AN ANALYSIS OF THE VALUE-ALTERING EFFECT OF MOTIVATING OPERATIONS

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Motivating operations (MOs) may affect behavior in two ways; A) an MO momentarily alters the frequency of behavior for which a particular consequence has served as reinforcement (evocative-effect) and B) an MO momentarily alters the behavioral effects of the relevant consequence (value-altering effect). Many studies have empirically demonstrated the evocative function of MOs, however, few if any studies have attempted to systematically manipulate and measure the value-altering effect. The focus of this study was to investigate the value-altering effect by measuring choice and response allocation across two alternative tasks. Participants were two female girls diagnosed with autism. During conditioning sessions, experimenters created a history for the children in which clicking on a moving square on a computer monitor produced a small piece of edible. Prior to some conditions, the participants were allowed 5 min of free-access to the edibles, and in other sessions, access to edibles prior to session was restricted. During these sessions, the square was either red or blue depending on the condition type (pre-access or restricted-access). During probe sessions, both colored squares were concurrently available and participants were allowed to allocate their responding to whichever square they chose. One participant preferred the square associated with restricted-access, which may support the notion of the value-altering effect. Difficulties during conditioning sessions interfered with the ability to run sufficient probes with the other participant to evaluate a value-altering effect. Results suggest that the use of these procedures may be useful to differentiate evocative and function-altering effects of MOs.
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CHAPTER 1

INTRODUCTION

The motivational influences that account for momentary variability in operant behavior have long been of interest to behavior analysts (Skinner, 1953). Keller and Schoenfeld discussed motivation in *Principles of Psychology* (1950). In this classic text, the authors refer to “drives” and “establishing operations” (EO) as precursors to behavior. For the next three decades the concepts of drive and motivation would receive little attention in the behavior analytic literature until Michael addressed them in the early 1980’s. Michael (2000) reported that his 1982 and 1993 papers on establishing operations (EOs) were attempts to make motivational concepts more important parts of current behavior analysis theory. Despite the small number of articles specifically referring to MOs during this period, their applied relevance was becoming more apparent.

Behavior analysts have identified two general types of antecedent influences on operant behavior. One class of variables that can alter the probability of occurrence of behavior is discriminative in nature. These stimuli or conditions affect operant behavior because of historical correlations between the presence or absence of the stimulus when a reinforcing or punishing event occurs. Another class of variables that can affect operant behavior is related to an organism’s motivation with respect to specific environmental stimuli. This class of variables is known as motivating operations1 (MO) (Laraway, Sncerski, Michael, & Poling, 1993).

An MO is defined as a stimulus or condition that affects an organism in two ways

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1 Here the author introduces the term “motivating operation”, or “MO”, which is the currently accepted umbrella term for motivating variables. As is later discussed in the manuscript, a change in terminology was suggested by Laraway, Sncerski, Michael and Poling (2003) because the terminology used was confusing for a number of reasons. Prior to their article, behavior analysts used the term establishing operation (EO) to refer to MOs (either evocative or abative). This author will use the term MO (unless quoting directly) to refer to the broad category of motivating operations, and EO or AO to refer to specific variables.
(Laraway et al., 1993). First, an MO momentarily alters the frequency of behavior for which a particular consequence serves as reinforcement. For example, deprivation from food might increase the frequency of behavior that has produced food as reinforcement in the past. This is commonly called the “evocative effect”. Second, an MO momentarily alters the behavioral effects of the relevant consequence. This is commonly called the value-altering effect. The MO can alter the effectiveness of consequences in two different ways. Establishing operations, or EOs, increase the reinforcing/punishing effectiveness of some consequence, and abolishing operations or AOs decrease the reinforcing/punishing effectiveness of some consequence.

MOs have not always been clearly discussed. Laraway, Syncerski, Michael and Poling (2003) pointed out that the then-current notion of the EO was in need of modification. Prior to the publication of this paper, the term establishing operation was used to describe any stimulus or event that could affect behavior through evocative and function-altering effects. Even as this was accepted, it was confusing, because it is not the case that all motivative variables are evocative or increase the value of consequences. The term establishing itself carries with it some embedded meaning of producing a positive change in rate, which is not consistent with the effect of satiation techniques on behavior. Thus the authors introduced the term motivating operations (MOs) which encompassed EOs as well as abolishing operations (AOs). According to their suggestions, EOs increase the effectiveness of some consequence as a reinforcer or punisher, as well as momentarily increase the rate of associated behavior. Conversely the AOs decrease the effectiveness of some consequence as a reinforcer/punisher and momentarily decrease rate of associated behavior. The terminology suggested in this paper represents the current technical vocabulary.
The basic unit of analysis of operant behavior is the three-term contingency. This contingency encompasses relations between antecedent stimuli/events, behaviors, and consequences. Although this model is sufficient in helping to interpret many environment-behavior relations, it does not sufficiently account for or describe all elements of behavioral contingencies. As such, this model has been amended to include a fourth component in the form of the MO which falls under the category of antecedents. Keller and Schoenfeld (1950) described why the three-term contingency alone is not sufficient; “Because responses can be controlled in other ways than by reinforcement… a new descriptive term is called for and a new behavioral concept emerges” (p. 264). Michael (1993) succinctly described the importance of this notion, suggesting that much of applied psychology is concerned with getting people to do things that they know how to do but don't want to do.

Some authors have suggested that the complexity of antecedent influences on behavior require new ways of conceptualizing these variables – that operant principles of discrimination and motivation simply cannot adequately account for these influences (e.g., Kantor, 1970; Wahler & Fox, 1981). Smith and Iwata (1997) reviewed the applied literature on antecedent influences of problem behavior and interpreted the effects of those influences in terms of discriminative stimuli (SD) and MOs (or, in certain cases, as variables that physically interfered with the occurrence of behavior). The authors suggested that no new or special processes need be invented to describe antecedent influences (e.g., setting events), appealing to parsimony in our conceptual systems. They proposed several directions for future research related to antecedent influences, suggesting in particular that motivation could be evaluated by manipulating antecedent events while holding constant the consequences that maintain behaviors. Several
researchers have used that general protocol to investigate motivational variables affecting a range of behaviors (O’Reilly et al., (2006), Sy & Borrero (2009).

Michael’s interest in motivational variables and their potential utility in applied settings was apparent in one of the earliest recorded examples of applied behavior analysis (ABA) in the empirical literature. Ayllon and Michael (1959) used a satiation procedure to change maladaptive behavior of adults living in Saskatchewan Hospital, Canada. Diagnoses ranged from schizophrenic to mentally defective which seemed to evoke an attitude of acceptance. Nurses and staff believed that these individuals were incapable of learning or behaving appropriately. Four male individuals engaged in hoarding behavior that impaired their abilities to function normally. The most problematic case of hoarding was shown by Harry. He carried such large amounts of trash and, so persistently, that it caused skin rashes. The nurses had to “dejunk” him several times a day. The researchers determined that his behavior was likely multiply controlled by the attention he received for it, as well as the actual scarcity of printed material available to him in the ward. Nurses reported that they occasionally brought printed materials in for patients, but they were ripped up or disappeared so quickly that the nurses did not bring these materials frequently. The treatment plan included flooding the ward with printed materials, as well as extinction of attention associated with “dejunking” the individuals. The nurses were instructed “During this program the patients Harry, Mac, Joe and Tom must not be given reinforcement (attention) for hoarding. There will be a full supply of magazines in the dayroom. Every night, after all the patients have gone to bed, replenish the magazine supply in the dayroom. Every night while the patients are in bed, check their clothes to record the amount of hoarding. Do not, however, take their hoarding from them” (p. 332). This program was incredibly effective for all of the individuals who engaged in hoarding. After nine weeks of a treatment, the nurses chose to
terminate the program since hoarding was no longer a problem. Four days after beginning the
treatment program, Harry no longer carried the trash or paper in his clothing. Rather, he held a
stack of magazines on his lap while he sat in the day room.

Egel (1981) evaluated the effects of varied versus constant reinforcers on correct
responding and on-task behavior of three young boys with developmental disabilities. Results
showed that rates of correct and on-task behavior declined more rapidly in the constant reinforcer
sessions as compared with the varied reinforcer sessions. Egel suggested that these outcomes
resulted from satiation occurring in the constant reinforcer sessions. This study represents an
early example of a behavior-analytic assessment of the effects of satiation procedures.

Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994) developed a functional analysis
methodology to identify maintaining variables of self-injurious behavior (SIB). In order to
identify sources of reinforcement for SIB, attention was paid to antecedent variables that might
alter the effectiveness of behavioral consequences. For example, a control condition was
arranged that included free access to preferred stimuli and social interaction. The findings
suggested that “physical and social characteristics associated with such an "enriched
environment" may produce a number of beneficial outcomes, including reductions in self-injury”
(p. 207). This conclusion might be interpreted to mean that providing a more enriched
environment prior to occurrence of SIB may reduce motivation relative to the consequences that
maintain the behavior. This is an early example of a treatment suggestion which includes MO
manipulation.

2 The term “satiation” is used in other scientific fields to describe hormonal changes (i.e., a rise in blood glucose
levels, distension of the belly and more) due to ingestion. It can be said to produce behavioral changes as well.
“Habituation” is a term which may refer to a change in behavior due to repeated exposure to a specific stimulus such
that over time, an organism may not react to the stimulus as it did initially. In any given example, it will be
incredibly difficult to say which of these is responsible for any given behavioral change. It may be beneficial to refer
to both of these as agents of change. More inquiry into the extent to which each plays a role in behavioral changes
would beneficial.
Vollmer and Iwata (1991) directly investigated the effects of deprivation and satiation operations on the behavior of five adult males with developmental delays. Access to small edibles, music, and social praise was manipulated in order to examine the effects of pre-session access versus no-access on the performance of arbitrary tasks (stacking blocks or closing switches) when the stimuli were presented as consequences. Results showed that “…response rates during reinforcement conditions varied as a function of relative deprivation versus satiation” across subjects (p.289), with periods of access associated with lower rates of responding than when access was withheld. The authors suggested that failures of reinforcement may sometimes be a function of motivational variables, and therapy providers should carefully consider scheduling and timing of potentially reinforcing events throughout an individual’s day. Said another way, when a positive reinforcement procedure fails, it may not be because the procedure was performed incorrectly or the consequence would not otherwise function as a reinforcer. Rather, it may be that the consequence was not serving as reinforcement at the moment it was delivered because of motivationally-relevant variables, such as recent contact with the stimulus. For example, the delivery of snack items as reinforcement for appropriate behavior directly after a meal time may not be as effective as if the same items were contingently delivered before a meal or a few hours after a meal. Results of this and other investigations of deprivation operations suggest that these effects can be produced through relatively minor adjustments to clients’ daily schedules, suggesting that these types of manipulations might represent easy, efficient, and nonintrusive ways to maximize reinforcement effects.

McGill (1999) discussed MOs and their relevance to the treatment and prevention of problem behavior in individuals with developmental disabilities. Attention was paid to conditioned establishing operations (CEOs) as well as the relevance of specific EOs to problem
behavior. The author described each of the types (surrogate, transitive, reflexive) of CEOs and provided an example of each. Suggestions were made for possible experimental manipulations that might be used to study these phenomena. For instance, McGill suggested that it might be easier to study surrogate CEOs by manipulating something that can change faster than food deprivation (such as temperature increases/decreases). The author illustrated how a specific maintaining variable such as social attention, might become more valuable as a consequence if certain antecedent conditions were in place. In example, if a client engaged in SIB that was followed by attention, it might serve to better reinforce that occurrence of SIB following conditions of deprivation from attention as opposed to a recent experience of an attention rich environment. McGill pointed out the importance of this fact and how it relates to the analysis of MOs in functional analysis (FA) methodology as well as treatment plans. He illustrated these suggestions with 3 points; A) in cases in which the EO is found to represent an unacceptable state of affairs for the clients, treatments that do not address these issues would be unwise and likely ineffective B) analysis of the EO might help to explain otherwise unforeseen variability in behavior that is essentially always a part of the same contingency. In other words, high levels of variability in the frequency of problem behavior which is always conseuated in the same manner may be observed if the EO operates differently across time. C) Knowledge of the role of MOs in the occurrence of problem behavior may advise selection of specific interventions. Said another way, problem behavior may be managed in multiple ways, and knowing something with regards to the EOs at play with a particular client may help to suggest which of the many treatment options is most advisable. McGill concluded that “… the notions revived in Michael’s (1982, 1993) treatment of the EO have been shown to have considerable relevance to conceptions of problem behavior and its assessment, treatment, and prevention. They enable a
more complete account of problem behavior to be given, both generally and with respect to particular individuals” and as well, their evaluation can impact behavior analysis in a more general context (p. 412).

O’Reilly et al. (2006) attempted to isolate the evocative effects of the EO for positively reinforced problem behavior of two individuals with autism. First an FA of problem behavior was conducted, showing that tangible delivery and attention maintained the behaviors. Next, pre-session access to tangibles and attention was manipulated (pre-access or restricted-access) prior to tangible and attention test sessions (i.e., problem behavior resulted in the delivery of tangibles or attention). Results showed that higher levels of problem behavior occurred following restricted access to attention and tangibles. Next, the experimenters manipulated pre-access in the same manner, but implemented extinction of problem behavior during sessions. Results of this phase indicted that higher levels of problem behavior occurred under extinction when restricted-access to attention or tangibles was allowed. These outcomes suggest that manipulation of relevant EOs can aid in the assessment process when results of an FA are undifferentiated. In addition, providing non-contingent access to reinforcers identified to maintain problem behavior during extinction may mitigate some of the negative side effects of extinction.

Gutierrez and colleagues (2007) taught four individuals with developmental disabilities to use two different mands to request two different preferred items. Following mand training, participants were given free access to one of the preferred items (such that there should be no motivation to request it) while access to the other item was restricted. Three of four participants
emitted discriminated\(^3\) manding using the picture exchange communication system (PECS; Bondy, 1994). One participant did not acquire discriminated manding until topographically distinct mands were taught, suggesting that discrimination training may not be sufficient in teaching discriminated manding when multiple pictures of items are being used. In other words, children may choose the incorrect picture in that it might not depict the item or activity that they are trying to access at the moment. Results also showed that depriving the children of access to just one of the preferred items was a valid assessment tool for testing if the children were capable of discriminated manding. This study suggests that using MO manipulations might not only be beneficial, but possible necessary to teach some learners to correctly identify and exchange pictures of things that they need or want.

Sy and Borrero (2009) evaluated effects of pre-session access to reinforcing stimuli on rates of problem behavior. Specifically, access to small, medium or large amounts of edible and non-edible reinforcers was provided immediately before sessions in which identical reinforcers were contingent on problem behavior. Results showed that pre-session access to edibles produced different results across individuals, reducing responding for some but increasing responding for others. In addition, results varied across parameters of access, suggesting that “…duration may influence the reinforcing efficacy of some stimuli” (p. 836). The outcomes of this study suggest that prior access to stimuli that are subsequently presented contingent on behavior may produce both sensitization and habituation, and that these effects may differentiate across participants and also be mediated by the extent of access. As such, assessments that track both occurrence and effects of outside access to reinforcers may assist in effective programming.

\(^3\) Discriminated in this context refers to the child choosing the correct picture to exchange. In other words, the children could discriminate between the pictures that represented the items they were deprived of (and were actually seeking) and other pictures.
O’Reilly and colleagues examined the effects of three different types of pre-session conditions on problem behavior (2009). Analogue FAs identified delivery of tangible items as the maintaining variable of problem behavior in two students with autism. Next, the students were exposed to (a) brief access (b) no-access (c) satiation to tangible item conditions prior to a tangible condition session. Lower levels of problem behavior were emitted following the satiation pre-access condition than either the brief access or no-access conditions. The findings were discussed in terms of how best to define satiation in similar types of evaluations. Behavioral indicators of satiation were noted as one important measure such as latency to first response might be another indicator of interest.

Michael has been influential in shaping the ongoing discussion about motivation in behavior analysis. From 1982 to 1999, the cumulative number of citations to Michael (1982, 1993) and the usage of the term EO in the Journal of Applied Behavior Analysis (JABA) increased each year (Iwata et al., 2000). His contributions to the topic of motivation are many and most notably include the clarification and further refinement of the vernacular associated with motivation, as well as his suggestion that it may be beneficial to distinguish between a stimulus which signals the availability of reinforcement for engaging in a particular response; discriminative stimulus (SD), and an EO.

In practice, MOs may be manipulated to achieve at least two effects. As noted by Michael (2006), many behavioral interventions are chosen because of (a) value-altering or behavior-altering effect, or (b) its function-altering effect as reinforcer or a punisher. Although a considerable amount of effort has been devoted to conceptualizing the MO, most empirical work has focused on one of its putative effects – the evocative function- to the exclusion of its putative function-altering effect. In order to advance our understanding of antecedent-behavior relations,
it will be necessary to conduct additional research to more closely examine both the value-altering and behavior-altering effects of MOs. Cherpas (1993) suggested that the evocative effects of MOs are not in question; however, few studies have systematically attempted to emphasize the value-altering effect of MOs. The very basis of behavior analysis is parsimony and data-based decision making. Thus, it would follow that before an intervention involving such manipulations is prescribed, a comprehensive body of empirically validated studies pertaining to MOs exist.

According to Michael's definitions, behavior that produces a reinforcing consequence while a strong EO is in effect should be more effectively, or strongly, reinforced than when behavior produces the same consequence under conditions when motivation is weak. That is, behavior reinforced during strong EOs should be more likely to occur later, under similar conditions, than behavior reinforced during weak EOs. Thus, to demonstrate this effect, it would be necessary to show that a history of earning reinforcement while an EO was in effect increases the future occurrence of a response relative to a history of reinforcement during which the EO was not in effect. One potential tactic for evaluating the value-altering effect might take the form of a choice test. Given the option to choose between two stimuli that have been paired with different histories of access to a reinforcer prior to sessions in which the reinforcer was presented contingent on identical tasks, an MO account would predict that participants would choose the stimulus that was paired with deprivation from the reinforcer. In the current experiment food was used to reinforce an arbitrary response (clicking on a moving square on a computer screen) under two conditions: one in which the participant did not have access to the particular food for at least 24 hr. (zero access) and one in which a substantial amount of the food was freely available immediately prior to sessions (free access). Two previously neutral stimuli (the color of
the moving squares on the computer screen) were paired with two condition types, which varied from one another only according to pre-session access (i.e., sessions were controlled so that the tasks were identical, the same number of responses were reinforced and the same number of reinforcers were earned across access vs. no-access conditions\(^4\)). Following three yoked pairs of sessions, participants were permitted to choose which color of square (the color associated with restricted-access or the color associated with pre-session access) to view and/or click on during probe sessions. If deprivation from the food functioned to increase its reinforcing effectiveness, one would expect that the stimulus that was paired with restricted-access would be chosen more frequently and might also show more durable behavior (i.e., resistance to extinction). Results showing responding in the opposite direction might raise interesting questions regarding the effects of satiation and deprivation procedures, as well as about the putative function-altering characteristic of MOs. In other words, in order to test the value of some stimulus, it would be advisable to offer the participants the choice between the stimuli. If one stimulus is more chosen or more favored in terms of responses than the other, it would show that the participant preferred that stimulus. The current study may be set apart from the rest because it attempts to specifically evaluate the value-altering function of MOs by analyzing the choice behaviors of participants after a conditioning history has been built in which MOs have been manipulated. This procedure will allow analysis of the lasting effects of the manipulations to prior access of edibles on the perceived value of the squares associated with differing availabilities of edibles.

\(^4\) The number of reinforcers earned across conditioning sessions was not always held constant for all participants, a more in depth discussion of this follows in the method, results and discussion section.
CHAPTER 2

METHOD

Participants and Setting

Two females who attended a school for children with developmental disabilities served as participants for this study. Possible participants were identified by the school’s director and various teachers. Participants were recruited by flyers sent home with the children’s daily take-home folders. To be eligible for participation in this study the student must have had (a) a guardian who gave permission to participate in the study, (b) an extensive history of using a computer with a mouse and (c) a reported preference of some snack items. The participants had demonstrated the ability work independently on a variety of academic assignments using a computer, mouse and keyboard with minimal assistance.

Ellen was a 13 year-old female who attended a classroom where she experienced a 6.5:1 student/teacher ratio. She was diagnosed with autism by an independent medical practitioner, and had an intelligence quotient (IQ) of 71 according to the Wechsler Intelligence Scale for Children, fourth edition (WISC IV). She functioned on a 6.9 grade level, according to the Woodcock-Johnson III Test of Achievement (Woodcock, McGrew, & Mather, 2001) and her age equivalent according to the same test was 13. Ellen could generally follow multi-step instructions, answer simple questions, and engage in age typical conversation.

Beatrix was a 6 year-old female who attended a different classroom and experienced a 5:1 student/teacher ratio. She was diagnosed with autism by an independent practitioner and had an IQ of 108 according to the WISC IV. She functioned on a 1.9 grade level, according to the WJ III Test and her age equivalent according to the same test was 6.83. She could follow multi-step
instructions, answer complex questions, engage in age typical conversations, and asked questions if she did not understand instructions or needed assistance.

All experimental sessions were conducted in a room (approximately 1.83 m x 3.05 m) containing two desks, four chairs, a bookshelf, and the study apparatus. Sessions were conducted three to five days a week. Because the sessions involved consumption of edible items, sessions were only conducted once daily for all participants.

Apparatus and Task

The apparatus consisted of a cubicle constructed from hardy board that was nailed together in an “H” shape, providing for a participant side and an experimenter side. A 6.35cm diameter PVC tube protruded through the front of the apparatus and a 35.56 cm x 30.48cm color computer monitor was mounted above the tube on the participant side. Cables and control wires passed out of site of the participant to the experimenter side via a hole behind the monitor. Starting, stopping, and data logging of the experimental session was accomplished via a keyboard on the experimenter side of the cubicle. Images including exact measurements are shown in Figure 1. The apparatus was designed to automate as much of the experiment as possible in order to control for social variables that could have affected behavior such as subtle cues in the form of facial expressions, or the participants’ histories with experimenters. In essence, we tried to create a human operant chamber to maintain extra control over experimental sessions. The computer program used was written in LabView™ (National Instruments, Austin, TX). In general, the experimental sessions required the participants to click on a moving, 1.9cm x 1.9cm square that appeared on the screen to receive edible items. The square could take on one of two colors, red or blue, which served as stimuli for different conditions. During conditioning
sessions, a solid tab was present on a tab at the top of the screen; the tab was the same color as the square and served as an additional color stimulus for the conditioning sessions; the tab for the other condition (red or blue) was present, but grayed out. Responses on the grayed tab had no programmed consequences. During sessions the square moved continuously around the screen to random locations at random intervals; when the square appeared; it remained on the screen for approximately three seconds before jumping to a new location (this duration was lengthened to approximately six seconds for Beatrix during the second phase of conditioning sessions). The movement of the square was designed to increase the sensitivity of participants to the task (e.g., Madden & Perone, 1999). The target response was mouse clicks on the square. For both the “red” and “blue” conditioning sessions, each consecutive five clicks to the operative square resulted in the delivery of an edible (see below) by the experimenter. Clicks off the square reset the counter. The sessions stopped automatically after ten minutes or by the experimenter’s hitting the “S” key in certain circumstances (see below).

Probe trials were intermingled with training sessions. Probe trials were similar to conditioning sessions in appearance except that both colored tabs at the top of the screen were concurrently operative, and the participant could choose between the “red” and “blue” conditions. The schedule requirement remained the same during probe trials. In effect, probe trials were Findley concurrent arrangements (Findley, 1958) and participants could toggle between each condition freely by clicking the tabs at the top of the screen. When changing from one component to the other, a 4-s change-over delay was imposed. During the change-over delay, the squares were invisible to the participant. At the end of 4 s, the square re-appeared. Changing between components did not affect the current count of clicks, as before, only clicks off the square reset the response counter. All other parameters were likewise the same as
training sessions. For both components, each time a square was clicked five times in a row without error, a brief chime noise played.

Measurement and Interobserver Agreement

Pre-Conditioning Assessments

During the color preference assessment, a color selection response was defined as touching, pointing or otherwise making contact with the hand to a single colored square. During the edible preference assessment, a selection response was defined as the participant making physical contact of the hand with the edible on the plate. During the reinforcer assessment, a response was defined as grasping a colored ball with one hand and removing it from the crate it was housed in, to deposit it into the other crate. A response was not tallied unless the child let go of the ball with all fingers upon releasing it into the other crate. Data were collected independently by trained observers who circled colors, scored tally marks or wrote the appropriate number using pencil and paper. Interobserver agreement (IOA) data were scored for each participant during edible preference assessment and reinforcer assessment. No IOA data were collected for either participant during the color preference assessment. IOA was measured for the edible preference assessment by calculating the point by point agreement of each edible selection per round. So if observer 1 and 2 disagreed that Ellen chose Goldfish crackers first, this would count as one disagreement. If they both agreed that Cheetos were selected third, this would count as one agreement. Agreements were divided by agreements plus disagreements and that number was multiplied by 100. For Ellen, IOA was 95% agreement during the edible preference assessment. For Beatrix, IOA was 100% during the edible preference assessment. IOA was measured for the reinforcer assessment by calculating the smaller number of responses
by the larger number of responses and multiplying by 100. For Ellen, IOA was 100% during the reinforcer assessment. For Beatrix, IOA was 95% during the first reinforcer assessment and 100% during the second reinforcer assessment.

*Conditioning Sessions and Probes*

During conditioning and probe sessions target responses were clicks using a standard mouse on a PC. Target clicks were defined as clicks that occurred when the arrow was located on a box that moved continuously and randomly across a computer screen. Off-target clicks were defined as clicks to any other portion of the computer screen. Data were collected automatically and saved by the computer during all sessions. The computer program recorded all responses in real time, and data were summarized for each session as frequencies of target responses and off-target responses (conditioning and probes), the number of minutes spent with each square (conditioning and probes), and the number of switch-overs between stimulus conditions (probes).

*Procedure*

*Color Preference/Side Bias Assessment*

Prior to conditioning sessions, several pre-conditioning assessments were conducted. A paired choice assessment was conducted to determine if preferences existed among five differently colored squares and to determine if participants exhibited left or right side bias. Although squares of only two colors were used in the experiment, additional colors were evaluated (1) in case any pre-experimental preferences for red or blue were observed or (2) in case it was determined to use additional stimuli as the experiment progressed. The experimenter and child sat across from each other at an empty table. The experimenter placed two 101.6 mm
colored squares of paper parallel to one another approximately 304.8 mm in front of the participant and told the participant “pick a square”. A selection was scored if the participant touched or handed the square to the experimenter. Each colored square was paired twice with every other colored square and each color was presented on the left and right side once out of every pairing. The total frequency of choice of each color and side was tallied. If the participant chose either the red or blue square more frequently than the other color, the experimenter used that color as the stimulus to be paired with pre-access conditions. A description and explanation of this follow in the “conditioning sessions” section.

**Edible Preference Assessment**

The experimenter asked the children’s parents to list some of the child’s preferred edible items. The experimenter also asked each participant individually to name his or her favorite snacks. Following identification of at least ten reported preferences, a multiple stimulus without replacement (MSWO) preference assessment, as described by DeLeon & Iwata (1996), was conducted using the suggested edible items. Three sessions were completed before lunch, and three sessions were completed in the early afternoon to ensure that time of day or recent consumption of food did not affect preference. Participants were brought to the experimental room and sat at a table across from the experimenter. Ten small pieces of the identified food items were placed on clear plastic plates. The plates were set on a table such that the edibles were 30.48 cm in front of the participant. Prior to allowing the participant to make any selections, the experimenter pointed to each of the edible items and labeled it for the child. The experimenter then informed the participants “Each turn you get to choose a snack to eat. You can only pick one at a time. Let’s begin now. Choose one.” If the child touched an item, the
experimenter allowed the child to consume the item and recorded the child’s selection. If the child attempted to touch more than one item, the experimenter blocked this and reminded the child “You can only choose one at a time.” If the child asked any questions about the rules, the experimenter answered them. Each time an edible was chosen; the experimenter removed the empty plate and mixed the remaining plates around. This procedure continued until all of the edible items had been selected or until the child did not make a selection among the remaining items. The assessment was repeated six times for each child in order to identify stable preferences. The rank scores were summed and the edible that was selected before the others most consistently was chosen for inclusion in a subsequent reinforcer assessment.

**Reinforcer Assessment**

A concurrent operants paradigm was used in order to evaluate behavior with respect to each colored ball. The child and experimenter entered the room and sat across from one another at the same table used for the preference assessment. The table supported two opaque plastic crates on either end. A small clear plastic plate was placed between the crates. One crate contained two plastic balls about 114.3mm in diameter, one orange and one green. For Ellen, the experimenter physically guided her hand to reach into the crate and grasp the green ball. The experimenter then physically guided her arm to the other crate and guided her release the ball. The experimenter immediately delivered an M&M onto the plastic plate between the two crates. This response was prompted and followed by delivery of the edible a total of three times. Next the experimenter physically prompted Ellen to engage in the same response with the orange ball; however, this was not followed by delivery of an edible. This response was prompted three times as well. The experimenter then waited for the participant to engage with the materials. If ten
seconds passed with no engagement, the experimenter said “You may keep going if you want to.” The preferred edible was delivered contingent on moving and releasing the green ball into the crates for two minutes. There was no consequence for moving the orange ball. After two minutes, the experimenter said “Let’s take a break” and removed the materials for 30 s. Following the break the experimenter represented the materials and performed the same procedure as above except that the edible was delivered contingent on moving the orange ball rather than the green ball. Each time the participant moved a colored ball to the other crate, a trained observer scored a tally mark in the appropriate column such that the number of responses per ball was measured.

The initial assessment for Beatrix showed that she moved both balls an almost equal number of times. A behavior pattern emerged in which she first moved the orange ball and then moved the green ball (which was followed by delivery of the edible. Apparently, a superstitious chain of behavior was thus established in which she moved both balls equally (Figure 14). We amended this problem by using a reversal (ABA) design in which “A” components featured edible delivery following movement of the green ball and “B” components did not feature edible delivery. During the “B” component, Beatrix asked why no edibles were delivered (e.g., “Bailey, excuse me, but where’s my fish?”) or made statements such as “I don’t understand. I’m doing everything right but you won’t give me my bloody fish”. At one point Beatrix removed the orange ball from the crate, placed it on the plastic plate in front of her and asked “Am I supposed to pretend that this is spaghetti and meatballs? I cannot eat this!” Beatrix emitted many vocal verbal mands for Swedish fish and engaged in much variability in performance in an effort to receive some. The following session was a return to the “A” condition in which Swedish fish were again delivered contingent on moving the green ball back and forth.
Maximum Edible Probe

In order to determine the amounts of edible items to be delivered in pre-access conditions during conditioning sessions, a five minute probe was conducted. The experimenter filled a 50 oz. bowl almost to the top and told the participant “You may eat this if you want.” The participant was permitted unlimited access to the edible for 5 min. The experimenter monitored to insure that eating behaviors did not become unsafe (e.g., to insure that the child did not eat at a rate that produced gagging, etc.). The pre-access amount was determined to be 75% of the total amount consumed during the probe. The maximum amount of edible that the child could earn during conditioning sessions was set at 50% of the total amount consumed during the probe. Ellen was allotted 30g of M&Ms™ prior to pre-access sessions, could earn up to 17 individual of M&Ms™ during sessions. Beatrix was allotted 30 Swedish Fish™ prior to pre-access sessions and could earn up to 15 individual Swedish Fish™ during sessions.

Conditioning Sessions

Two types of conditioning sessions were conducted: pre-access and restricted-access. These sessions differed in three ways. First, in the pre-access condition, the participants received five minutes of free access (up to the maximum amounts determined in maximum edible probes) to the selected edible immediately prior to the session. During restricted-access sessions, the participants did not receive access to the edible item for at least 24 hours prior to the session (note: the duration of the period of restriction of the relevant edible was increased to 48 hours following the fourth pair of probe sessions for Ellen and the first pair of probe sessions for Beatrix; see “Procedural amendments” below for details). Second, the color of the computer-generated square with which participants interacted corresponded with the type of conditioning
session. For Ellen, the box was red during pre-access sessions and blue during restricted-access sessions. The colors were reversed for Beatrix. Third, if a participant did not consume all available food during a pre-access session, the amount of food available during the subsequent restricted-access session was yoked to the amount consumed in the prior pre-access session. So, for example, if seven food items were earned in a restricted-access session, only seven food items were available in the next restricted-access session. The number of food items earned in pre-access and restricted-access sessions were yoked in order to insure that variability in responding during probes was not a function of differences in the number of food items earned across conditions (it was not possible to completely control this variable with Beatrix; see the subsequent description of her results for a discussion). Except for these differences, conditions in effect during pre-access and restricted-access conditioning sessions were identical in every way.

All conditioning sessions began with the child seated at the table with the apparatus present. The experimenter sat on the other side of the apparatus such that neither child nor experimenter could directly see the other. Experimenters wore headphones that were plugged into the laptop that the experimenter used to control sessions. The purpose of the headphones was to unobtrusively cue the experimenters when to deliver an edible (i.e., when the target response sequence had been completed). A target response sequence was defined as five consecutive clicks in a row to the area of the square, without error. The experimenter started the session by activating the computer program and stating “Use the mouse and see what happens. You can stop whenever you want to by saying “I’m done or stop please”. Following Beatrix’s first probe session, in which some apparent extinction-induced behaviors were observed, the statement “Remember, sometimes you will earn snacks and sometimes you will not” was added to the instructions. If participants asked questions about whether they would receive edibles the
experimenter responded “I don’t know, you will have to try it to find out”, using a neutral tone of voice.

The session ended in one of two ways; (a) the participant requested to be done or (b) the participant earned all of the allotted reinforcers and the experimenter terminated the task. An error or off-target click was defined as one that occurred to any space outside of the target box. Reinforcers were delivered for every target response sequence. When a target response occurred, the computer generated a chime through the headphones which signaled the experimenter to dropped an edible into the PVC tube.

After pairs (pre-access/restricted-access) of conditioning sessions were conducted a pair of probe sessions was conducted. The experiment continued in this manner until a level of stability in the probe pairs was sufficient to stop data collection.

**Probe Sessions**

Probe sessions were similar to conditioning sessions in that the participant and experimenter were seated at the apparatus and the participant engaged in a computer task. As during conditioning, sessions began with the presentation of a colored square (either red or blue) that moved randomly and continuously about the computer screen. However, during probe sessions the computer screen displayed one red tab and one blue tab at the top of the screen, and clicks to the respective tabs resulted in presentation of the square of corresponding color. The participant could change the color of the square at any time during sessions by clicking on the tab at the top of the screen corresponding to the other color; however, all clicks to the tabs were followed by a 5-s changeover delay in order to discourage rapid alternation between the colored squares. During the changeover period no square was present on the screen. Except when
otherwise specified (see below), clicks on the squares produced no programmed consequences during probe sessions. Most probe sessions were conducted after at least 24 hours of no access to the edible item (see procedural amendments for an exception). Because each probe session began with either a red or blue square present on the computer screen, probes were conducted in pairs. The color of the square presented at the start of the first session was semi-randomly determined (if the same color was presented first for two consecutive probe pairs, the next pair started with a square of the other color). For the second session of each probe pair, the alternate colored square was presented at the start of the session. Data were summarized across probe pairs (i.e., probe pairs were treated as a single session for data analysis). Probe sessions ended either a) after ten minutes elapsed or b) the participant requested to be done.

Procedural Amendments

*Increase in Duration of Food Restriction*

Initially, restricted-access sessions were conducted after a minimum of 24 hours of no-access to the relevant edible item. However, after the fourth pair of probe sessions with Ellen and the first pair of probe sessions with Beatrix, a minimum of 48 hours between a pre-access conditioning session and the following restricted-access conditioning session was instituted (see Figures 7,8,16, and 17). For both participants, the change was made in order to strengthen the potential EOs for the food items. For Ellen, this decision was based on the observation of relatively modest effects of the initial restriction period. For Beatrix, the change was made because she frequently terminated restricted-access sessions prior to earning all possible food items, thus making it difficult to insure that she received an equal amount of food in each condition.
Presentation of Food during Probes

As stated above, probe pairs were initially conducted under extinction conditions. This procedure was changed for Ellen after seven probe pairs (see Figures 7 and 8) because her clicks on the squares showed decreasing trend during probes and switch-over responses were at zero. The historical correlation between the presence of the red and blue tabs at the top of the screen and the absence of a contingency between clicks on the boxes and food presentation appeared to result in generalized extinction of task-related behavior. Anecdotally, she seemed to have very little interest in the task when it became evident to her that she would receive no edibles. We did not have the opportunity to implement this change with Beatrix because we were not able to progress past two probe pairs. This limitation is discussed in detail in the results and discussion sections.

Probe under Pre-Access Conditions

Nearly all probes were conducted under deprivation conditions; however the last probe pair performed with Ellen was conducted immediately following five minutes of pre-access. Because during conditioning the blue square was always correlated with a period of food restriction, it was possible that food restriction had acquired discriminative control over selecting/working with the blue box. To ensure that the behavior during probes was a function of differences in MOs during conditioning rather than a form of state dependent learning (Overton, 1966), the final probe pair was conducted under pre-access conditions. If Ellen continued to allocate more responding to the blue square during these probes, additional support for an MO account would be provided. If, on the other hand, she allocated more responding to the red
square, it would be necessary to consider the possibility that her behavior was under discriminative, rather than motivational control.
CHAPTER 3

RESULTS

Ellen

*Pre-Conditioning Assessments*

As shown in Figure 3, Ellen showed no preference with respect to the colors red and blue. She also showed no side bias, as shown in Figure 4. Figure 5 depicts results of the preference assessment data which indicate that M&Ms™, chocolate chip cookies, gummy bears, and peanut butter chips tied for highest preference. M&Ms™ candies were chosen to use during the reinforcer assessment because they were cost efficient and easily delivered using the apparatus.

In the reinforcer assessment, Ellen emitted 29 responses to the green ball and 45 to the orange ball when each produced edible delivery. She emitted 8 and 10 responses to the balls when they did not produce edible delivery (respectively) as shown in Figure 6.

*Conditioning Sessions*

Figures 7 and 8 depict different dimensions of the conditioning data for Ellen. On both graphs the phase change line indicates an increase in time between pre-access and restricted-access conditioning sessions to at least 48 hours (this represents an attempt to strengthen the behavioral effects observed during probe sessions). Figure 7 shows the frequency of clicks emitted by Ellen during conditioning sessions. Ellen emitted more off-target clicks during the pre-access sessions than she did during the restricted-access sessions. Figure 8 depicts the number of target responses emitted. Recall that a target response sequence was defined as five consecutive clicks in a row to the square without error. She emitted almost identical numbers of target responses (5 consecutive clicks in a row to the square without error) across conditions.
Therefore, she clicked more accurately during the restricted-access conditions in which she was deprived of M&Ms™ for at least 24 hours.

Figure 8 shows the frequency of target responses (top panel) as well session duration (bottom panel). The top panel serves as a visual depiction of procedural integrity with respect to yoked edible deliveries between conditioning sessions. Target responses and session length in each condition were quite consistent across conditioning sessions (i.e., the number of responses emitted was identical for 94% of session pairs). There was substantial variability in the target responses emitted across session pairs and a general increasing trend was observed as conditioning progressed. Session duration in minutes remained very consistent throughout conditioning (excluding the first few sessions in which Ellen was learning the task). Ellen always earned the maximum number of edibles; therefore, no sessions ended based on her request to stop. During the first few conditioning sessions Ellen completed sessions in the restricted-access conditions slightly more quickly. As conditioning progressed, little difference was observed in session time.

**Probe Sessions**

As noted previously, probe sessions were conducted in pairs, one in which a red square was displayed first on the computer screen and one in which a blue square was displayed first. Figures 9 and 10 and 11 depict different dimensions of Ellen’s probe data. The first phase of these figures shows the behavior under extinction conditions, when Ellen was at minimum 24 hours deprived of M&Ms™. The second phase shows the behavior during probes after an increase in time between pre-access and restricted-access conditioning sessions was imposed. The third phase represents the introduction of edible delivery contingent on target responses
aimed at recovering responding which was nearly extinguished. The fourth phase depicts behavior during the last probe pair which was conducted under pre-access conditions to test whether the value-altering effects observed were due to discriminative properties of the blue square. The top panel of Figure 9 shows both on and off-target clicks and the bottom panel shows target responses. An on-target click is defined as a click which occurred to the square, but may not have contributed to a run of five consecutive clicks. Ellen generally allocated more responses (both on and off-target) to the square associated with restricted-access conditioning sessions (blue). Figure 10 illustrates the length of time Ellen spent in the presence of each square. Generally speaking, Ellen allocated more of her time to the blue square (associated with restricted-access conditions) than she did to the red square (associated with pre-access conditions). Figure 11 shows the number of switch-overs that she emitted in each session that began with a red square (associated with restricted-access conditions) and each session that began with a blue square (associated with pre-access conditions). A switch-over is the behavior of choosing to switch the color of the square by clicking on the other available tab at the top of the monitor. Ellen always switched from the red square (associated with pre-access conditions) to the blue square (associated with restricted-access conditions). In only one of the probe pairs did Ellen switch the square from blue (associated with restricted-access conditions) to red (associated with pre-access conditions) and maintain that. Additionally, this occurred during the first probe pair in which she only had exposure to three conditioning session pairs. By phase two, Ellen’s switch-over behavior had apparently extinguished and overall responding showed a large decrement to near zero levels. When reinforcement was added to probes, most dimensions of Ellen’s behavior were recovered; however, switch-over behaviors never resurfaced. Interestingly, following addition of reinforcement into probes (third phase), Ellen allocated more than twice as
much responding and time to the blue square (associated with restricted-access conditions) for three consecutive probe pairs. During the final probe pair conducted under pre-access conditions, Ellen still emitted more behavior (clicks, target responses and time) to this square than she did to the square associated with pre-access conditions.

Beatrix

Pre-Conditioning Assessment

Figure 12 depicts data from Beatrix’s color preference assessment. She chose blue 6 out of 7 opportunities, and red only 2 out of 7 opportunities. However, Beatrix did not show any evidence of having a side bias as shown in Figure 13. This suggests that Beatrix had a preference for the color blue over the color red. Because it was possible that the color associated with deprivation might be chosen more frequently during tests (probes) it was determined to be most prudent to associate the blue colored box with the pre-access (satiation operation) condition.

Figure 14 depicts the preference assessment results which indicate that Swedish Fish™ were the most highly preferred edible, followed by Mike &Ike™ and Jelly Beans.

Figure 15 shows results of the first reinforcer assessment conducted with Beatrix. She emitted 14 responses to the green ball when it produced edible delivery as well as to the orange ball when moving it had no programmed consequences. She emitted 17 responses to the orange ball when it produced edible delivery and to the green ball when it was not. Thus, no reinforcement effect was shown.

Figure 16 depicts the results of the second reinforcer assessment. Beatrix emitted zero responses during the non-delivery (B) component and over 80 during the edible delivery components (A).
Conditioning Sessions

Figures 17 and 18 depict different dimensions of the conditioning data for Beatrix. The phase change line marks the point during conditioning when the speed of the square’s movement was slowed down and the time between pre-access and restricted-access conditioning sessions was increased to at least 48 hours. Beatrix appeared to have a great deal of difficulty successfully completing target responses initially during conditioning (due to poor fine motor control). Therefore, the length of time that the square remained in one place was increased in order to make the task easier for her. Figure 17 depicts the frequency of clicks emitted by Beatrix during conditioning sessions. The top panel of Figure 18 shows the frequency of target responses in each session. Beatrix emitted less erroneous clicks and more target responses in the pre-access conditioning sessions. Sessions were supposed to be yoked in pairs; however were only successfully yoked 64.7% of sessions. This issue arose because Beatrix earned fewer reinforcers after she experienced deprivation procedures. In other words, Beatrix earned a considerable amount of edibles after she experienced the five minutes of free-access to the treat, but requested to be done prematurely during restricted-access conditioning sessions. Beatrix only reached probe criteria (three yoked conditioning pairs) two times during the course of the study. The bottom panel of Figure 18 depicts session duration during conditioning sessions. Session duration decreased drastically across session types, after the manipulation to the speed of the square was made. This change in duration is likely due to the decrease in the difficulty of the task. There is much variability in on and off-target clicks as well as target responses throughout conditioning sessions. These data are in contrast to those of Ellen’s.
Probes

Figures 19 and 20 depict different dimensions of the probe data collected for Beatrix. The phase change line represents the same procedural change as outlined above. The speed of the square was adjusted during conditioning and probe sessions. The top panel of Figure 19 represents both on and off-target clicks that Beatrix emitted to both the red and blue square. She engaged in minimal responding of any kind during the first probe pair. The square jumped around at a rate that was too quick for Beatrix and she was unsuccessful in completing many target responses. Anecdotally the experimenter noticed that she tried to click on the square but became flustered and lost interest fairly quickly. The second probe pair shows that Beatrix was more successful in emitting target responses, and that she emitted more total responses as well. Her verbal responding resembled that which occurred during the extinction (B) component of the second reinforcer assessment. She made comments such as "Ms. Bailey, I'm quite hungry and my plate is empty. Where are my fishes? I'm doing everything right. Something is broken." She even reached up through the PVC pipe with her hand and flailed it around, indicating that Swedish Fish™ are of some value to her. She also held her empty plate up above the apparatus as evidence for the experimenter to view. In contrast to Ellen, Beatrix emitted more responses to the square associated with pre-access conditions. The first probe session of the second probe pair began with a blue square (paired with pre-access) and she engaged in four switch-over behaviors to end up finishing with the blue square again (Figure 21). When she switched-over to the red square (paired with restricted-access) she only emitted a total of two clicks, and they were both off-target. Prior to the start of the second probe session of the second probe pair, instructions were added. Beatrix was told to “Use the mouse and see what happens. Sometimes you will earn
candy, and other times you will not. Remember you can be done whenever you want, just say stop or finished.”

Beatrix asked, “Well, will I earn any fishes today?”

The experimenter responded, “Not today.” Following her receipt of that information, she emitted just a few responses and then requested to be done. As such, the large amount of data shown for probe pair two occurred mostly during the first day of the probe pair.
CHAPTER 4
DISCUSSION

The effects of different conditioning histories on the clicking behavior of two females with autism were examined via choice and extinction tests. Conditioning sessions were conducted for Ellen such that two neutral stimuli were each paired with either restricted access or free access to a preferred food just prior to sessions. As a result, the previously neutral stimuli appeared to acquire some of the reinforcing or abating properties of the conditions which preceded them. During probes, Ellen selected the square associated with restricted-access conditions most frequently, allocated more responding (mouse clicks) to the that square, and spent more time in the presence of that square, relative to the square associated with pre-access. Ellen’s disproportionate allocation of behavior and time to the blue square relative to the red square demonstrates a preference for that square. In order to further evaluate Ellen’s preference between the colored squares, red and blue squares of paper were presented to her following completion of the final probe session. She was asked which one she preferred, and she pointed to the blue paper and stated “blue” without hesitation.

These outcomes are consistent with the notion that, for Ellen, restricted access to M&Ms™ functioned as an EO that may have strengthened their effectiveness as reinforcement. That is, pairing the blue square with a preferred food following a period of relative deprivation effectively established it as more preferred than the square paired with pre-access conditions. Conversely, when a red square was paired with the same preferred food following a period of relative satiation, the red square was less effectively conditioned as reinforcement. Importantly, these effects were demonstrated during probe sessions conducted separately from conditioning sessions. By comparing how Ellen allocated responding between red and blue squares
independently of conditioning sessions in which potential motivating conditions were
manipulated, it was possible to observe differences in the value-altering effects of those
conditions. Piazza et al., (1996) compared the reinforcing efficacy of stimuli that were deemed
“preferred” based on a paired choice preference assessment and found that “…a choice
assessment can be used to predict the relative reinforcing value of various stimuli” (p.1). This
study is unique in that it focuses on the value-altering effect by measuring the choice behaviors
of the participants. It is difficult to tease apart the evocative and value-altering effects of MOs,
however, this study is unique because it provides a methodology that may do so. Until probe
sessions, the participants in this study had never received reinforcement for engaging in a switch-
over, because they had never been exposed to a condition in which both squares were available.
Thus, Ellen’s behavior of switching-over to the square associated with restricted access cannot
be due solely to the evocative effect. Choice has been shown to be an indicator of preference and
reinforcing efficacy, and the participants never received reinforcement for making a forced
choice response, thus, Ellen’s choice to allocate greater responding to the square associated with
restricted access may suggest that she preferred that square, and lend support to the notion of the
value-altering effect.

In addition to the conditioned reinforcement effect described above, it is possible that the
current procedures resulted in establishment of the blue square as a conditioned establishing
operation (CEO). This account is consistent with results indicating that Ellen consistently
emitted more clicks in the presence of the blue square during probe sessions suggest that the blue
square acquired an evocative function for mouse clicks.

Another potential account for Ellen’s outcomes is that the blue square became an S^D for
target responses. Although the consequences for clicking were formally identical across
conditioning sessions, those consequences may have been functionally different due to differences in prior access of the edibles. In other words, if pre-access to M&Ms™ was effective as an AO, then M&Ms™ earned during those sessions did not function as reinforcement and stimuli differentially associated with pre-access would acquire no discriminative properties. Thus, two different discriminative conditions may have been created: one in which behavior was followed but not effectively reinforced by M&Ms™, and one in which behavior was followed and reinforced by M&Ms™. Such conditions would more effectively establish the blue square as SD relative to the red square.

It may be difficult to definitively label the square associated with restricted-access conditions as an SD or a CEO. The surrogate CEO as defined by Michael (1993) is “The simplest relation” because it “…is a correlation in time; the neutral event is paired with or systematically precedes a UEO (or another CEO). As a result of this pairing, the neutral event may acquire the motivational characteristics of the UEO that it is paired with” (p. 198). This implies that the important relation lies between the stimulus and the antecedent (unconditioned motivating operation {UMO}). Whereas an SD becomes so because of a historical correlation between some event and the likelihood of a particular functional consequence. In this study, it is suggested that the consequence has its’ functional effects because of the manipulation to edibles before sessions (UMO) thus suggesting that this is due to more than a simple pairing of the two. However, there was also a correlation between the color of the square during the task and the receipt of edibles. As such, a deeper analysis of the mechanisms responsible for the value change of the squares will be reserved for future research and discussion.

The switch-over data for Ellen show that, during the first several probes, when she was provided with an opportunity to choose to work in the presence of the blue or red square she
tended to either remain in the presence of the blue square (associated with restricted access) or switch from the red square (associated with pre access) to the blue square. These outcomes indicate a preference for the blue square. However, this pattern decreased over the course of the experiment. This change corresponded with changes in procedures in which target responses during probes produced access to M&Ms™, thus, it is possible that the decreases in switch-overs observed during the final phases of testing occurred because reinforcers were available in both stimulus conditions.

Overall, the outcomes of Ellen’s assessment appear to support the value-altering effect of MOs. This advances our understanding of MOs; although previous investigations have demonstrated the evocative function of MOs by evaluating differences in responding in the presence versus absence of motivating conditions, few if any prior studies have evaluated the long-term effects of differential exposure to MOs. Differentiation in several aspects of Ellen’s behavior during probe sessions conducted after differential conditioning histories strongly suggest that those histories resulted in differential reinforcement effects.

Different effects were observed in Beatrix’s behavior. For Beatrix, the red square was paired with restricted-access procedures and the blue square was paired with pre-access procedures. Thus, if restricted-access functioned as an EO, Beatrix should have selected the red square, spent more time in the presence of the red square, and clicked more in the presence of the red square during probe sessions. However, the outcomes for Beatrix were generally equivocal and somewhat unexpected. Few consistent differences in response measures were observed during conditioning sessions, and only 64.7% of conditioning sessions could be successfully yoked because she requested to terminate several restricted-access sessions. Based on these outcomes, only two probe pairs were conducted. During the second probe pair she allocated a
much larger amount of behavior to the blue square (associated with pre-access), spending more
time and emitting more clicks in its presence. In addition, her switch-over behavior was
consistent with these outcomes, showing a general tendency to switch from red (associated with
restricted-access conditions) to blue (associated with pre-access conditions). The outcomes of the
probes should be considered as very tentative, however, given the very limited amount of data
available.

Beatrix’s outcomes illustrate some challenges encountered when attempting to evaluate
motivational effects. In this case, procedures that resulted in predictable response patterns for
Ellen had the contrary effect on Beatrix’s behavior. One possible account for these differences
may be the generation of verbal rules by Beatrix. During the last conditioning session with
Beatrix the experimenter asked, “Which square do you like working with the best?” Beatrix
responded, “The blue one.”

The experimenter questioned, “Why?”

Beatrix responded, “Because the fish always come first”, referring to the Swedish Fish candy she was allotted during sessions.

Her responses may indicate that she preferred the square that was preceded by free-access
to the candy. It is possible that the process underlying this preference was respondent, rather than
operant in nature. The temporal pairing of the blue squares (neutral stimuli [NS]) with a
condition in which free access to the Swedish Fish TM (unconditioned stimulus [US]) was
presented may have resulted in the blue square acquiring conditioned stimulus (CS) properties.
Typically, respondent conditioning is most effective when the NS is presented immediately prior
or simultaneously with the US. However Cooper, Heron and Heward (2007) suggest that
“…some effects can be achieved…with backward conditioning in which the US precedes the
NS” (p. 30). If Beatrix’s behavior was sensitive to the temporal pairing regardless of order, then it is possible that the stimulus that followed pre-access acquired the reinforcing properties associated with a large amount of free candy. A way of testing this might be to increase the temporal distance between free-access to candy and conditioning sessions. However, it may be important to note that Beatrix showed a definitive preference for the color blue during the color preference assessment, and this may have affected her behavior during probes as well.

Typically in the literature, the types of manipulations conducted in the current experiment are referred to as satiation or deprivation procedures. However, other disciplines use this nomenclature—particularly “satiation”—to describe both operations (experimental manipulations) and in particular well-established bio-behavioral mechanisms (Smith & Churchill, 2002). When describing the processes that underlie changes in behavior that occur following repeated exposure to particular stimuli, it may be important to distinguish between the influences of satiety factors (e.g., a rise in blood glucose levels, distension of the belly) and habituation (a general decrement in responsiveness to stimuli following repeated presentation). It is the case that a large amount of free candy was delivered prior to some sessions; however, it is unknown if the participants became physically satiated after consuming it because no measures involving physiological events were taken. Rather, it is likely that a combination of satiation and habituation due to repeated exposures to the stimulus properties of the candy led to the change in behavior emitted by Ellen. Conversely, repeated exposure did not appear to result in habituation for Beatrix. She emitted more behavior and earned more edibles after receiving pre-access than following restricted-access; thus, it appears that the pre-access actually had establishing (possibly sensitizing) effects, consistent with the findings of Roantree and Kennedy (2006). Those experimenters found that pre-session access to attention served to increase the value of attentions
as a positive reinforcer for stereotypy. Future research should investigate variables associated with satiation, habituation, and sensitization in order to improve our understanding of how these mechanisms account for individual differences in responding as well as how they are reflected in parametric manipulations of stimulus presentation.

Data from both participants have substantial applied implications. These findings may support the already ongoing use of MO manipulations in the treatment of children with autism. Ellen’s data support the use of deprivation procedures to increase motivation. Not only did Ellen emit more behavior under deprivation conditions, her responding was more accurate. These data may suggest that if a deprivation procedure serves to increase motivation to work, it may also increase the effectiveness of that work. More research is needed to clarify these findings.

Conversely, Beatrix’s data, along with the outcomes of Roantree and Kennedy (2006), suggest that a satiation or pre-access type of procedure can actually have an evocative rather than abative effect on behavior. These inconsistent outcomes suggest that it is advisable that practitioners perform some type of preliminary assessment prior to using stimulus delivery either to sensitize (in order to increase behavior) or habituate/satiate (in order to decrease behavior) as part of a treatment procedure. This may be especially relevant to the use of free-access or non-contingent reinforcement (NCR)/fixed-time (FT) procedures in the treatment of problem behavior. If such procedures served to sensitize, rather than habituate/satiate, then their use would be contraindicated. Similarly, procedures such as differential reinforcement of other behavior (DRO) and differential reinforcement of alternative behavior (DRA) could potentially result in sensitization and serve to increase motivation to engage in the behavior targeted for reduction.
It may be particularly advantageous for practitioners to conduct a brief test designed to determine whether EO or AO effects will occur prior to implementing NCR treatments to decrease problem behavior. For example, measuring the rate, intensity, or other relevant dimensions of an arbitrary response which the client can already perform when exposed to pre-access or deprivation to the relevant reinforcer could indicate whether pre-access results in sensitization or habituation. These outcomes could identify harmful or helpful tactics in the treatment of maladaptive behavior for that individual, and could be performed without risking harm to the individual. Much like reinforcing pre-cursors to problem behavior in an attempt to treat without evoking the problematic behavior itself (Dracobly and Smith 2012), this tactic would provide useful clinical information based on variability in arbitrary behavior instead of exposing the individual or others to potential harm. Future research could examine the validity and utility of generalizing from effects on an arbitrary response to those of problem behaviors. This study represents an extension of previous research on MOs and it may provide an example of the development of a CMO.

These results contribute to the literature pertaining to MO manipulations; however there are a few limitations that should be considered. First, although the sessions were computerized and data collection was automated, launch and control of the program required experimenter intervention. Thus, the computer program could not run perfectly unless the experimenter operating it performed perfectly; this was not always achieved. For instance, the experimenter was responsible for ending sessions when the participant requested to be finished or when she received the allotted number of edibles. On some occasions, the experimenter did not terminate the program immediately, and some mouse clicks were recorded that actually occurred after session termination criteria had been met. This measurement error can be seen in data from
Ellen’s conditioning sessions, which showed apparent variability between session pairs when, actually, no differences in edible delivery occurred (i.e., the sessions were successfully yoked).

It could be said that the criteria set for some procedures were based on “best guesses” rather than empirically established criteria. For example, the decision to conduct probes following three yoked conditioning sessions was based largely on what seemed reasonable. It is possible that more or less frequent probes would have been more informative. This issue may be particularly relevant for Beatrix, for whom criteria to conduct probes were met only twice. Similarly, we conducted a maximum edible probe; however we did not measure the effect that consumption of that amount had on behavior; rather we measured how much (up to a maximum determined by caloric/sugar content) was consumed in a five-minute session. However, both of these variables, represent empirical questions which did were un-answered at the time of the study. Future researchers may want to build upon the data set collected in this study to more systematically determine these criteria. One important question regards the parametric effects of varying amounts of prior edible consumption. Researchers could investigate the physical amounts of edibles and their effects on behavior (e.g., Sy and Borrero, 2009). Such a manipulation might have indicated the use of more edible items during Beatrix’s conditioning sessions; however, it did not seem advisable to offer her a larger amount of candy prior due to potential health concerns.

Another limitation involves the items we manipulated access to. Our study focused on edible treats, specifically additional sweet treats that were not an essential part of the children’s normal diet. We performed this study using treats because we could concretely measure and manipulate hours of deprivation since last time of consumption. As of yet there is not a widely accepted method of measuring satiation or deprivation with respect to leisure items. Said another
way, we could most reliably and easily manipulate access to treats as compared with other types of reinforcers. As such, it may be difficult to recruit participants if parents show concern for the health risks associated with extra caloric and sugar intake. Furthermore, the use of edibles as reinforcement does not permit a determination of whether changes in behavior were due to satiation or habituation. The use of edibles also may require that longer durations of time pass between sessions than might if a preferred game or toy is used. In example, if a child has a highly preferred game, one might be able to restrict access to it for just minutes in order for it to be an effective reinforcer, whereas edibles may lose their potency due to some satiation like effects based on other meal or snack times as well as recent consumption of that edible. One way of manipulating access to reinforcers other than edibles might be to use tokens that the children can earn during conditioning sessions, and exchange at the end of session to gain access to a preferred activity.

These findings provide preliminary evidence of the value-altering effect of MOs. Despite different results across participants, these findings also suggest that the use of MO manipulations in applied settings can be valid and useful. In order to increase the efficacy of treatment packages that include such manipulations, more research is needed to investigate specific effects across participants as well as generality across participants and behaviors.
Figure 1. Aerial view of the experimental apparatus.

Figure 2. Front view of the apparatus.
Figure 3. Number of times Ellen selected each color.

Figure 4. Number of time Ellen selected the stimulus on the right versus the left.
**Preference Assessment: Ellen**

![Bar chart showing mean rank order for each edible item chosen by Ellen.]

*Figure 5.* Mean rank for each edible item chosen by Ellen.

**Reinforcer Assessment: Ellen**

![Bar chart showing frequency of responses for each colored ball.]

*Figure 6.* Frequency of responses allocated to each colored ball. (EXT) indicates that no edible was delivered for moving that ball and (SR+) indicates that an edible was delivered for moving that ball.
Figure 7. Frequency of clicks during conditioning sessions emitted by Ellen. “off-target” represents a click outside of the moving square. “on-target” indicates that a click was made to the square.
Figure 8. (Top panel) Frequency of target responses (5 clicks in a row to the square) emitted by Ellen during conditioning sessions. (Bottom panel) Length of conditioning sessions for Ellen.
Figure 9. (Top panel) Frequency of on and off-target clicks emitted by Ellen during probes. (Bottom panel) Frequency of target responses (five clicks in a row to the square) emitted by Ellen to each square.
Figure 10. Number of minutes Ellen allocated to each square during probes.

Figure 11. Percentage of switch-over patterns Ellen emitted during each probe (Note: The tabs dictate which squares {paired with pre-access or restricted-access conditions} the probe sessions began with and ended with).
Figure 12. Number of times that Beatrix chose each color.

Figure 13. Number of times Beatrix selected the stimulus on the left versus the right.
**Preference Assessment: Beatrix**

![Preference Assessment Graph]

*Figure 14.* Mean rank for each edible item chosen by Beatrix.

**Reinforcer Assessment (1): Beatrix**

![Reinforcer Assessment Graph]

*Figure 15.* Frequency of responses allocated to each colored ball. (EXT) indicates that no edible was delivered for that ball and (SR+) indicates that an edible was delivered for that ball.
Figure 16. Frequency of ball moving responses emitted by Beatrix during each phase of the second reinforcer assessment.
Figure 17. Frequency of clicks during conditioning sessions emitted by Beatrix. “off-target” represents a click outside of the moving square. “on-target” indicates that a click was made to the square.
Figure 18. (Top panel) Frequency of target responses (5 clicks in a row to the square) emitted by Beatrix during conditioning sessions. (Bottom panel) Length of conditioning sessions for Beatrix.
Figure 19. (Top panel) Frequency of on or off-target clicks emitted by Beatrix during probes. (Bottom panel) Frequency of target responses (5 clicks in a row to the square) emitted by Beatrix to each square.
Figure 20. Number of minutes Beatrix allocated to each square during probes.

Figure 21. Percentage of switch-over patterns Beatrix emitted during each probe (Note: The tabs dictate which squares {paired with pre-access or restricted-access conditions} the probe sessions began with and ended with).
REFERENCES


