratching (Bucky) was defined as scraping the fingernail across the hand in a forward or backward motion, or rubbing the hand on a hard or rough surface (e.g., clothing, a desk). Hand mouthing (Sandy) was defined as insertion of the fingers (i.e., the first knuckle) past the plane of the lips. Face slapping (Dave) was defined as forceful, audible contact of an open hand to the side of the face. Head banging (Dave) was defined as forceful, audible
contact of the head to any hard surface (e.g., tables, chairs). Screaming (Sue) was defined as brief (e.g., 1 to 2 second) vocalizations above conversational level. These topographies were chosen for intervention because they were the primary reason of referral (Bucky and Dave) or because they remained in the participant’s repertoire after other problem behavior had been treated prior to this study (Sandy and Sue).

During the functional analyses, observers collected data on the frequency of problem behavior and certain therapist behavior (e.g., instruction delivery). During the treatment analyses, observers collected data on the frequency of problem behavior, reinforcer delivery, and alternative behavior. Data also were collected on the duration of item manipulation. Reinforcer delivery was defined as the therapist providing access to a stimulus by handing the item to the participant or by placing the item on a table in front of the participant. Alternative behaviors, which varied across participants, were stuffing a piece of paper into an envelope (Bucky), placing a block in a bucket (Sandy and Sue), and placing a plastic ring on a peg (Dave). Item manipulation was defined as the participant interacting with each item in the manner in which it was intended to be manipulated (e.g., playing music on a radio; talking into a microphone). Response rates were calculated for all frequency measures by dividing the total number of responses by the length (in minutes) of each session. Duration data for item manipulation were expressed as percentage of session time consumed by the behavior by dividing the total number of seconds of item manipulation by the length of the session (in seconds).

To summarize, the primary dependent measure for the functional analysis was the frequency of problem behavior in each test condition. The primary dependent measures for the EE and DRO treatments were the frequency of problem behavior and the duration
of item manipulation. The primary dependent measures for the DRA treatment were the frequencies of problem behavior and alternative behavior and the duration of item manipulation.

Exact interobserver agreement (IOA) was calculated for all independent and dependent measures using the procedures described in Experiment 1. Interobserver agreement was assessed on 65.4% of functional analysis sessions, 71.0% of EE sessions, 68.7% of DRO sessions, 52.9% of DRA sessions, and 48.1% of DRA/DRO sessions. For Bucky, IOA on SIB averaged 98.0% (range, 81.7% to 100%) during the functional analysis, 97.3% (range, 66.7% to 100%) during EE, 93.3% (range, 48.0% to 100%) during DRO, and 96.4% (range, 63.3% to 100%) during DRA. IOA on Bucky’s item manipulation averaged 96.6% (range, 0% to 100%) in EE, and 96.5% (range, 88.9% to 100%) in DRA. Item manipulation data were not collected during Bucky’s DRO. The average IOA on alternative behavior during Bucky’s DRA was 95.9% (range, 86.7% to 100%). For Sandy, IOA on SIB averaged 94.8% (range, 81.2% to 100%) during the functional analysis, 97.5% (range, 88.5% to 100%) during EE, 92.7% (range, 84.9% to 100%) during DRO, and 97.3% (range, 89.3% to 100%) during DRA. IOA on Sandy’s item manipulation averaged 95.1% (range, 83.6% to 100%) in EE, 88.9% (range, 75.3% to 100%) in DRO, and 86.3% (range, 28.9% to 100%) in DRA. The average IOA on alternative behavior during Sandy’s DRA was 96.2% (range, 75.2% to 100%). For Dave, IOA on SIB averaged 92.3% (range, 75% to 100%) during the functional analysis, 94.6% (range, 67% to 100%) during EE, and 92.8% (range, 62% to 100%) during DRA/DRO. IOA on Dave’s item manipulation averaged 75.7% (range, 0% to 100%) in EE and 90.1% (range, 64.5% to 100%) in DRA/DRO. IOA averaged 91.5% (range, 82% to 100%) on
alternative behavior during Dave’s DRA. For Sue, IOA on screaming averaged 98.6% (range, 95.6% to 100%) during the functional analysis, 99.8% (range, 98.4% to 100%) during EE, 98.6% (range, 94.9% to 100%) during DRO, and 99.4% (range, 96.1 to 100%) during DRA. IOA on Sue’s item manipulation averaged 98.3% (range, 88.2% to 100%) in EE, 94.9% (range, 87.8% to 100%) in DRO, and 96.1% (range, 87.5% to 100%) in DRA. The average IOA on alternative behavior during Sue’s DRA was 97.8% (range, 91.7% to 100%).

Procedures

Functional analysis. An analogue functional analysis was conducted for each participant to identify the reinforcer maintaining problem behavior. Functional analysis procedures were similar to those described by Iwata et al. (1982/1994). In the attention condition, the participant had access to an array of leisure materials. A therapist was present and engaged in another activity (e.g., paper work) but ignored the participant. Contingent on the occurrence of problem behavior, the therapist provided brief (e.g., 5 seconds) attention in the form of statements (e.g., reprimands, statements of concern) and/or physical interaction (e.g., hugs). The purpose of this condition was to determine if the behavior was maintained by positive reinforcement in the form of attention. In the escape condition, the therapist presented continuous instructions to the participant. Instructions were chosen based on the participant’s educational training program and included pre-vocational (e.g., sorting or folding) or academic (e.g., writing letters) tasks. Instructions were presented using a graduated three-prompt sequence (verbal, model, physical; Horner & Keilitz, 1975). A new instructional sequence was presented approximately every 30 seconds. Contingent on the occurrence of problem behavior,
instructional items were removed, and the participant was given a break from instructions for 20 seconds (Bucky and Dave) or for the remainder of the 30-second instructional interval (Sandy and Sue). The purpose of the escape condition was to determine if problem behavior was maintained by negative reinforcement in the form of escape from instructional activities. In the materials condition (conducted for Dave only), Dave was given access to his most preferred stimulus (as identified in the choice assessment) before the session. When the session began, the therapist removed the item and restricted access to it. Contingent on the occurrence of SIB, the therapist provided access to the preferred stimulus for approximately 20 seconds. The purpose of this condition was to determine if Dave's SIB was maintained by positive reinforcement in the form of contingent access to preferred stimuli. It should be noted that this condition was included for Dave because his mother reported that she sometimes gave him preferred toys when he exhibited problem behavior. In the no interaction condition, the therapist was in the room with the participant; however, the therapist did not interact with the participant, and no preferred activities were available. No programmed consequences were delivered contingent on the target behavior. The purpose of this condition was to determine if problem behavior was maintained by automatic reinforcement (i.e., if the behavior persisted in the absence of social consequences). Finally, a control condition was conducted in which the participant had continuous, noncontingent access to preferred stimuli and attention, and no instructions were presented. Three to five functional analysis sessions were conducted within each session block. All sessions lasted 10 minutes and were presented using an alternating treatments design. Additional analyses were conducted to clarify undifferentiated results for some individuals (e.g., Vollmer, Marcus, Ringdahl, & Roane,
Typically, the additional analyses consisted of conducting a series of extended-length (e.g., 20 minute) no interaction sessions.

Following the functional analyses, three treatments for problem behavior were evaluated to compare the treatment efficacy of the high-preference versus the low-preference stimulus assessed in the behavioral economic assessment. The treatments were presented in a random order for each participant. Treatment sessions typically lasted 10 minutes, although the length of some sessions was corrected for the amount of time in which reinforcers were delivered (see below). Sessions were conducted in blocks of time that ranged from one to two hours, depending on the availability of the participants. Two to five sessions were conducted within each session block, three to five days per week.

**Environmental Enrichment (EE).** Baseline sessions were identical to the no interaction condition of the functional analysis. EE sessions were similar to baseline sessions; however, the participant had continuous, noncontingent access to one of the stimuli compared in the behavioral economic assessment. The item was placed on a table or desk in front of the participant or was available in the therapy room, but the participant was not prompted to manipulate the item. The therapist did not interact with the participant, and no programmed consequences were provided for problem behavior. All participants were exposed to two treatment conditions using an alternating treatments design. In one condition, continuous access to the high-preference stimulus was provided; in the other condition, continuous access to the low-preference stimulus was provided.

**Differential Reinforcement of Other Behavior (DRO).** Baseline sessions were identical to the no interaction condition of the functional analysis. Treatment sessions were conducted similar to baseline; however a preferred stimulus was provided.
contingent on the omission of problem behavior for a predetermined interval of time. The DRO interval was based on the mean inter-response time (IRT) of each participant's behavior during the entire baseline (Poling & Ryan, 1982). The mean IRT was calculated by averaging the amount of time between episodes of problem behavior during baseline. If no problem behavior occurred in the DRO interval, reinforcement was delivered for 20 seconds, and the DRO interval was reset at the end of the reinforcement interval. The DRO interval was immediately reset if problem behavior occurred at any time during the interval; otherwise, any occurrences of problem behavior were ignored. DRO sessions with high and low preference stimuli were compared by alternating the two conditions in an alternating treatments design, with the exception of Bucky, whose treatment comparison was conducted in a reversal (ABAC) design. DRO sessions were corrected for reinforcer delivery time by stopping the session timer when the reinforcer was delivered. Session length was corrected to ensure that the amount of time without reinforcement was the same under both stimulus conditions. That is, it was hypothesized that the presence of alternative items would affect the rate of problem behavior. Thus, correcting for the availability of the reinforcers would show the rate of problem behavior independent of interaction with alternative reinforcers. Problem behavior that occurred while the reinforcer was delivered was not included in the overall session data.

**Differential Reinforcement of Alternative Behavior (DRA).** During baseline, no programmed consequences were provided for problem behavior or alternative behavior (identical to the no interaction condition of the functional analysis). During treatment, each occurrence of an alternative response (described above) resulted in access to one of the items for 20 seconds, and no contingencies were placed on problem behavior. The
effectiveness of the two stimuli was evaluated in an alternating treatments design. Session length was corrected for reinforcer access time (as described above).

**DRA plus DRO (Dave only).** For Dave, the DRO contingency was superimposed upon the DRA. This condition was similar to the DRA conducted for the other participants; however, Dave was required to refrain from SIB for a specified amount of time (i.e., 10 or 20 seconds) in order for the reinforcer to be delivered. Thus, in this condition, reinforcement delivery was contingent upon the occurrence of the alternative response (i.e., placing plastic rings on a peg) and on the completion of a brief DRO interval. If any SIB occurred during reinforcement delivery, the items were immediately removed, and the task materials were re-presented. Session length was corrected for reinforcer access time (as described above). This analysis was conducted for Dave in a combined reversal (ABCDAD) and alternating treatments design.

**Results and Discussion**

Figure 3 shows the outcome of each participant’s functional analysis. Sessions are plotted on the x-axes while responses per minute of problem behavior are plotted on the y-axes. For Bucky, SIB occurred almost exclusively in the no interaction condition. These data indicated that Bucky’s SIB was maintained by automatic reinforcement. For the remaining participants (Sandy, Dave, and Sue), variable rates of SIB occurred across all experimental conditions. Furthermore, SIB persisted throughout a series of extended-length no interaction sessions. These results also suggested that automatic reinforcement was the variable maintaining these participants’ SIB.
Figure 3: Responses per minute of problem behavior during the functional analysis for each participant in Experiment 2.
Due to the idiosyncratic patterns of responding observed across participants during treatment, each participant's data will be presented on a case-by-case basis. As mentioned above, the order of treatments varied across participants. For simplicity, the treatment data for the participants will be presented in the same order (i.e., EE, DRO, and DRA).

Figures 4 and 5 show the outcome of the treatment analyses for Bucky. Bucky's treatments were conducted in the following order: DRO, EE, and DRA. The upper panel of Figure 4 shows the outcome of the EE analysis for Bucky. Variable rates of SIB were observed in baseline ($M = 1.4$ responses per minute [rpm]). By contrast, decreases in SIB were observed upon implementation of treatment using the microphone ($M = 0.2$ rpm). However, when treatment was implemented with the musical toy, no decreases in SIB occurred ($M = 1.9$ rpm). Item manipulation averaged $99.3\%$ for the microphone and $57.5\%$ for the musical toy. These data reveal that the microphone (i.e., the high preference stimulus from the behavioral economic assessment) was more effective in reducing SIB than the low preference item. The lower panel of Figure 4 shows the outcome of the DRO analysis conducted with Bucky. During the first baseline phase, high rates of SIB were observed ($M = 3.9$ rpm). A DRO interval of 40 seconds was identified based on the average IRT observed during baseline. The first item introduced into treatment (i.e., the microphone) produced a modest decrease in SIB ($M = 1.3$ rpm). A reversal to baseline showed a re-emergence of SIB, with rates somewhat lower than those of the initial baseline ($M = 2.9$ rpm). Upon introduction of the second item (i.e., the musical toy), a modest reduction in SIB was again observed ($M = 1.1$ rpm). Data on item manipulation were not collected during Bucky's DRO. Results of Bucky's DRO analysis...
revealed that both items produced similar reductions in SIB when incorporated into treatment although neither item completely suppressed SIB. The upper panel of Figure 5 shows the outcome of the DRA treatment for SIB. Baseline was characterized by variable rates of SIB (M = 2.3 rpm). In treatment, lower rates of SIB were observed with both items; however, the microphone produced lower rates of SIB (M = 0.2 rpm) than the musical toy (M = 1.5 rpm). The lower panel of Figure 5 depicts data for alternative behavior. Baseline was characterized by low and variable responding (M = 0.8 rpm). During treatment, higher levels of alternative responding occurred when the microphone was presented contingent on behavior (M = 3.3 rpm) than when the musical toy was presented contingent on behavior (M = 0.5 rpm). Item manipulation averaged 61.9% for the microphone and 10% for the musical toy during DRA. These data indicated that the microphone (i.e., the high preference stimulus) was more effective in reducing SIB and increasing alternative responding in the DRA than the musical toy.

Figures 6 and 7 show the outcome of the treatment analyses for Sandy. Sandy’s treatments were conducted in the following order: EE, DRO, DRA. The upper panel of Figure 6 shows the outcome of Sandy’s EE evaluation. Moderate rates of hand mouthing were observed in the initial baseline (M = 1.9 rpm). When continuous access to alternative stimuli was provided, an immediate and sustained reduction in hand mouthing was observed with the teether (M = 0.4 rpm). Conversely, only small reductions in hand mouthing were observed when the musical toy was presented continuously (M = 1.4 rpm). Item manipulation averaged 99.1% for the teether and 95.6% for the musical toy. The bottom panel of Figure 6 shows the outcome of the DRO evaluation. Baseline levels of hand mouthing were high and variable (M = 2.4 rpm). The DRO interval derived from
Figure 4: Responses per minute of self-injury during the EE and DRO evaluations for Bucky.
Figure 5: Responses per minute of self-injury (upper panel) and responses per minute of alternative behavior (lower panel) during the DRA evaluation for Bucky.
the mean IRT during baseline was 10 seconds. Upon implementation of the DRO for Sandy, hand mouthing increased relative to baseline levels (M = 3.1 rpm for teether and M = 3.3 rpm for musical toy). Item manipulation during the DRO averaged 28.3% for the teether and 20.2% for the musical toy. The upper panel of Figure 7 shows the outcome of Sandy’s DRA treatment for hand mouthing. Variable rates of hand mouthing were observed during baseline (M = 0.8 rpm). Treatment with DRA did not decrease hand mouthing for either item (M = 0.8 rpm for teether; M = 0.9 rpm for musical toy). The bottom panel of Figure 7 shows the rates of alternative responding during DRA. No differences in the level of alternative behavior occurred with either stimulus (M = 0.8 rpm, baseline; 1.3 rpm, teether; 1.0 rpm, musical toy). The average amount of item manipulation was 31.3% for the teether and 23.1% for the musical toy. Thus, for Sandy, it appeared that EE was the only effective treatment for hand mouthing. Furthermore, it appeared that only the teether (i.e., the high preference stimulus) reduced levels of hand mouthing during EE.

Figure 8 shows the outcome of Dave’s treatment analysis. The treatments for Dave were conducted in the following order: EE and DRA/DRO. The baseline condition for the EE evaluation was characterized by high rates of SIB (M = 20.8 rpm). Introduction of treatment produced an immediate decrease in SIB with both items, although overall the MegaMouth® produced lower rates of SIB (M = 0.2 rpm) than the noise stick (M = 1.1 rpm). Item manipulation during this phase averaged 91.3% for the MegaMouth® and 93.4% for the noise stick. The middle panel of Figure 8 shows the effects of the combined DRA/DRO intervention on SIB. Compared to the EE baseline,
Figure 6: Responses per minute of self-injury during the EE and DRO evaluations for Sandy.
Figure 7. Responses per minute of self-injury (upper panel) and responses per minute of alternative behavior (lower panel) during the DRA evaluation for Sandy.
lower, more variable rates of SIB were observed in the DRA/DRO baseline condition ($M = 5.5$ rpm). The first treatment phase (DRA only) produced moderate decreases in SIB with both items ($M = 2.7$ rpm for MegaMouth®, and $M = 2.8$ rpm for noise stick). Due to the small treatment effects observed with the DRA, a 20-second DRO contingency was added. The introduction of the DRO component resulted in variable and increased rates of SIB with the MegaMouth® ($M = 6.8$ rpm) relative to the noise stick ($M = 3.4$ rpm). Following this phase, the DRO interval was decreased to 10 seconds to increase treatment effectiveness. The implementation of the 10-second DRO resulted in decreases in SIB relative to the previous phase ($M = 1.6$ rpm for MegaMouth®, $M = 1.8$ rpm for noise stick). Based on the treatment effects observed with the implementation of the 10-second DRO, a reversal to baseline was conducted. The reversal to baseline showed levels of SIB that were lower ($M = 1.9$ rpm) than those observed in the initial baseline ($M = 5.5$ rpm). A subsequent reversal to the combined DRA/DRO phase with the 10-second DRO showed similarly low rates of SIB for both stimuli ($M = 0.7$ rpm for MegaMouth® and $M = 1.3$ rpm for noise stick). The bottom panel of Figure 8 reflects the effects of the combined DRA/DRO intervention on levels of alternative responding. Baseline resulted in low levels of alternative responding ($M = 1.5$ rpm), whereas increases in alternative responding were observed with both stimuli, but were higher with the MegaMouth® ($M = 10.8$ rpm) than the noise stick ($M = 5.5$ rpm). Following implementation of the DRO contingency for SIB, levels of alternative behavior decreased slightly with both items ($M = 6.9$ rpm for MegaMouth® and $M = 6.4$ rpm for noise stick). When the DRO interval
Figure 8: Responses per minute of self-injury during the EE and DRA/DRO evaluations (upper and middle panels) and responses per minute of alternative behavior during DRA/DRO (lower panel) for Dave.
was decreased to 10-seconds, adaptive behavior increased for both items (M = 12.1 rpm for MegaMouth® and M = 9.1 rpm for noise stick). The reversal to baseline showed higher rates of alternative behavior (M = 2.9 rpm as compared to 1.5 rpm of the initial baseline). Following reinstatement of the 10-second DRO, increases in alternative behavior were observed for both items (M = 12.6 rpm for MegaMouth® and M = 19.2 rpm for noise stick). Item manipulation across all phases of the DRA/DRO evaluation averaged 71.1% for the MegaMouth® and 62.4% for the noise stick. To summarize, results of Dave’s analyses indicated that the continuous, noncontingent presentation of alternative items produced a decrease in SIB, whereas the contingent presentation of the alternative items did not appear to produce a substantial reduction in SIB. That is, the average rates of SIB in the treatment phases of the DRA/DRO analyses (M = 2.6 rpm) were higher than those observed in the treatment phases of the EE analysis (M = 0.7 rpm). Despite the variability of the behavior across conditions, it appeared that, in general, both stimuli were equally effective in reducing (or not reducing) the occurrence of SIB and increasing the occurrence of alternative behavior.

Figures 9 and 10 show the treatment outcome for the final participant, Sue. Treatment evaluations for Sue were conducted in the following order: DRO, EE, DRA. The upper panel of Figure 9 depicts results of the EE analysis. During baseline, Sue demonstrated increasing levels of screaming (M = 0.7 rpm). Following implementation of EE, screaming immediately dropped to zero in the presence of the radio, while high levels of screaming occurred with the keyboard. However, these response patterns were not maintained with either stimulus in that both stimuli resulted in variable levels of responding. Overall, lower rates of screaming were observed with the radio (M = 0.1
rpm) relative to the keyboard \( (M = 0.2 \text{ rpm}) \), although both items produced decreases in screaming. Item manipulation during EE averaged 98.2\% for the radio and 51.5\% for the keyboard. The bottom panel of Figure 9 shows the outcome of the DRO analysis conducted with Sue. Throughout baseline, variable rates of screaming occurred \( (M = 0.8 \text{ rpm}) \). In treatment, Sue was given access to one of the stimuli if she did not scream for a period of time (initially 80 seconds). However, no clear reductions occurred at the 80-second interval with either stimulus. Therefore, the DRO interval was reduced by 50\% (to 40 seconds) to increase the probability of treatment success (i.e., Sue would gain access to the stimuli more frequently). Although an initial reduction was observed across both stimuli, these effects waned over the course of treatment. Overall, no clear difference in the rate of screaming was observed with either stimulus \( (M = 0.8 \text{ rpm with the radio, and } M = 0.5 \text{ rpm, with the keyboard}) \). During DRO, item manipulation averaged 37.6\% with the radio and 28.6\% with the keyboard. The upper panel of Figure 10 shows the outcome of Sue’s DRA for screaming. Baseline was characterized by low and variable rates of responding \( (M = 0.1 \text{ rpm}) \). When DRA was implemented, levels of screaming were similar to those observed during baseline for both the radio \( (M = 0.2 \text{ rpm}) \) and the keyboard \( (M = 0.3 \text{ rpm}) \). By contrast, large differences between the stimuli were observed for alternative responding (bottom panel of Figure 10). In baseline, low rates of the alternative behavior were observed \( (M = 0.2 \text{ rpm}) \). However, when reinforcement was delivered contingent on the occurrence of the alternative behavior, responding increased to higher levels with the radio \( (M = 9.8 \text{ rpm}) \) than with the keyboard \( (M = 0.8 \text{ rpm}) \). Significantly more item manipulation was observed in the DRA with the radio \( (M = 74.4\%) \) than the keyboard \( (M = 14.7\%) \). In general, Sue’s results
Figure 9: Responses per minute of screaming during the EE and DRO evaluations for Sue.
Figure 10. Responses per minute of screaming (upper panel) and responses per minute of alternative behavior (lower panel) during the DRA evaluation for Sue.
showed that access to the radio (i.e., the high preference stimulus) resulted in lower rates of screaming than access to the keyboard, no decreases in screaming occurred with either stimulus during DRA (although more alternative responding occurred with the radio), and neither stimulus effectively reduced screaming during DRO. Finally, across all treatment evaluations, more item manipulation occurred with the radio than the keyboard, independent of treatment effectiveness.

At least one reinforcement-based treatment was effective at reducing problem behavior for all participants. Furthermore, for three of the participants (Bucky, Sandy, and Sue), lower levels of problem behavior were associated with the presentation of the stimulus identified as highly preferred in the behavioral economic assessment (the microphone, teether, and radio, respectively). Also, for Bucky and Sue, the high preference stimulus resulted in more alternative responding. Finally, for all participants, the high preference stimulus was associated with higher levels of item manipulation than the low preference stimulus. Thus, the stimulus associated with more responding in the behavioral economic assessment performed more effectively in several aspects of treatment. The results of Experiment 2 suggest that shifts in preference that occur under progressively increasing response requirements might be indicative of the effectiveness of the stimuli as components of reinforcement-based interventions. That is, stimuli that were more preferred under increased response requirements were generally more effective at decreasing inappropriate behavior and increasing appropriate behavior than stimuli that were less preferred (i.e., those that resulted in lower levels of responding). However, due to the inconsistent results observed across participants, the utility of the behavioral economic assessment as a predictive tool warrants further investigation.
CONCLUSION

Results of Experiment 1 demonstrated that the behavioral economic assessment could differentiate between stimuli that were identified as similarly preferred in the choice preference assessment. Results of Experiment 2 suggested that items identified as differentially preferred in the behavioral economic assessment were generally more effective in the treatment of problem behavior maintained by automatic reinforcement (particularly EE). Although previous investigations have shown that stimuli identified as highly preferred function as effective reinforcers (e.g., Fisher et al., 1992; Piazza, Fisher, Hagopian, et al., 1996), these reinforcers have been evaluated with low effort responses (e.g., moving between squares, approach responding) and, with some exceptions, have not been fully evaluated in the treatment of automatically reinforced behavior. Results of the current investigation demonstrated that stimuli that appear to be equally preferred might not be equally effective reinforcers, particularly as response requirements increase. These outcomes may account for the failure of some behavioral treatments that have used preferred stimuli identified via preference assessments (e.g., Piazza, Fisher, Hanley, et al., 1996; Shore et al., 1997) That is, although two stimuli may appear similarly preferred (based on preference assessment outcomes), preferences may change as response requirements increase; thus, the effectiveness of these stimuli as treatment components (i.e., reinforcers) may also change. Toward this end, the current study may extend previous research on reinforcer identification by providing a method for evaluating stimuli under increasing response requirements within the course of a single session and by assisting in the development of reinforcement-based treatments with maximally effective stimuli.
The data presented in this study indicate that the preferences for two stimuli may change as the requirements to access these items are increased. These results replicate the findings of both Tustin (1994) and DeLeon et al. (1997). Unlike those studies, however, the procedures used in the current investigation allowed for a more expeditious examination of responding as response requirements varied. In the studies conducted by Tustin and DeLeon et al. individuals were exposed to different reinforcement schedules over multiple sessions. By contrast, the method employed in the current investigation identified shifts in preferences in a relatively brief amount of time due to the implementation of progressive ratio schedules within sessions rather than single reinforcement schedules across sessions.

Results of Experiment 2 revealed the extent to which choices observed during preference assessments corresponded with the effectiveness of stimuli used in reinforcement-based interventions. Specifically, preferences that emerged under varying response requirements were indicative of the differential effectiveness of these stimuli as reinforcers for decreasing aberrant behavior and increasing appropriate behavior. For all effective treatment evaluations (3 of 9 total conducted with Bucky, Sandy, and Sue), lower rates of problem behavior were associated with the stimulus identified as highly preferred in the behavioral economic assessment. For Bucky and Sandy, the high preference stimulus produced immediate and sustained decreases in SIB during EE, whereas the low preference stimuli demonstrated more modest, if any effectiveness. For Sue, both stimuli had similar effects on screaming in EE, although the high preference stimulus was somewhat more effective than the low preference stimulus for the first 20 sessions of treatment. Also, for Bucky and Sue, increases in adaptive behavior occurred
when adaptive behavior resulted in presentation of the high preference stimulus. Thus, the differences in preference exhibited in the behavioral economic assessment reflected differences in the effectiveness of stimuli in treatment. Results for these participants were similar to those reported by Vollmer et al. (1994) in that highly preferred stimuli were more effective in the treatment of problem behavior than less preferred stimuli. However, unlike the study conducted by Vollmer et al., two stimuli that appeared to be equally preferred in a choice preference assessment (rather than a single, highly preferred stimulus) were compared in treatment.

Conversely, the behavioral economic assessment for Dave revealed that both items were similarly preferred (i.e., resulted in similar levels of responding) under increasing response requirements. Also, similar effects were observed in the treatment evaluations conducted for Dave (i.e., similar levels of inappropriate and appropriate responding were observed across both stimuli). Thus, Dave's data seem to indicate that if differences in responding are not observed in the behavioral economic assessment, it is likely that differences in the effectiveness of these stimuli in treatment will not occur.

Results of this investigation raise two issues regarding the treatment of behavior maintained by automatic reinforcement. The first issue concerns the relative effectiveness of high versus low-preference stimuli during treatment. High preference stimuli were likely more effective because of the quality of reinforcement produced by their manipulation. That is, because all participants interacted with the stimuli in treatment, it is hypothesized that item manipulation was maintained by automatic reinforcement (i.e., toy play occurred in the absence of social consequences). For Bucky, Sandy, and Sue, higher rates of toy play were observed with the high preference stimulus across all
treatment conditions (although item manipulation data were not collected for Bucky’s DRO). Thus, it follows that the quality of reinforcement obtained from the high preference stimulus was greater than that obtained from the low preference stimulus. A related possibility for the relative effectiveness of the high preference stimuli may involve the specific properties of the stimuli. Previous research has demonstrated that continuous access to stimuli that produce sensory stimulation similar to that hypothesized to be produced by problem behavior results in decreases in SIB. For example, Piazza et al. (1998) showed that decreases in pica occurred when access to alternative stimuli that produced oral stimulation (i.e., the stimulation hypothesized to be derived from pica) was provided continuously. Results for Sandy and Sue are consistent with this factor. For example, a teether (i.e., a source of oral stimulation) decreased Sandy’s hand mouthing, which may have produced oral stimulation via insertion of the hand into the oral cavity. Similarly, Sue’s screaming (possibly maintained by auditory stimulation) was reduced by both the radio and the keyboard, both of which produced auditory stimulation. However, this hypothesis cannot account for the results of Bucky and Dave’s treatment analyses. That is, the stimuli used in these participants’ treatments (i.e., the microphone for Bucky and the MegaMouth® and noise stick for Dave) produced reinforcement unlike that hypothesized to be produced by SIB.

The second issue related to the treatment of problem behavior maintained by automatic reinforcement concerns the effectiveness of specific treatments (i.e., EE was more effective than DRO or DRA). One possible explanation for the general ineffectiveness of these treatments may involve the lack of control over the reinforcer maintaining each participant’s problem behavior. Results of several studies suggest that
differential reinforcement procedures may be ineffective without extinction (e.g., Mazaleski, Iwata, Vollmer, Zarcone, & Smith, 1993; Shirley, Iwata, Kahng, Mazaleski, & Lerman, 1997). EE may have been the most effective treatment for several reasons. One possibility concerns the relative effort required to access alternative stimuli. As a treatment, EE presents a choice paradigm in which response allocation toward problem behavior or item manipulation depends on the quality of reinforcement derived from each response. If stimulation derived from item manipulation is more preferred than that derived from problem behavior, responding should be allocated toward alternative stimuli (Herrnstein, 1970). In DRO and DRA, a choice paradigm is also present. However, individuals are required to either wait for a period of time or to emit an alternative response before gaining access to alternative stimuli. Thus, the effort required to access alternative stimuli during DRO or DRA is greater than that required during EE. Shore et al. (1997) found that slight increases in the effort required to obtain reinforcement (from continuous to delayed presentation) could alter response allocation from toy play to SIB. Similarly, the ineffectiveness of DRO and DRA (relative to EE) may indicate that increasing the effort required to access alternative stimuli may alter response allocation to problem behavior. It is interesting to note that for Dave and Sue, alternative behavior increased during DRA without a concomitant decrease in problem behavior. Thus, it appears that these participants responded to obtain both the reinforcer produced by problem behavior and the reinforcer produced by item manipulation. Perhaps with these participants, a more effective evaluation of DRA would have been to select an alternative response that was incompatible with the problem behavior.
Another possible reason for the ineffectiveness of the treatments was the quality of the stimuli selected in the treatment analyses. That is, in the current study, two stimuli that were similarly preferred in the choice assessment were evaluated. For most participants, the stimuli evaluated were not the most preferred in the choice assessment. Vollmer et al. (1994) showed that highly preferred stimuli were effective at decreasing rates of problem behavior; thus, it is possible that the inclusion of the most preferred stimulus would have resulted in a greater reduction for all treatments. However, the reinforcing items evaluated with Sue were the most preferred in the stimulus preference assessment, but no effective treatments were identified. It is also possible that DRO may be a relatively ineffective treatment for behavior maintained by automatic reinforcement. In previous research (e.g., Piazza et al., 1996; Shore et al., 1997), DRO produced inconsistent treatment effects for behavior maintained by automatic reinforcement. For Bucky, Sandy, and Sue, DRO was the least effective treatment overall and resulted in the least amount of differentiation between the two comparison stimuli. Thus, these results provide further evidence that DRO often may be ineffective as treatment for behavior maintained by automatic reinforcement.

One limitation of this study is the lack of modifications made to each participant’s treatment procedure. Combining reinforcement-based treatments with other procedures, such as punishment, or varying the reinforcers to prevent satiation may have produced greater reductions in behavior (e.g., Vollmer et al., 1994; Ringdahl et al., 1997). However, it should be noted that the specific purpose of the current investigation was to evaluate the differential effectiveness of two stimuli as components of behavioral interventions rather than the effectiveness of the interventions per se. Another possible
limitation was the schedule progressions selected for the behavioral economic assessment. Changes in the PR values were determined somewhat arbitrarily, and thus, may not have progressed in a manner necessary to determine changes in preference. It should be noted, however, that the manner in which schedule requirements were determined was similar to that used in previous investigations.

A final limitation of this study involves the identification of automatic reinforcement as the maintaining variable for SIB. As mentioned previously, an automatic reinforcement function is typically determined when the highest rates of behavior occur in the no interaction condition or when results of the functional analysis are undifferentiated (as was the case for 3 of the 4 participants in Experiment 2). However, undifferentiated functional analysis outcomes may be due to other factors, such as the presence of multiple reinforcers, interaction effects across conditions, or lack of discrimination among conditions. Additionally, other behavioral mechanisms could account for the persistence of behavior in the absence of social consequences. For example, behavior could be maintained by intermittent schedules of reinforcement in the natural environment (e.g., attention is provided following repeated occurrences of the behavior).

Several directions for further research can be derived from this investigation. First, the effectiveness of the behavioral economic assessment both as a method for differentiating stimulus preferences and as a method for predicting relative stimulus effectiveness in treatment should be evaluated. Although the data reported in the current investigation suggested that high preference stimuli may be more effective in treatment with EE, these results were not consistent across participants and other treatments.
Therefore, more research should be conducted to determine the efficacy of the behavioral economic assessment as a reinforcer identification method as it pertains to treatment development.

A second potential direction of future research may involve the analysis of within-session response patterns during the choice preference assessment. If two stimuli are identified as similarly preferred in the choice assessment, within-session patterns may reveal how these stimuli compared when presented concurrently. That is, if the pair was presented twice, within-session patterns may show that one stimulus was chosen on both occasions. Within-session examinations of the choice assessments conducted in the current investigation were inconclusive (i.e., one comparison stimulus was not consistently chosen over the other). However, if further research shows that within-session patterns often match results of the behavioral economic assessment, it may be possible to forgo a more extended analysis of responding under increasing response requirements.

A third direction of future research might involve comparing other types of stimuli using the behavioral economic assessment. For example, preference for highly preferred stimuli could be compared to that of “matched” stimuli (i.e., stimuli that produce sensory consequences similar to those produced by problem behavior; Piazza et al., 1998). As mentioned before, previous research has demonstrated that matched stimuli are effective at reducing the occurrence of automatically reinforced problem behavior. However, the extent to which matched items are preferred over unmatched items in choice preference assessments has received less investigation. The differential effectiveness of these items as treatment components for problem behavior could be
compared to determine why some stimuli are more effective than others in the treatment of aberrant behavior maintained by automatic reinforcement. In addition, relative preferences for alternative stimuli and preferences for social reinforcers that maintain problem behavior could be evaluated using a behavioral economic assessment. For example, if SIB was maintained by attention, and an alternative stimulus was identified as highly preferred in a preference assessment, both reinforcers could be presented under varying schedules of reinforcement. Results may indicate that either reinforcer is effective under low response requirements (and low effort treatments), but one stimulus is more preferred under more effortful requirements (e.g., DRO). Such an analysis may or may not reveal that functional and alternative reinforcers are equally effective as reinforcers in some treatments.

Another interesting extension would be to compare stimuli that are identified as highly preferred and less preferred in the choice assessment. These results may indicate that some stimuli appear highly preferred under low response requirements (i.e., in the choice assessment) while others appear nonpreferred, but that these preferences reverse under more effortful response requirements. Tustin (1994) showed that a stimulus that was more preferred than another stimulus under low schedule requirements (i.e., FR 1) was less preferred than the other stimulus under more strenuous requirements (e.g., FR 10). However, DeLeon et al. (1997) failed to replicate this finding. Thus, future research using the behavioral economic assessment could further evaluate this possibility.

Finally, and more generally, future research should further evaluate reinforcement-based treatments for behavior maintained by automatic reinforcement. One method of increasing treatment effectiveness might involve the incorporation of response
reduction methods into reinforcement-based treatments. However, the use of punishment procedures is often controversial. Therefore, future research should attempt to develop methods of improving interventions based on reinforcement only (e.g., Ringdahl et al., 1997). Also, few studies have examined the long-term effectiveness of EE treatments. Thus, future research should evaluate methods of fading the schedule of reinforcement used in EE as well as methods for varying the reinforcers used in EE.

In summary, this study demonstrated that stimuli that appeared to be similarly preferred in a commonly used stimulus preference assessment, might be differentially preferred as response requirements increase. Furthermore, stimuli that are more preferred under increased response requirements generally functioned more effectively in treatment. These data suggest that practitioners should be aware of these changes when designing treatments for behavior maintained by automatic reinforcement.
REFERENCES


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VITA

Henry S. Roane is doctoral candidate in school psychology at Louisiana State University. He did his pre-doctoral work with Timothy Vollmer and Dorothea Lerman, and completed an APA-accredited internship at the Kennedy Krieger Institute and the Johns Hopkins University School of Medicine under the supervision of Cathleen Piazza and Wayne Fisher. He is currently employed as a case manager at the Marcus Institute at the Emory University School of Medicine. His research interests include functional analysis of severe behavior disorders, application of stimulus preference assessments, and the etiology of self-injurious behavior. He expects to receive the degree of Doctor of Philosophy in Psychology in May 2000.
Candidate:  Henry S. Roane

Major Field:  Psychology

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