A SYSTEMATIC EVALUATION OF VARIABLES UNDERLYING

RESPONSE EFFORT MANIPULATIONS

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A SYSTEMATIC EVALUATION OF VARIABLES UNDERLYING RESPONSE EFFORT MANIPULATIONS

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Amy Susanne Polick, daughter of Ms. Jane Polick and Mr. Raymond L. Polick, was born May 16, 1979, in Pittsburgh, Pennsylvania. She graduated from Thomas Jefferson High School in 1997. She attended college for 4 years at Florida State University in Tallahassee, Florida, graduating cum laude with a Bachelor of Science degree in Psychology in 2001. In 2004, she graduated with a Master of Science degree in Psychology from Florida State University, with a specialization in Applied Behavior Analysis. She entered Graduate School at Auburn University's Department of Psychology in August, 2004, in pursuit of furthering her education and working towards a doctoral degree.

THESIS ABSTRACT

A SYSTEMATIC EVALUATION OF VARIABLES UNDERLYING

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A number of studies have investigated the effects of manipulating the physical effort required for an individual to emit a response. This research overwhelmingly shows that as force requirements increase, response rates decrease (Friman & Poling, 1995). However, the literature does not clarify the variables underlying the changes in responding after effort is applied. It is not clear whether increasing effort serves as a form of punishment or whether it merely delays access to reinforcement (because increasing effort requires more time to complete the response). This study investigated the relations between physical effort and delay to reinforcement by isolating and manipulating these variables using a concurrent match to sample task. Three participants, aged 4.5, 4.1, 4.2, were presented two behavioral tasks requiring building blocks into a particular shape formation. Each pair of tasks consisted of varying effort (weights added to blocks) and reinforcer delay (time delay added between task completion and access to reinforcement). These variables were systematically manipulated per session. During each choice, one variable was held constant while the other was manipulated. Once presented with the block tasks, the participants were prompted to choose one alternative and match the blocks to a visual stimulus (picture of a shape formation). Each session consisted of two trials in which the student sampled each choice, followed by six consecutive choice trials in which the child was prompted to choose which choice of blocks they wanted to build. The individual's choice, time to complete the task, accuracy, and verbal responses about preference (they were asked at the end which alternative was their favorite) were recorded over multiple sessions. Results of the study showed that all participants exhibited a strong preference for the low effort task when compared against a high effort one, allocating an average of 96% of choices to the low effort alternative (*M*=94, 95, and 99% for the three participants). A consistent preference when choosing between low reinforcer delay and high reinforcer delay was evident with one participant (*M*=93% responses to low delay), and the other two participants showed mixed responding, often switching between low and high delay alternatives during sessions. These results add to the literature existing on response effort and reinforcer delay and suggest that effort and delay affect responding in different ways in a choice context.

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CHAPTER I. INTRODUCTION

History of Research

Response Effort

The application of basic behavioral research to humans in applied settings is a fundamental aspect of applied behavior analysis. Many well known behavioral procedures used in applied settings have their origins from basic research with nonhumans (e.g. reinforcement schedules, time out, and extinction). One procedure that originates in basic literature, which has potential of being a very important clinical tool, is the manipulation of response effort.

Basic Research

Beginning more than sixty years ago and continuing sporadically until today, a multitude of laboratory studies has investigated the effects of manipulating the physical effort required for an animal to emit a response. Friman and Poling (1995) reviewed the basic research on response effort and provided summaries of the findings. The results of these studies overwhelmingly support an inverse relationship between the amount of response effort required to obtain reinforcement and rate of responding. These studies showed that 1) when force requirements increase, response rates decrease and vice versa (i.e. when the effort required is lowered, responding increases) and 2) increasing the force requirement in the second component of a two component chain decreases the rate of responding during the first component (Friman & Poling, 1995). Other research in this review investigated the relations between increased response effort and extinction. These studies reported that extinction was quicker when effort was increased, animals escaped effortful situations, and animals chose lower effort responses over more effortful ones. Overall, each of the experiments on response effort reviewed by Friman and Poling (1995) found that increasing response effort directly affects responding in animals.

These behavior reducing effects from increasing effort have been found across nonhuman species. Elsmore (1971) manipulated response effort by increasing the number of responses necessary for pigeons to obtain a food reinforcer in a fixed-ratio (FR) schedule of reinforcement. In this study, the schedule was changed from an FR-1 to a more effortful schedule of an FR-16 requirement to receive grain. The results showed that as the FR requirement increased, the rate of key pecking by the pigeons decreased. Chung (1965) performed a parametric analysis on the effects of differing amounts of response effort on key pecking with pigeons. In this study, the minimum effective force for a key peck was varied. The results showed there was minimal effect on responding up to a certain threshold of force, above which a decrease in responding was found. A change in the requirement from high force to low force showed increases in response rates. Subsequently when high force conditions were reinstated, response rates decreased below a stable rate level.

Research on the effects of increased effort has also been conducted with rats and squirrel monkeys. Aiken (1957) manipulated the effort required to open a swinging door to obtain food for two groups of rats in a learning task. The effort necessary to displace the door was varied by placing either a 50 gram weight in the weight cup of the chamber apparatus (high effort) or leaving it empty (low effort). The results of this study showed that the learning criterion (latency of responses equaling less than 5s for 5 trials) was reached significantly sooner for the low effort group, suggesting that the more effort involved in responding, the longer the latency to respond and the lower the rate of responding. Alling and Poling (1995) also found reduced rates of responding due to increased force requirements. These authors varied the force requirements for rats responding under multiple fixed-ratio schedules of reinforcer (food) delivery. They manipulated the force of lever pressing in Newtons from .25 N to 2.00 N. They found across three experiments that as the force of the lever press increased, response rates decreased. Furthermore, Mowrer and Jones (1943) performed a bar-pressing experiment during which they manipulated the effort in responding with rats. They obtained a decrease in trials to extinction with increased effort, further supporting the finding that as effort increases responding decreases. Adair and Wright (1976) extended this research to monkeys. They manipulated the force required to pull a chain to adjust air temperature in a test chamber with adult squirrel monkeys. In this study, they found that as the force increased from 2.94 N to 6.86 N, the time between responses (inter-response time) increased showing a decrease in response rates.

Human Research

The behavior reducing effects from increasing response effort seen in non-human species have also been found in research with human participants. An early laboratory application of a response effort manipulation was done by Yacorzynski (1942). This study used an open/closed runway to test degrees of effort in a behavioral task with adult males and females. The task could be completed using three different methods of varying difficulty and was used to determine the effects of minimum or maximum degrees of effort on human performance. In each session, the participants were able to use different tools to complete the runway task. The three methods to complete the task were considered less or more effortful by the amount of physical movement required. The results of their study showed that as effort increased, the adult subjects took longer to complete the runway test, resulting in a decrease in correct response rate. Boldt and Ellis (1954) assessed the number of block turning responses made by college students while wearing wrist cuffs with varying weights inside. Their study reported that the number of responses to complete the block turning was inversely related to the amount of weight in the cuffs, such that as the weights increased, block turning decreased. Endsley (1966) conducted a study investigating response effort with children. He increased response effort of a goal reaching task by manipulating children's access to the goal (blocked or not) in order to observe the effects on response speed and amplitude. He found that when the effort of reaching the goal was increased (goal was blocked) there was a greater delay in responding.

Though the early human studies clearly documented the same behavior reducing effects in a laboratory setting that were reported in the basic behavior analytic literature, the more recent applied studies on response effort have investigated the clinical usage of increasing effort to decrease the occurrence of problem behaviors. Wallace, Iwata, Zhou, and Goff (1999) increased the response effort of head hitting and hand mouthing with 2 individuals with mental retardation by using arm sleeves containing weights. They manipulated the effort of engaging in the self-injurious behaviors (SIB) by inserting varying metal stays (weights) into the arm restraints worn by the participants. The different effort conditions included no restraint (low effort), sleeves without stays, and sleeves with 5, 10, 15, 20, or 25 thin (.5 mm thick) metal stays in them (higher effort), and sleeves with 5 thick (2 mm thick) metal stays (highest effort). The application of the arm restraints with stays successfully decreased SIB with both participants. Moreover, the analysis of differing degrees of effort allowed the authors to target the least amount of effort that resulted in significant self-injurious behavior reduction for both participants: 15 thin stays for one child and 20-25 thin stays for the other.

Van Houten (1993) also investigated the effects of increasing the physical effort involved in self-injurious behavior. In this study, the participant engaged in face slapping. The intervention included soft wrist weights the participant was required to wear for progressively longer periods. Data on the frequency of face slapping showed that during the time periods after weight was applied to the wrists face slapping decreased. By the end of the study, face slapping continued to not occur, which carried over during follow-up. This intervention was successful in decreasing the problematic self-injurious behavior of face slapping. Furthermore, Zhou, Goff, and Iwata (2000) increased the effort of single arm-bending movements with sleeves that increased rigidity of arm movement and showed that increasing the response effort of movements involved in engaging in SIB resulted in a decrease in the self-injurious behaviors.

Applying restraints with or without weights are not the only way that response effort has been manipulated in the applied literature. Piazza, Roane, Keeney, Boney, and Abt (2002) varied response effort by increasing physical effort to obtain materials to reduce pica for three females with severe mental retardation. To increase the effort, pica materials were placed in containers or placed further out of reach, which made them harder to obtain and place in the mouth. This study showed how effort of a response (pica) can be manipulated through environmental arrangements to decrease the occurrence of the problem behavior. More specific details of this study will be discussed later.

Other studies in the applied literature have investigated increasing effort as a consequence for problem behavior and have shown that this approach has reduced target problem behaviors. Sailor, Guess, Rutherford, and Baer (1968) reduced tantrums emitted by a child with mental retardation in a verbal training task. In this study, the child was required to change from a simple to a more difficult verbal task contingent upon tantrum behaviors. Tasks defined as difficult were more effortful by requiring the child to imitate and say more syllables and words contingent upon tantrums. This study showed that as effort contingent upon tantrums increased, the overall rate of tantrum behaviors decreased.

Similar results have been reported with other problem behaviors. Epstein, Doke, Sajwaj, Sorrell, and Rimmer (1974) found that requiring a sequence of physical movements (raising arms and stretching out legs) contingent upon inappropriate hand and foot movements reduced the problem behaviors for two children with schizophrenia. Foxx and Azrin (1973) made an effortful oral hygiene routine contingent upon self-stimulatory mouthings (of objects or hands) made by two children with mental retardation. The oral hygiene routine consisted of a chain of responses including: brushing gums and teeth immersed with mouthwash, wiping outer mouth, and spitting the solution into a cup. The results of the contingent effort (referred to as overcorrection) completely eliminated the mouthing responses.

Definitional Variations of Response Effort

Differences in Interpretation

The literature shows that researchers have defined and manipulated response effort in different ways. In the basic research literature, response effort has been defined by physical measures such as force of key pecks in grams (Elsmore, 1971), pressure in grams to swing open a door (Aiken, 1957), and force involved in lever pressing (Alling & Poling, 1995). However, the definitions of response effort in the applied literature are more varied.

Some studies have defined response effort as involving physical force of a response in a manner similar to basic research investigations. Such definitions have included the degree of force required to emit a response (Friman & Poling, 1995), muscle tension and energy units (Bitterman, 1944), and physical expenditure of muscle movements (Luce, Delquadri, & Hall, 1980; Luiselli, 1984). Other studies have referred to response effort in a less direct way, by referring to the application of restraints to increase the effortfulness of a response, such as manipulating the rigidity of physical restraints (Zhou, Goff, & Iwata, 2000), or the number of weights in an arm restraint (Wallace, Iwata, Zhou, & Goff, 1999).

Some researchers have further expanded the definition of response effort to include task difficulty (Yacorzynkski, 1942; Neef, Shade, & Miller, 1994), difficulty of eating certain textures or volumes of foods (Patel, Piazza, Layer, Coleman, & Swartzwelder, 2005; Kerwin, Ahearn, Eicher, & Burd, 1995), number of responses required to obtain reinforcement (Horner & Day, 1991; Perry & Fisher, 2001; Richman, Wacker, & Winborn, 2001; Buckley & Newchok, 2005), and distance traveled to obtain items (Van

Camp, Vollmer, & Daniel, 2001; Piazza, Roane, Keeney, Boney, & Abt, 2002). These varied definitions pose a problem because response effort is being used to refer to different behavioral relationships.

Theoretical Perspective

Definitional variations may partly depend on the perspective of researchers toward behavior environment contingencies. Since the 1930's, some behaviorists have suggested that behavior cannot be understood by focusing on events of the moment (Baum, 1994, p.47). Emphasis on momentary relations between behavior and the environment constitutes a molecular view. This perspective focuses on discrete stimuli and responses occurring at a particular point in time. For example, a single lever-press involves a class of acts, all of which achieve the necessary movement of the lever (Baum, 2002). Baum argued that Skinner took this view when he wrote that response rate would be the outcome of probability acting moment to moment, as if at every moment a probability gate determined whether a response would occur just then.

A contrasting view involves a molar perspective. Although the molecular perspective focuses on response strength, the molar view focuses on response allocation. Viewing behavior in a molar fashion involves considering not only present but also past events as well as how behavior occurs over time rather than single moments (Baum, 1994, p.47). In a lever pressing example, a single lever press constitutes a molecular unit, but a fixed-ratio (FR) run of lever presses would make up a molar unit of behavior (presses).

The molar/molecular distinction is important when defining response effort because it bears on how the unit of behavior is conceptualized. The physical effort of a single arm movement measured in Newtons is indeed an aspect of response effort, with the response in this case defined at the molecular level. However, the number of responses required in an FR schedule of reinforcement also involves response effort, with the response unit including a number of responses, which is consistent with the molar view of behavior. Therefore, any definition of response effort must take into consideration the different "levels" of response effort in order to fully encompass what may be functionally similar, if not equivalent.

Behavioral Economics

Behavioral economics is another important area of research that may bear on how response effort is defined. Behavioral economics refers to the area of economic research concerned with controlling and predicting behavior (Madden, 2000). This research direction was first proposed by Kagel and Winkler (1972) and has since grown into a significant approach to the analysis of behavior. In the behavioral economics model, a consumer pays to receive goods or services. More specifically, a consumer emits a behavior (cost) to produce an outcome or reinforcer. *Consumption* refers to a variety of events such as eating, drinking, or using reinforcers and *spending* refers to the response output (Madden, 2000). In this model, there are different variables that affect the individual consumer's behavior, including price, alternative sources of reinforcement, consumer discount in the value of delayed consequences, and income. The variable of price is relevant to the definition of response effort.

The price of an outcome in behavioral economics describes how much effort is involved in obtaining a reinforcer. The consumer's behavior is dependent on price, such that when price changes, the consumer's behavior changes, too. The effects of a price change on consumption have been formalized in what is known as the economic demand law. The demand law states that, all else being equal, consumption of a reinforcer will decrease as the price unit increases (Madden, 2000). In other terms, this means as the effort of a response (its price) increases, the frequency of that response (the consumption) decreases. From a behavioral economics perspective, then, response effort is described as a response cost. This should not be confused with the term "response cost" used in applied studies and clinical settings which is a form of negative punishment referring to a removal of a specified amount of a reinforcer (commonly as part of a token economy; Conyers, et al., 2004) contingent on the occurrence of a problem behavior (Miltenberger, 2004).

Proposed Definition

From the examples presented, it is evident that the response effort literature lacks a coherent definitional foundation. Clarification of the definitional issues will facilitate development of an integrated response effort literature across varied research interests. To obtain clarification, a new definition of response effort can prevent further confusion. First, in order to be considered response effort, active responding must occur. Furthermore, this responding is followed by consequences. Therefore, the most basic definition of response effort can be simply conceptualized as the physical force of a response producing an outcome. This definition will be useful in bringing together all of the research on response effort, which can be organized into five levels or categories. These include: 1) effort of an individual response, 2) effort of multiple responses in a single response class, 3) effort of multiple response classes, 4) manipulation of effort of a non-target behavior, and 5) application of response effort as a consequence for behavior.

These categories will be explained further in reference to other applied studies on response effort.

Categories of Response Effort

Effort of an Individual Response

The first category of response effort manipulation involves the effort of a single response. Any single response involves expenditure of energy. The response might involve small brief movements (a single arm movement) or a more complex action of some duration (writing or typing). The definition of response effort at this level is the physical force required to emit an individual response that produces an outcome. In order to be considered response effort, a response must occur and be measurable. Measures of effort that could be included at this level include, but are not limited to, calories burned, weighted force in grams, pounds, or Newtons, and/or physical exertion of a single response.

Several studies manipulated response effort at the level of the individual response. Those that have implemented restraints or other apparatus to increase rigidity of movement and/or add physical exertion of a behavior fall under this category. Irving, Thompson, Turner, and Williams (1998) used increased response effort to decrease the single response of hand mouthing for two individuals with developmental disabilities. These authors utilized an arm restraint that made it difficult to flex the elbow, which was part of the topography of hand mouthing. To alter the restraint rigidity, nylon stays (weights) were used, to change the force required to bend the arm. A response effort analysis (the authors probed the restraint at increased weight amounts) was conducted to determine the amount of force necessary to increase the rigidity of the arm movement, but not make the arm movement impossible. The researchers alternated the application of the arm restraint (on or off) paired with the availability of toys in a reversal design. The results showed that hand mouthing decreased significantly when the restraint with stays was worn, and was at high baseline levels when the restraint was not worn. This study showed that the availability of toys alone without restraint was not sufficient to produce reduction of hand mouthing, but together with the added response effort supplied by the restraint, hand mouthing decreased to near zero levels.

The use of arm restraints to increase response effort of a behavior was also used by Zhou, et al. (2000). They also evaluated the effects of a response-effort intervention on the occurrence of self-injurious hand mouthing with four individuals with mental retardation. During baseline, all participants had high levels of hand mouthing. The effortful intervention consisted of requiring the participants to wear soft, flexible sleeves that increased resistance for elbow flexion, but still allowed them to engage in the behavior. To determine the force required to make the arm movements more rigid, the researchers attached a digital scale to a stick with the soft sleeve on it to record the amount of force required to bend the arm ninety degrees upward (while wearing the sleeve). From this analysis, they determined that a force averaging 1.44 kg was necessary to make the arm movement more rigid, but not impossible. Results of this study showed that after application of the arm sleeves, significant decreases in hand mouthing occurred for all participants.

The manipulation of response effort at this level does not always require restraints to be worn. As mentioned previously, Piazza, et al. (2002) increased the response effort of pica (placing non-edible items in the mouth and/or swallowing) with three participants. In order to increase the effort of the pica behavior, they made non-edible items more effortful to obtain. To determine the effort required, they observed the participants engage in the behavior. One participant engaged in pica only with items only above her waist, so in her case, response effort was increased by placing items below her waist. For the other two females, pica items were placed in plastic containers to increase the effort in obtaining them. The results of these effort manipulations on the participants' pica responses showed that high levels of pica for all participants occurred during baseline when there was low effort involved. Immediately upon introduction of increased response effort, pica decreased for all three females.

Effort of Multiple Responses in a Single Class

Though response effort manipulations can successfully decrease behavior by increasing effort at the level of the individual response, they can also be used to decrease responding by increasing the effort involved in emitting multiple responses in a response class. At this level, response effort is defined as the physical force of multiple responses in a class necessary to produce reinforcement. Thus, it is the collective effort of a number of responses. The schedule of reinforcement determines the number of responses necessary for reinforcement. To manipulate response effort at this level is to increase or decrease the response requirement in ratio schedules of reinforcement.

Applications of response effort manipulations of this category have been used in functional communication training (FCT). Horner and Day (1991) decreased the response effort involved in an appropriate communicative behavior (requesting help) in order to increase FCT responses and subsequently replace self-injurious behavior. The response effort was manipulated by changing the number of signs (in sign language) necessary to receive help. When the schedule of reinforcement for signing was an FR-3 (three signs required for help), the participant had increased SIB and less signing than he did when the signs were on a schedule of FR-1. By making the functional communication response of signing help easier to produce the outcome, the individual increased the signing response and decreased the problem behavior of SIB to zero.

Perry and Fisher (2001) also manipulated the effort of multiple responses in a single class with functional communication training. They altered the number of compliance responses necessary for the FCT to be available (FR-0, FR-1, FR-4) which allowed access to a tangible reinforcer. The authors found that emitting appropriate communicative responses decreased as the response effort for producing reinforcement increased. When the ratio of responses to obtain the FCT card (effort) was increased, engagement in destructive behaviors increased. However, when the effort of obtaining the FCT card was low (FR-1), the compliance behaviors increased and destructive behaviors were reduced to near zero.

Both of these studies showed that making appropriate alternative behaviors easier (decreasing requirement in the FR-schedule) increased the engagement of the appropriate communicative behaviors which, in turn, provided a reduction in problem behaviors. They also exemplified that when appropriate alternatives are more effortful than the problem behavior, the functional communication training will be less effective in reducing problem behaviors.

An example of multiple responses in a single class that does not include functional communication training was published by Kerwin, et al. (1995). These researchers provided a behavioral economic analysis of food refusal. In their study, they provided children varying amounts of pureed food on a spoon (empty, dipped, quarter, half, and level) and recorded whether the children accepted the food, refused the food, or ate the food (evidenced by the mouth being clean after acceptance). The children did not feed themselves independently, thus the effort was assumed by the physical exertion involved in eating the various amounts that were accepted into the mouth. These authors found in two experiments, that increasing spoon volume resulted in a decrease in instances of acceptance and eating the foods. They noted that each child exhibited a different, but orderly demand function of response (acceptance, refusal, mouth clean) by cost (spoon volume) for the same pay off (social attention and toys were provided for accepting and eating foods) (Kerwin, et al., 1995).

Although, these researchers were not originally seeking to determine the effects of response effort on eating behaviors, they did find that increasing the amount of responses in the single response class of “eating” (more chews and swallows to finish larger volumes of food) resulted in a decrease in eating behaviors and avoidance of eating overall (refusing the food). They concluded that lessening the effort of eating (provide small volumes) would help increase eating behaviors in children with food refusal.

Effort of Multiple Response Classes

Not only is response effort identifiable at the level of a single response and at the level of multiple responses of the same response class, but it can also be categorized at a third level. This level involves the effort associated with multiple response classes, and it shows the extension of behavior in a time frame. Consistent with the molar perspective of behavior, this level is broader than the two levels previously mentioned. The conceptualization of effort involves the number of response classes in a sequence to complete an action producing reinforcement. Higher effort would include sequences with more classes and low effort would be a shorter sequence. The effort essentially is the caloric/physical expenditure required to emit a sequence of response classes.

Buckley and Newchok (2004) provided a response effort manipulation at the level of multiple response classes. They sought to increase the use of mands (requests) in a functional communication training treatment program for a child with autism by altering the response effort of manding. The low effort condition consisted of a picture card being within reach of the child to easily grasp and hand to his therapist to receive access to a video (the reinforcer). In the high effort condition, the FCT card was placed on a board 4.5 feet away from the child. In order to obtain the card to hand to the therapist, the child completed a longer sequence of different response classes. These included: getting out of his seat, walking to the felt board, pulling the picture from the board, walking back to his seat, and handing it to his primary instructor (Buckley & Newchok, 2004). This study compared the two conditions and also assessed the effects on the child's aggressive behaviors. Their results showed that during the low effort condition picture exchanges were high and aggressive behaviors were low. The child's behavior changed when the high effort condition was introduced. When the effort for manding was high, picture exchanges reduced to zero while his aggressive behaviors increased to above baseline levels.

Richman, Wacker, and Winborn (2001) also manipulated the effort to complete a manding (requesting) sequence to investigate the effects on a child's hitting and slapping. They conducted a functional analysis and found the child's problem behaviors were maintained by access to toys. Two communicative responses of differing effort were chosen for the child to emit in order to obtain reinforcement (toys). The first was the low effort response of signing “please” and the second more effortful response required handing a communication card to his mother (more physical expenditure) to receive toys. The second response class was a chain that included orienting and moving toward the card, picking up the card from the floor and turning towards his mother, moving within 30cm of his mother, and placing the card in her hand (Richman, et al. 2001). The results showed that when the low effort of signing please resulted in reinforcement, responding was exclusively allocated to signing and no problem behaviors occurred. Therefore, altering the effort of manding, more specifically making the sequence shorter, resulted in a decrease of a child’s hitting and slapping.

These studies showed that decreasing the effort required to complete a manding sequence can result in an increase in a child’s requesting. It also provided evidence that response effort can be manipulated by altering the number of response classes in a sequence necessary to produce reinforcement. Although the response effort of the manding sequences was measured qualitatively and not quantitatively (Richman, et al., 2001), the results showed that making access to reinforcement easier resulted in less problem behavior. This third level of response effort manipulation further provides a useful way to increase or decrease effort that result in changes in responding.

Effort of a Non-Target Behavior

The previous categories described direct manipulations of response effort of behaviors targeted for reduction. However, other studies have manipulated response effort of a non-target behavior to reduce a target problem behavior or to increase a target skill. Response effort defined in this way warrants a separate category, because it does not involve direct effort of the target behavior, but the effort of an alternative behavior, which constitutes an indirect intervention for the target behavior. Effort in this category is defined as force associated with an alternative behavior (non-targeted) which when emitted produces reinforcement.

Response effort manipulations in this category have decreased responding of a problem behavior by making a less effortful alternative behavior available or increased engagement in a target skill for acquisition by increasing the effort of an alternative. Decreasing the effort associated with an appropriate response may increase its frequency and thereby decrease the rate of a problematic alternative (Friman & Poling, 1995). In order to decrease a problem response in this way, an appropriate alternative resulting in the same outcome must be established that requires less effort than the problem behavior. This approach has been used in functional communication training (Richman, et al., 2001; Perry & Fisher, 2001) and in the treatment of pica (Piazza, et al., 2002).

As already mentioned, Piazza, et al. (2002) varied response effort to reduce pica. However, they also manipulated the effort of a non-target behavior to increase its occurrence. This non-target behavior was item interaction, a desirable behavior to complete with the pica response. The effort to obtain the alternative items (such as edible food, strobe light, etc.) was manipulated by changing the location in the environment to make access easier than access to the pica items (and simultaneously pica items were harder to obtain). The results showed that in conditions when alternative items were easy to obtain and pica items were difficult to get, the participants engaged in near zero levels of pica and increased their interaction with the appropriate items.

Piazza, et al. (2002) manipulated response effort at the level of an individual behavior for two behaviors at the same time. When the effort of pica was increased and the alternative items were not made available, this provided less behavior reduction than when alternative items were made easy to obtain (Piazza, et al., 2002). Though, manipulating response effort can serve as an effective behavior reduction procedure, this study showed that simultaneously making an appropriate alternative behavior easier provided greater results.

Zhou, et al. (2000) also chose a non-target behavior to make easier while increasing effort of hand mouthing. To decrease hand mouthing, the effort of moving the arm was increased by applying soft arm sleeves, and simultaneously, a competing response of object manipulation (holding or manipulating an object with either hand) was chosen to increase. In order to make object manipulation less effortful than hand mouthing, during the intervention leisure objects were continuously available and within easy reach. Object manipulation did not require arm bending, and the participants could play with the items with hands opposite to the one they mouthed. When hand mouthing was more effortful than object manipulation, the participants decreased hand mouthing and increased play with the leisure items to very high levels. This study further showed that making an appropriate behavior less effortful than a problem behavior will increase the likelihood of the person engaging in the “good” than “bad” behavior.

Effort of a Non-Target Behavior as a Consequence

A final category of response effort also involves indirect manipulations that influence target behaviors. This category describes effort in terms of a consequence for a behavior targeted for reduction. Such interventions manipulate effort by requiring a person to engage in behavior (more effort) contingent upon the problem behavior's occurrence. The mandatory effort could be either topographically different or similar to the problem behavior. Such manipulations have included the use of contingent exercise or overcorrection procedures. In these arrangements, individuals are required to engage in some behavior as a consequence for a target behavior. The effort in this category is defined as caloric/physical expenditure of a response contingent upon engagement in a target behavior.

Luce, Delqudari, & Hall (1980) conducted two experiments to determine the effects of contingent exercise upon physical and verbal aggression emitted by children in public school classrooms. In both studies, the intervention required the children to stand up and sit on the floor five to ten times contingent upon aggressive responses. In the first study they targeted hitting with an open hand or closed fist with an elementary aged boy. In the second study, both verbally and physically aggressive behaviors were targets for another boy in the same elementary classroom. His responses included making threats, hitting, kicking, choking, or pushing. In both studies, baseline included no systematic contingencies for aggression, and with the introduction of the contingent exercise for each aggressive response, there was an immediate decrease in aggressive responses for both boys to low levels.

Luiselli (1984) evaluated the effectiveness of a brief contingent effort procedure to address the problem behaviors of aggression (punch, grab, slap) and hand biting (place hand in mouth and bite down on skin) of a child with a developmental disability. The experiment took place in the child's school classroom. During baseline, staff addressed the problem behaviors as they had done previously with no specific changes directed. The response effort intervention consisted of contingent exercise, during which the student was physically prompted to complete a three-movement arm sequence (raising arms above head, moving them to the side of the body, and placing them in front of the body) contingent upon occurrence of either problem behavior. The researcher found that frequencies of aggression and hand biting dramatically decreased to low levels following implementation of contingent effort. Luce, Delquadri, & Hall (1980) also implemented contingent effort in the form of exercises of sitting and standing up immediately after an aggressive response was emitted, and found that the intervention decreased aggressive behavior. These studies represented the effectiveness of applying effort as a consequence for problem behavior, in order to decrease the problem behavior.

Variables Underlying Response Effort Effects

Effort as Response Reducing

These categories of response effort manipulations provide a way of organizing applied studies on response effort in order to understand how effort has been defined and used differently as a behavior changing tool (see Table 1 for a summary). Both basic and applied research confirms that increasing required effort is an effective response-reduction procedure with enduring effects (Friman & Poling, 1995). However, this literature does not clarify variables underlying the changes in responding resulting from increases in response effort across these categories. In particular, it is not clear whether increasing effort serves as a form of punishment or whether it merely delays access to reinforcement.

Effort as Punishment

A decrease in responding due to an increase in effort suggests that the increase in effort may function as a punisher. From this perspective, more effortful responding could be construed as aversive. Increased aversiveness associated with increased effort could explain the decrease in the likelihood of the behavior occurring again in the future.

Table 1.

Summary of the Response Effort Categories Organizing Applied Studies

Category	**Definition**	**Direct or Indirect Manipulation**	**Examples**
1 Effort of Individual Response	Physical effort required for an individual response to be completed and produce reinforcement.	Direct: Effort involved with the response to be emitted	• Wrist weights, arm sleeves worn to increase rigidity of movement; force of single behavior
2 Effort of Multiple Responses in Single Class	Physical effort of multiple responses in a response class necessary to produce reinforcement.	Direct	• Ratio requirements in schedules of reinforcement
3 Effort of Multiple Response Classes	Physical effort required to emit a sequence of response classes that complete an action producing reinforcement.	Direct	• Obtaining reinforcers in Functional Communication Training (involving more than one action)
4 Effort of a non-target behavior	Physical effort required of an alternative behavior (non-targeted) which when emitted produces reinforcement.	Indirect: Effort not of the target response, but of alternative one	• Manipulating effort of an alternative behavior less than problem behavior, to reduce problem behavior
5 Effort as a consequence of action	Physical effort of a required non-target behavior contingent upon a target behavior.	Indirect	• Overcorrection, contingent exercise

Miller (1970) investigated the punishing effect of different response-force requirements in an experiment utilizing a two-component chain schedule for knob pulling with human adult participants. In this study, the two-component chain consisted of two pulls on a knob (equaling one inch) that came through the wall of the experimental chamber. The first component response was defined as a pull on the knob through .25 inches against a 1 pound spring. The force requirement for the second response was controlled by attaching a weight to the knob, effective through the last .75 inches of travel. When the full inch of the pull was completed, the participants could release the knob, and a reinforcer was presented. Each participant had one session with a 1 pound force for each knob, and from the second session forward, weight was added to the second component of the chain only in 10 pound increments, up to a maximum of 50 pounds.

The results of the study showed that the rate of responding for both the 1^{st} and 2^{nd} response in the chain decreased for all participants as the force requirement for the second component was increased. He also found that inter-response time increased as the force requirement increased, showing that reduction in response rate was accompanied by an increase in the interval between first-component responses. Miller concluded that the emission of a high force response is in some manner punishing, but he also added that there may still be other explanations for rate reduction (Miller, 1970).

Effort as Delayed Reinforcement

A second controlling variable may involve the temporal relation between responding and the reinforcer resulting from increased effort. An increase in effort of a response results in that response taking longer, whether the effort involves an increase in an FR schedule of reinforcement, a longer sequence of actions required to complete a task, a greater distance to travel, or a response class requiring increased physical exertion. A response requiring more effort results in a longer delay to obtaining reinforcement.

Studies on reinforcement delay have shown repeatedly that adding delays in obtaining reinforcement have resulted in reductions in overall responding, even when delays are slight (Ferster & Hammer, 1965; Williams, 1976; Sizemore & Lattal, 1978; Lattal, 1984; & Mazur, 1986).

The aversive aspects of effort and delay to reinforcement could both be controlling variables for the reduction in responding seen when increasing response effort. Applied studies have looked at the contribution of response effort and reinforcer delay in other contexts, such as reinforcer preference assessments (see Gwinn, et al. 2005; Piazza, et al. 1997; Piazza, Fisher, Hagopian, Bowman, & Toole, 1996), in assessing behavioral measures of impulsivity with children with Attention Deficit and Hyperactivity Disorder (ADHD) (see Neef, et al. 2005), and examining influential dimensions of reinforcers (Neef, Shade, & Miller, 1994). However, these studies have not distinguished the roles of effort and delay. Moreover, some have used inappropriate definitions of response effort (difficulty of math problems) that do not constitute physical exertion of emitting a response. The purpose of this study is to investigate the relations between physical effort and reinforcer delay in response effort manipulations.

CHAPTER II. METHOD

Participants

Participants were selected from a local pre-school, which was an Early Intensive Behavior Intervention (EIBI) pre-school serving students with and without developmental delays. Four pre-school students (three males and one female) were chosen to participate in the study based on parental consent and willingness to participate. Chad was a 4 year 9 month old boy, Mary was a 4 year 5 month old girl, Andy was a 4 year 1 month old boy, and Jon was a 4 year 2 month old boy. All participants were typically developing children (of healthy weight and appearance) without developmental delays or disabilities that could affect their performance in this study. Children at the pre-school with a diagnosed developmental delay or disability, or deficits in motor or visual abilities that could inhibit performance in a behavioral task, were not asked to participate in this study.

Setting

All experimental sessions took place in a small therapy room at the pre-school 3-5 days per week, with the experimenter, a research assistant (2-3 days per week), and the student present. The room contained a table set up against a wall, a large wooden cabinet, a sink, and three chairs. The materials necessary for running multiple trials over a session were set up on one wall of the room prior to student entry and others were placed on the floor or on the table by the experimenter and out of reach of the student. Each session lasted between 15- 30 minutes. Children participated in 2 sessions per day when they were able to complete both in 30 minutes time. In total, the study was conducted over a nine month period, with participants taking part in sessions for 8-10 weeks each.

Materials

A behavioral task consisting of building large, colorful, cardboard blocks (Imaginarium® Big Deluxe Building Blocks) together into formations was used for this study. The blocks were chosen for their large size, high appeal to children, and "tuck-n-fold assembly" (www.toysrus.com) which allowed for diving weights (Sea Pearl® hard and soft mesh weights) to be placed inside of them during high effort conditions. Ahead of the student, two pictures of different block formations (both laminated and 8 ½ by 11 inches in size) were presented at eye level, approximately two feet apart, and six feet ahead of the child's seat (See Figure 1). Below the pictures the blocks associated with each formation were placed in plastic bins on the floor (Sterilite® 54 quart bins: 23"L x 16 3/4"W x 11 7/8"H). From the pair of pictures, the child chose one and was instructed to match his choice by arranging the blocks according to the picture. To facilitate data collection, data sheets (8 ½ by 11 inches in size, see Appendix B), a stopwatch, and a kitchen timer were also used during experimental sessions.

Assessment Procedures

Prior to participation in the experimental sessions, the experimenter conducted two assessments with each participant. First, an initial assessment was completed to determine each student's eligibility to participate in the study. Second, a reinforcer preference assessment was conducted to determine items and activities that could serve as reinforcers to be used in the experiment. Both assessments took place in the therapy room where experimental sessions were held and consisted of the child, the experimenter, and a research assistant.

Figure 1. The set up of materials for experimental trials

Initial assessment. This assessment consisted of exercises from the Assessment for Basic Language and Learning Skills (ABLLS™-R; Partington, 2006) and was used to determine each students' competency in building blocks, matching, and working with an adult. Specifically, the following areas were probed with each participant: cooperation and reinforcer effectiveness (e.g. responding to social reinforcers, taking a tangible reinforcer, and waiting for a reinforcer) and visual performance (e.g. building blocks, matching, and forming block designs). This assessment was completed in one session for each child and all students scored high marks in each ABLLS™-R area and were able to take part in the rest of the sessions.

Reinforcer preference assessment. To determine individually for each child items they liked or enjoyed, a preference assessment (Pace, Ivancic, Edwards, Iwata, & Page,

1985) was conducted that consisted of both forced and free choice portions. During the free choice portion of the assessment, each participant was allowed to choose from a pool of approximately 15 items which were available at the pre-school. The items were chosen separately for each child according to the teacher's report of what each child liked and from observations of the child in the classroom. In this phase the participant sampled each item and was instructed to choose what he/she liked the best. Contingent upon the choice, the participant was given 30s access to the preferred item. After 30s, the item was recorded and removed from the choices. This procedure was repeated until the children chose their 6 favorite items.

A forced choice component immediately followed the free choice section to further assess preference. During this part, each participant was presented with successive trials of a systematic comparison of all 6 preferred items from the free choice portion. The experimenter presented pairs of items and asked, "Which would you like to have or do?" for 15 trials. Each item from the free choice section was presented for 6 trials. Trials lasted until all items from the free choice section had been paired together. The preference assessment was completed in a single session with each participant.

Pilot Studies

Some features of the experiment were determined from pilot tests conducted with one participant (Chad, aged 4 years 9 months) during the initial part of the study (see Table 2 for a summary of all phases of the study). The pilot sessions consisted of a concurrent match to sample procedure and focused on assessing factors that could affect the participation of a pre-school aged participant. To evaluate the cooperation of pre-school aged children, trial length, session length, number of trials, and number of sessions per week were manipulated during this time, as well as complexity, shape, and number of blocks that were included in the block formations.

Table 2.

Summary of Phases

Phase	Description	Number of Sessions
1. Assessments	Completed with all 4 participants prior to participation in block building trials o Initial assessment (ABLLS-R) o Reinforcer preference assessment	1
2. Pilot trials	One participant (Chad) o Assessed trial/session length o Determined effort and delay parameters o Tested and finalized data collection, block formations, and research design	20
3. Experimental trials	Three participants (Mary, Andy, Jon) o 36 sessions ▪ 6 choice pairings ▪ Replicated 6 times o Each session consisted of up to 8 trials [a] ▪ 2 sample trials ▪ 6 successive choice trials o Total number of trials per child ▪ Mary 284 ▪ Andy 248 ▪ Jon 229	Mary- 36 Andy- 32[b] Jon- 36

[a] Some sessions had less than 8 trials if time ran out. Figures 8-10 show data for all trials.
[b] Andy left the pre-school before completing the study.

Other procedural specifications of the experiment determined during pilot testing were the effort and reinforcer delay components. The amount of weight to include for the effort component was decided parametrically in an effort assessment (Irvin, et al., 1998). At first, sessions were run with zero weights added to the blocks, followed by sessions with weights added to individual blocks in increments of .5, 1, 2, 3, and 4 pounds. During this effort assessment, high effort was achieved when the participant required two hands to lift a single block. This occurred when four pounds were added to each block used in the behavioral task. Once high effort was determined, medium effort was defined as half the weight of high effort and was set at 2 pounds. Reinforcer delay was also assessed parametrically. Sessions included zero imposed delay (immediate reinforcement), followed by delays of 10s, 15s, 20s, 30s, and 45s. From these observations, delays less than 30s did not appear to have an impact on responding, whereas the introduction of the 30s delay resulted in a decrease in response allocation to that choice. Therefore, a delay of 30 seconds was used for the high reinforcer delay condition in the experiment, with medium delay set at half of high delay: 15s.

A final determinant of the experiment assessed during pilot testing was the final research design and trial pairings. The pilot studies consisted of choices with both effort and delay components, however, the pilot sessions included trials that compared choices that could not be assessed for preference in data analysis. For example, a pairing of a high effort: low delay choice versus a low effort: high delay choice could not result in the student's choice being interpretable for preference, because it wouldn't be clear what variable affected the choice, effort or delay (no variable was constant across the choices). These trials were removed for the experimental phase of the study, and instead a sampling procedure followed by successive trials of the same choice was added to the procedure (described below).

Design overview

Research on choice behavior suggests that an individual's response allocation to choice alternatives can be a precise way to measure preference (Powell, Symbaluk, & Macdonald, 2005). A concurrent match to sample choice procedure was used to determine preferences among choices of activities involving differing degrees of effort and delays to reinforcement. Each session, two simultaneously available alternatives were presented, one of the left and one on the right. Both tasks correlated with some level of effort and delay. Preference was assessed from the individual's choice among the alternatives as one variable was held constant across the choices while the other differed at a low or high level. With this arrangement, there were 6 possible pairs to be included in the study: low and high effort across low, medium, and high delay (3 pairs) and low and high delay across low, medium, and high effort (3 pairs). Table 3 shows the pairs that were presented in the experimental trials, separated by choices assessing preference for delay or effort (rectangular borders were added to emphasize the pairs).

Table 3.

Choice Alternatives Assessing for Delay or Effort Preferences

A. Delay Choice Trials

Task Components		**DELAY** Low ("0"s) Eff/Del	**DELAY** High (30s) Eff/Del
EFFORT	Low (0 lbs)	L / L	L / H
	Medium (2 lbs)	M / L	M / H
	High (4 lbs)	H / L	H / H

B. Effort Choice Trials

Task Components		**DELAY** Low ("0s") Eff/Del	**DELAY** Medium (15s) Eff/Del	**DELAY** High (30s) Eff/Del
EFFORT	Low (0 lbs)	L / L	L / M	L / H
	High (4 lbs)	H / L	H / M	H / H

Note: Choice pairs are enclosed with rectangular borders. In A, effort is constant across alternatives. In B, delay is constant across alternatives. In the combination L/L (effort/delay), the letter on the left stands for effort and the letter on the right for delay. L/L is low effort + low delay (choice has 0 lbs added and results in immediate reinforcer). The choice pair of L/L: L/H stands for the left choice being low effort/low delay, and the right choice being low effort/high delay (0 lbs with 30s reinforcer delay).

In all choice trials, the individual was prompted to choose an alternative with either low or high effort or delay. In a trial assessing delay preference (delay choice trials), the two alternatives of block formations were equal in all aspects, including: number of blocks to build (all block formations included 5 blocks), complexity of the stimulus to match (defined by the overall shape of the formation and the number of blocks in the shape requiring stacking), and physical effort of picking up blocks. However, the delays associated with each alternative differed. One alternative resulted in immediate reinforcement (low delay) and the other had a reinforcer delay of 30s (high delay). To aid in discrimination of choices, an extra-stimulus prompt was added to the block pictures when a choice had a delay (see Figure 2). For trials assessing effort preference (effort choice trials), both alternatives were equal in all aspects (number of blocks, complexity, and delay to reinforcement). The difference between the alternatives in these trials involved the response effort. One alternative had zero weight added to each block (low effort) and the other alternative had four pounds added to each block (high effort).

Figure 2. Extra-stimulus prompt signaling delay (1 hand for 15s, 2 hands for 30s)

Throughout the experiment, each session consisted of one pair of choices presented over multiple trials (up to 8 total), as part of the concurrent match to sample procedure (explained in further detail in the next section). After six sessions all 6 pairs of choices had been presented and this was considered as completing a *set* of sessions. To control for side preference and other possible biases, the experiment consisted of a replication of the first set of sessions five more times, with the sides of the choices switched with each successive set (from left to right and vice versa). The experimenter chose choice pairings (e.g. L/L:L/H) per session at random and followed a grid to determine sessions in need of completion (see Table 4). The experimenter continued sessions with each participant until all sets were completed.

Table 4.

Grid Outlining the Choice Pairs Presented per Session

Sessions (Eff/Del:Eff/Del) Left : Right	Session Set 2	Session Set 3	Session Set 4	Session Set 5	Session Set 6
1. L/L : L/H	L/H : L/L	L/L : L/H	L/H : L/L	L/L:L/H	L/H : L/L
2. M/L : M/H	M/H : M/L	M/L : M/H	M/H : M/L	M/L:M/H	M/H : M/L
3. H/H : H/L	H/L:H/H	H/H : H/L	H/L : H/H	H/H:H/L	H/L : H/H
4. L/L : H/L	H/L:L/L	L/L : H/L	H/L : L/L	L/L:H/L	H/L : L/L
5. L/M : H/M	H/M:L/M	L/M : H/M	H/M : L/M	L/M : H/M	H/M : L/M
6. L/H : H/H	H/H:L/H	L/H : H/H	H/H : L/H	L/H : H/H	H/H : L/H

Note: Each session consisted of multiple trials: 2 sample trials, and up to 6 choice trials. Six sessions made up one set. L/L: L/H stands for the left choice being Low Effort + Low Delay and the right choice being Low Effort + High Delay. Each column represents one set of sessions, which were replicated across the study. The presentation of choices switched sides (left to right and vice versa) with each successive set.

Concurrent match to sample procedure

In this concurrent-operant arrangement, two simultaneously available, match to sample block building tasks were presented that correlated with high or low effort and delay (as described previously). Figures 3a and 3b show the block formations that were used in the study.

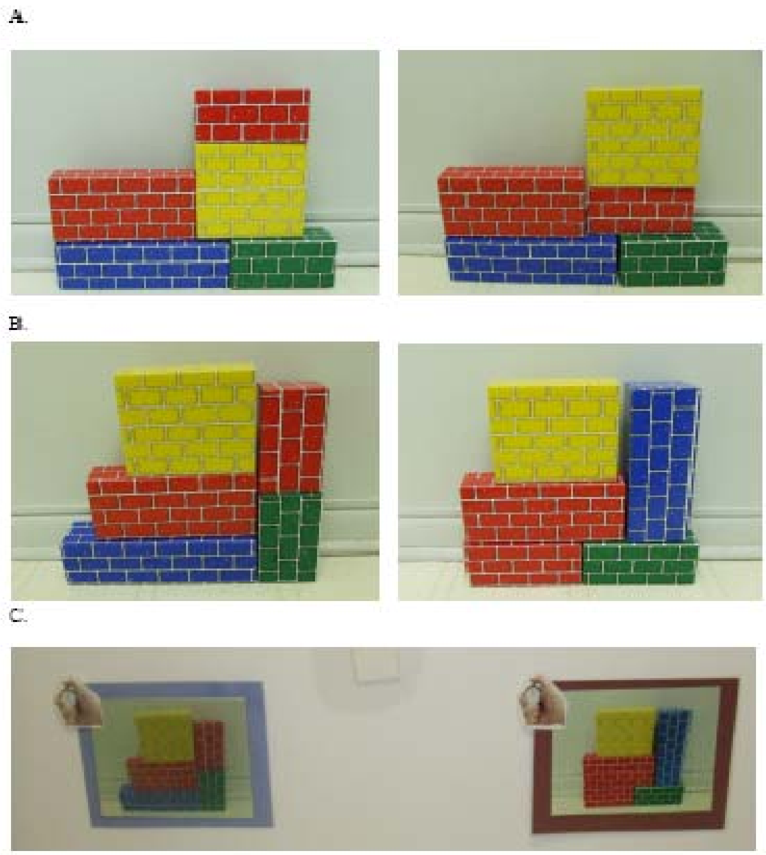


Figure 3. Block formations used for the concurrent match to sample task

The procedure was a choice procedure during which the student sampled each choice then chose successively which formation they preferred to build for up to six consecutive trials. In order to discriminate between the choices, each session colors were randomly assigned to each alternative by attaching the block pictures to a plain construction paper background (11 x 14"and laminated) using Velcro™ (as shown in Figure 3c). The colors used had no correlation to the conditions in effect for the choices and were individually determined per child, specifically as colors that were not favored (probed during the preference assessment).

At the beginning of each session, the student entered the room, and sat down in his chair. The materials for the match to sample task were set up ahead of the student (as shown previously in Figure 1). The first two trials consisted of *sample trials* during which the child sampled both alternatives in the choice set. For the first trial the student was given the prompt to begin building one of the alternatives (chosen randomly) displayed on the wall ahead. When the child first touched a block to lift it out of the box, the experimenter started the stopwatch to record the duration of the task and the overall trial (with delay added). Depending on the condition, blocks had zero, 2, or 4 pounds of weight inside (low, medium, or high effort respectively) and feedback was given immediately or after a delay of 15 or 30 seconds (low, medium, and high delay, respectively). Feedback consisted of verbal praise for finishing ("Great job building the blocks, you finished") and a report of how accurately the child matched the block picture ("You matched all the blocks" or "Good try but two of the blocks don't match, they should look like this").

After feedback was given, the experimenter recorded the task and trial durations and provided the child access to a reinforcer (individually chosen per child from the preference assessment) for an intertrial interval (ITI) of 15s. During this time the experimenter replaced the blocks in the designated box and set up for the next trial. The second trial of each session was another sampling trial, which consisted of building the second alternative of the pair and the trial was run in the same manner as just described.

When the student completed both samples, *choice trials* took place. The participant was reminded of the alternatives completed and was instructed to make a choice of the blocks to build next. For example, the experimenter pointed to the options and said "Mary, you did blue and you did brown. Which one would you like to do: blue or brown?" Once a choice was made, the experimenter removed the picture correlating with the alternative not chosen, recorded the student's choice, provided praise for choosing, and verbally prompted the student to match the blocks. No other prompting was provided for the matching task. Any verbal responses, off-task, or maladaptive behavior was ignored. Reinforcer access and feedback were given as described above in the sample trials.

Choice trials continued for up to six repeated trials with a 15s ITI if session time permitted (some sessions consisted of 3-5 choice trials). Once all choice trials were completed, the child was given the prompt "Today you did blue and brown, which one was your favorite?" The verbal response was recorded, and access to an array of reinforcers and reinforcing activities was given for up to 5 minutes. If no session time remained after choice trials were completed, the children were not asked for their favorite and instead were given brief access to an edible reinforcer and taken back to class. Figure 4 provides a summary of the events that took place during an experimental session.

Data collection and analysis

The experimenter collected data on the following: the choice that was made, the effort associated with each choice, the reinforcer delay associated with each choice, the duration of task completion, the overall trial duration (task completion plus delay), the

Materials ready, child sat in a chair facing two block tasks

↓

1st sample trial, child completed one of the tasks
(left or right, chosen at random)

↓

Praise/feedback/reinforcer access: 15s intertrial interval (ITI)

↓

Child sampled the other task

↓

Praise/feedback/reinforcer access: 15s ITI

↓

1st choice trial (Left and Right choice presented, child chose one)

↓

Praise/feedback/reinforcer access: 15s ITI

↓

Repeat steps 6 and 7 up to 5 more times (6 choice trials total)

↓

At the end of the session, child asked “Which was your favorite and why?”

↓

Access to reinforcers for up to 5 minutes (given remaining session time)

Figure 4. Sequence of events for an experimental session

number of blocks correctly matched to the sample (Figure 5 shows a correct match), and participants' verbal response about their favorite choice. During the sessions, the experimenter kept all records on a data sheet, used a stopwatch to record task and trial duration, and used a kitchen timer to signal the intertrial intervals.

The data collected on choice was analyzed in the context of the choice paradigm. With all trials consisting of alternatives with one constant component (effort or delay) and another experimentally manipulated, responses allocated toward a particular alternative were assessed for preference over multiple trials and sessions. For example, if *High Effort*, *High Delay* was presented on the left and *Low Effort*, *High Delay* was presented on the right, and the child chose the right alternative, this suggested a preference toward low effort, because delay was constant across both. The design of this study included 8 consecutive choice trials after sampling the alternatives for each session, and multiple replications of sessions, in order to determine if consistent choice responding for one alternative or the other would exist.

Figure 5. Example of a correct matching to sample block arrangement

CHAPTER III. RESULTS

Preference Assessment

The results of the reinforcer preference assessments for each of the participants are depicted in Figure 6. The assessments identified items and activities that the children enjoyed individually, and these were included in each child's sessions in the study. The items and activities that Mary enjoyed from most to least were dolls, bubbles, edibles (crackers and candy), playing with toy food items (plastic vegetables and fruit), playing dress up, and coloring. For Andy, his most to least preferred items were toy cars, edibles (candy and chips), toy animals, a bouncing ball, a fire station toy set, and doctor toy accessories (plastic stethoscope, thermometer, etc). Jon's preferred items included edibles (candy and chips), a Spider-Man® book, a helicopter toy, toy figurines, pegs, and a musical numbers game (from most to least respectively). For each child, their preferred tasks were combined with an array of varied toys and games throughout the study to control for changes in preference over time.

Response Allocation (Choice)

Average response allocation. Individual choice data averaged across all conditions are shown in Table 5. Preference was evaluated by the percentage of response allocation toward a particular alternative in the delay or effort conditions (high or low) across the three comparisons of the opposite variable (low, medium, and high). Results showed that

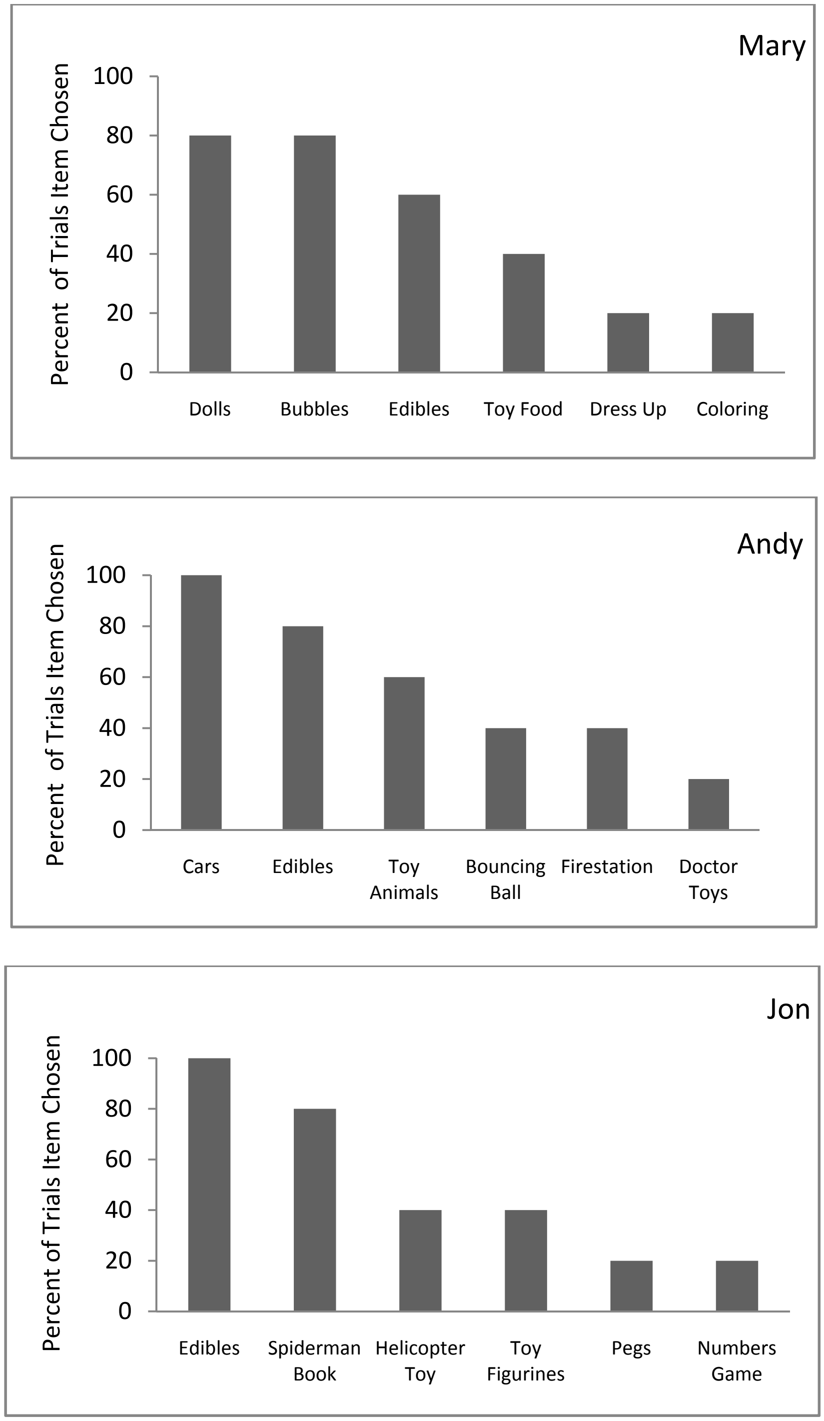


Figure 6. Reinforcer preference assessments as measured by the percent of trials the item was chosen during the forced choice assessment.

all children showed a clear preference for at least one variable (effort or delay). Mary allocated a higher percentage of her choices to alternatives with low effort (*M*=94%) than those with low delay (*M*=62%). Her preference for delay was mixed, averaging 61, 64, and 61% across low, medium, and high effort respectively.

Andy's choice responding was similar to Mary's, in that his preference for low effort was higher than that for low delay. When choosing between low or high delay, Andy allocated an average of 55% of his responses to low delay choices (*M*=48, 46, and 70% across low, medium, and high effort respectively). Andy's responding did show an increase of preference for low delay when effort was high, yet overall his delay preference was variable. Rather, Andy exhibited a stable preference when effort was the choice, averaging 95% of his responses to alternatives with low effort (*M*=96, 88, and 100% across low, medium, and high delay respectively).

Jon showed a similar preference for low effort (*M*= 98% of responses), however, his preference for low delay was much higher than Mary and Andy. Jon chose alternatives with low delay 95% of the time they were available (*M*=100, 89, and 95% across low, medium, and high effort respectively), which was 30-40% higher than the other two participants (to see the averaged data depicted graphically, see Figures A1 and A2).

Overall, each child showed a very high preference for low effort (*M*=94, 95, and 98% for Mary, Andy, and Jon respectively), however, preference for low or high delay was mixed for Mary and Andy. These data were averaged over the entire study. Analyses of the participants' responses over sets of sessions and choices made during each trial are discussed in the further sections.

Table 5.

Average Percent Response Allocation

MARY	Low Delay	High Delay		Low Effort	High Effort
Low Effort	61	39	Low Delay	89	11
Medium Effort	64	36	Medium Delay	97	3
High Effort	61	39	High Delay	97	3
TOTAL AVG.	62	38		94	6

ANDY	Low Delay	High Delay		Low Effort	High Effort
Low Effort	48	52	Low Delay	96	4
Medium Effort	46	54	Medium Delay	88	12
High Effort	70	30	High Delay	100	0
TOTAL AVG.	55	45		95	5

JON	Low Delay	High Delay		Low Effort	High Effort
Low Effort	100	0	Low Delay	97	3
Medium Effort	89	11	Medium Delay	100	0
High Effort	95	5	High Delay	97	3
TOTAL AVG.	95	5		98	2

Response allocation per session (delay). During each of these sessions, the children chose between two tasks of equal effort and different reinforcer delays: low (immediate reinforcement) or high (30s delay). Participants' percentage of responses allocated to low or high delay per session is displayed in Figure 7. This graph also shows the participants' response allocation across all sets of sessions of the study. The x-axis displays the levels of effort held constant across alternatives for each session of the set (low, medium, high) and the y-axis indicates the percentage of choice responses allocated to either low or high delay. Each set consisted of 3 sessions, and each session included 2 data points (one for low delay and one for high delay, emphasized with a circle for Mary) that equaled 100% (total response allocation).

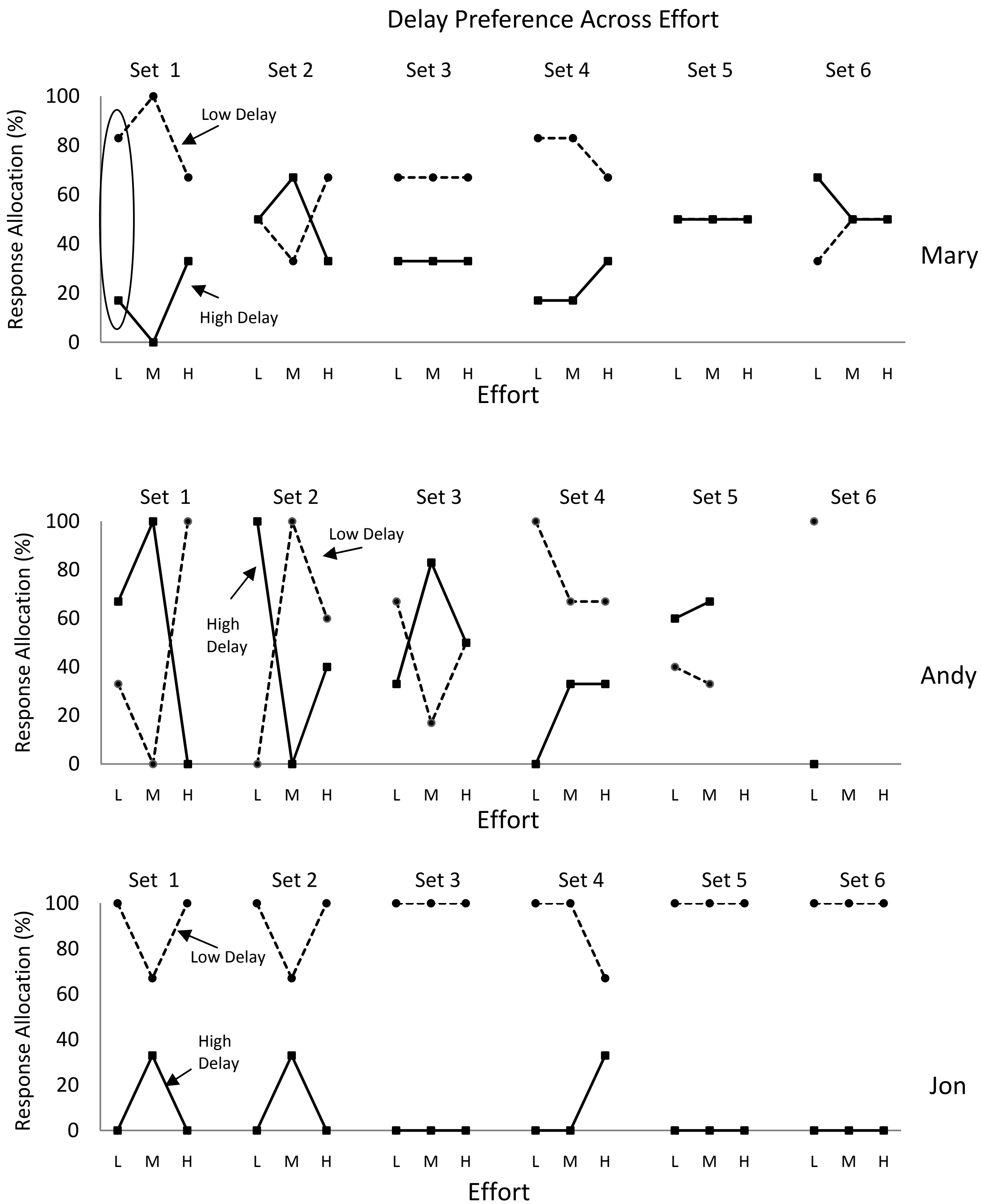


Figure 7. Delay choices across levels of effort (low, medium, and high). Each session includes 2 data points (low/high delay) whose sum is 100% (circled in Mary's graph).

As discussed previously Mary and Andy's average response allocation data did not show a clear preference for high or low delay, whereas Jon favored low delay the most. Across sessions, Mary favored low delay during sets 1, 3, and 4. In Set 1, Mary averaged 83% of her choices to low delay, but after continued replications, her overall preference for low delay decreased and waivered around 40%. In sets when Mary chose high delay, she tended to do so in sessions when effort was low or medium, and chose low delay more often when effort was high. In Set 5 and most of Set 6, she chose both low and high delay equally. Overall, Mary's preference was close to 50/50 for low and high delay across sessions.

Andy's preference for low or high delay was the least clear of the three participants. Like Mary, he also chose high delay most often when effort was low or medium (*M*=53%) and least often when effort was high (*M*= 30%). However over sessions his choosing often switched from high to low delay and vice versa, showing variability in his responding from set to set.

The participant with a clear preference for low delay was Jon. Across sessions, he chose low delay options the majority of the time (*M*=95%) and there were only three sessions in which he explored the high delay option. This occurred during Sets 1, 2, and 4. For two sessions (Set 1 and 2), he chose high delay 33% of the time when effort was medium, and for one session he chose high delay 33% of the time when effort was high (Set 4). Jon's overall response allocation to high delay was very low (*M*=5%) in comparison to the other children (*M*=41 and 45% for Mary and Andy respectively).

Response allocation per session (effort). During these sessions the child chose between two tasks with equal delays to reinforcement and different effort levels: low (0 pounds added to blocks) and high (4 pounds added to blocks). Participants' percentage of responses allocated to low or high effort per session is displayed in Figure 8. This graph is similar to Figure 7 in that 3 sessions took place per set and each session consisted of 2 data points (low/high effort) whose sum was 100% (total response allocation).

All children exhibited a clear preference for the low effort task across sessions, as evidenced by their total response allocation toward low effort (94, 95, and 98% for Mary, Andy and Jon respectively). Though Mary chose low effort most often, she did explore the high effort option in Sets 1, 2, and 5. In her first session with low delay constant, she chose low effort 67% and high effort 33% of the trials. After the first set of sessions, Mary's preference for low effort increased and for three sets (3, 4, and 6) she chose low effort exclusively.

Andy started off his first set of sessions choosing low effort 100% of the time, and in Set 2 had a 50/50 session for low/high effort when delay was constant at 15s (medium). After Set 2, his preference for low effort immediately increased and for 2 sessions of Set 3 and all of Sets 4, 5, and 6, he chose only the low effort option. Jon's choice preference was also strong for low effort, though he did explore high effort during his first and last sessions by allocating 17% of his total choice to high effort both times (which was 1 trial out of the 6 total).

Response allocation per trial. Previous sections have discussed choice and preference in terms of percentage of response allocation. Figures 9, 10, and 11 show choices per trial made by Mary, Andy, and Jon across the different conditions of effort and delay. Figure 9 shows Mary's responses for all trials of the study. In trials when the choice was low or high delay (across constant effort conditions), Mary's choices were extremely variable.

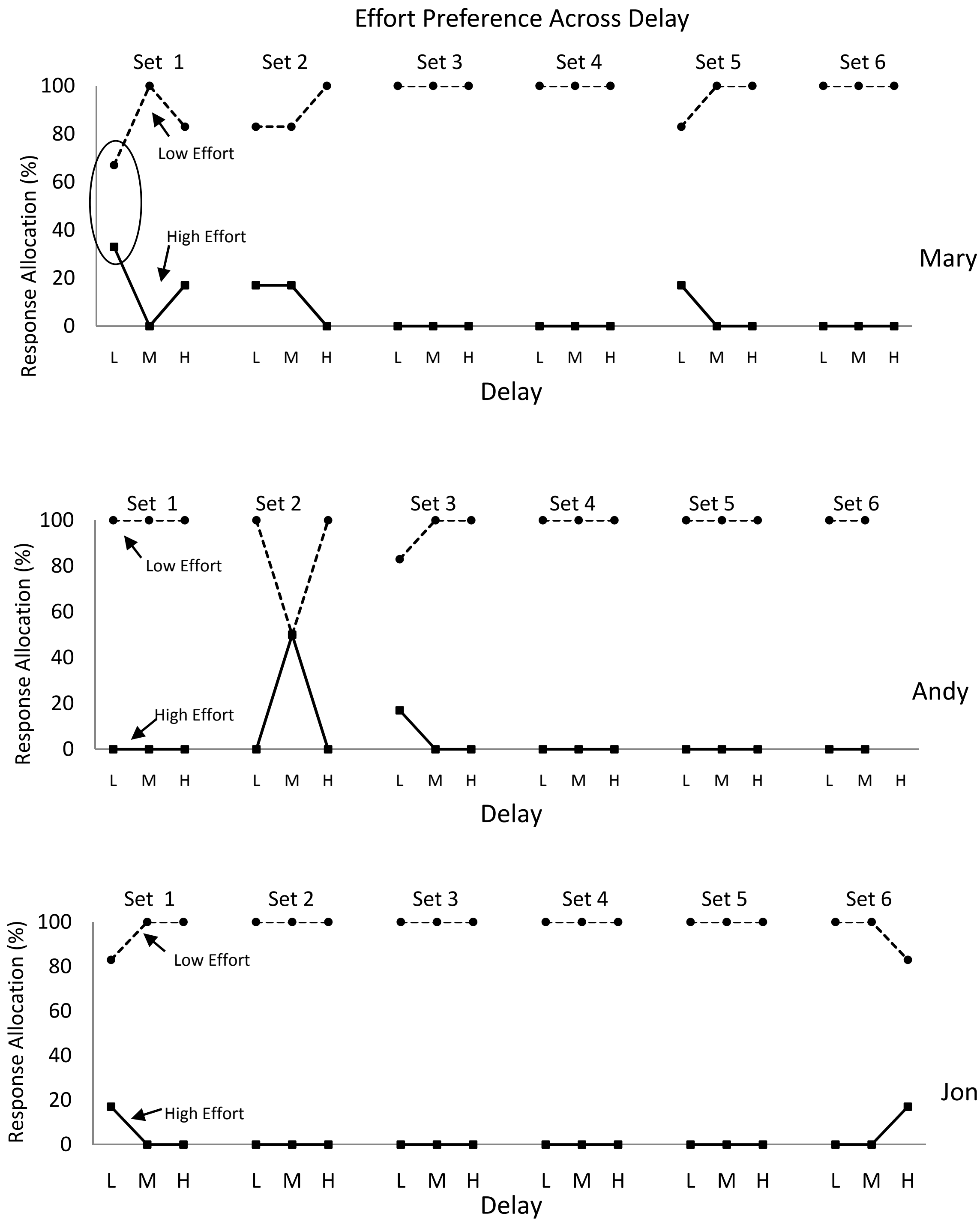


Figure 8. Effort choices across levels of delay (low, medium, and high). Each session includes 2 data points (low/high effort) whose sum is 100% (circled in Mary's graph).

Often in sessions she alternated between the low and high delay options, regardless of the effort condition in effect. When choosing involved low or high effort, she chose low effort more consistently. Across all trials she chose high effort only 6 times. Most of those choices were made when delay was low (4 out of 6). After initial trials in all conditions, Mary chose low effort continuously throughout the study.

Andy's choices per trial are displayed in Figure 10. Like Mary he also switched choices between low and high delay across effort, however, his choosing was less variable than Mary's as he engaged in bouts of choices, some for low delay and some for high. Overall, Andy's responding did not show a clear preference for low or high delay, but when the choice was low or high effort, Andy chose low effort for all trials except 4, showing a strong preference for tasks with low effort.

Jon's choices per trial are shown in Figure 11. Though Mary and Andy were variable in choosing between low or high delay, Jon's responding showed a clear preference for low delay. In the low effort condition, he chose low delay exclusively and only explored the high delay option in 4 trials, 3 when effort was medium, and 1 when effort was high. His preference for low delay was significantly different from the other two participants (see Figure A3). When choosing between low or high effort, Jon chose low effort in more trials than Mary and Andy, however, his performance was not significantly different from theirs (see Figure A3). In effort trial, Jon chose high effort twice. One time was during the first trial of the first session when the weighted block condition was introduced, and the other was during the first trial of the last session. Other than those two trials, he allocated all of his choices to low effort.

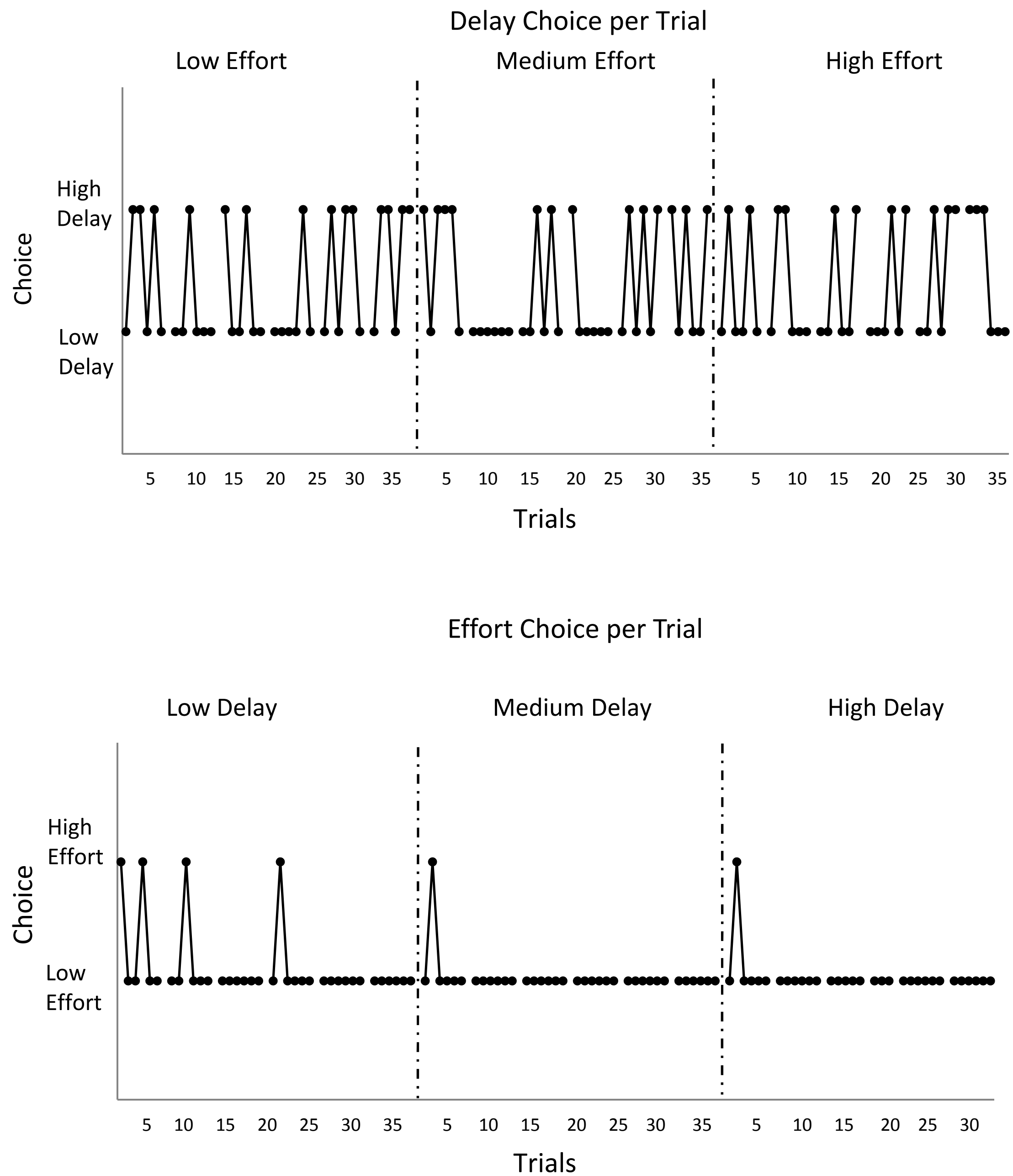
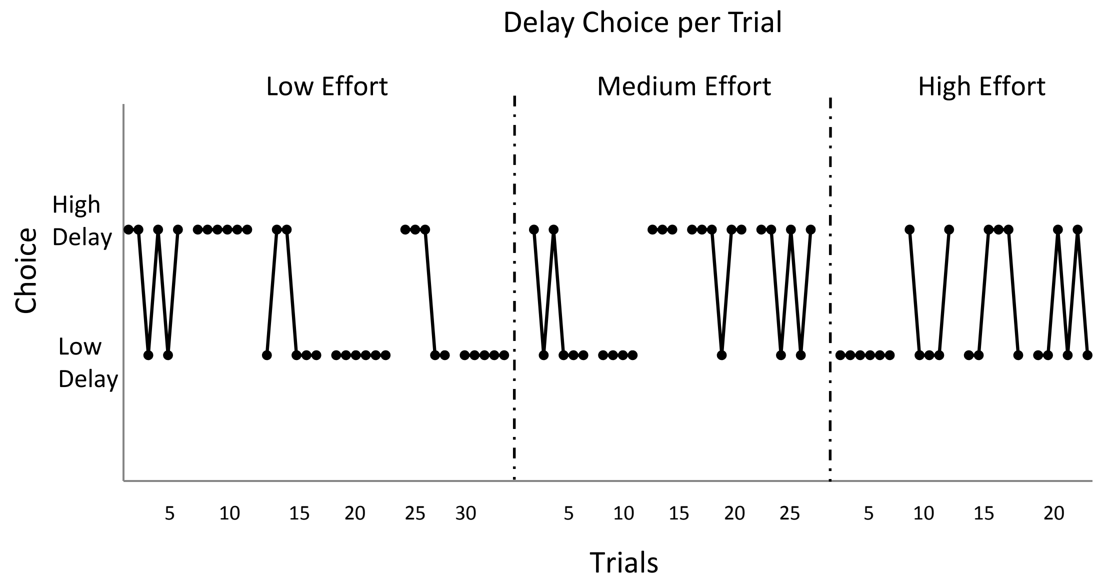


Figure 9. Mary's choice responses for all trials of the study. Broken lines indicate session breaks.



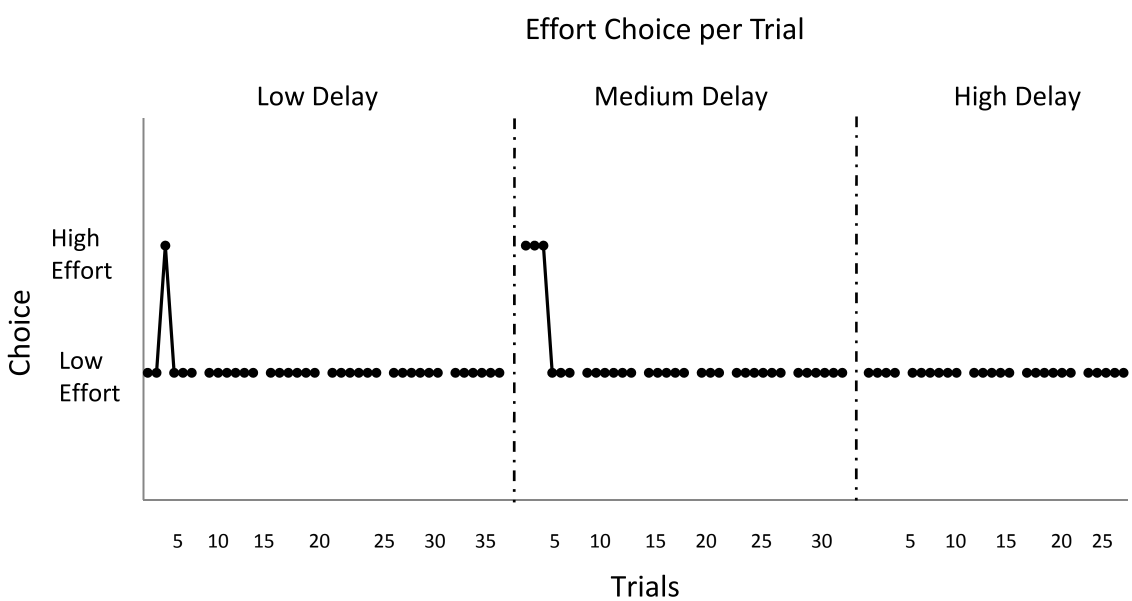
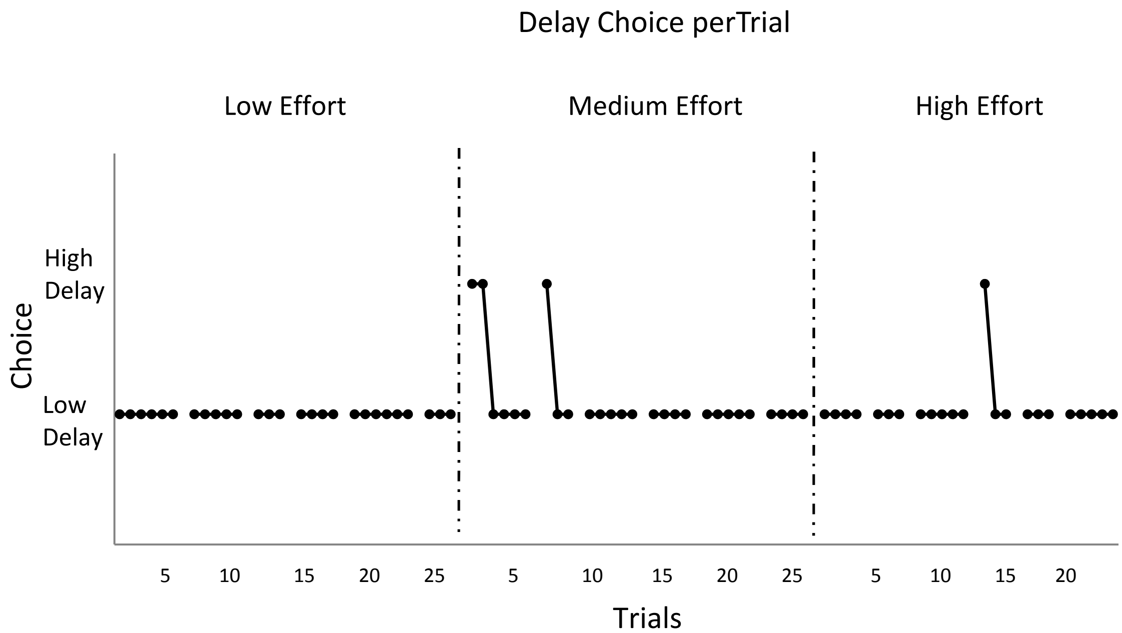


Figure 10. Andy’s choice responses for all trials of the study. Broken lines indicate session breaks.



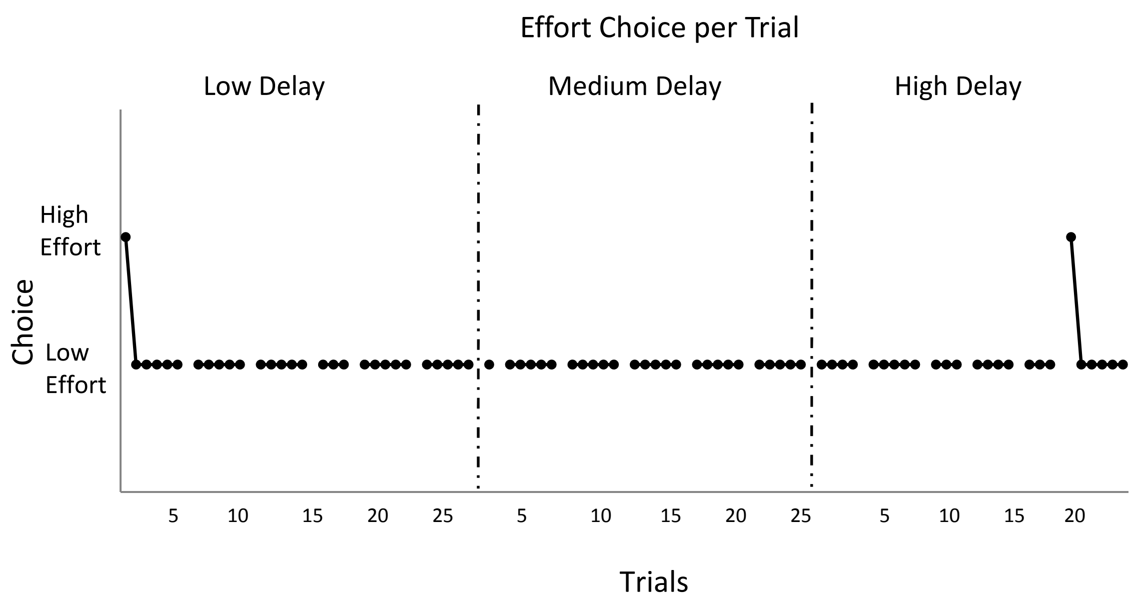


Figure 11. Jon's choice responses for all trials of the study. Broken lines indicate session breaks.

Trial Length

The average lengths of trials for all conditions (separated by trials involving delay or effort choice) are shown in Table 6. These data reflect the overall length for each trial (time to complete task + delay) and combines trial lengths of both sample trials and choice trials. The difference column (*D*) shows the time difference between trials involving low or high delay and low or high effort. To see average trial length depicted graphically, please refer to Figure 12.

Table 6.

Average Trial Length per Session in Seconds (D= difference)

	DELAY CHOICE TRIALS				EFFORT CHOICE TRIALS		
MARY	Low Delay	High Delay	*D*		Low Effort	High Effort	*D*
Low Effort	27	65	38	Low Delay	25	51	26
Medium Effort	39	76	37	Medium Delay	39	66	27
High Effort	50	88	38	High Delay	59	93	34
TOTAL AVG.	39	76	37		41	70	29
ANDY	Low Delay	High Delay	*D*		Low Effort	High Effort	*D*
Low Effort	60	88	28	Low Delay	48	82	34
Medium Effort	52	112	60	Medium Delay	72	119	47
High Effort	44	87	43	High Delay	85	126	41
TOTAL AVG.	52	96	44		68	109	41
JON	Low Delay	High Delay	*D*		Low Effort	High Effort	*D*
Low Effort	25	71	46	Low Delay	24	73	49
Medium Effort	40	76	36	Medium Delay	52	90	38
High Effort	59	128	69	High Delay	63	81	18
TOTAL AVG.	41	92	51		46	81	35

Note: Low delay was 0 added seconds, medium delay was 15s, and high delay was 30s

Delay choice trials. Results showed that Mary completed trials in the shortest amount of time when compared to Andy and Jon. When the choice was between low or high delay, she completed trials with low delay in an average of 39s. Within those trials, when delay was low and effort was high, trial length was longer (*M*=50s). When completing tasks with a high delay component, her trial length averaged 76s with the longest trial time being high effort with the high delay (*M*=88s). Overall, Andy's time to complete trials was the highest for all conditions, except for high effort + high delay. On average, Andy completed low delay choice trials in 52s and high delay trials in 96s, with his longest trial time when the choice was medium effort + long delay (*M*=112s). Jon's time to complete delay choice trials was similar to Mary's, except when a high delay option also involved high effort (he averaged 128s in that condition to Mary's 76s). In tasks with low delay Jon averaged 41s trial length and for high delay trial length increased to an average of 92s.

Effort choice trials. These data were calculated from trials which involved low or high effort across the different levels of delay (right hand side of Table 6). Similar to delay choice trials, Mary completed trials the quickest, followed by Jon and then Andy. Interestingly, all participants' trial lengths were moderately similar across conditions (delay choice vs. effort choice). Mary averaged 41s to complete low effort trials and 70s to finish high effort trials, compared to her average trial length of 39s and 76s for low and high delay. Andy's trials lengths were slightly longer in the effort choice trials with an average of 68s for low effort and 109s for high effort (compared to 52s and 96s for low and high delay). Like Mary, Jon also had a very close comparison across conditions for trial length with an average time of 46s in low effort and 81s in high effort, compared to his averages of 41s in low delay and 92s in high delay.

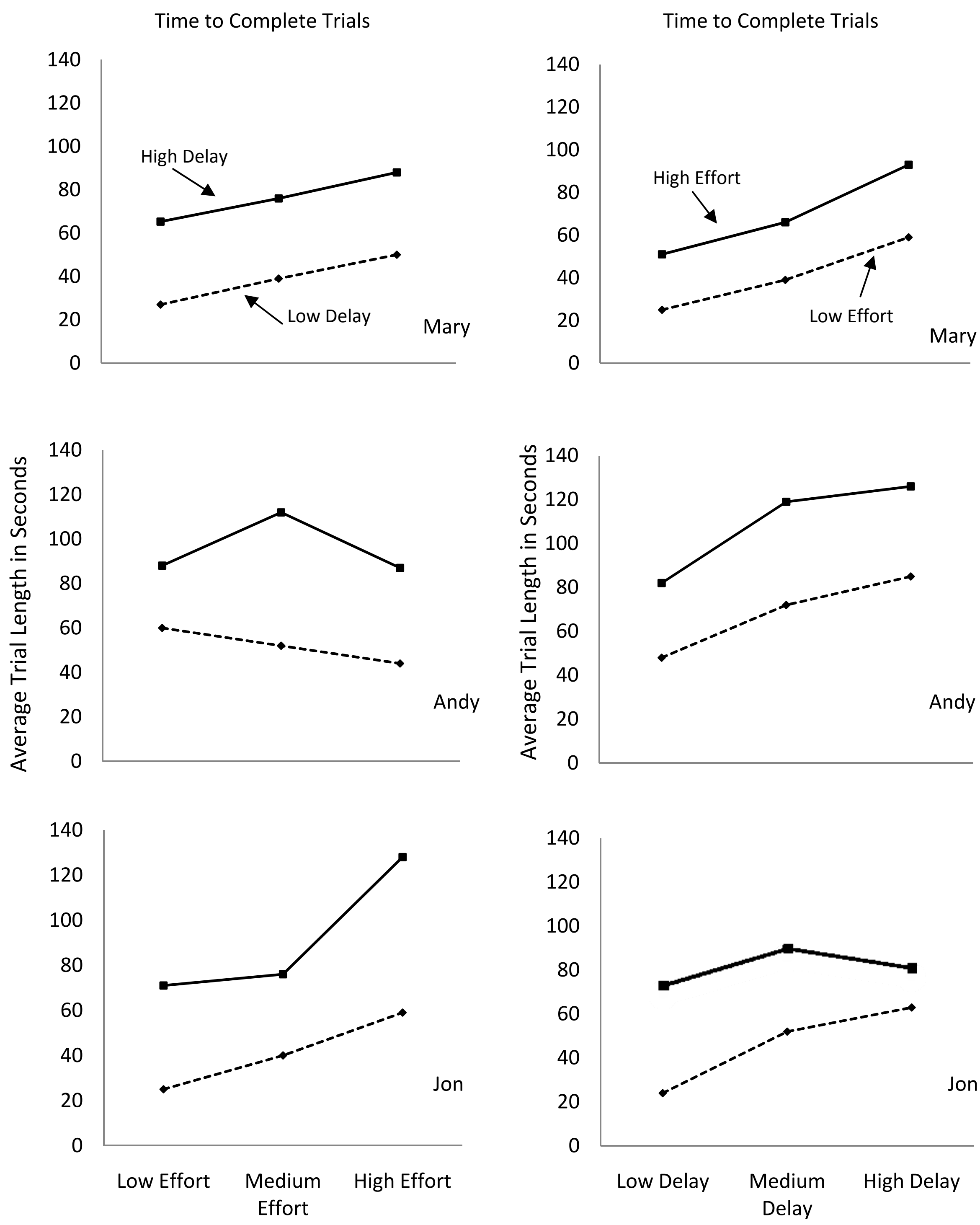


Figure 12. Average trial length per child for all conditions of the study

Accuracy

Accuracy of matching to sample for Mary, Andy, and Jon is displayed in Figure 13 (individual accuracy data is shown in Figure A4). Accuracy was defined as the percent of blocks correctly matched to the sample block formation. On average, Mary matched 95% of the blocks correctly, Andy matched 97% of the blocks correctly, and Jon matched 91% of the blocks correctly. For Mary and Jon, their accuracies of matching the blocks to the sample started high (88-100%) for the first 15-20 sessions, followed by a drop in accuracy. Jon's accuracy fell between 75-85% between sessions 16 and 25 and Mary's accuracy plummeted to 56% at session 25. During those sessions Jon's most common mistakes were mixing up blocks, such as the red and green blocks or the two red blocks, and Mary's mistakes were due to building blocks oppositely or building the blocks with her eyes closed.

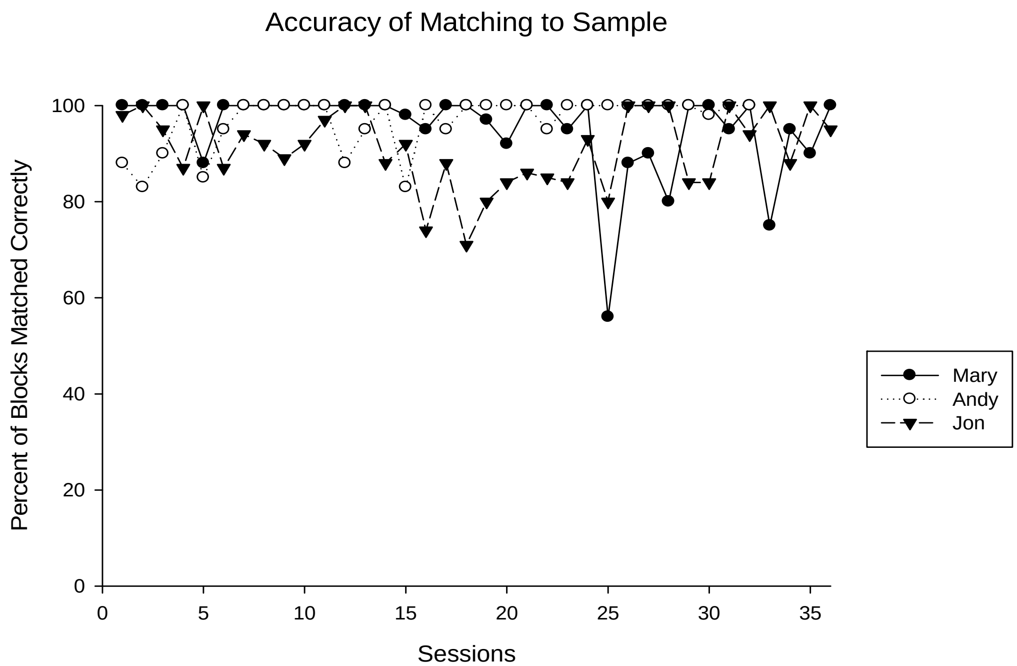


Figure 13. Percent of blocks matched correctly to sample across all sessions.

Andy, however, maintained a high level of accuracy throughout the entire study. Sessions were not conducted over consecutive school days, due to student absences, school breaks, or inability to run trials for other reasons (experimenter absence, room unavailable, field trips, etc). Furthermore children were often able to complete two sessions in one day. Figure 13 shows the accuracy data in terms of cumulative sessions (first to last) in which the children participated. In real time this encompassed 8-10 weeks. Accuracy data per session over calendar days for all participants is shown in Figure A5.

Verbal Responses

At the end of sessions the experimenter asked the participants, “Which choice was your favorite? And why?” Table 7 summarizes the responses from each participant according to the choice trials in effect (effort or delay). Responses were not collected from all sessions for each participant, given time constraints. Mary’s responses were from 31 out of 36 sessions, Andy’s responses were from 25 out of 32 sessions, and Jon’s verbal responses were from 21 out of 36 sessions.

When asked, all participants verbally identified the low effort option as their favorite when sessions required a choice between low and high effort. This further suggests that the children preferred the low effort task to the high effort option, which was strongly supported by the data discussed previously (participants averaged 94-98% of choice responses to low effort). When asked why it was their favorite, the children most commonly answered that the choice was not heavy or that the other option was “too heavy.”

Table 7.

Summary of Verbal Responses When Asked "Which was your favorite and why?"

	EFFORT Favorite? Low E	EFFORT Favorite? High E	EFFORT Verbal Responses	DELAY Favorite? Low D	DELAY Favorite? High D	DELAY Verbal Responses
MARY	100%	0%	– 81% the other one was heavy and no pink – 13% other one heavy – 7% liked the color	93%	7%	– 47% no pink and other one heavy – 47% no pink – 6% other one heavy
ANDY	100%	0%	– 36% it wasn't heavy – 36% the other one was heavy – 21% "I like blocks" – 7% likes blocks and other one heavy	63%	37%	– 72% likes blocks – 18% likes blocks and other heavy – 10% likes doing heavy ones
JON	100%	0%	– 55% it wasn't heavy – 45% liked the color	90%	10%	– 60% liked the color – 10% it wasn't heavy – 10% didn't want to wait – 10% don't know – 10% liked because it was heavy

During sessions in which the children chose between low or high delay, Mary identified the low delay option as her favorite 93% of the time, Andy liked the low delay choice 63% of the time, and Jon favored low delay 90% of the time. When asked why, common answers were that their favorite color wasn't available, the other one was heavy (even though effort was constant), they liked the color of the choice, or that they "like doing blocks." One session, Jon answered "I didn't want to wait." However, over sessions, he responded more often about the color of the choice.

It is important to note that in delay conditions the children's answers did not always match their choice responding. For instance, they may have said low delay was their favorite, when the majority of their responses were for high delay. However, in the effort condition, their vocalized preference consistently matched the data.

CHAPTER IV. DISCUSSION

Summary of Findings

Research has shown that both increasing response effort and delaying reinforcement are effective behavior reducing strategies (Miller, 1970; Ferster & Hammer, 1965). This study isolated and manipulated both response effort and reinforcer delay to evaluate their effects on choice behavior. Specifically, one of the goals of this study was to evaluate if these two variables affect choice differently and exploring if one is a more powerful punisher than the other. Results of the experiment overwhelmingly showed that all participants preferred low effort to high effort alternatives, but not all participants preferred tasks associated with immediate reinforcement to those with high delays. With delay, two of the three participants had variable responding for low or high delay tasks, often alternating between the two during sessions. It appeared that high effort alternatives were avoided more often than high delay alternatives, suggesting that waiting for a reinforcer was not as punishing as exerting physical effort. This suggests that in response effort interventions, when effort is added, the underlying variable of physical effort may be more aversive and the more potent response reducing variable, rather than delays to reinforcement that may result from a task taking longer to complete.

The results of this study add to the literature that supports the notion that increased response effort is aversive (Alling & Poling, 1995; Friman & Poling, 1995) and also provides evidence of preference for non-aversive stimuli in a choice context. Basic research investigating the effects of punishment on choice have found that if punishment is imposed with one or both alternatives in a concurrent arrangement, more behavior will be allocated toward the no-punishment alternative (Rasmussen & Newland, 2008). Though this study did not implement punishment as a consequence for task completion, it does suggest that alternatives associated with punishing stimuli (heavy weights) will be avoided and responses will be allocated to the less aversive alternative.

This experiment was based on the widely supported proposition that response effort is aversive, yet a recent study suggests otherwise. Zarcone, Chen, & Fowler (2008) investigated different response force requirements (2, 4, 8, 16, and 32 grams of force) on disk presses made by mice and found that response rates increased with increases in force requirements. These authors concluded that increased effort was not aversive, but rather served as a form of intermittent reinforcement, as mice engaged in both successful and unsuccessful responses of disk pressing during sessions. Unsuccessful responses included other responses made by the mice during sessions that did not make a complete disk press, and hence, did not result in reinforcement.

Though the current study supports the theory of aversiveness rather than intermittent reinforcement (because choices for high effort alternatives were suppressed not increased), Zarcone, Chen, & Fowler (2008) provided evidence for another function of effort and also discussed some important points in relation to future response effort research. These authors expressed the need for exact definitions of response effort (similar to the proposed definition made in this paper) and the investigation of changes in topography of the target response when effort is increased (using two paws to push a lever, biting a lever, etc). Future research is needed to investigate effort as intermittent reinforcement and also other functions and side effects it may have on behavior.

Another purpose of the current study was to address another area in the response effort literature that is lacking by investigating the relations between response effort and reinforcer delay. All behavior requires effort and time (Zarcone, Chen, & Fowler, 2008) and in response effort interventions the two are inherently intertwined (increasing effort takes longer to obtain reinforcement). Results of the study showed that the participants' preference for low effort was consistent across levels of reinforcer delay, thus, it appeared that changes in reinforcer delay did not affect choice for effort. However, the level of effort may affect preference for low or high reinforcer delay. One child's preference for low delay went from an average of 48% when effort was low to 46% when effort was at the medium level to 70% when effort was high. The other two participants also favored immediate to delayed reinforcement (30s) when effort was high (*M*=61 and 93% for Mary and Jon respectively), however, these results were consistent with their other preferences across low and medium effort as well, thus increasing effort not appear to affect their choice greatly. From these findings it is possible that response effort and reinforcer delay have independent effects on choice (Hunter & Davison, 1982), rather than an interactive relation.

Further discussion of the temporal dimension of responding is needed. This study isolated effort and delay while keeping one variable constant, thus, the two variables were also intertwined in this study, i.e. high effort choices took longer to complete, as well as high delay choices took longer to obtain reinforcement. The data on trial length showed that overall delays to reinforcement from trial start to finish were highest when choices involved high delay or high effort (as shown in Table 6 and Figure 12). In all trials, the participants had the option to choose the quickest access to reinforcement, and shortest task duration by choosing either the low effort or low delay alternatives. And if the overall temporal delay to finishing the task and obtaining reinforcement was the main contributing factor in choice, one would have expected the choice responses to reflect a bias toward low delay and low effort. However, the results only showed a strong bias toward low effort and not low delay. Thus, it further suggests that effort influenced choice differently than reinforcer delay, perhaps independently of the temporal dimension.

Limitations

Though this study has promising implications for understanding response effort and its affect on behavior, there are limitations to what one can conclude. This study utilized a novel procedure and research design. It is possible that the results of this study were due to the procedure itself and may not be found with other preparations. Also, this experiment was implemented with only three participants, which could further limit generality of results. Replications of this study with additional children would help determine if the results found in this study would remain with other participants.

Other factors could also have influenced results, such as those associated with implementing this study in an applied setting. Though the experimental trials were conducted in an analog room, full control of all variables outside of that context was not possible. This limitation was most evident in the number of choice trials that were able to be conducted with all children. In the pre-school, sessions could not take place or session time was cut for various reasons, such as student absence, teacher’s schedules running behind, student noncompliance, the student being pulled from session early for an activity, etc. These unplanned events did not appear to severely affect data collection, as each child participated in over 200 trials replicating choices over several sets of sessions. However, when sessions included less than 6 choice trials (range 1-5) it is not known if the participants' choices during those trials would have changed or shown different results than what was collected in this study.

The variability of choice responding for low or high delay could also have confounding factors. This study found that two of the three children had a variable preference for delay, often choosing between low and high delay alternatives. It is possible that the delay of 30s was not aversive enough for these children, as it was not a variable they chose to avoid. Though research has shown that even short delays can affect responding, it may be possible that a longer delay would have affected choice differently. Gwinn et al. (2005) found that a 54s reinforcer delay affected choice responding. However, in their study, the introduction of the 54s reinforcer delay resulted in variable choosing, similar to this study, therefore, it is not known if a longer delay could result in a consistent choice preference.

It is also possible that the delay was a reinforcing time for the two participants who often chose high delay. During the 30s time, children could have been engaging in private behaviors, such as singing, talking, or counting to themselves or it is possible that the children could have saved an edible reinforcer from the previous trial to eat during the break, though Mary did not receive edibles between trials and Andy received them toward the end of the study. Also trials occurred quickly and successively with an ITI of 15s. The participants (Mary and Andy) could have sought the 30s delay as a break from block building. In reviewing the verbal responses of the children saying they "liked doing the blocks" and looking through other anecdotal recordings of what the participants did while waiting (saying "I'm done, I'm done," tapping the shoulder of the experimenter, making heavy sighs, etc) it is not likely that the 30s delay was a break time for them, but nonetheless it is noteworthy.

On the other hand, Jon's clear preference for low delay could be related to other factors, such as issues of impulsivity. Neef et al. (2005) found that choices of ADHD children were influenced principally by reinforcer immediacy, regardless of receiving ADHD medication or not. Though at 4 years of age Jon was not diagnosed with any type of ADHD, it is possible that he chose immediate reinforcement (low delay) more often than the other two children due to some impairment in ability to wait.

Future Directions

More research is needed to further evaluate the relations between response effort and reinforcer delay. As described earlier, there are different ways to evaluate effort. Presently, the focus was on the response force as determined by the effort of picking up blocks and then putting them in a block design (Category 1 definition of response effort). Future studies should replicate this study using different categories of effort (Table 1), such as changing the number of blocks required to build the design for low and high effort (e.g. FR-3 vs. FR-10; Category 2), or increasing the responses in a chain required to perform the block task from low to high (Category 3). It is possible, and has been suggested by the literature, that different types of response effort have different effects on choice (Sumpter, Temple, & Foster, 1998).

Also, this research design could contribute to the existing literature on reinforcer preference in choice behavior. Research investigating dimensions of reinforcers (Gwinn et al., 2005; Neef et al., 1994; Neef et al., 2005) have utilized a choice procedure in which effort and delay have been manipulated. However, these studies did not use alternatives with both effort and delay components in each choice as the present study did. Furthermore, the present study did not focus on the effects of different reinforcers (preferred vs. non-preferred) on choices involving effort or delay. Therefore, future experiments could look at replicating this study with the added component of low/high preferred items to determine the effects on choice responding. It is not known if separating the highly preferred reinforcers from the less preferred items (across the choice alternatives) would have resulted in different choices across levels of effort and delay.

Finally, this experiment was both time and labor extensive as it required sets of blocks to be set up and removed in quick intertrial intervals (15s) and required over 200 trials to be run with each child. Future replications could utilize the same research design with a different task. With human participants, this experiment could be replicated with a computer task and in the animal laboratory this study could be done with key pecking (pigeons) or lever pressing (rats). Furthermore, it would be interesting to determine if different species respond in different ways to this choice arrangement.

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APPENDICES

APPENDIX A.

Figure Captions

Figure A1.

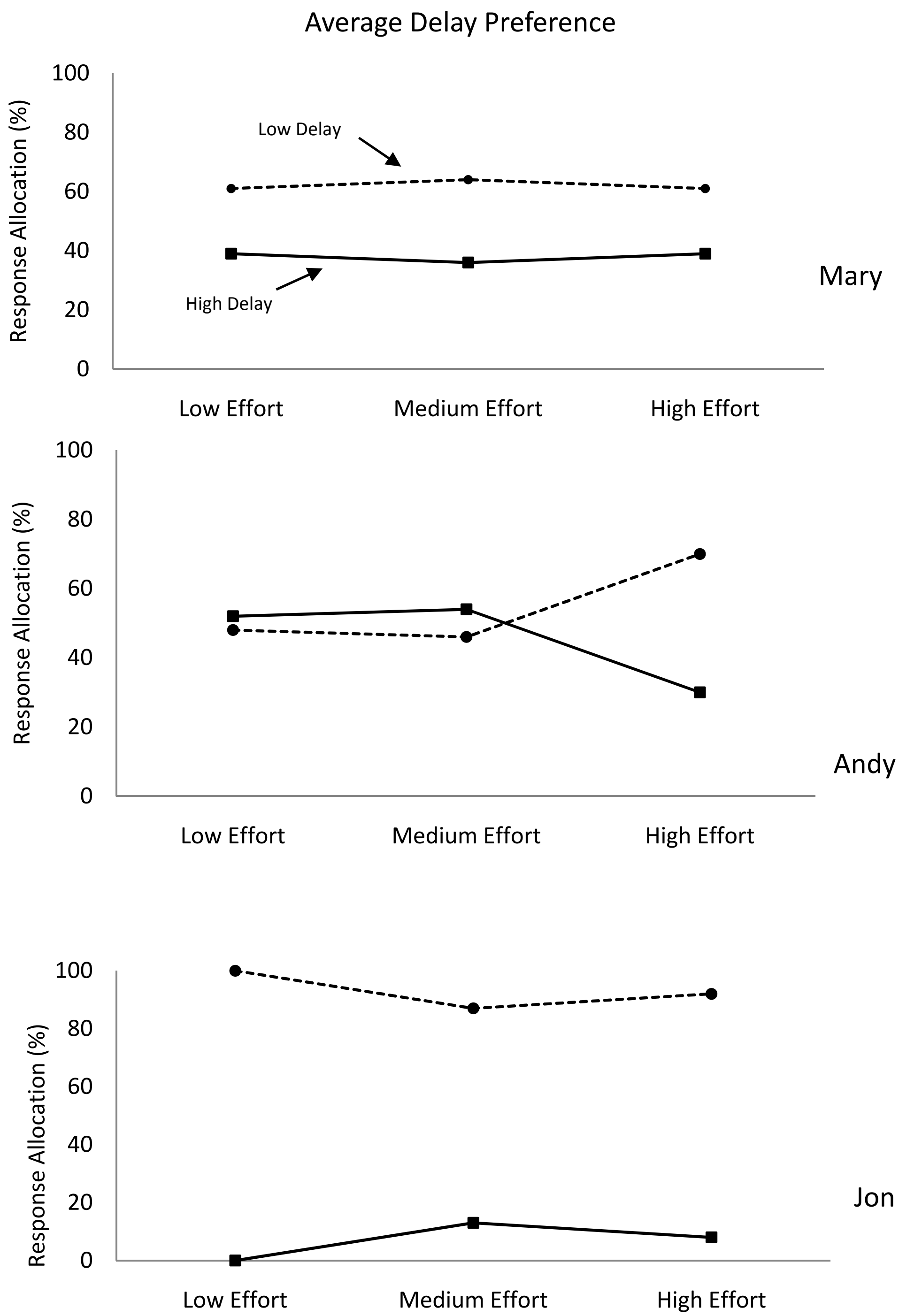
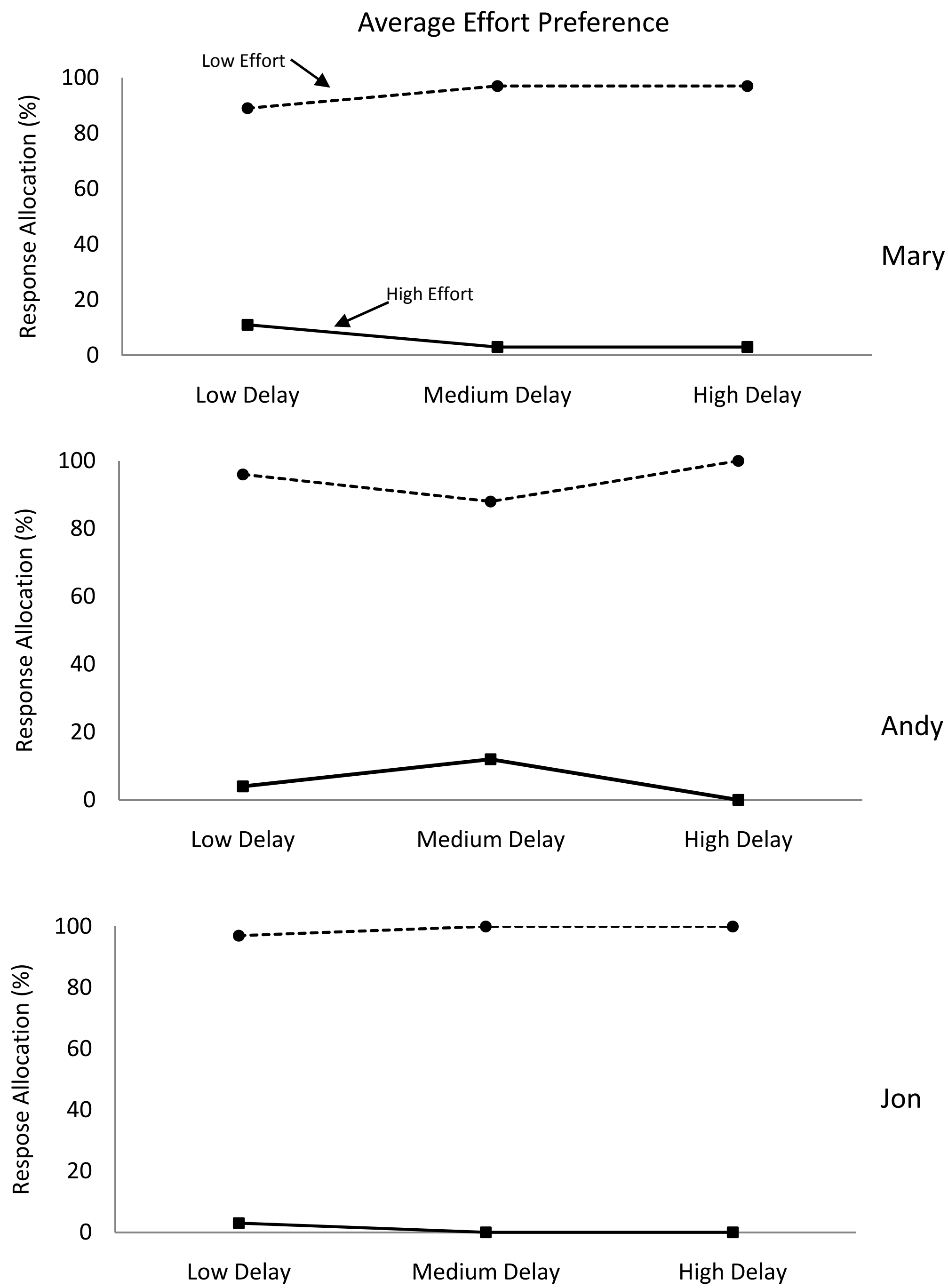
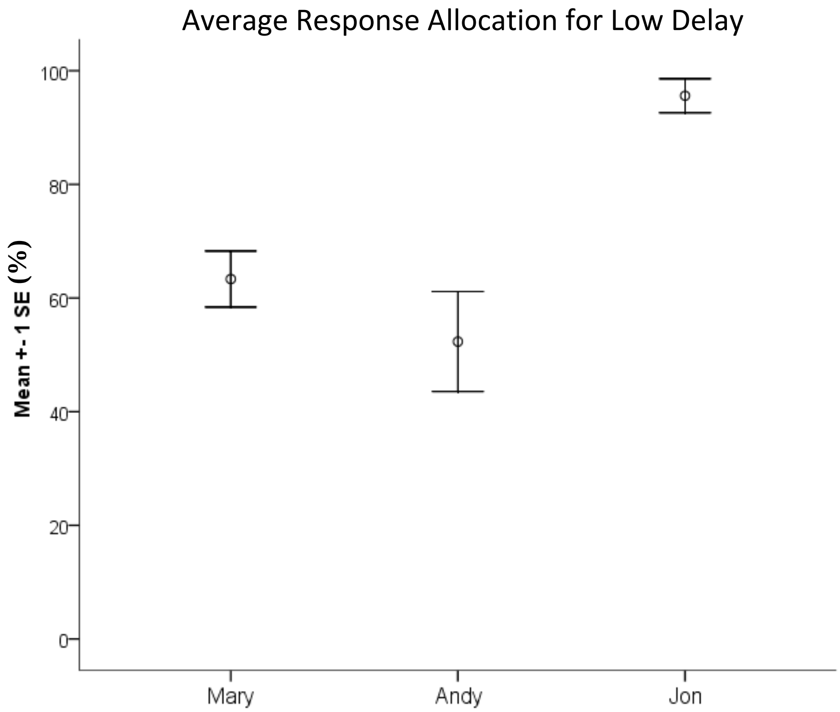

Average Delay Preference
Response Allocation (%)
100
80
60
40
20
0
Low Delay
High Delay
Mary
Low Effort
Medium Effort
High Effort
Andy
Jon

Figure A2.



Average Effort Preference
Low Effort
High Effort
Response Allocation (%)
100
80
60
40
20
0
Low Delay
Medium Delay
High Delay
Mary
Andy
Jon
Respose Allocation (%)

Figure A3.


Average Response Allocation for Low Delay
Mean +- 1 SE (%)
0
20
40
60
80
100
Mary
Andy
Jon

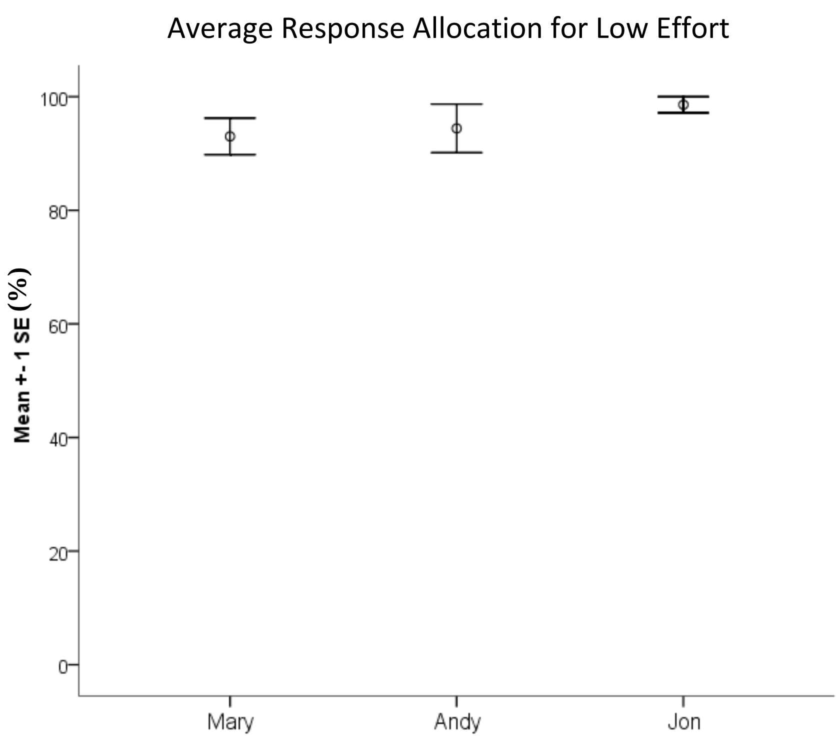
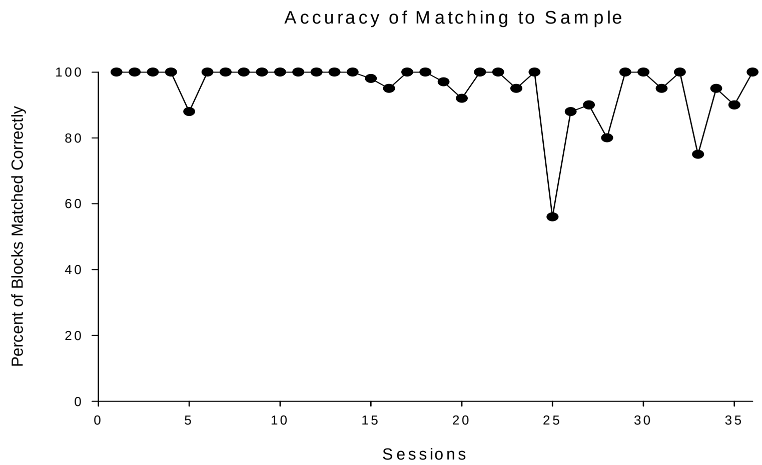
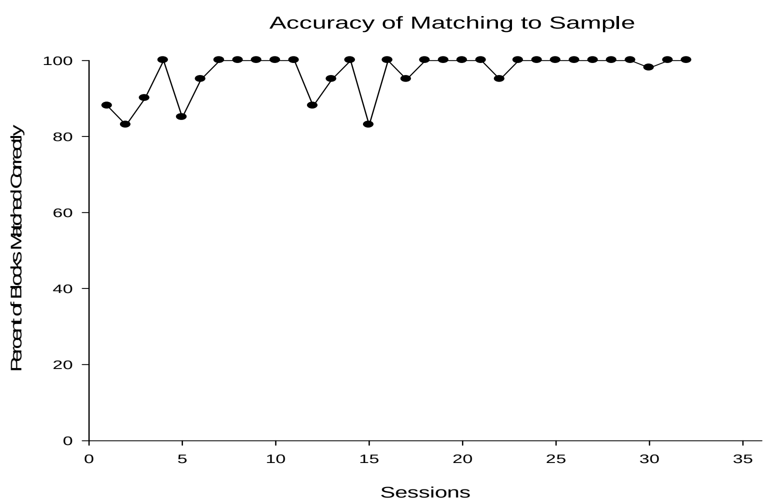

Average Response Allocation for Low Effort
Mean +- 1 SE (%)
0
20
40
60
80
100
Mary
Andy
Jon

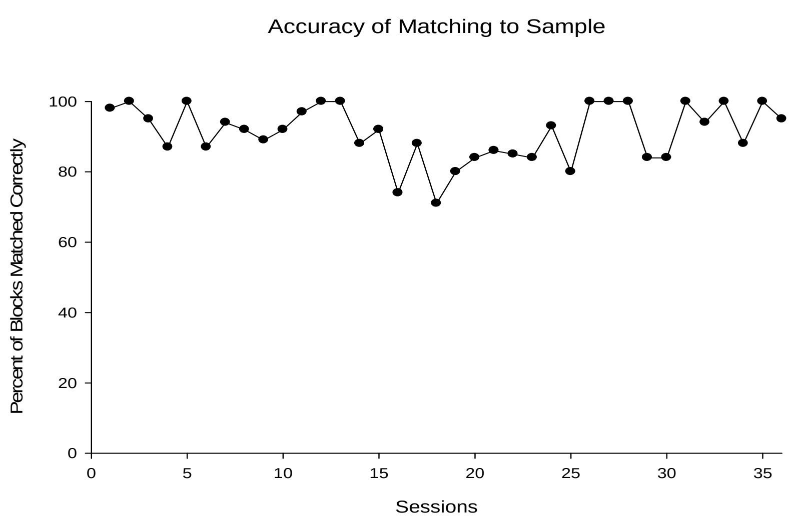
Figure A4.



Mary

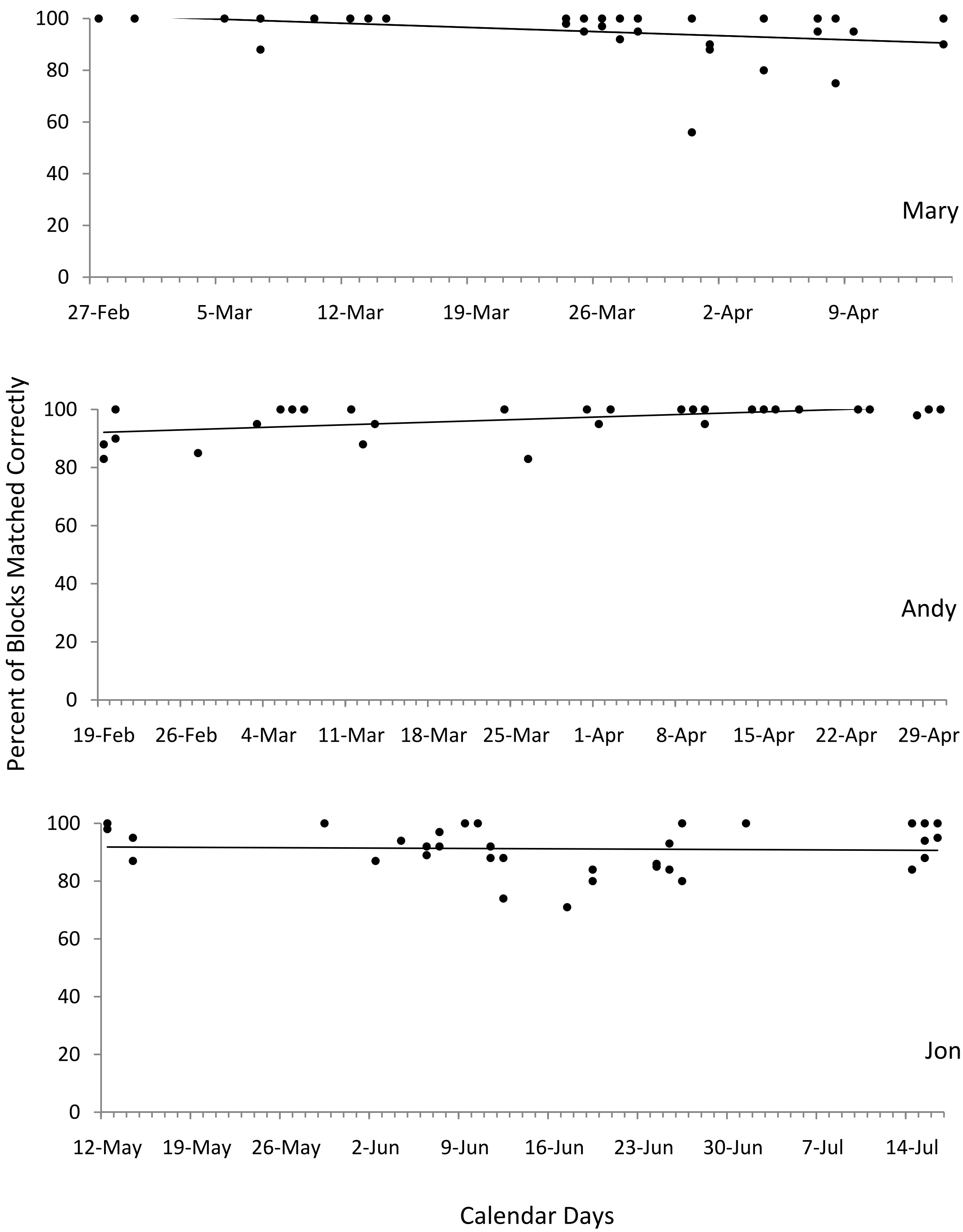


Andy



Jon

Figure A5.



100
80
60
40
20
0
27-Feb
5-Mar
12-Mar
19-Mar
26-Mar
2-Apr
9-Apr
Mary
Percent of Blocks Matched Correctly
100
80
60
40
20
0
19-Feb
26-Feb
4-Mar
11-Mar
18-Mar
25-Mar
1-Apr
8-Apr
15-Apr
22-Apr
29-Apr
Andy
100
80
60
40
20
0
12-May
19-May
26-May
2-Jun
9-Jun
16-Jun
23-Jun
30-Jun
7-Jul
14-Jul
Jon
Calendar Days

APPENDIX B.

Figure Captions

Figure B1. Reinforcer preference assessment data sheet

Figure B2. Data collection sheet used for each session of the study

Figure B1.

Reinforcer Preference Assessment Data Sheet

Participant Code: ____________________ Date: __________________

Part I: Free Choice. Participant will have free access to items in the following list (to be completed individually from interviews). Record the top 6 preferred items that are chosen (A-F).

Choices:

_____________ _____________ _____________ _____________ _____________
_____________ _____________ _____________ _____________ _____________
_____________ _____________ _____________ _____________ _____________
_____________ _____________ _____________ _____________ _____________

A- ______________________ B- ______________________ C- ______________________

D- ______________________ E- ______________________ F- ______________________

Part II: Forced Choice. Assessor will place two items on the table and ask the participant "What do you want?" Circle the choice made according to the letter. Each cell in the grid represents one trial of choices presented. The assessor will complete all cells in the grid in a random order.

Trial Grid: Circle the participant's choice

A B	B C	C D	D E	E F
A C	B D	C E	D F	A D
B E	C F	A E	B F	A F

DATA SUMMARY:

A: _____ / __5__ = ______% **D: _____ / __5__ = ______%**

B: _____ / __5__ = ______% **E: _____ / __5__ = ______%**

C: _____ / __5__ = ______% **F: _____ / __5__ = ______%**

Figure B2.

DATA COLLECTION SHEET

Student Code: ___________ Date: __________ Time: ________ Condition: L ________ R _________

Trial	Choice	Time	Delay	Overall Time	# blocks correct	# blocks total	% correct	Comments (tally)	
								Effort	Delay
SAMPLE TRIALS									
1	Left								
2	Right								
TEST TRIALS									
1	L R								
2	L R								
3	L R								
4	L R								
5	L R								
6	L R								

Which was your favorite? **Why?**

Comments: