An Evaluation of Delay and Effort Discounting as Behavioral Measures of Impulsivity in Preschoolers

Julyse A. Migan-Gandonou

A Dissertation Submitted to the Faculty of

The Chicago School of Professional Psychology

In Partial Fulfillment of the Requirements

For the Degree of Doctor of Philosophy in Applied Behavior Analysis

July 21, 2019

An Evaluation of Delay and Effort Discounting as Behavioral Measures of Impulsivity in Preschoolers

---

A Dissertation Submitted to the Faculty of

The Chicago School of Professional Psychology

In Partial Fulfillment of the Requirements

For the Degree of Doctor of Philosophy in Applied Behavior Analysis

---

Julyse A. Migan-Gandonou

2019

Approved By:

____

Julie A. Ackerlund Brandt, Ph.D., Chairperson
Assistant Professor, Applied Behavior Analysis Department

____

Annette Griffith, Ph.D., Member
Assistant Professor & Associate Chair, Applied Behavior Analysis Department

____

Amy Odum, Ph.D., Member
Professor, Department of Psychology, Utah State University

Acknowledgements

I would first like to acknowledge all the people who have played an influential part in my academic career and whose support and encouragement have led me to this point. I would like to thank Dr. Bertram Ploog for being the person to introduce me to the science of behavior analysis, and for teaching my very first course in Applied Behavior Analysis so well that it acted as the catalyst for me to pursue a career in this wonderful field. I would also like to thank Dr. Haydee Toro for seeing my full potential and encouraging me to pursue a Doctorate degree. Your faith in me and your unwavering support have meant and continue to mean the world to me. I'd like to thank my advisor Dr. Julie Brandt for your advice, guidance, and support during these last three years; Dr. Griffith, for making me appreciate statistical analyses and seeing their utility in Behavior Analysis; and Dr. Odum, for encouraging me to continue my work in delay discounting and for emphasizing the importance and relevance of my research ideas.

To all the people in my personal life who have supported me and made this accomplishment possible, I cannot thank you enough. To my father, thank you for always believing in me and pushing me to go to the top. To my amazing mother, you and your continuous prayers are the reason I am where I am today: "*I will always be the head, never the tail!*". Those powerful words couldn't be truer. To my number one cheerleader at work and the best boss any employee can ask for, Claudia Axelrod, thank you for your unwavering support. To my beloved fiancé and soon-to-be husband Corey, words cannot express how blessed and grateful I am to have had you by my side from the first day of my PhD journey to this moment. You have been my rock and my strongest support system. You have carried me emotionally, mentally, and intellectually throughout this journey and I know I have made you proud.

Dedication

I dedicate this dissertation to my mother Esther Fatima, my soon-to-be husband Corey, and my Faith. I would not have made it to the finish line without these three.

"*I can do all things through Christ Jesus who strengthens me*"- Philippians 4:13

Abstract

In behavior analysis, impulsivity is described as impulsive choice and is viewed as operant behavior described as a preference for smaller immediate reinforcers over larger delayed reinforcers. Impulsivity is related to a number of psychiatric disorders and behaviors of social significance and can be assessed using operant choice tasks and delay discounting tasks from the delay discounting framework. Delay discounting refers to the decrease in the subjective value of rewards as the delay to their receipt increases and describes a behavioral process whereby organisms discount the value of rewards when those rewards are delayed. Another behavioral process whereby organisms discount the value of rewards is effort discounting, which refers to the decrease in the subjective value of rewards as the effort required to obtain the rewards increases. However, this behavioral process has been relatively under-investigated in behavior analysis. The aim of the present study was to evaluate and compare delay and effort discounting as behavioral measures of impulsivity in preschoolers, and to evaluate the utility of the effort discounting framework as a behavioral measure of impulsivity. A choice delay and a choice effort task which paralleled delay and effort discounting tasks were administered to three preschoolers. Results revealed similar but not identical patterns of choice responding across tasks and participants, suggesting delay and effort discounting to be related but not equivalent processes.

Table of Contents

List of Tables

List of Figures

Chapter 1: Nature of the Study

Background

In traditional psychology literature, impulsivity is generally defined as a lack of regard for future consequences and rapid responding to external and internal stimuli (Hamilton et al., 2015), an inability to inhibit responding and reduce reaction times (Forzano, Michels, Carpella, Conway, & Chelonis, 2011), or an inability to delay gratification (Mischel et al., 1989). In behavior analysis, impulsivity is described as impulsive choice and is viewed as operant behavior described as a preference for smaller immediate reinforcers over larger delayed reinforcers.

Impulsivity is related to a number of psychiatric disorders and behaviors of social significance including but not limited to ADHD, bipolar disorder, personality disorders, substance abuse, pathological gambling, obesity, risky sexual behavior (Anokhin et al., 2015; Broos et al., 2012; Hamilton et al., 2015; Petry, 2002; Reynolds & Schiffbauer, 2005). In young children for instance, research suggests that impulsivity can be a predictor of undesirable social behaviors in adolescence (e.g., Bembenutty & Karabenick, 2004; Mischel, Shoda, & Peake, 1988) and preadolescence (e.g., Funder, Block, & Block, 1983; Seeyave, Coleman, Appugliese, Corwyn, Bradley, Davidson et al., 2009). In children with ASD or intellectual and/or developmental disabilities, impulsivity is a hallmark of various aberrant behavior (e.g., aggression) because the immediate reinforcers are more valuable than competing delayed reinforcers (Vollmer, Borrero, Lalli, & Daniel, 1999).

In traditional psychology, impulsivity has been assessed using a variety of validated personality and cognitive tests (Broos et al., 2012; de Wit, 2008). For instance, the most common behavioral test of impulsivity in children is the *delay of gratification* test (see Mischel & Ebbesen, 1970; Mischel, Ebbesen, & Zeiss, 1972; Mischel & Metzner, 1962), which originated from developmental and personality psychology, and was developed to assess preschoolers’ ability to wait for a preferred larger reward. Behavior analytic research, however, suggests that impulsivity can best be assessed using a behavioral framework (Farmer & Golden, 2009), particularly experimental operant *choice tasks* such as the choice delay task (Garon, Johnson, & Steeves, 2011), or the self-control test (Forzano et al., 2011). However, one of the most common behavioral tests and measures of impulsivity is the delay (or temporal) discounting task (Reed & Martens, 2011; Wilson, Mitchell, Musser, Schmitt, & Nigg, 2011), which is derived from the delay discounting framework.

Delay discounting refers to the decrease in the subjective value of rewards as the delay to their receipt increases, and the weakening of consequences as a function of delays (Critchfield & Kollins, 2001; Da Matta, Goncalves, & Bizarro, 2012; Odum, 2011; Staubitz, Lloyd, & Reed, 2018). Delay discounting describes the process responsible for the effects of delays on the value of rewards and the effects of delayed outcomes; therefore, it is not only useful for assessing the effects of delayed consequences on choice behavior, but also for assessing a variety of socially significant behaviors in which impulsivity (i.e., steep discounting) and the many behaviors correlated with it are of concern.

Problem Statement

Another variable which may also influence impulsivity (i.e., impulsive choice) is effort. In behavior analysis specifically, research has shown that increasing response effort generally results in decreased rates of responding in human and non-human organisms (Friman & Poling, 1995; Grossbard & Mazur, 1986; Irvin, Thompson, Turner, & Williams, 1998; Lerman, Addison, & Kodak, 2006) and that there is a strong functional relation between response effort and choice behavior. It has been proposed that the mechanism responsible for this functional relation is effort discounting, which refers to the decrease in the subjective value of rewards as the effort required to obtain the rewards increases (Mitchell, 1999; Mitchell, 2003; Ostaszewski, Babel, &

Swebodzinski, 2013). As with delay discounting, effort discounting is integral to decision-making and choice behavior (Ostaszewski et al., 2013). However, unlike delay discounting, effort discounting is an area with scarce research in behavior analysis (Mitchell, 2003), which is unfortunate considering the fact that impulsivity is choice behavior and research suggests that effort and delay discounting are related processes (Ostaszewski et al., 2013).

Given that delay discounting is an index of impulsivity and research suggests that delay and effort discounting are related, it is possible that the effort discounting framework may function as a complementary index, measure, or assessment of impulsivity (Mitchell, 1999). Although previous studies have investigated the relationship between delay and effort discounting of rewards (e.g., Malesza & Ostaszewski, 2013; Malesza, 2015; Sugiwaka & Okouchi, 2004), to the author's knowledge, no study to date has directly compared delay and effort discounting of real rewards in young children, specifically, preschoolers. Longitudinal studies have shown correlations between impulsive behavior as a child and undesirable social and academic behaviors in later years (Funder, Block, & Block, 1983; Mischel, Shoda, & Peake, 1988; Seeyave et al., 2009), therefore predictive measures such as assessing impulsivity during those early years is warranted, if not paramount.

Purpose of the Study

The aim of the present study was two-fold: a) to evaluate and compare delay discounting and effort discounting as behavioral measures of impulsivity in preschoolers, using choice delay and choice effort tasks involving real rewards and outcomes; and b) to evaluate the utility of the effort discounting framework as a complementary behavioral measure and potential index of impulsivity.

Research Questions and Hypotheses

The overall questions guiding this study were: Can tasks which parallel delay and effort discounting tasks be efficaciously and reliably used with preschoolers to measure impulsive choice? Given that delay and effort discounting are related processes, can effort discounting also function as an index of impulsivity?

In order to evaluate and compare delay and effort discounting as behavioral measures of impulsivity, two choice tasks – a choice delay and a choice effort task, each paralleling delay discounting and effort discounting tasks, respectively – were administered to three preschoolers between the ages of 3 and 4. In each choice task, participants were asked to choose between a smaller immediate or smaller effortless reward, and a larger delayed or larger effortful reward. Delays and effort requirements were systematically manipulated by the experimenter, and data on the frequency and percentage of selections were obtained. Results revealed similar but not identical patterns of choice responding across tasks and participants, suggesting delay and effort discounting to be related but not substitutable for each other with respect to indices of impulsivity.

Chapter 2 will present literature related to impulsivity, delay discounting, and effort discounting. Chapter 3 will present a detailed look at the methodology used to evaluate delay and effort discounting as behavioral measures of impulsivity. Chapter 4 will present the results of the investigation, and chapter 5 will present a detailed discussion of the present study’s findings and their implications. Suggestions for future research will also be discussed.

Chapter 2: Literature Review

In behavior analysis, *impulsivity* is described as impulsive choice and is viewed as operant behavior (Anokhin et al., 2015; Broos et al., 2012; Neef, Bicard, & Endo, 2001) described as a preference for smaller immediate reinforcers (SIRs) and larger delayed punishers (LDPs) over larger delayed reinforcers (LDRs) and smaller immediate punishers (SIPs), or the inability to forego SIRs for LDRs (de Wit, 2008; Forzano, Szuba, & Figurilli, 2003; Hamilton et al., 2015; Morrison, Madden, Odum, Friedel, & Twohig, 2014; Newquist, Dozier, & Neidert, 2012; Patros et al., 2016). In traditional psychology literature, impulsivity is generally defined as a lack of regard for future consequences and rapid responding to external and internal stimuli (Hamilton et al., 2015), an inability to inhibit responding and reduce reaction times (Forzano, Michels, Carpella, Conway, & Chelonis, 2011), or an inability to delay gratification (Mischel et al., 1989). In everyday language, impulsivity is often used to refer to or describe acting without thinking, taking risks, and an inability to wait (de Wit, 2008). Impulsivity is related to a number of psychiatric disorders and behaviors of social significance including but not limited to ADHD, bipolar disorder, personality disorders, substance abuse, pathological gambling, obesity, risky sexual behavior (Anokhin et al., 2015; Broos et al., 2012; Hamilton et al., 2015; Petry, 2002; Reynolds & Schiffbauer, 2005).

Assessing Impulsivity in Children

Although impulsivity has been assessed via a variety of validated personality and cognitive tests in traditional psychology research (Broos et al., 2012; de Wit, 2008), research suggests that impulsivity (e.g., impulsive actions, impulsive choice, impulsive behavior) can best be conceptualized, defined, and assessed using a behavioral framework (Farmer & Golden, 2009). In children particularly, the most common behavioral test of impulsivity is the *delay of gratification test* (see Mischel & Ebbesen, 1970; Mischel, Ebbesen, & Zeiss, 1972; Mischel &

Metzner, 1962), which originated from developmental and personality psychology, and over the years, has been referred to as the “Marshmallow experiment”. The test was developed to assess preschoolers’ ability to wait for a preferred larger reward; in other words, the ability to delay gratification (i.e., self-control). In a typical delay of gratification experiment with procedures similar to those in Mischel’s original experiment, children are asked to choose between a smaller or less preferred reward delivered immediately (or after a self-imposed delay) and a larger or more preferred reward delivered after an experimenter-imposed delay (15 to 20 minutes). Mean wait times is typically the primary measure of impulsivity. Children who initially select the larger or the more preferred reward but switch to the smaller or less preferred reward during the delay are described as impulsive. Children who select the smaller or less preferred reward would be described as impulsive. Inversely, children are described as self-controlled if they initially select the larger or more preferred reward and sustain their choice by waiting the entire delay. This well-known test of impulsivity (and self-control) has been replicated – directly and systematically – in human as well as nonhuman participants (Grosch & Neuringer, 1981; Reynolds et al., 2002).

In young children, cognitive and developmental psychology research suggests that impulsivity can be a predictor of – and has been correlated with – maladaptive or undesirable social and academic behaviors in adolescence (e.g., Bembenutty & Karabenick, 2004; Mischel, Shoda, & Peake, 1988) and preadolescence (e.g., Funder, Block, & Block, 1983; Seeyave et al., 2009). For instance, Mischel et al. (1988) recruited 95 adolescents (mean age of 15 years) who had participated in a series of delay of gratification experiments 10 years before and examined correlations between their ability to delay gratification as preschoolers and their cognitive (i.e., academic) and social coping (i.e., stress tolerance) competencies as adolescents. Consistent with their hypothesis, the investigators found significant and consistent correlations between preschoolers' delay time and their ratings as adolescents. Specifically, children with longer wait times during the prior experiment had higher ratings on academic, social, verbal fluency, and coping competences than their counterparts with lower wait times during the prior experiment. In a similar longitudinal study, Funder et al. (1983) compared delay of gratification indices to personality ratings of 116 children at ages 3, 4, 7, and 11. Their findings revealed that children who delayed gratification (or waited longer) were described as attentive, cooperative, intelligent, and competent, among other personality traits. By contrast, children who did not delay gratification (or did not wait long) were described as irritable, aggressive, and unable to cope with stress, among other descriptors.

In a more recent study, Seeyave et al. (2009) investigated the relationship between the ability to delay gratification at age 4 and being overweight at age 11. A sample of 966 children served as participants, and delay of gratification measures and body mass index (BMI) scores were obtained for each participant at age 4. At age 11, BMI scores were obtained from 805 of the original 966 children, and children with a BMI greater than the 85th percentile at age 11 were categorized as overweight. Results showed that 47% of the 4-year-olds were unable to delay gratification and 33% of the children were overweight at age 11, suggesting an association between delay of gratification and risk of overweight. Furthermore, the results indicated that children who did not delay gratification were 1.3 times more likely to be overweight at 11 years of age.

In children with ASD or intellectual or developmental disabilities, impulsivity – the inability to forego SIRs for LDRs – plays a critical role with respect to problem behavior such as noncompliance/task refusal maintained by escape from non-preferred tasks, or aggression maintained by access to tangibles because the immediate reinforcers are more valuable than competing delayed reinforcers, for which the values are discounted (Vollmer, Borrero, Lalli, & Daniel, 1999). Vollmer et al. (1999), evaluated impulsivity and self- control in two developmentally disabled children who engaged in aggression. Following functional communication training (FCT), the experimenters administered an impulsivity test consisting of a concurrent free-operant choice procedure which varied slightly across participants. For one participant, aggression resulted in the immediate delivery of one edible, and mands resulted in the delayed delivery of three edibles. For the other participant, aggression resulted in immediate 30-s access to television, and mands resulted in delayed 60-s access to television. Results showed aggression was maintained by smaller amounts of immediate access to food or television, indicating that aggression was a form of impulsive behavior.

In behavior analysis, the most common behavioral tests of impulsivity (and self-control) involve experimental operant *choice tasks* such as the choice delay task (Garon, Johnson, & Steeves, 2011) and the self-control test (Forzano et al., 2011); and the delay (or temporal) discounting task (Reed & Martens, 2011; Wilson, Mitchell, Musser, Schmitt, & Nigg, 2011). The delay discounting task is derived from the delay discounting framework, which provides an empirically validated behavioral measure and assessment of impulsivity (Da Matta et al., 2012; Hamilton et al., 2015; Reynolds & Schiffbauer, 2005). However, unlike the delay of gratification test, most delay discounting tasks are typically administered to adults or older children (e.g., 13 years of age and older; see metanalysis by Staubitz et al., 2018), with relatively fewer number of studies administering delay discounting tasks in younger populations. For instance, Reed and Martens (2011) administered a hypothetical delay discounting task to 46 11- and 12-year-old children, in order to examine the relation between children’s responses on the hypothetical task and their responses to immediate and delayed rewards as part of a group classroom contingency. The delay discounting task consisted of asking children to choose between a smaller immediate monetary reward and a larger delayed monetary reward (available after delays ranging from 1 day to 5 years). Following the delay discounting task, a class-wide intervention was implemented to increase on-task behavior. On-task behavior resulted in the delivery of either a sooner reward or a delayed reward (available after 24 hours). Results revealed validity between the hypothetical delay discounting task and the classroom intervention across classrooms. More importantly, results validated the delay discounting task as a measure of impulsive (and self-control) behavior.

Using even younger participants (8- to 12-year-old children), Rosch and Mostofsky (2016) investigated whether children with ADHD discounted rewards more steeply (i.e., were more impulsive) than typically developing children. Children were administered a classic delay discounting task in which some of the choices and rewards were real, and a novel "real-time" delay discounting task in which rewards were real; and were asked to choose between smaller immediate and larger delayed monetary rewards. The investigators' findings were consistent with previous research indicating that children with ADHD discount rewards more steeply – are more impulsive – than typically-developing children.

Taken together, all of these findings (from traditional psychology and behavior analysis research) suggest that a) it is possible to assess impulsivity and self-control in children, and b) it may be beneficial to determine young children's ability to demonstrate self-control (e.g., delaying gratification, foregoing SIRs for LDRs), which may be done using behavioral tests such as the delay of gratification test (traditional psychology) and experimental/operant choice tasks (behavior analysis). However, although impulsivity can be assessed using the delay of gratification framework and the operant-choice behavior analytic framework, research suggests that the two are not equivalent, but rather, discrete yet related measures of impulsivity (Reynolds, de Wit, & Richards, 2002; Reynolds & Schiffbauer, 2005; Forzano et al., 2011). Nevertheless, both are valid behavioral tests of impulsivity, and research findings from both frameworks explain the functional relationship between delays and children's impulsive choice.

Delay Discounting

Delay discounting (also known as temporal discounting) refers to both the decrease in the subjective value of rewards as the delay to their receipt increases, and the weakening of consequences as a function of delays (Critchfield & Kollins, 2001; Da Matta, Goncalves, & Bizarro, 2012; Odum, 2011; Staubitz, Lloyd, & Reed, 2018). Rooted in behavioral economics, delay discounting describes a behavioral process whereby organisms (human and non-human) discount the value of rewards when those rewards are delayed (Francisco, Madden, & Borrero, 2009; Reed, Niileksela, & Kaplan, 2013). Meaning, the longer an individual must wait to receive a reward – or the more delayed an outcome – the less value that reward or outcome. From an applied behavior analytic perspective, this translates into smaller amounts of a reinforcer, if delivered substantially sooner, having a larger reinforcing value than a larger amount delivered later. For example, suppose a child is told she may have 90 minutes of television time at the end of the evening, or she may have 15 minutes of television time immediately, due to the fact that access to the larger reinforcer requires a long delay, its reinforcing value decreases, and the child is likely to select the immediate but smaller reinforcer. Although, this is simply a hypothetical situation, delay discounting has been evaluated and assessed using various experimental and applied methods throughout the literature.

Assessing Delay Discounting

In human and in non-human subjects, delay discounting is typically assessed using *choice tasks* (i.e., choice delay tasks, or CDTs; see meta-analytic review by Marx, Hacker, Yu, Cortese, & Sonuga-Barke, 2018), which involve presenting the subject two concurrently available alternatives, a smaller reward available immediately (smaller immediate reward or SIR) and a larger reward available after a delay (larger delayed reward or LDR), and asking the subject to choose one of the two alternatives (Critchfield & Kollins, 2001; Da Matta et al., 2012). This procedure is repeated across several trials. In many basic research experiments on delay discounting in non-human subjects, choice delay task procedures consist of *forced-choice* trials in which only one stimulus is available, thus "forcing" the subject to experience the consequence associated with that stimulus, and these are followed by *free-choice* trials in which both stimuli are presented concurrently, thus allowing the subject to be "free" to select their preferred option (Calvert, Green, & Myerson, 2010; Evenden & Ryan, 1996; Green & Estle, 2003; Green, Myerson, & Calvert, 2010; Rachlin & Green, 1972). In measuring the frequency of selection between the two options, researchers are able to determine the relative reinforcing value of different amounts of stimuli at various delays.

In many delay discounting experiments with non-human subjects, directly consumable rewards (i.e., primary reinforcers such as foods and liquids) are the commodity of choice (Calvert et al., 2010; Cano, Murphy, & Lupfer, 2016; Green & Estle, 2003; Green et al., 2010; Jackson & Hackenberg, 1996; Mazur, 1987; Reynolds et al., 2002). With human subjects, however, both directly consumable rewards such as food (e.g., Odum & Rainaud, 2003; Odum et al., 2006; Epstein, Salvy, Carr, Dearing, & Bickel, 2010) and abused substances such as cocaine (e.g., Washio, Higgins, Heil, McKerchar, Badger, Skelly, & Dantona, 2011), opioids (e.g., Madden, Bickel, & Jacobs, 1999), cigarettes (e.g., Johnson, Bickel, & Baker, 2007), and alcohol (e.g., Estle, Green, Myerson, & Holt, 2007; Richards, Zhang, Mitchell, & De Wit, 1999; Odum & Rainaud, 2003) and non-consumable rewards (i.e., conditioned/generalized reinforcers) such as money (e.g., Rachlin, Raineri, & Cross, 1991; Myerson & Green, 1995; Green, Myerson, Lichtman, Rosen, & Fry, 1996; Odum & Rainaud, 2003; Odum, Baumann, & Rimington, 2006; Green, Myerson, Oliveira, & Chang, 2013), leisure/activity rewards (e.g., music, DVD, books; Charlton & Fantino, 2008); access to free play, (e.g., Falcomata, Cooper-Brown, Wacker, Gardner, & Boelter, 2010), points (e.g., Hyten, Madden, & Field, 1994), tokens (e.g., Reed & Martens, 2011), sexual partners (e.g., Jarmolowicz, Lemley, Asmussen, & Reed, 2015), and a combination of various commodities (body image, retirement, medical treatment, retirement; e.g., Weatherly, Terrell, & Derenne, 2010) have been used to assess delay discounting. Money is the most commonly used non-consumable reward (Madden & Johnson, 2010); however, researchers suggest that directly consumable rewards are generally discounted more steeply than non-consumable rewards. For instance, Estle et al. (2007) compared delay and probability discounting of directly consumable (i.e., candy, soda, and beer) hypothetical rewards and non-consumable hypothetical rewards (i.e., money) in 47 undergraduate students. Their findings revealed steeper discounting of the consumable rewards than the non-consumable ones; meaning, the consumable stimuli (i.e., candy, soda, and beer) decreased in value at a higher rate than the non-consumable stimulus (i.e., money).

In a similar prior study, Odum and Rainaud (2003) examined delay discounting functions of money (non-consumable reward) compared to food and alcohol (directly consumable rewards) in 20 adult participants with no self-reported medical or psychological disorders. Participants were administered a discounting task in which they were asked to choose between hypothetical immediate and delayed food, hypothetical immediate and delayed alcohol, and hypothetical immediate and delayed money. Consistent with prior research (Kirby & Guastello, 2001), Odum and Rainaud found that alcohol and food were discounted more steeply than money; however, alcohol and food were discounted at similar rates.

Irrespective of the types of commodities used in human delay discounting research, much of delay discounting experiments use choice delay tasks or choice scenarios in which the rewards (i.e., money) or outcomes (e.g., gains, losses) are hypothetical (see reviews by Critchfield & Kollins, 2001; Da Matta et al., 2012; & Odum, 2011). Several reviews of the delay discounting literature have found hypothetical (e.g., monetary) rewards to be the most commonly used commodity (e.g., Critchfield & Kollins, 2001; Da Matta et al., 2012; Hamilton et al., 2015; Staubitz et al., 2018). In hypothetical choice scenarios, prior to administration of the choice delay tasks, participants are informed that the questions are hypothetical and that they will not actually receive the reward; however, they are instructed to choose as though they would be receiving the reward (Estle et al., 2007; Johnson & Bickel, 2002; Odum & Rainaud, 2003). Although it is very common to use hypothetical outcomes, several delay discounting studies have employed the use of real outcomes (e.g., Reynolds & Schiffbauer, 2004; Scheres, Tontsch, Thoeny, & Kaczkurkin, 2010), potentially real outcomes (e.g., Buono, Whiting, & Sprong, 2015), and/or a combination of real and hypothetical outcomes (e.g., Johnson, 2012; Rosch & Mostofsky, 2016; Scheres, Sumiya, & Thoeny, 2010; Shiels et al., 2009). For example, Reynolds and Schiffbauer (2004) developed an experiential discounting task (EDT) to measure state changes (i.e., sleep deprivation) in delay discounting of real monetary rewards in 12 adult participants (18-23 years of age). Across blocks of trials, participants made choices between a certain, immediate-adjusting amount of money and a probabilistic, delayed-fixed amount of money (e.g., 30 cents). The EDT differed from other discounting tasks or choice delay tasks in that participants experienced choice consequences and delays (for every single choice) in real time, during the assessment. Results suggested EDT to be an effective procedure for measuring state changes in delay discounting and provided preliminary support for the use of EDTs as measures of discounting.

Scheres et al. (2010) also used a similar discounting task to measure delay discounting in 137 typically developing and ADHD-diagnosed participants (6-17 years of age). Participants were assigned to three groups (control/typically developing, ADHD-Combined, and ADHD-Inattention) and were exposed to three discounting tasks in which they chose between a small, variable reward (e.g., 6 cents) delivered immediately and a large, constant reward (e.g., 10 cents) delivered after a delay (5, 10, 20, 30, or 60 seconds). For each choice, children experienced the outcome (amount and delay of reinforcement) associated with that choice. Steeper discounting (i.e., smaller AUC values) was associated with the ADHD-inattentive group than with the ADHD-combined group. Consistent with Reynolds & Schiffbauer's findings on the use of real, experiential tasks and outcomes, Scheres et al.'s findings also demonstrate the utility of choice tasks involving real consequences.

Aside from the practical, cost-efficient advantages of using hypothetical rewards, Odum (2011) proposed some reasons why hypothetical rewards are not only commonly used, but why they may be effective in assessing delay discounting in human delay discounting experiments: a) individuals are reporting on current choice behavior, as opposed to past behavior; b) individuals' answers are neither right nor wrong because there is no obvious right or wrong answer, and c) there are no punishment contingencies associated with the individual's choice. However, it has been argued that the absence of real consequences (i.e., consumption of or contact with rewards) may reveal different (i.e., slower) discounting rates (Navarick, 2004). Furthermore, for populations with difficulties demonstrating abstract reasoning or understanding the concept of time (e.g., intellectually and developmentally disabled populations), it has been argued that experiential tasks may be more appropriate, given that the individual is directly exposed to and directly contacts the outcomes associated with their choice (Hamilton et al., 2015). Nevertheless, regardless of the nature of the outcomes (real vs. hypothetical), the delay discounting literature shows strong parallels in degree of discounting between the two (Critchfield & Kollins, 2001; Johnson & Bickel, 2002; Odum, 2011). Additionally, a review of recent (2005-2016) publications on delay discounting in children revealed hypothetical choice tasks and outcomes were used twice as much as real ones (see review by Staubitz et al., 2018). This suggests that even in children populations, in which discounting may be difficult to measure using non-operant choice procedures, choice delay task procedures using hypothetical choices and outcomes are efficacious.

Measuring Delay Discounting: Administering Discounting Tasks

An example of a typical discounting task administration may consist of asking participants to choose between an SIR (e.g., $5 now) and an LDR (e.g., $10 in 7 days). Oftentimes, computerized discounting tasks involve the participant clicking on or touching the hypothetical item on the screen, which is recorded as a selection (Buono et al., 2015; Estle et al., 2007; Scheres et al., 2010); whereas, non-computerized administrations (e.g., paper-and-pencil questionnaires, index cards, etc.) involve the participant indicating their choice by circling, touching, pointing to, or vocalizing their selection (Green, Fry, & Myerson, 1994; Madden et al., 1999; Odum & Rainaud, 2003; Rachlin, Raineri, & Cross, 1991) and these (computerized or non-computerized) procedures are repeated across several trials until an indifference point is identified. The *indifference point* is the value at which participants' preferences switch from the LDR to SIR (Madden & Johnson, 2010; Odum, 2011); meaning, the indifference point represents the subjective value of the LDR, or the point at which the SIR and the LDR are equal in terms of subjective value.

In nearly all delay discounting experiments with human and non-human subjects, an adjusting-amount procedure (e.g., Richards, Mitchell, De Wit, & Seiden, 1997), an adjusting-delay procedure (e.g., Mazur, 1987), or a combination of both (e.g., Green, Myerson, Shah, Estle, & Holt, 2007) is used to obtain the indifferent point(s). In the *adjusting-delay* procedure, the delay to the larger reward is systematically manipulated (increased or decreased), while the SIR remains constant. In the *adjusting-amount* procedure, the amount of the SIR is manipulated (increased or decreased) while the LDR remains constant. In both adjusting-amount and adjusting-delay procedures, a fixed (e.g., Rachlin et al., 1991) or titrating sequence (e.g., Mazur 1987; Richards et al., 1997) can be used to determine the sequence of choice presentation across delays, and the SIR and LDR amounts can be presented in ascending (increasing SIR) or descending (decreasing SIR) order (Critchfield & Kollins, 2001). Another procedure used in delay discounting experiments is the *within-and-between-session procedure* developed by Evenden and Ryan (1996). In this procedure, delay discounting is measured by gradually and systematically increasing delays of reinforcement within one session and across/between multiple sessions. Irrespective of the type of DDT measurement procedure used, most DDTs aim at determining the indifference point(s) at each delay, which is subsequently used in data analyses.

Quantitative analyses. In behavioral models of delay discounting, the hyperbolic equation proposed by Mazur (1987) is the most supported method to analyze and quantify delay discounting results, or the degree of discounting for a particular reward. The *hyperbolic equation* proposes that $V= A/1 + kD$, where V represents the current subjective value of the LDR, A represents the amount of the LDR, D represents the delay of the LDR; and *k* is a free parameter interpreted as the degree of discounting, or an index of sensitivity to delay (Critchfield & Kollins, 2001). Large *k* values are indicative of steep discounting and preference for SIRs over LDRs, which is interpreted as *impulsivity*; whereas, small *k* values are indicative of more gradual (or slow) discounting and preference for LDRs over SIRs, which is interpreted as *self-control* (Odum, 2011). The *hyperbolic discounting curve* is a visual analysis of the degree of delay (and other types of) discounting and is obtained by plotting indifference points for each delay onto the x-axis of a graph and using nonlinear regression techniques (Madden & Johnson, 2010). The steeper the discounting curve/slope, the steeper the rate or degree of discounting (Odum, 2011).

Recently, an increasingly common measure of delay discounting has been the area under the curve (AUC; e.g., Buono et al., 2015; Myerson, Green, & Warusawitharana, 2001; Ong, Graves, Berry, Odum, & Twohig, 2018; Reed & Martens, 2011; Weatherly et al., 2010). AUC is a theoretically neutral measure of discounting, consisting of drawing vertical lines from each data point (subjective values) to the x axis values (delays in time), thus forming a series of trapezoids below the discounting (hyperbolic) curve (Myerson et al., 2001). AUC is calculated by summing the areas of each trapezoid. The smaller the area under the curve, the steeper the discounting (more impulsive). AUC values can be normalized such that AUC can range from 0.0 (steepest discounting) to 1.0 (no discounting). A previously proposed advantage of using AUC as a measure of discounting is that it provides a neutral, simple, empirical, non-theoretical alternative to the theoretical models of discounting (Myerson et al., 2001; Odum, 2011).

Overall Implications

Delay discounting inarguably provides an account for the effects of delays on the value of rewards and the effects of delayed outcomes. Delay discounting describes a process, and delay discounting research has demonstrated that as the delay to receipt of a reward increases, the value of that reward decreases (e.g., Critchfield & Kollins, 2001; Da Matta et al., 2012; Epstein et al., 2010; Madden & Johnson, 2010; Odum, 2011; Odum & Baumann, 2010). Delay discounting research has also demonstrated that delay discounting can be analyzed across species (Broos et al., 2012), populations (Ahn et al., 2011; Buono et al., 2015; Johnson et al., 2007; Wilson et al., 2011), age groups (Patros, Alderson, Kasper, Tarle, Lea, & Hudec, 2016; Green et al., 1994; Green, Myerson, & Ostaszewski, 1999), and commodities (Weatherly et al., 2010). Delay discounting is not only useful for assessing the effects of delayed consequences on choice behavior, but also for assessing a variety of socially significant behaviors in which steep discounting, and the many behaviors correlated with it, is of concern. It is also worth noting that delay discounting also has predictive value in determining how likely an individual is to forego larger future – and possibly more beneficial – rewards or outcomes for smaller immediate – less beneficial and potentially harmful – rewards or outcomes (Isen, Sparks, & Iacono, 2014; Reed & Martens, 2011). Simply stated, steep discounting is indicative and predictive of impulsivity, and delay discounting provides an empirical and behavioral model of impulsive choice (Anokhin, Grant, Mulligan, & Heath, 2015).

Effort Discounting

Basic and applied research on delay discounting, delayed consequences, and the immediacy of reinforcement have successfully and repeatedly demonstrated that a) delayed outcomes and consequences (reinforcing and punishing) influence behavior – including choice behavior – and b) delayed outcomes and consequences are much less valuable and consequently much less effective than immediate ones. However, another variable which may also influence choice – including impulsive choice – is effort; specifically, the relation between effort and choice behavior.

Effort in Behavior Analysis

Decades of behavior analytic – basic and applied – research have shown that increasing response effort generally results in decreased rates of responding in human and non-human organisms (Friman & Poling, 1995; Grossbard & Mazur, 1986; Irvin, Thompson, Turner, & Williams, 1998; Lerman, Addison, & Kodak, 2006). Response effort has been manipulated in various interventions to reduce aberrant and maladaptive behavior in individuals with intellectual developmental disorders (Hanley, Piazza, Keeney, Blakeley-Smith, & Worsdell 1998; Piazza, Roane, Keeney, Boney, & Abt, 2002; Van Houten, 1993; Zhou, Goff, & Iwata, 2000).

Van Houten (1993) manipulated response effort as an intervention to reduce face-slapping of a 10-year-old boy with severe developmental disability. The effort required to engage in face-slapping was increased by placing a pair of 0.68-kg wrist weights on the participant's wrists for multiple 10-min intervals. Face-slapping decreased significantly while the wrist weights were worn and after they were removed. These findings demonstrated a negative functional relationship between response effort and rate of responding; meaning, as effort increased, the rate of responding decreased. These results have been replicated and validated by Hanley et al. (1998), on the self-injurious behavior of a 6-year-old boy with severe developmental disability and by Piazza et al. (2002), on the pica of three female teenagers with developmental disabilities. Taken together, these studies demonstrate that a) increasing effort is an effective intervention for various types of problem behavior; and b) there is a strong functional relation between response effort and behavior, including choice behavior. However, none of these studies have directly investigated the underlying mechanism responsible for this functional relation; nor have they evaluated the effect of effort on a stimulus' reinforcing value. This may be evaluated using effort discounting.

Effort discounting refers to the decrease in the subjective value of rewards as the effort required to obtain the rewards increases (Mitchell, 2003; Ostaszewski, Babel, & Swebodzinski, 2013). In other words, the higher the response effort (or work) required to obtain a reward, the less valuable the reward. Research on effort discounting is predominantly found in the neuroscience and psychopharmacology literature, where it is used to assess motivation and related aberrant motivational states and deficits (e.g., apathy, depression) commonly found in clinical disorders such as schizophrenia (Docx, de la Asuncion, Sabbe, Hoste, Baeten, Warnaerts, & Morrens, 2015; Hartman, Hager, Tobler, & Kaiser, 2013; Klein-Flugge, Kennerly, Saraiva, Penny, & Bestmann, 2015; Reddy et al., 2015).

As with delay discounting, effort discounting research suggests that this process is integral to decision-making and choice behavior (Ostaszewski et al., 2013). However, unlike delay discounting, effort discounting is an area with scarce research in behavior analysis (Mitchell, 2003). Despite the abundance of basic and applied research on response effort and the validated effectiveness of manipulating response effort as treatment for aberrant behaviors (see Friman & Polling, 1995), there appears to be no substantial research examining the mechanism(s) responsible for the negative functional relationship between effort and operant behavior. Given that choice is an operant behavior, we can speculate that effort discounting may be the underlying mechanism responsible for that functional relationship between effort-based interventions and problem behavior.

Assessing Effort Discounting

Effort discounting has been primarily assessed in adult populations using hypothetical (Nishiyama, 2014; Ostazewski et al., 2013; Sugiwaka & Okouchi, 2004), real (Docx et al., 2015; Floresco, Tse, & Ghods-Sharifi, 2008) and potentially real rewards and/or effort requirements (Mitchell, 1999). Physical and cognitive efforts are the most common types of effort investigated

(Chong, Bonnelle, & Husain, 2016) and research suggests the two types are positively correlated (Ostaszewski et al., 2013); meaning, as the steepness of physical effort discounting increases, so does the steepness of cognitive effort discounting. A typical effort discounting experiment consists of a task in which participants are asked to choose between low-effort (or effortless) tasks for smaller rewards and high-effort tasks for larger rewards (Mitchell, 2017).

Nishiyama (2014) examined whether individuals discounted the value of monetary rewards if more effort was required to obtain them. Ninety-three undergraduate students completed a questionnaire in which they were asked to choose between completing an effortless task (e.g., engaging in no work) for a smaller amount of money and an effortful task (e.g., engaging in the most subjective effortful physical and/or psychological work) for a larger amount of money. Results were that participants initially selected the higher effort higher reward option but switched their selections to the lower effort lower reward option as both rewards became equivalent. Consistent with other effort discounting studies (Mitchell, 1999), these findings demonstrated that rewards were discounted steeply when the effort required to obtain them increased.

Mitchell (1999) investigated whether cigarette smokers were more impulsive than non-smokers using personality questionnaires and three behavioral choice tasks (i.e., delay task, probability task, and work task) as measures of impulsivity. Participants (20 smokers and 20 "never" smokers) were asked to choose between a "standard" or an "alternative" option in each task. In the effort discounting task ("work task"), the maximum voluntary contraction (MVC) or the strength needed to successfully squeeze a hand dynamometer, was used to measure effort. The standard option for the effort task was $10.00 available after squeezing a hand dynamometer for 10 s with 10, 25, 50, 75, 90, or 100% of the MVC measured during their initial screening.

The alternative option for the effort task ranged from $0.01 to $10.50 available after 10 s of a 10% of the MVC from their initial screening. Results showed that regular smokers were more impulsive than non- or never-smokers on all measures of impulsivity, including the effort discounting task, similar to results found in delay discounting research comparing smokers to non- or never-smokers (e.g., Johnson et al., 2007).

It has been suggested that effort and delay discounting are “related but not equivalent processes” (Ostaszewski et al., 2013). Consistent with that assumption and given that delay discounting is an index of impulsivity, it is possible that the effort discounting framework may also function as a complementary index, measure, or assessment of impulsivity (Mitchell, 1999). Although previous studies have investigated the relationship between delay and effort discounting of rewards (e.g., Malesza & Ostaszewski, 2013; Malesza, 2015; Sugiwaka & Okouchi, 2004), to the author’s knowledge, no study to date has directly compared delay and effort discounting of real rewards in young children, specifically, preschoolers. Given that longitudinal studies have shown correlations between impulsive behavior as a child and undesirable behaviors in later years (Seeyave et al., 2009), assessing impulsivity during those early years as a preventative measure is warranted, if not paramount. Therefore, the purpose of the present study was two-fold: a) to evaluate and compare delay discounting and effort discounting as behavioral measures of impulsivity in preschoolers, using choice delay and choice effort tasks involving real rewards and outcomes; and b) to evaluate the utility of the effort discounting framework as a complementary behavioral measure and potential index of impulsivity.

Chapter 3: Research Design and Method

Method

Participants

Three typically developing children (Gabriel, 3-year-old Hispanic male; Edith, 4-year-old African-American female; and Elena, 4-year-old bi-racial female) were recruited and served as participants. Edith and Elena were recruited from a local private school, and Gabriel was recruited from the first author's place of employment. None of the children's parents reported any diagnosis of Autism Spectrum Disorder, Intellectual Disabilities, neurological disorder, or developmental delays. All participants communicated using full and complete sentences and demonstrated the ability to follow at least three- to five-step instructions (e.g., "Touch your nose", "Point to the blue crayon", etc.), which was required in order to be eligible to participate in the study. Additionally, all participants were either native English-speakers (Edith and Elena) or bi-lingual with English as their primary language (Gabriel). None of the participants' parents reported any visual and/or hearing impairments at the time of the study.

Consent & Assent. Informed consent was obtained from the participants' primary caregivers prior to the start of the study. During the consent process, each participant's primary caregiver was asked to provide their child's age, gender, developmental history, racial and ethnic background (e.g., White/European descent, Black/African descent, Hispanic/Latino, Mixed-race, or Asian), and complete a brief questionnaire regarding their child's preferred foods, toys, and leisure items, including any food allergies (see procedures below). Assent was obtained from each participant prior to the beginning of each session. Assent procedures consisted of the experimenter asking the participant if he or she wanted to play a "choosing game" with candy and waiting for the participant to indicate "yes" by vocally saying "yes" or nodding "yes", following which the experimenter escorted the participant to the session area. If the participant did not provide assent (as evidenced by the participant shaking their head "no" or crying), the experimenter said, "It's ok, you don't have to, maybe another time", and would let the child resume their previous activity.

Settings & Materials

Edith's and Elena's sessions were conducted in the back of their regular classroom during times when the other students were in a different classroom (e.g., art class). The back of the classroom was selected due to the fact that it was the only area of the classroom with bare walls and no materials other than chairs and desks. Prior to the beginning of each session, the room was arranged such that only one desk and two to three chairs were present. Elena's sessions were conducted three days a week and each session lasted approximately one to one and a half hours a day. Edith's sessions were conducted on days during which her teacher reported that she completed her work. Her sessions lasted one and a half to two hours a day.

Gabriel's sessions were conducted in a social skills room at the experimenter's place of employment. Prior to the beginning of each session, the social skills room was cleared of toys, additional chairs and tables, and other potential distractors. The room was arranged such that only a small table and three chairs were present. Gabriel's sessions were conducted one day a week and lasted two hours per day.

For all participants, session materials included various snack and candy items identified from the questionnaire completed by each participant's parents prior to the start of the study. Additional session materials included a push button, timers, white 5-inch round paper plates, and an iPad tablet and laptop computer for data collection.

Dependent Variables & Response Measurement

The primary and secondary dependent variables were *frequency of selections* and *percentage of impulsive choices*, respectively. A *selection* was defined as the participant pointing to or touching (using one hand) one of the presented options. *Impulsive choice* was defined as any selection of the smaller immediate reinforcer (SIR) or the smaller effortless reinforcer (SER). If a participant made his or her selection using both hands or using any other body part or object, the experimenter paused the trial, modeled the correct selection response, then re-started the trial and re-presented the option(s). A tertiary dependent variable was *area under the curve* (AUC), which was used to quantify impulsive choice. Data were also collected on *correct experimenter responses*, defined as the delivery of the SIR/SER, control, and LDR/LER plates according to the condition- and selection-specific delays, for procedural integrity.

Interobserver Agreement & Procedure Integrity

Prior to the start of the study, the primary investigator trained a second observer until 90% accuracy was attained. The trained second observer (a master-level Board Certified Behavior Analyst or a Registered Behavior Technician) simultaneously but independently collected data on frequency of selections during 66.38% of all sessions for all participants. A trial-by-trial interobserver agreement (IOA) method was used to assess interobserver reliability. An agreement was scored if the same responses were scored in a trial by both observers. IOA calculations consisted of dividing the number of agreements by the total number of trials and multiplying the result by 100%. IOA for all of Gabriel’s sessions averaged at 94.16 % (range of 87.5% - 100%); IOA for all of Edith’s sessions averaged at 98.33% (range of 93.33% - 100%); and IOA for all of Elena’s sessions averaged at 100%.

The secondary observer also collected data on experimenter responses during 50% of sessions. A trial-by-trial method was used to assess procedural integrity also. A correct response was scored if the observer scored the researcher as engaging in the correct response in a trial based on the condition and selection of that session and trial, respectively. At the end of each session, the number of correct behaviors was divided by the total number of trials and multiplied by 100%. Correct experimenter responses across all sessions for all participants averaged at 99.55%.

Experimental Design

A concurrent-schedule arrangement (also referred to as a concurrent operants paradigm) was used to evaluate selection responses in the reinforcer magnitude assessment, delay assessment, choice delay task, effort assessment, and choice effort task conditions. Concurrent-schedule arrangements in both basic and applied research have been used extensively to evaluate choice responding in organisms and are most appropriate for identifying stimuli correlated with higher rates of responding (Fisher & Mazur, 1997; Fisher, Piazza, Bowman, Hagopian, Owens, & Slevin 1992). In the present study, three options were presented concurrently in each trial, and participants were asked to select one of the three presented options. One of the three presented options was an empty plate, which served as the control option, thus showing experimental control (Newquist et al., 2012).

Indirect preference assessment. The Reinforcer Assessment for Individual with Severe Disabilities (RAISD; Fisher, Piazza, Bowman, & Amari, 1996) was administered by the experimenter, to each participant’s primary caregiver during the consent process. The RAISD is an empirically validated structured interview designed to integrate caregiver reports of potential reinforcers with operant choice assessments.

Paired-stimulus preference assessment (PSPA). Prior to the study, six stimuli (i.e., candy) were compared using a 30-trial paired-stimulus preference assessment (PSPA) with procedures similar to those developed by Fisher et al. (1992). This was done to identify at least two highest- and moderately preferred candy stimuli which would be used as reinforcers in the subsequent sessions. During each trial, two stimuli were presented concurrently, and the participant was asked to select one stimulus. A PSPA session ended once every stimulus had been paired with every other stimulus at least once. Highest preferred (HP) stimuli were stimuli the participant selected in at least 80% of trials; moderately preferred (MP) stimuli were stimuli selected in between 50% and 79% of trials; and lowest preferred (LP) stimuli were stimuli selected in less than 50% of trials.

Procedure

Following the PSPA, five assessments were administered in the following order for each participant: a reinforcer magnitude assessment (RMA), a delay assessment (DA), a choice *delay* task (CDT), an effort assessment (EA), and a choice *effort* task (CET). Prior to each RMA, DA, CDT, EA, and CET session, six practice trials were conducted in order to expose the participants to the contingency associated with each selection (Dixon, Rehfeldt, & Randich, 2003). Each practice trial consisted of the experimenter presenting three plates at a time (by placing them on the table directly in front of the participant but out of arms' reach) and prompting the participant to make a selection by instructing "*Touch this plate*"). Touching the plate resulted in the removal of the non-selected plates and the delivery of the selected plate according to the condition-specific contingency. Following the six practice trials, five assessment trials were conducted; assessment trials were identical to practice trials except the experimenter prompted the participant to make a selection by instructing "*Which one?".* Prior to the practice trials for each session, an informal, one-trial multiple-stimulus preference assessment was conducted to control for satiation; the experimenter presented three HP and/or MP candy items and asked the participant to indicate their preferred candy by pointing to it. The candy item selected was used during the subsequent practice and assessment trials within that session. Across all sessions, a trial was terminated and re-started if no response was emitted by the participant within 5 seconds or if the participant grabbed more than one plate at a time; and position of the plates (except the empty plate) was randomly alternated after every 5-trial session to control for position and side bias.

Reinforcer magnitude assessment (RMA). A reinforcer magnitude assessment (RMA) was conducted to assess behavioral sensitivity to reinforcer magnitude at equal delays (Vollmer et al., 1999) and at equal response efforts, thus measuring response allocation when reinforcer delivery is immediate (0s-delay) and effortless (low effort). Participants were presented with three identical plates with candy items identified from the PSPA and the one-trial multiple stimulus preference assessment equidistant from each other: a small-magnitude plate (one piece of candy), a large-magnitude plate (three pieces of the same candy), and an empty plate (no candy). The empty plate served as the control. Each RMA session consisted of six practice trials followed by five assessment trials. The criterion for moving to the next assessment condition (i.e., delay assessment) was at least 60% of trials with selection of the large-magnitude reinforcer for two consecutive sessions. A 30-s ITI was used across practice and assessment trials to ensure that the time between each trial remained constant across options. The numbers of RMA sessions conducted for Gabriel, Edith, and Elena were 2, 4, and 2, respectively.

Practice trials. The experimenter placed the three plates on the table directly in front of the participant, out of their reach, and prompted the participant to select a plate by instructing "*Touch this plate, please.*" Touching the small-magnitude plate resulted in the *immediate* delivery of the plate with one piece of candy; touching the large-magnitude plate resulted in the *immediate* delivery of the plate with three pieces of candy; and touching the empty plate resulted in the *immediate* delivery of the plate with no candy.

Assessment trials. The assessment trials were procedurally identical to the practice trials except a) the experimenter prompted the participant to select one of the plates by instructing "*Which one?*", and b) the experimenter removed the non-selected plates after delivering the selected plate.

Delay assessment (DA). Following the RMA, a delay assessment with procedures similar to those described by Newquist et al. (2012) was conducted to assess behavioral sensitivity to delays with equal reinforcer magnitudes. DA practice and assessment sessions were identical to the RMA sessions except: a) the three plates presented consisted of a small-immediate plate (one piece of candy) delivered *immediately*, a small-delayed plate (one piece of the same candy) delivered *after a 15-s delay*, and an empty plate (no candy) delivered *immediately*; b) a 45-s ITI was used; and c) the criterion for moving to the next assessment condition (i.e., choice delay task) was at least 60% of trials with selection of the small-immediate reinforcer for two consecutive sessions. The numbers of DA sessions conducted for Gabriel, Edith, and Elena were 4, 2, and 3, respectively.

Choice Delay Task (CDT). Following the DA, a choice delay task with procedures similar to those described by Evenden and Ryan (1996) and Rachlin et al. (1991) was conducted to assess frequency of SIR, LDR, and control selections across increasing delays. The CDT condition consisted of five delay sessions, and within each delay session, the amount of the SIR was increased (1, 2, 3, 4, then 5 pieces of the same candy) across five trials until the SIR and LDR amounts were equal, while the delay within that session remained constant. The number of delays (5) was selected based on a review of 21 delay discounting studies using children participants, which showed that 66% of the studies reviewed included five delays. CDT practice and assessment sessions were identical to the DA practice and assessment sessions except: a) the three plates presented consisted of a smaller-immediate plate (one piece of candy) delivered *immediately*, a larger-delayed plate (five pieces of the same candy) delivered after the following increasing between-session delays: 15 s, 30 s, 45 s, 60 s, and 90 s, and an empty plate (no candy) delivered *immediately*; b) an ITI of 30 s plus the session-specific delay was used; for instance, in the 15-s delay session, the ITI was 45 s; in the 30-s delay session, the ITI was 60 s, and so on and so forth; and c) the criterion for moving to the next delay session was at least three consecutive trials with the same selection. This was to control for undifferentiated responding due to participants failing to attend to the stimuli (i.e., distractions). The numbers of CDT delay sessions conducted for Gabriel, Edith, and Elena were 5, 10, and 5, respectively.

Effort assessment (EA). Following CDT sessions, an effort assessment was conducted to assess behavioral sensitivity to effort requirements with equal reinforcer magnitudes. EA practice and assessment sessions were identical to the DA sessions except: a) effort (number of button presses) was substituted for delay, and the effort requirement consisted of pressing the button one or five times depending on the selection; b) the three plates presented consisted of a small-*effortless* plate (one piece of candy) delivered immediately after the participant pressed the button *once*, a small-*effortful* plate (one piece of the same candy) delivered immediately after the participant pressed the button *five times*, and an empty plate (no candy) delivered immediately after the participant pressed the button *once*; c) after participants made their selection, the experimenter immediately stated "*Press the button X time(s)*" and delivered the selected plate contingent upon the specified number of button presses (BPs); and d) the criterion for moving to the next assessment condition (i.e., choice effort task) was at least 60% of trials with selection of the small-effortless reinforcer for two consecutive sessions. The numbers of EA sessions conducted for Gabriel, Edith, and Elena were 4, 4, and 2, respectively.

Choice Effort Task (CET). Following the EA, the CET was conducted to assess frequency of SER, LER, and control selections across increasing effort requirements. Similar to the CDT condition, the CET condition consisted of five (effort) sessions, and within each effort session, the amount of the SER was increased (1, 2, 3, 4, then 5 pieces of the same candy) across five trials until the SER and LER amounts were equal, while the effort requirement within that session remained constant. CET practice and assessment sessions were identical to the EA practice and assessment sessions except: a) the three plates presented consisted of a smaller-*effortless* plate (one piece of candy) delivered immediately after pressing the button once, a larger-*effortful* plate (five pieces of the same candy) delivered after the following between-session progressive-ratio schedule: 5, 10, 15, 20, and 25 button presses, and an empty plate (no candy) delivered immediately after pressing the button once; and c) the criterion for moving to the next effort-requirement session was at least three consecutive trials with the same selection. The numbers of CET effort sessions conducted for Gabriel, Edith, and Elena were 5, 10, and 10, respectively.

Chapter 4: Results

Figure 1 displays the results of the RMAs for Gabriel, Edith, and Elena. Gabriel's RMA results show 0% selection of the small-magnitude reinforcer, 100% selection of the large-magnitude reinforcer, and 0% selection of the control option. Edith's RMA results show 30% selection of the small-magnitude reinforcer, 70% selection of the large-magnitude reinforcer, and 0% selection of the control option. Elena's RMA results show 20% selection of the small-magnitude reinforcer, 80% selection of the large-magnitude reinforcer, and 0% selection of the control option. Across participants, the percentage of selections of the large-magnitude reinforcer was higher than that of the small-magnitude reinforcer, indicating preference for – and behavioral sensitivity to – larger reinforcer magnitudes (i.e., larger quantities of candy). In other words, participants understood the difference between *smaller* and *larger*, which was a pre-requisite for participating in the remainder of the study.

Figure 2 displays the results of the DAs for each participant. Gabriel's DA results show 70% selection of the small-immediate reinforcer, 30% selection of the small-delayed reinforcer, and 0% selection of the control option. Edith's DA results show 80% selection of the small-immediate reinforcer, 20% selection of the small-delayed reinforcer, and 0% selection of the control option. Elena's DA results show 80% selection of the small-immediate reinforcer, 20% selection of the small-delayed reinforcer, and 0% selection of the control option. Across participants, the percentage of selections of the small-immediate reinforcer was higher than that of the small-delayed reinforcer, indicating behavioral sensitivity to delays and preference for immediate reinforcers.

Figure 3 displays the results of the choice delay task for each participant. Gabriel's total cumulative frequencies of SIR, LDR, and control selections across all five delays were 16, 9, and 0, respectively. Gabriel's frequencies of SIR selections during the 15-s, 30-s, 45-s, 60-s, and 90-s delays were 2, 2, 3, 4, and 5, respectively. Edith's total cumulative frequencies of SIR, LDR, and control selections across all five delays were 20, 5, and 0, respectively. Edith's frequencies of SIR selections during the 15-s, 30-s, 45-s, 60-s, and 90-s delays were 4, 4, 4, 4, and 4, respectively. Elena's total cumulative frequencies of SIR, LDR, and control selections across all five delays were 20, 5, and 0, respectively. Elena's frequencies of SIR selections during the 15-s, 30-s, 45-s, 60-s, and 90-s delays were 4, 4, 4, 4, and 4, respectively. For all participants, the cumulative frequency of SIR selections was higher than that of the LDR selections.

Figure 4 displays the results of the EAs for each participant. Gabriel's EA results show 80% selection of the small-effortless reinforcer, 20% selection of the small-effortful reinforcer, and 0% selection of the control option. Edith's EA results show 80% selection of the small-effortless reinforcer, 20% selection of the small-effortful reinforcer, and 0% selection of the control option. Elena's EA results show 70% selection of the small-effortless reinforcer, 30% selection of the small-effortful reinforcer, and 0% selection of the control option. Across participants, the percentage of selections of the small-effortless reinforcer was higher than that of the small-effortful reinforcer, indicating behavioral sensitivity to response effort and preference for effortless reinforcers.

Figure 5 displays the results of the choice effort task for each participant. Gabriel's total cumulative frequencies of SER, LER, and control selections across all five effort requirements were 14, 11, and 0, respectively. Gabriel's frequencies of SER selections during the 5-bp, 10-bp, 15-bp, 20-bp, and 25-bp effort requirements were 1, 2, 3, 4, and 4, respectively. Edith's total cumulative frequencies of SER, LER, and control selections across all five effort requirements were 15, 10, and 0, respectively. Edith's frequencies of SER selections during the 5-bp, 10-bp, 15-bp, 20-bp, and 25-bp effort requirements were 1, 2, 3, 4, and 5, respectively. Elena's total cumulative frequencies of SER, LER, and control selections across all five effort requirements were 18, 7, and 0, respectively. Elena's frequencies of SER selections during the 5-bp, 10-bp, 15-bp, 20-bp, and 25-bp effort requirements were 3, 3, 4, 4, and 4, respectively. For all participants, the cumulative frequency of SER selections was higher than that of the LER selections. Across all tasks and assessments, no participant selected the control option, thus demonstrating experimental control.

Figure 6 displays the mean percentage of impulsive choices (SIR and SER selections) from the choice delay and choice effort tasks for each participant. Gabriel's percentage of impulsive choices (SIR selections) in the CDT was 64%, and the percentage of impulsive choices (SER selections) in the CET was 56%. Edith's percentage of impulsive choices (SIR selections) in the CDT was 80%, and the percentage of impulsive choices (SER selections) in the CET was 60%. Elena's percentage of impulsive choices (SIR selections) in the CDT was 80%, and the percentage of impulsive choices (SER selections) in the CET was 72%.

Figure 7 displays AUC measures of impulsive choice from the CDT and CET for each participant. Proportion AUC values from the CDT and CET for Gabriel were 0.5 and 0.56, respectively. Proportion AUC values from the CDT and CET for Edith were 0.36 and 0.53, respectively. Proportion AUC values from the CDT and CET for Elena were 0.36 and 0.43, respectively.

Figure 8 shows participants normalized mean subjective values of the edible reinforcers across increasing combined delay and effort magnitudes (Malesza & Ostazewski, 2013). Subjective values were the value at which a participant's selection switched from the LDR/LER to the SIR/SER. Subjective values were normalized according to the following formula: at each delay and effort magnitude, the subjective value for that magnitude was divided by the

LDR/LER (i.e., 5 pieces of candy). Normalized mean subjective values for the five increasing delay magnitudes were 0.53, 0.53, 0.46, 0.4, and 0.33; and normalized mean subjective values for the five increasing effort magnitudes were 0.86, 0.73, 0.53, 0.4, and 0.33.

Figure 9 displays side-by-side comparisons of the percentage of SIR selections across each delay (left-side graphs), and the percentage of SER selections across each effort requirement (right-side graphs) for each participant. Gabriel's percentages of SIR selections during the 15-s, 30-s, 45-s, 60-s, and 90-s delays were 40%, 40%, 60%, 80%, and 100%, respectively. Gabriel's percentages of SER selections during the 5-bp, 10-bp, 15-bp, 20-bp, and 25-bp effort requirements were 20%, 40%, 60%, 80%, and 80%, respectively. Edith's percentages of SIR selections during the 15-s, 30-s, 45-s, 60-s, and 90-s delays were 80%, 80%, 80%, 80%, and 80%, respectively. Edith's percentages of SER selections during the 5-bp, 10-bp, 15-bp, 20-bp, and 25-bp effort requirements were 20%, 40%, 60%, 80%, and 100%, respectively. Elena's percentages of SIR selections during the 15-s, 30-s, 45-s, 60-s, and 90-s delays were 80%, 80%, 80%, 80%, and 80%, respectively. Elena's percentages of SER selections during the 5-bp, 10-bp, 15-bp, 20-bp, and 25-bp effort requirements were 60%, 60%, 80%, 80%, and 80%, respectively.

Chapter 5: Discussion and Conclusions

Summary

The primary objective of the present study was to evaluate and compare delay discounting and effort discounting as behavioral measures of impulsivity in preschoolers, using choice (delay and effort) tasks involving real reinforcers and consequences. Across both choice tasks, all participants displayed impulsive choice, as evidenced by higher frequencies and percentages of SIR and SER selections, thus suggesting that impulsive choice may be assessed and measured using discounting-derived choice tasks. This finding is consistent with findings from prior studies in which choice tasks with real rewards and real consequences were effectively used to assess impulsivity (and/or self-control) in this population (Forzano & Logue, 1995; Forzano et al., 2003; Forzano et al., 2011; Garon et al., 2011). Additionally, the present study's findings further support views of impulsivity (and its assessment) from a behavioral perspective (Farmer & Golden, 2009). Although previous studies have demonstrated the utility of delay discounting tasks in assessing impulsivity (Reed & Martens, 2011; Rosch & Mostofsky, 2016; Wilson et al., 2011) in children, the present study extends those studies with much younger children, using a task which parallels typical delay discounting tasks.

A secondary objective of the present study was to evaluate the utility of the effort discounting framework as a complementary behavioral measure and potential index of impulsive choice in preschoolers. The author also argued that effort discounting may be the underlying mechanism for the functional relation between effort and choice behavior. To the author's knowledge, the present study is the first to a) use a task which parallels typical effort discounting tasks to assess impulsivity in preschoolers, and b) directly compare effort and delay discounting in this age group. Additionally, the present study's findings established a functional relation between effort and choice behavior by systematically increasing effort requirements and evaluating their effect on impulsive choice.

It is worth mentioning that both types of discounting have been directly compared in previous studies (Malesza & Ostaszewski, 2013; Malesza, 2015), with adult and teenage populations. Nevertheless, consistent with findings from effort discounting studies, results from the CET used in the present study showed that as the effort required to obtain rewards increases, individuals are more likely to choose the reward or outcome which requires the least effort. The present study results showed that this is also true in preschoolers; more importantly, these results provide a preliminary demonstration of the efficacy of using effort discounting tasks, specifically the CET, to assess and measure impulsive choice with effortful rewards in that population.

Findings

One interesting finding from the present study was the difference in patterns of responding between the CDT and CET (Figure 9). Specifically, impulsive choice was stagnant across delays for 2 out of 3 participants (Edith and Elena) in the CDT; meaning the frequency and percentage of SIR selections remained at 4, and 80%, respectively, across each of the five increasing delays. This pattern differs from typical responding in delay discounting tasks whereas the delays to the receipt of rewards increase, so does the frequency or the percentage of SIR selections (Reed & Martens, 2011). However, the pattern of responding observed in the CDT was not observed in the CET, where for all three participants, as the effort requirement increased, so did the frequency and percentage of SER selections. This pattern seems to be more consistent with patterns seen in other effort discounting studies (Malesza & Ostaszewski, 2013; Mitchell, 2004; Mitchell 2017).

Other interesting findings from the CDT and CET comparisons were the higher percentages of SIR selections (Figures 6 and 9), lower proportion AUC values (Figure 7), and the lower subjective values of the edible reinforcers (Figure 8) across participants in the CDT compared to the CET. Recall that from a behavioral perspective, impulsivity is operationally defined as a preference for SIRs over LDRs, and both percentage of SIR selections and AUC values are valid measures of impulsivity. The present study's results showed higher levels of impulsivity in the CDT, thus suggesting that participants were more impulsive with delayed reinforcers than with effortful reinforcers. Behaviorally speaking, participants' choice behaviors were more sensitive to delays than to effort. This is also evident in Figure 8, which shows a relatively steeper decrease in the subjective value of delayed reinforcers (despite an overlap of the last two subjective values). This finding is consistent with the Malesza and Ostaszewski (2013) findings, which also revealed steeper discounting (i.e., higher impulsivity) of delayed rewards when compared to discounting of effortful rewards.

One possible explanation for these aforementioned findings, specifically participants' higher behavioral sensitivity to – and higher levels of impulsivity with – delays may be the fact that delays require the passage of time, which is inevitable and uncontrollable, whereas effort can be manipulated and controlled; meaning, one can engage in an effortful activity at a pace of their choosing, however, one cannot "speed up" the passage of time. Furthermore, although effortful responses such as pressing a button 25 times inherently involve some sort of delay (i.e., the time it takes to complete the effortful response), studies have shown that engaging in concurrent physical or verbal activities (i.e., intervening activities) during delays may actually function as a tolerance response, especially during longer or progressively increasing delays (Binder et al., 2000; Dixon et al., 2001; Dixon & Falcomata, 2004; Dixon et al., 2003). For example, Binder et al (2000) evaluated a delay tolerance intervention (i.e., self-control training) consisting of a progressive-delay procedure combined with two types of intervening verbal activity (repeating a rule out loud or expressively tacting objects depicted on flashcards during the delay) with three children with ADHD. The authors found the combination of the progressive delays and intervening verbal activity to be effective at increasing self-control (higher percentage of LDR selections) for all participants. It is however worth mentioning that in the present study, the ITIs used in both choice delay and choice effort tasks were held constant within each delay and effort requirement, to ensure that the time between each delay and effort trial was identical. This meant that although participants had control over the speed at which they could complete the effortful task (button pressing) in order to obtain the reinforcer, after its receipt, they were still required to wait before being presented with the next choice opportunity.

Another explanation as to why participants were more impulsive with delayed rewards than with effortful rewards is the inability to cope with delays, which has been proposed to be one of seven categories of impulsive behavior (see Farmer & Golden, 2009). Early studies (e.g., Mischel & Metzner, 1962) on preschoolers' ability to demonstrate self-control (i.e., select the LDR over the SIR) have shown that population to be more likely to display impulsive behavior and therefore having a higher likelihood of being unable to cope with delays than older populations. In addition, delay discounting and delay of gratification studies have shown steep discounting (higher impulsivity) to decrease with age and preference for delayed rewards to increase with age (Green et al., 1994; Green et al., 1999; Mischel & Metzner, 1962). Taken together, these findings suggest that inability to cope with delays is not only synonymous with but may be a strong indication of impulsivity.

A third possible explanation for the lower frequencies and percentages of impulsive choices with respect to effortful rewards is participants' history of reinforcement (and punishment) with delays and effort. It is highly probable that participants have been – and continue to be – exposed to delayed reinforcement (e.g., requesting an item, person, or activity and being told to wait). However, it is less probable that participants have been exposed to the effort-based contingencies used in this study's CET.

Lastly, it is possible that the different ranges of delay and effort requirements may have been responsible for the difference in frequency and percentages of impulsive choices between the choice delay and choice effort tasks. Although the delays in the present study were relatively short when compared to the typically longer delays used in hypothetical discounting tasks, using even shorter delays (i.e., delays ranging from 5 s to 25 s) in the CDT may have closely paralleled the number of seconds it would take to press the button for the required number of times in the CET, thus ensuring the two choice tasks were in fact comparable.

Although the present study demonstrated the utility of effort discounting tasks or choice effort tasks in measuring – and assessing – impulsive behavior, the differences observed between the CDT and CET suggest that delay and effort discounting are related and integral to choice behavior; however, the two are not equivalent measures of impulsive choice (impulsivity). This is consistent with Malesza (2013), who found a positive correlation between delay and effort discounting. Whereas delay discounting is an empirically validated index and measure of impulsivity, more research is needed to determine whether this is also true of effort discounting (recall that the current body of literature on effort discounting suggests that effort discounting is an index of motivation). Nevertheless, given the higher levels of impulsive choice observed in both the choice delay and the choice effort task across participants, the present findings suggest that effort discounting can be used as a complementary – but neither a stand-alone nor a substitute – measure of impulsivity.

Limitations and Recommendations

There were at least four possible limitations of the present study. The first was the arbitrary selection of the effort requirement (i.e., button pressing). Although results of the CET showed that as effort increased, selection of the LER decreased, for all participants, LER selections were higher than LDR selections. It is possible that either a) button pressing more than once was not as physically effortful – or aversive – as perhaps tracing a letter more than once; or b) button pressing in and of itself was a "fun" activity (e.g., the clicking sound from pressing the button may have been reinforcing). Future replications of this study should first determine if the stimulus (i.e., push button) used in the effort requirement may have potential preferential properties; this can be done via a preliminary preference assessment using that stimulus (i.e., button).

The second limitation of the present study was the low number of participants, low number of data sets, and consequent inability to perform a correlational (i.e., Pearson r) analysis in order to examine the strength of the relationship between delay and effort discounting. Although the CDT and CET results revealed similar patterns of responding across participants, statistical analyses were not performed to determine how similar the two variables were. Future researchers should investigate the relationship between delay and effort discounting in a larger sample of preschoolers.

The third limitation of the present study was the order in which the assessments were administered (RMA, DA, CDT, EA, and CET); for each participant, all five assessments were administered in the same order (no counterbalancing). Counterbalancing the order of conditions is essential to control for sequence – or serial carry over – effects from one condition or one assessment to the next (Brooks, 2012; Ward-Horner & Sturmey, 2010). In the present study, the CDT preceded the CET for all participants, which means all participants were exposed to delays prior to being exposed to effort. Given the absence of a counterbalancing method in the present study, it is possible that the effects of one assessment condition (i.e., choice delay task) may have carried over or influenced participant's responding in a subsequent assessment condition (i.e., choice effort task). Future extensions or replications of the present study should include a counterbalancing method to control for possible carry over effects from one assessment to the next.

The fourth limitation was the fact that the procedure used in the CET was not designed to emulate real-life decision-making situations with respect to effort in that no delay was imposed following a selection and before the delivery of the reinforcer. In real-life, concurrent arrangements of contingencies, engaging in effortful behavior (i.e., choosing the larger effortful reward) does not necessarily result in immediate access to the larger reinforcer. For example, suppose an overweight individual seeking to lose weight chooses to forego taking the elevator for the staircase every day; selecting the larger effortful option (in this case, taking the staircase) over the smaller effortful option (taking the elevator) will not result in immediate access to the reinforcer (in this case, weight loss). Although there are real-life instances in which choosing the LER results in immediate access to reinforcement (i.e., a basketball player choosing and scoring a 3-point shot and immediately receiving the added points), in many real-life decision-making situations in which effort is involved, this is not the case. Future research should consider comparing the two choice tasks with the addition of fixed delays following selection of either alternative or prior to the delivery of the reinforcer.

Implications

Despite its limitations, the present study has clinical implications in the assessment and treatment of aberrant behaviors associated with impulsivity, particularly in children with ADHD, ASD, or intellectual and developmental disorders. For instance, noncompliance is a common problem behavior in this population, and research suggests that it is correlated with psychiatric diagnoses such as oppositional defiant behavior (Lipschultz & Wilder, 2017). Studies examining the effects of response effort manipulation (e.g., decreased response effort) on compliance have found response effort manipulation in combination or supplemented with reinforcement-based interventions to be an effective intervention for increasing compliance (Fischetti et al., 2012; Radley & Dart, 2016). In interventions in which response effort is the independent variable (i.e., when it is manipulated as part of an intervention to reduce maladaptive behavior), a clinician interested in manipulating (i.e., increasing) response effort in order to reduce aberrant behavior can employ the CET used in this study as a pre-intervention (or baseline) assessment of the response effort an individual can tolerate in order to access the reinforcer responsible for maintaining that aberrant behavior. Clinicians can also use both the CDT and CET to determine whether an individual's behavior is more sensitive to delayed or effortful reinforcers, prior to developing an individualized behavior intervention plan. However, given that the present study was a pilot investigation of choice tasks based on delay and effort discounting as behavioral measures of impulsivity, more research is needed to examine both tasks' clinical utility and relevance, specifically the CET.

The present study also has implications in the early assessment of impulsive behavior, given the correlation between impulsive behavior at a young age and maladaptive behavior and negative outcomes in adolescence (Funder et al., 1983; Seeyave et al., 2009). Although the delay of gratification test would have been appropriate for the sample (i.e., preschoolers) recruited in this study, the CDT used in this study has two major advantages over the delay of gratification test. One of those advantages is the CDT's combined adjusting-delay and adjusting-amount procedures, which allows the experimenter to obtain indifference points (i.e., the subjective value of the LDR) at each delay and examine patterns of impulsive choice responding across increasing delays; this is not the case in most delay of gratification experiments, where participants' choices are assessed in a single and longer delay (e.g., 15-20 min).

Another advantage of the CDT is its utility in assessing impulsive choice when delays are externally imposed (i.e., *commitment*-choice) rather than self-imposed (*sustained*-choice; see Forzano et al., 2011 and Reynolds & Schiffbauer, 2005). In a choice tasks with an externally imposed delay (Rachlin & Green, 1972), the experimenter determines and sets the delay and participants are asked to choose between the smaller immediate and the larger delayed alternatives. When participants select the delayed alternative (i.e., the LDR), they are unable to reverse their choice and are thus "forced" to experience the delay in its entirety; in other words, participants are *committed* to their initial choice. However, at the next trial or choice opportunity, participants can opt to forgo the larger delayed alternative for the smaller immediate alternative. In a choice task with a self-imposed delay (Reynolds et al., 2002), although the experimenter determines the length of the delay to the larger alternative, participants ultimately determine how long they able to wait. In other words, once the larger delayed alternative is selected, participants are allowed to reverse their initial choice (e.g., switch from the delayed to the immediate alternative) at any time during the delay, thus foregoing the larger reward for the smaller reward. An individual who initially selects the LDR but reverses his or her choices during the delay is said to have not sustained their initial choice and would consequently be labeled as impulsive. However, an individual who initially selects the delayed alternative (LDR) and experiences the entire delay without reversing their choice is said to have sustained their initial choice and consequently, this individual would be labeled as having self-control. Research strongly suggests that given the opportunity to reverse their choice (i.e., select the smaller immediate option after having initially selected the larger delayed option), human and non-human organisms are more likely to display impulsive choice. The CDT administered in the present study assessed impulsive choice using externally imposed delays, therefore eliminating choice reversal as a confounding variable responsible for the higher levels of delay-based impulsivity.

The results of the present study suggest the potential utility and practicality of administering choice (delay, effort) tasks to assess impulsivity. Clinicians could potentially benefit from using these or similar choice tasks to obtain baseline levels of their clients' impulsivity (or self-control), and design empirically derived interventions aimed at increasing self-control.

References

Ahn, W-Y., Rass, O., Fridberg, D. J., Bishara, A. J., Forsyth, J. K., Breier, A., … & O'Donnell, B. F. (2011). Temporal discounting of rewards in patients with bipolar disorder and schizophrenia. *Journal of Abnormal Psychology, 120,* 911-921. doi:10.1037/a0023333.

Anokhin, A. P., Grant, J. D., Mulligan, R. C., & Heath, A. C. (2015). The genetics of impulsivity: Evidence for the heritability of delay discounting. *Biological psychiatry, 77,* 887-894. doi:10.1016/j.biopsych.2014.10.022.

Bembenutty, H., & Karabenick, S. A. (2004). Inherent association between academic delay of gratification, future time perspective, and self-regulated learning. *Educational Psychology Review, 16,* 35-57.

Binder, L. M., Dixon, M. R., & Ghezzi, P. M. (2000). A procedure to teach self-control to children with Attention Deficit Hyperactivity Disorder. *Journal of Applied Behavior Analysis, 33,* 233-237.

Brooks, J. L. (2012). Counterbalancing for serial order carryover effects in experimental condition orders. *Psychological Methods, 17,* 600-614. doi: 10.1037/a0029310.

Broos, N., Schmaal, L., Wiskerke, J., Kostelijk, L., Lam, T., Stoop, N., … & Goudriaan, A. E. (2012). The relationship between impulsive choice and impulsive action: A cross-species translational study. *PLoS ONE, 7,* 1-9. doi:10.1371/journal.pone.0036781.

Buono, F. D., Whiting, S. W., & Sprong, M. E. (2015). Comparison of temporal discounting among obese college students and obese adults. *Behavior Analysis: Research and Practice, 15*, 139-147.

Calvert, A. L., Green, L., & Myerson, J. (2010). Delay discounting of qualitatively different reinforcers in rats. *Journal of the Experimental Analysis of Behavior, 93,* 171-184.

Cano, A. M., Murphy, E. S., & Lupfer, G. (2016). Delay discounting predicts binge-eating in Wistar rats. *Behavioural Processes, 132,* 1-4.

Carroll, M. E., Anker, J. J., Mach, J. L., Newman, J. L., & Perry, J. L. (2010). Delay discounting as a predictor of drug abuse. In G. J. Madden & W. K. Bickel (Eds.), *Impulsivity: The behavioral and neurological science of discounting* (pp. 243–271). Washington, DC: American Psychological Association.

Charlton, S. R., & Fantino, E. (2008). Commodity specific rates of temporal discounting: Does metabolic function underlie differences in rates of discounting? *Behavioural Processes, 77,* 334-342.

Chong, T. T., Bonnelle, V., & Husain, M. (2016). Quantifying motivation with effort-based decision-making paradigms in health and disease. In B. Studer & S. Knecht (Eds.), *Progress in Brain Research* (pp. 71-100). Elsevier.

Cook, J. E., Subramaniam, S., Brunson, L. Y., Larson, N. A., Poe, S. G., & St. Peter, C. C. (2015). Global Measures of Treatment Integrity May Mask Important Errors in Discrete-Trial Training. *Behavior Analysis in Practice*, *8*, 37–47.

Critchfield, T. S., & Kollins, S. H. (2001). Temporal discounting: Basic research and the analysis of socially important behaviors. *Journal of Applied Behavior Analysis, 34,* 101-122.

Da Matta, A., Goncalves, F. B., & Bizarro, L. (2012). Delay discounting: Concepts and measures. *Psychology & Neuroscience*, *5,* 135-146. doi: 10.3922/j.psns.2012.2.03.

de Wit, H. (2008). Impulsivity as a determinant and consequence of drug use: A review of underlying processes. *Addiction Biology, 14,* 22-31. doi:10.1111/j.1369-1600.2008.00129.x.

de Wit, H., Flory, J. D., Acheson, A., McCloskey, M., & Manuck, S. B. (2007). IQ and nonplanning impulsivity are independently associated with delay discounting in middle-aged adults. *Personality and Individual differences, 42,* 111-121.

de Wit, H., & Mitchell, S. H. (2010). Drug effects on delay discounting. In G. J. Madden & W. K. Bickel (Eds.), *Impulsivity: The behavioral and neurological science of discounting* (pp. 213–241). Washington, DC: American Psychological Association.

Dixon, M. R., & Cummings, A. (2001). Self-control in children with autism: Response allocation during delays to reinforcement. *Journal of Applied Behavior Analysis, 34,* 491-495.

Dixon, M. R., & Falcomata, T. S. (2004). Preference for progressive delays and concurrent physical therapy exercise in an adult with acquired brain injury. *Journal of Applied Behavior Analysis, 37,* 101-105.

Dixon, M. R., & Holcomb, S. (2000). Teaching self-control to small groups of dually diagnosed adults. *Journal of Applied Behavior Analysis, 33,* 611-614.

Dixon, M. R., Marley, J., & Jacobs, E. A. (2003). Delay discounting by pathological gamblers. *Journal of Applied Behavior Analysis, 36,* 449-558.

Dixon, M. R., & Tibbetts, P. A. (2009). The effects of choice on self-control. *Journal of Applied Behavior Analysis, 42,* 243-252.

Dixon, M. R., Rehfeldt, R. A., & Randich, L. (2003). Enhancing tolerance to delayed reinforcers: The role of intervening activities. *Journal of Applied Behavior Analysis, 36,* 263-266.

Docx, L., de la Asuncion, J., Sabbe, B., Hoste, L., Baeten, R., Warnaerts, N., & Morrens, M. (2015). Effort discounting and its association with negative symptoms in schizophrenia. *Cognitive Neuropsychiatry, 20,* 172-185. doi: 10.1080/13546805.2014.993463.

Du, W., Green, L., & Myerson, J. (2002). Cross-cultural comparisons of discounting delayed and probabilistic rewards. *The Psychological Record, 52*, 479-492.

Epstein, L. H., Salvy, S. J., Carr, K. A., Dearing, K. K., & Bickel, W. K. (2010). Food reinforcement, delay discounting and obesity. *Physiology & Behavior, 100,* 438-445. doi:10.1016/j.physbeh.2010.04.029.

Estle, S. J., Green, L., Myerson, J., & Holt, D. D. (2007). Discounting of monetary and directly consumable rewards. *Psychological Science, 18,* 58-63.

Evenden, J. L., & Ryan, C. N. (1996). The pharmacology of impulsive behavior in rats: The effects of drugs on response choice with varying delays of reinforcement. *Psychopharmacology, 128,* 161-170.

Falcomata, T. S., Cooper-Brown, L. J., Wacker, D. P., Gardner, A. W., & Boelter, E. W. (2010). A brief experimental analysis of reinforcer and response dimensions related to self-control in an outpatient clinic. *Journal of Behavioral Education, 19*, 257-272. doi 10.1007/s10864-010-9113-6.

Farmer, R. F., & Golden, J. A. (2009). The forms and functions of impulsive actions: Implications for behavioral assessment and therapy. *International Journal of Behavioral Consultation and Therapy, 5,* 12-30.

Fischetti, A. T., Wilder, D. A., Myers, K., Leon-Enriquez, Y., Sinn, S., & Rodriguez, R. (2012). An evaluation of evidence-based interventions to increase compliance among children with autism. *Journal of Applied Behavior Analysis, 45,* 859-863. doi:10.1901/jaba.2012.45-859

Fisher, W. W., & Mazur, J. E. (1997). Basic and applied research on choice responding. *Journal of Applied Behavior Analysis, 30,* 387-410.

Fisher, W.W., Piazza, C.C., Bowman, L.G., & Amari, A. (1996). Integrating caregiver report with a systematic choice assessment to enhance reinforcer identification. *American Journal on Mental Retardation, 101,* 15-25.

Fisher, W., Piazza, C. C., Bowman, L. G., Hagopian, L. P., Owens, J. C., & Slevin, I. (1992). A comparison of two approaches for identifying reinforcers for persons with severe and profound disabilities. *Journal of Applied Behavior Analysis, 25,* 491-498.

Fisher, W. W., Thompson, R. H., Hagopian, L. P., Bowman, L. G., & Krug, A. (2000). Facilitating tolerance of delayed reinforcement during functional communication training. *Behavior Modification, 24*, 3-29.

Flora, S. R., & Pavlik, W. B. (1992). Human self-control and the density of reinforcement. *Journal of The Experimental Analysis of Behavior*, *57*, 201-208.

Floresco, S. B., Tse, M. T., & Ghods-Sharifi, S. (2008). Dopaminergic and glutamatergic regulation of effort- and delay-based decision making. *Neuropsychoparmacology, 33,* 1966-1979. doi:10.1038/sj.npp.1301565.

Forzano, L. B., & Logue, A. W. (1995). Self-control and impulsiveness in children and adults: Effects of food preferences. *Journal of the Experimental Analysis of Behavior, 64,* 33-46.

Forzano, L. B., Michels, J. L., Carapella, P. C., & Chelonis, J. J. (2011). Self-control and impulsivity in children: Multiple behavioral measures. *The Psychological Record, 61,* 425-448.

Forzano, L. B., Szuba, M., & Figurilli, J. M. (2003). Self-control and impulsiveness in children: Effects of visual food cues. *The Psychological Record, 53,* 161-175.

Francisco, M. T., Madden, G. J., & Borrero, J. (2009). Behavioral economics: Principles, procedures, and utility for applied behavior analysis. *The Behavior Analyst Today, 10,* 277-294.

Friman, P. C., & Poling, A. (1995). Making life easier with effort: Basic findings and applied research on response effort. *Journal of Applied Behavior Analysis, 28,* 583-590.

Funder, D. C., Block, J. H., & Block, J. (1983). Delay of gratification: Some longitudinal personality correlates. *Journal of Personality and Social Psychology, 44,* 1198-1213.

Green, L., & Estle, S. J. (2003). Preference reversals with food and water reinforcers in rats. *Journal of the Experimental Analysis of Behavior, 79,* 233-242.

Green, L., Fry, A. F., & Myerson, J. (1994). Discounting of delayed rewards: A life-span comparison. *Psychological Science, 5,* 33-36.

Green, L., Myerson, J., & Calvert, A. L. (2010). Pigeons' discounting of probabilistic and delayed reinforcers. *Journal of the Experimental Analysis of Behavior, 94,* 113-123.

Green, L., Myerson, J., & Ostaszewski, P. (1999). Discounting of delayed rewards across the life span: Age differences in individual discounting functions. *Behavioural Processes, 46,* 89-96.

Green, L., Myerson, J., Shah, A. K., Estle, S. J., & Holt, D. D. (2007). Do adjusting-amount and adjusting-delay procedures produce equivalent estimates of subjective value in pigeons? *Journal of the Experimental Analysis of Behavior, 87,* 337-347.

Green, L., Myerson, J., & Vanderveldt, A. (2014). Delay and probability discounting. In McSweeney, F. K., Murphy, E. S. (Eds.), *The Wiley-Blackwell Handbook of Operant and Classical Conditioning*. John Wiley & sons, Oxford, pp. 307-337.

Green, L., Myerson, J., Lichtman, D., Rosen, S., & Fry, A. (1996). Temporal discounting in choice between delayed rewards: The role of age and income. *Psychology and Aging, 11,* 79-84.

Green, L., Myerson, J., Oliveira, L., & Chang, S. E. (2013). Delay discounting of monetary rewards over a wide range of amounts. *Journal of The Experimental Analysis of Behavior, 100,* 269-281.

Grosch, J., & Neuringer, A. (1981). Self-control in pigeons under the Mischel paradigm. *Journal of the Experimental Analysis of Behavior 35,* 3-21.

Grossbard, C. L., & Mazur, J. E. (1986). A comparison of delays and ratio requirements in self-control choice. *Journal of the Experimental Analysis of Behavior, 45,* 305-315.

Hamilton, K. R., Wing, V. C., Bickel, W. K., Lane, S. D., Littlefield, A. K., …... & Moleller, F. G. (2015). Choice impulsivity: Definitions, measurement issues, and clinical implications. *Personality Disorders: Theory, Research, and Treatment, 6,* 182-198. doi: 10.1037/per0000099.

Hanley, G. P., Piazza, C. C., Keeney, K. M., Blakeley-Smith, A. B., & Worsdell, A. S. (1998). Effects of wrist weights on self-injurious and adaptive behaviors. *Journal of Applied Behavior Analysis, 31,* 307-310.

Hartmann, M. N., Hager, O. M., Tobler, P. N., & Kaiser, S. (2013). Parabolic discounting of monetary rewards by physical effort. *Behavioural Processes, 100,* 192-196.

Heerey, E. A., Robinson, B. M., McMahon, R. P., & Gold, J. M. (2007). Delay discounting in schizophrenia. *Cognitive Neuropsychiatry, 12,* 213-221. doi:10.1080/13546800601005900

Hyten, C., Madden, G. J., & Field, D. P. (1994). Exchange delays and impulsive choice in adult humans. *Journal of the Experimental Analysis of Behavior, 62*, 225-233.

Irvin, D. S., Thompson, T. J., Turner, W. D., & Williams, D. E. (1998). Utilizing increased response effort to reduce chronic hand mouthing. *Journal of Applied Behavior Analysis, 31*, 375-385.

Isen, J. D., Sparks, J. C., & Iacono, W. G. (2014). Predictive validity of delay discounting behavior in adolescence: A longitudinal twin study. *Experimental and Clinical Psychopharmacology, 22*, 434-443. doi:10.1037/a0037340.

Iwata, B. A., Dorsey, M. F., Slifer, K. J., Bauman, K. E., & Richman, G. S. (1994). Toward a functional analysis of self-injury. *Journal of Applied Behavior Analysis, 27,* 197-209.

Jackson, K., & Hackenberg, T. D. (1996). Token reinforcement, choice, and self-control in pigeons. *Journal of The Experimental Analysis of Behavior, 66*, 29-49.

Jarmolowicz, D. P., Lemley, S. M., Asmussen, L., & Reed, D. D. (2015). Mr. right versus Mr. right now: A discounting-based approach to promiscuity. *Behavioural Processes, 115*, 117-122.

Johnson, M. W. (2012). An efficient operant choice procedure for assessing delay discounting in humans: Initial validation in cocaine-dependent and control individuals. *Experimental and Clinical Psychopharmacology, 20*, 191-204. doi:10.1037/a0027088.

Johnson, M. W., & Bickel, W. K. (2002). Within-subject comparison of real and hypothetical money rewards in delay discounting. *Journal of The Experimental Analysis of Behavior, 77*, 129-146.

Johnson, M. W., & Bickel, W. K., & Baker, F. (2007). Moderate drug use and delay discounting: A comparison of heavy, light, and never smokers. *Experimental and Clinical Psychopharmacology, 15,* 187-194. doi: 10.1037/1064-1297.15.2.187.

Kirby, K. N., & Guastello, B. (2001). Making choices in anticipation of similar future choices can increase self-control. *Journal of Experimental Psychology: Applied, 7,* 154-164. doi:10.1037/1076-898X.7.2.154.

Klein-Flugge, M. C., Kennerley, S. W., Saraiva, A. C., Penny, W. D., & Bestmann, S. (2015). Behavioral modeling of human choices reveals dissociable effects of physical effort and temporal delay on reward devaluation. *PLoS Computational Biology, 11,* 1-31. doi:http://dx.doi.org.tcsedsystem.idm.oclc.org/10.1371/journal.pcbi.1004116

Lawyer, S. R. (2008). Probability and delay discounting of erotic stimuli. *Behavioural Processes, 79,* 36-42.

Lerman, D. C., Addison, L. R., & Kodak, T. (2006). A preliminary analysis of self-control with aversive events: The effects of task magnitude and delay on the choices of children with autism. *Journal of Applied Behavior Analysis, 39,* 227-232.

Madden, G. J., Bickel, W. K., & Jacobs, E. A. (1999). Discounting of delayed rewards in opioid-dependent outpatients: Exponential or hyperbolic discounting functions? *Experimental and Clinical Psychopharmacology, 7,* 284-293.

Madden, G. J., & Johnson, P.S. (2010). A delay discounting primer. In G. J. Madden, & W. K. Bickel (Eds.), *Impulsivity: The behavioral and neurological science of discounting* (pp. 11–37). Washington, DC: American Psychological Association.

Madden, G. J., Petry, N., Badger, G. J., & Bickel, W. K. (1997). Impulsive and self-control choices in opioid-dependent patients and non-drug-using control participants: Drug and monetary rewards. *Experimental and Clinical Psychopharmacology, 5,* 256-262. doi:10.1037/1064-1297.5.3.256.

Malesza, M. (2015). Cloninger's psychobiological model of temperament and the discounting of delayed and effortful outcomes among adolescents. *Psychology Research, 5,* 452-463.

Malesza, M. (2018). The effects of potentially real and hypothetical rewards on effort discounting in a student sample. *Personality and Individual Differences*. Advance online copy. doi:10.1016/j.paid.2018.03.030.

Malesza, M., & Ostaszewski, P. (2013). Relations between Cloninger's dimensions of temperament and steepness of delay and effort discounting of monetary rewards. *Psychological Reports: Mental & Physical Health, 112,* 694-705. doi:10.2466/09.14.PR0.112.3.694-705.

Marx, I., Hacker, T., Yu, X., Cortese, S., & Sonuga-Barke, E. (2018). ADHD and the choice of small immediate over larger delayed rewards: A comparative meta-analysis of performance on simple choice-delay and temporal discounting paradigms. *Journal of Attention Disorders, 00,* 1-17. doi: 10.1177/1087054718772.

Mazur, J. E. (1987). An adjusting procedure for studying delayed reinforcement. In M. L. Commons, J. E., Mazur, J. A. Nevin, & H. Rachlin (Eds.), *Quantitative analyses of behavior: Vol. 5. The effect of delay and intervening events on reinforcement value* (pp. 55-73). Hillsdale, NJ: Erl-baum.

Mischel, W. & Ebbesen, E. B. (1970). Attention in delay of gratification. *Journal of Personality and Social Psychology, 16,* 329-337.

Mischel, W., Ebbesen, E. B., & Zeiss, A. R. (1972). Cognitive and attentional mechanisms in delay of gratification. *Journal of Personality and Social Psychology, 21,* 204-218.

Mischel, W., & Metzner, R. (1962). Preference for delayed reward as a function of age, intelligence, and length of delay interval. *Journal of Abnormal and Social Psychology, 64,* 425-431.

Mischel, W., Shoda, Y., & Peake, P. K. (1988). The nature of adolescent competencies predicted by preschool delay of gratification. *Journal of Personality and Social Psychology, 54,* 687-696.

Mitchell, S. H. (1999). Measures of impulsivity in cigarette smokers and non-smokers. *Psychopharmacology, 146,* 455-464.

Mitchell, S. H. (2003). Discounting the value of commodities according to different types of cost. In Rudy E. Vuchinich, & Nick Heather (Eds.), *Choice, Behavioural Economics and Addiction.* (pp. 339-362). Elsevier.

Mitchell, S. H. (2004). Effects of short-term nicotine deprivation on decision-making: Delay, uncertainty and effort discounting. *Nicotine & Tobacco Research, 6,* 819-828. doi:10.1080/14622200412331296002.

Mitchell, S. H. (2017). Devaluation of outcomes due to their cost: Extending discounting models beyond delay. In Jeffrey R. Stevens (Ed.), *Impulsivity: How time and risk influence decision making.* (pp. 145-161). Springer International Publishing.

Morrison, K. L., Madden, G. J., Odum, A. L., Friedel, J. E., & Twohig, M. P. (2014). Altering impulsive decision making with an acceptance-based procedure. *Behavior Therapy, 45,* 630-639. doi:10.1016/j.beth.2014.01.001.

Myerson, J., & Green, L. (1995). Discounting of delayed rewards: Models of individual choice. *Journal of The Experimental Analysis of Behavior, 64,* 263-276.

Myerson, J., Green, L., Warusawitharana, M. (2001). Area under the curve as a measure of discounting. *Journal of the Experimental Analysis of Behavior, 76*, 235-243.

Navarick, D. J. (2004). Discounting of delayed reinforcers: Measurement by questionnaires versus operant choice procedures. *The Psychological Record, 54,* 85-94.

Neef, N. A., Bicard, B. F., & Endo, S. (2001). Assessment of impulsivity and the development of self-control in students with attention deficit hyperactivity disorder. *Journal of Applied Behavior Analysis, 34,* 397-408.

Newquist, M. H., Dozier, C. L., & Neidert, P. L. (2012). A comparison of the effects of brief rules, a timer, and preferred toys on self-control. *Journal of Applied Behavior Analysis, 45,* 497-509.

Nishiyama, R. (2014). Response effort discounts the subjective value of rewards. *Behavioural Processes, 107*, 175-177.

Odum, A. L. (2011). Delay discounting: I'm a K, you're a K. *Journal of the Experimental Analysis of Behavior, 96,* 427-439.

Odum, A. L., & Baumann, A. A. L. (2010). Delay discounting: State and trait variable. In G. J. Madden & W. K. Bickel (Eds.), *Impulsivity: The behavioral and neurological science of discounting* (pp. 39–65). Washington, DC: American Psychological Association.

Odum, A. L., Baumann, A. A. L., Rimington, D. D. (2006). Discounting of delayed hypothetical money and food: Effects of amount. *Behavioural Processes, 73,* 278-284.

Odum, A. L., & Rainaud, C. P. (2003). Discounting of delayed hypothetical money, alcohol, and food. *Behavioural Processes, 64,* 305-313.

Olson, E. A., Hooper, C. J., Collins, P., & Luciana, M. (2007). Adolescents' performance on delay and probability discounting tasks: contributions of age, intelligence, executive functioning, and self-reported externalizing behavior. *Personality and Individual Differences*, *43,* 1886–1897.

Ong, C. W., Graves, K., Berry, M. S., Odum, A. L., & Twohig, M. P. (2018). Obsessive-compulsive symptoms are associated with increased delay discounting in a novel hand-washing task. *Behavior Analysis: Research and Practice, 19,* 136-149. doi:10.1037/bar0000096.

Ostaszewski, P., Babel, P., Swebodzinski, B. (2013). Physical and cognitive effort discounting of hypothetical monetary rewards. *Japanese Psychological Research, 55,* 329-337. doi: 10.1111/jpr.12019.

Patros, C. H. G., Alderson, R. M., Kasper, L. J., Tarle, S. J., Lea, S. E., & Hudec, K. L. (2016). Choice-impulsivity in children and adolescents with attention-deficit/hyperactivity disorder (ADHD): A meta-analytic review. *Clinical psychology Review, 43,* 162-174. doi:10.1016/j.cpr.2015.11.001.

Petry, N. M. (2001). Delay discounting of money and alcohol in actively using alcoholics, currently abstinent alcoholics, and controls. *Psychopharmacology, 154,* 243-250. doi:10.1007/s002130000638.

Petry, N. M. (2001b). Pathological gamblers, with and without substance use disorders, discount delayed rewards at high rates. *Journal of Abnormal Psychology, 110,* 482-487. doi:10.1037/0021-843X.110.3.482.

Petry, N. M. (2002). Discounting of delayed rewards in substance abusers: Relationship to antisocial personality disorder. *Psychopharmacology (Berlin), 162,* 425-432. doi:10.1007/s00213-002-1115-1.

Petry, N. M., & Casarella, T. (1999). Excessive discounting of delayed rewards in substance abusers with gambling problems. *Drug and Alcohol Dependence, 56,* 25-32. doi:10.1016/S0376-8716(99)00010-1.

Petry, N. M., & Madden, G. J. (2010). Discounting and pathological gambling. In G. J. Madden & W. K. Bickel (Eds.), *Impulsivity: The behavioral and neurological science of discounting* (pp. 273–294). Washington, DC: American Psychological Association.

Piazza, C. C., Roane, H. S., Keeney, K. M., Boney, B. R., & Abt, K. A. (2002). Varying response effort in the treatment of PICA maintained by automatic reinforcement. *Journal of Applied Behavior Analysis, 35,* 233-246.

Rachlin, H., & Green, L. (1972). Commitment, choice and self-control. *Journal of The Experimental Analysis of Behavior, 17,* 15-22.

Rachlin, H., Raineri, A., & Cross, D. (1991). Subjective probability and delay. *Journal of The Experimental Analysis of Behavior, 55,* 233-244.

Radley, K. C., & Dart, E. H. (2016). Antecedent strategies to promote children's and adolescents' compliance with adult requests: A review of the literature. *Clinical Child and Family Psychology Review, 19,* 39-54. doi: 10.1007/s10567-015-0197-3.

Ragotzy, S. P. (1988). *Self-control in mentally retarded adolescents: Choice as a function of amount and delay of reinforcement* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Global. (UMI No. 8827195)

Rasmussen, E. B., Lawyer, S. R., & Reilly, W. (2010). Percent body fat is related to delay and probability discounting for food in humans. *Behavioural Processes, 83,* 23–30.

Reddy, L. F., Horan, W. P., Barch, D. M., Buchanan, R. W., Dunayevich, E., Gold, J.M., …Green, M. F. (2015). Effort-based decision-making paradigms for clinical trials in schizophrenia: Part I- Psychometric characteristics of 5 paradigms. *Schizophrenia Bulletin, 41*(5), 1045-1054. doi: 10.1093/schbul/sbv089.

Reed, D. D., & Martens, B. K. (2011). Temporal discounting predicts student responsiveness to exchange delays in a classroom token system. *Journal of Applied Behavior Analysis, 44,* 1-18.

Reed, D. D., Niileksela, C. R., & Kaplan, B. A. (2013). Behavioral economics: A tutorial for behavior analysts in practice. *Behavior Analysis in Practice, 6*(1), 34-54.

Reynolds, B., & Schiffbauer, R. (2004). Measuring state changes in human delay discounting: An experiential discounting task. *Behavioural Processes, 67,* 343-356.

Reynolds, B., & Schiffbauer, R. (2005). Delay of gratification and delay discounting: A unifying feedback model of delay-related impulsive behavior. *The Psychological Record, 55,* 439-460.

Reynolds, B., de Wit, H., & Richards, J. B. (2002). Delay of gratification and delay discounting in rats. *Behavioural Processes, 59,* 157-168.

Richards, J. B., Mitchell, S. H., de Wit, H., & Seiden, L. S. (1997). Determination of discount functions in rats with an adjusting-amount procedure. *Journal of The Experimental Analysis of Behavior, 67,* 353-366.

Richards, J. B., Zhang, L., Mitchell, S. H., & De Wit, H. (1999). Delay or probability discounting in a model of impulsive behavior: Effect of alcohol. *Journal of The Experimental Analysis of Behavior, 71*, 121-143.

Rosch, K. S., & Mostofsky, S. H. (2016). Increased delay discounting on a novel real-time task among girls, but not boys, with ADHD. *Journal of the International Neuropsychological Society, 22,* 12-23. doi:10.1017/S1355617715001071.

Scheres, A., Sumiya, M., & Thoeny, A. L. (2010). Studying the relation between temporal reward discounting tasks used in populations with ADHD: A factorial analysis. *International Journal of Methods in Psychiatric Research*, *19,* 167-176. doi: 10.1002/mpr.309.

Scheres, A., Tontsch, C., Thoeny, A. L., & Kaczkurkin, A. (2010). Temporal reward discounting in Attention-Deficit/Hyperactivity Disorder: The contribution of symptom domains, reward magnitude, and session length. *Biological Psychiatry, 67,* 641-648. doi:10.1016/j.biopsych.2009.10.033.

Schweitzer, J. B., & Sulzer-Azaroff, B. (1988). Self-control: Teaching tolerance for delay in impulsive children. *Journal of The Experimental Analysis of Behavior, 50,* 173-186.

Seeyave, D. M., Coleman, S., Appugliese, D., Corwyn, R. F., Bradley, R. H., Davidson, N. S., et al. (2009). Ability to delay gratification at age 4 years and risk of overweight at age 11 years. *Archives of Pediatrics & Adolescent Medicine, 163,* 303–308. doi:10.1001/archpediatrics.2009.12.

Shamosh, N. A., & Gray, J. R. (2008). Delay discounting and intelligence: A meta-analysis. *Intelligence, 36,* 289-305. doi:10.1016/j.intell.2007.09.004.

Shiels, K., Hawk Jr., L. W., Reynolds, B., Mazzullo, R., Rhodes, J., Pelham Jr., W. E., … Gangloff, B. P. (2009). Effects of methylphenidate on discounting of delayed rewards in Attention Deficit/Hyperactivity Disorder. *Experimental and Clinical Psychopharmacology, 17,* 291-301. doi:10.1037/a0017259.

Staubitz, J. L., Lloyd, B. P., & Reed, D. D. (2018). A summary of methods for measuring delay discounting in young children. *The Psychological Record, 68,* 239-253.

Sugiwaka, H., & Okouchi, H. (2004). Reformative self-control and discounting of reward value by delay or effort. *Japanese Psychological Research, 46*, 1-9.

Van Houten, R. (1993). The use of wrist weights to reduce self-injury maintained by sensory reinforcement. *Journal of Applied Behavior Analysis*, *26*, 197-203.

Vollmer, T. R., Borrero, J. C., Lalli, J. S., & Daniel, D. (1999). Evaluating self-control and impulsivity in children with severe behavior disorders. *Journal of Applied Behavior Analysis, 32*, 451-466.

Ward-Horner, J., & Sturmey, P. (2010). Component analyses using single-subject experimental designs: A review. *Journal of Applied Behavior Analysis, 43,* 685-704. doi: 10.1901/jaba.2010.43-685.

Washio, Y., Higgins, S. T., Heil, S. H., McKerchar, T. L., Badger, G. J., Skelly, J. M., & Dantona, R. L. (2011). Delay discounting is associated with treatment response among cocaine-dependent outpatients. *Environmental and Clinical Psychopharmacology, 19,* 243-248. doi: 10.1037/a0023617.

Weatherly, J. N., Terrell, H. K., & Derenne, A. (2010). Delay discounting of different commodities. *The Journal of General Psychology, 137,* 273-286.

Weller, R. E., Cook III, E. W., Avsar, K. B., & Cox, J. E. (2008). Obese women show greater delay discounting than healthy-weight women. *Appetite, 51,* 563-569. doi:10.1016/j.appet.2008.04.010.

Wilson, V. B., Mitchell, S. H., Musser, E. D., Schmitt, C. F., Nigg, J. T. (2011). Delay discounting of reward in ADHD: Application in young children. *The Journal of Child Psychology and Psychiatry, 52,* 256-264. doi:10.1111/j.1469-7610.2010.02347.x.

Yi, R., Mitchell, S. H., & Bickel, W. K. (2010). Delay-discounting and substance abuse-dependence. In G. J. Madden & W. K. Bickel (Eds.), *Impulsivity: The behavioral and neurological science of discounting* (pp. 191–211). Washington, DC: American Psychological Association.

Zhou, L., Goff, G. A., & Iwata, B. A. (2000). Effects of increased response effort on self-injury and object manipulation as competing responses. *Journal of Applied Behavior Analysis, 33*, 29-40.

Table 1

Summary of percentages of SIR, LDR, SER, LER, and control selections during the choice delay and choice effort tasks.

	CDT			CET		
Participants	SIR	LDR	CONTROL	SER	LER	CONTROL
Gabriel	64%	46%	0%	56%	44%	0%
Edith	80%	20%	0%	60%	40%	0%
Elena	80%	20%	0%	72%	28%	0%

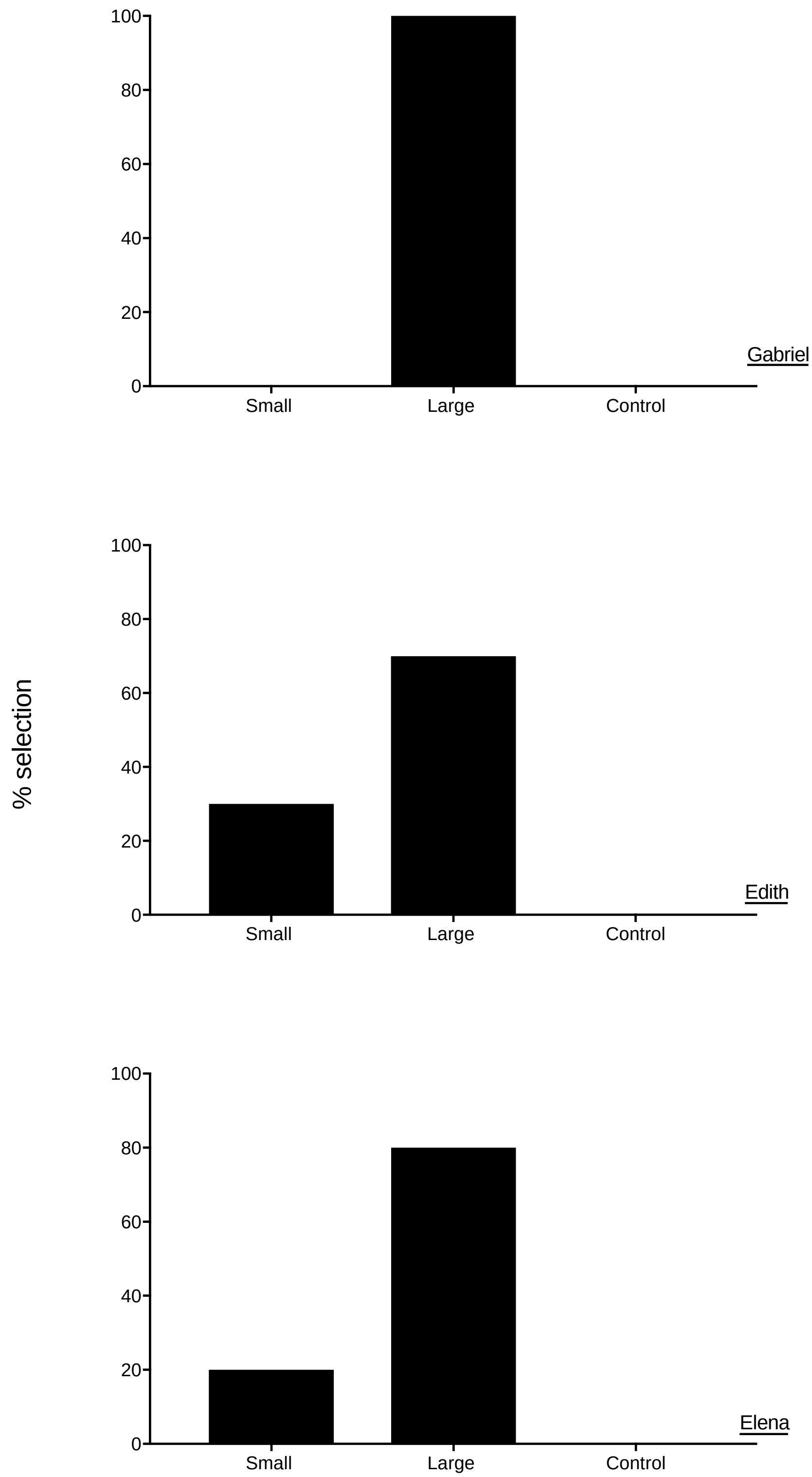

Figure 1. Percentage of small-magnitude reinforcer, large-magnitude reinforcer, and control selections during the Reinforcer Magnitude Assessment (RMA).

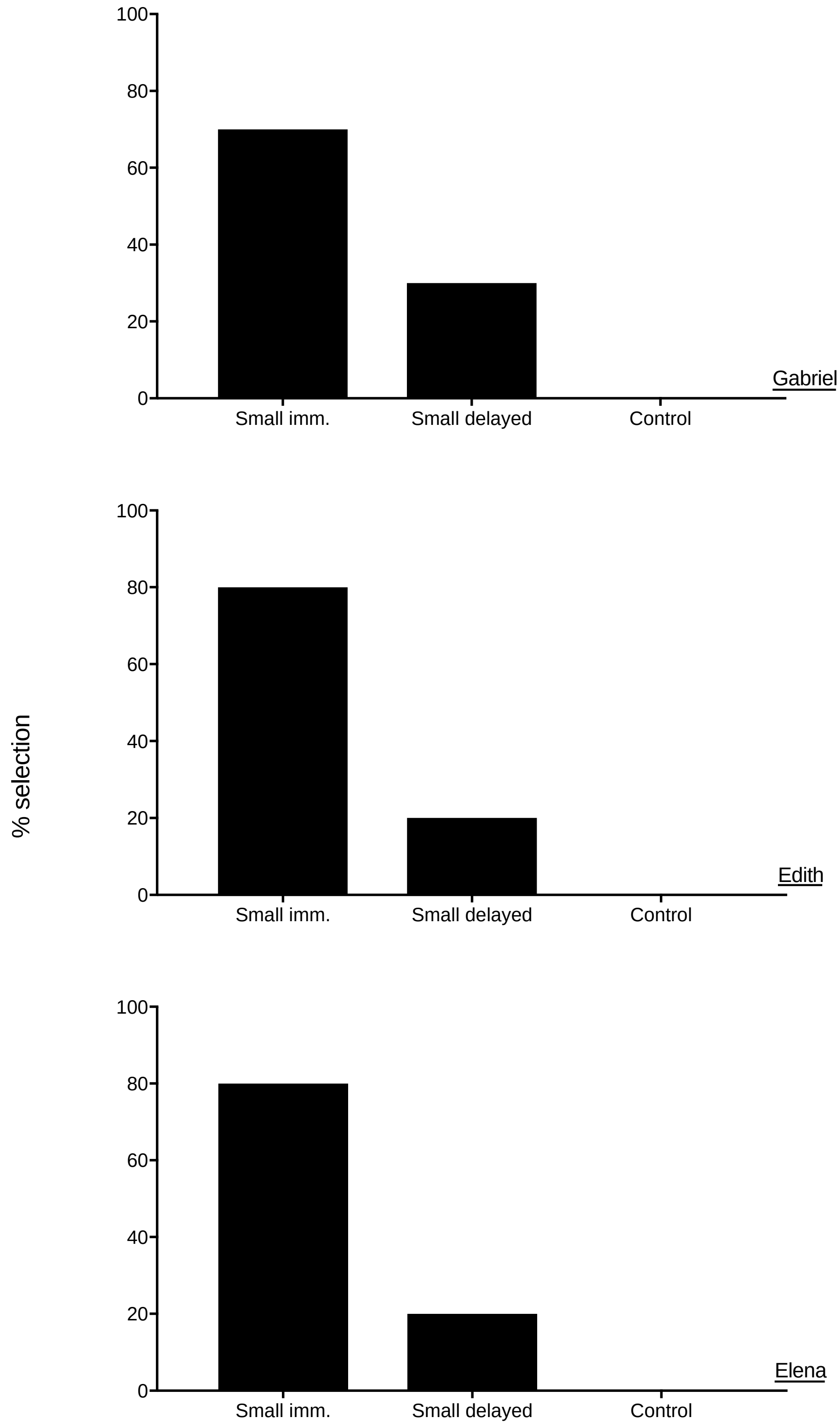

Figure 2. Percentage of small-immediate reinforcer, small-delayed reinforcer, and control selections during the Delay Assessment (DA).

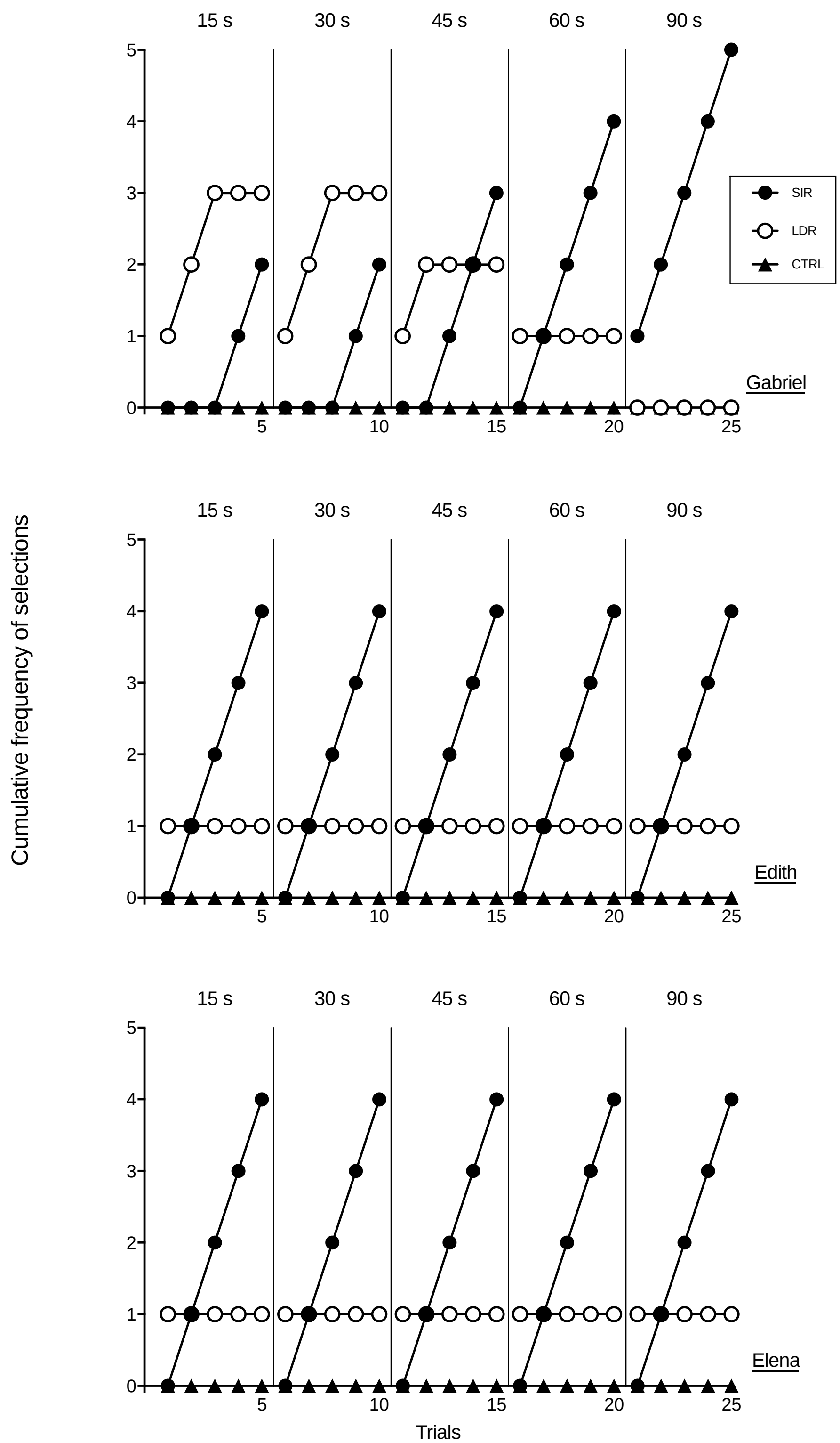

Figure 3. Cumulative frequency of smaller immediate reinforcer, larger delayed reinforcer, and control selections during the Choice Delay Task (CDT).

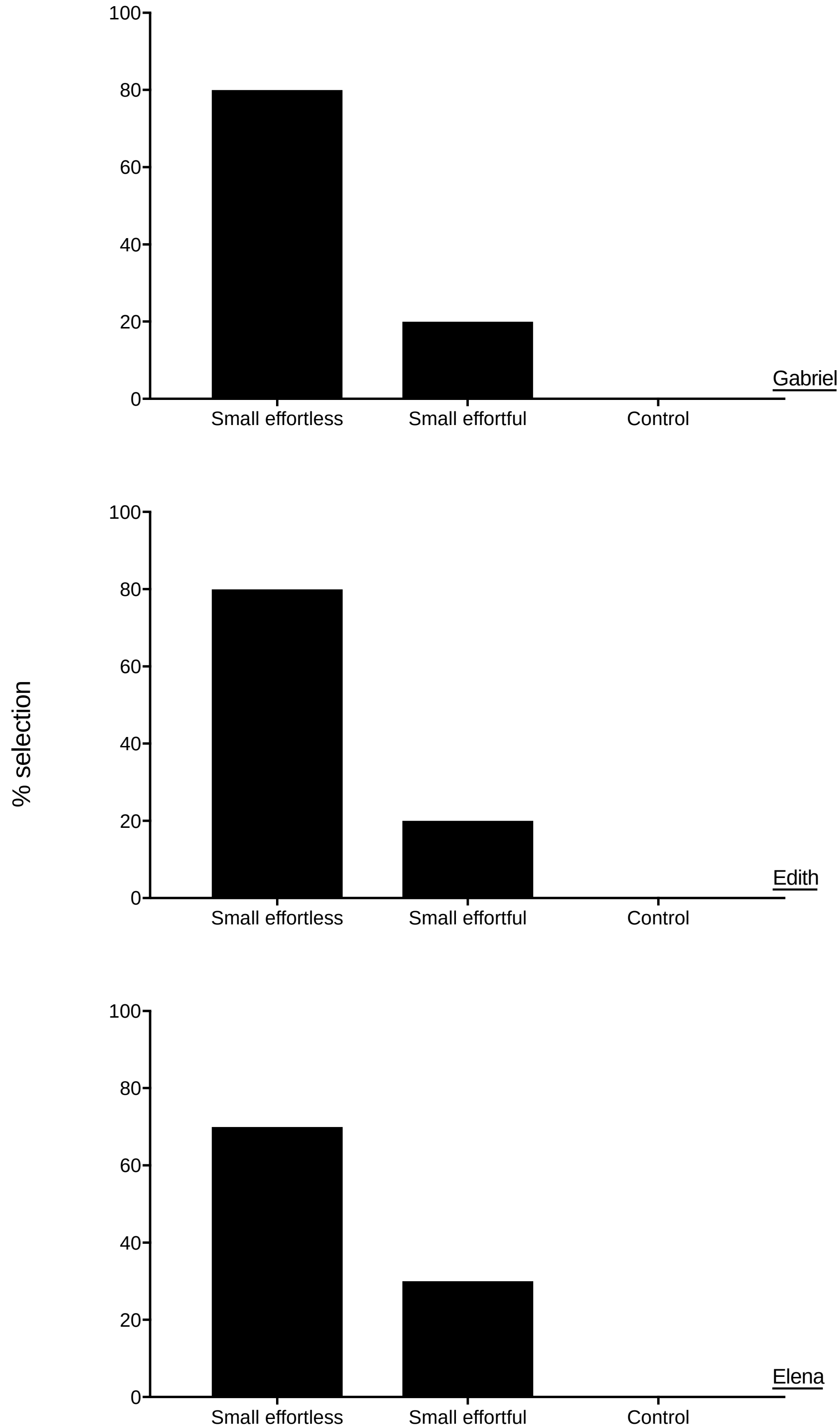

Figure 4. Percentage of small-effortless reinforcer, small-effortful reinforcer, and control selections during the Effort Assessment (EA).

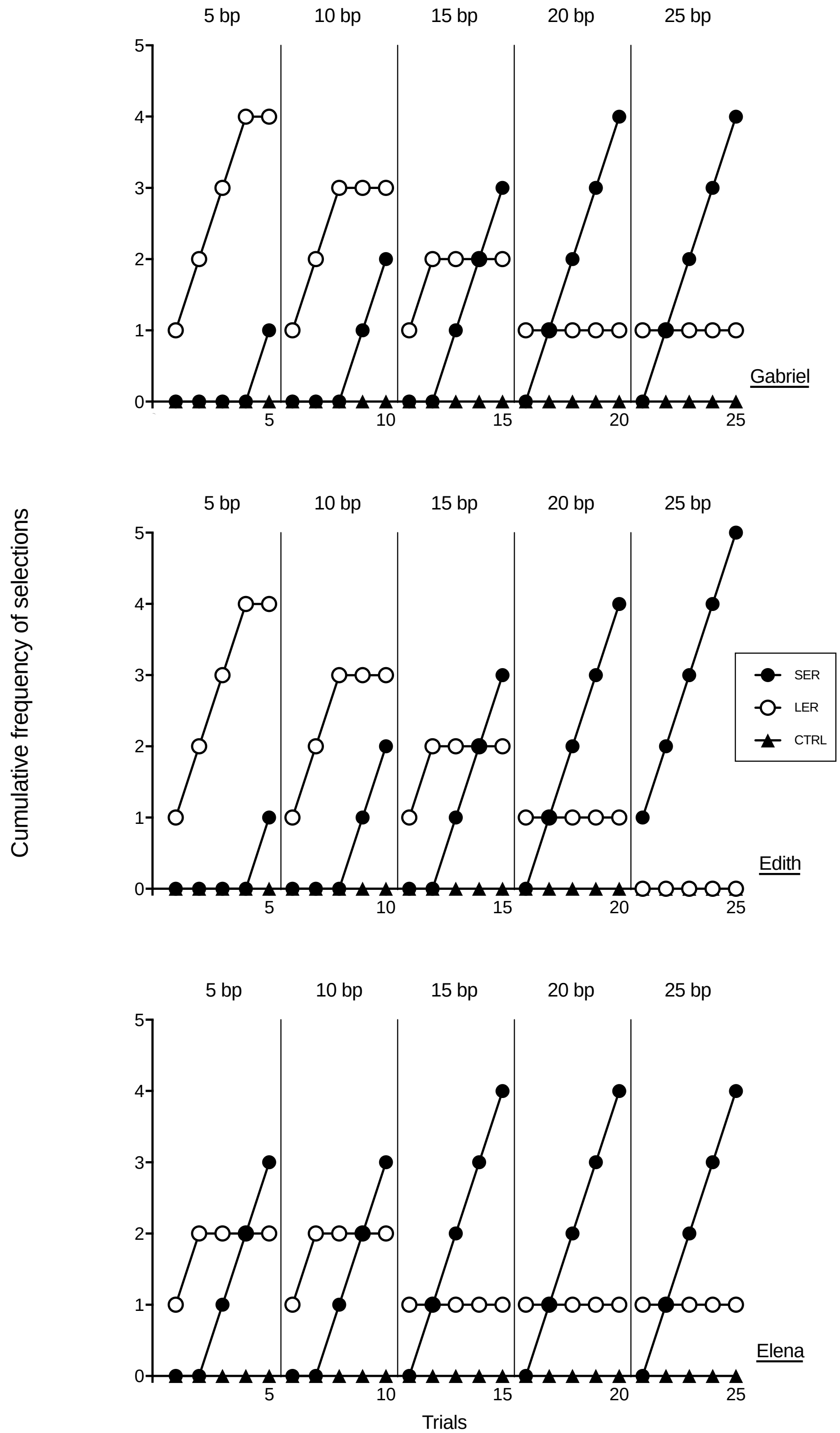

Figure 5. Cumulative frequency of smaller effortless reinforcer, larger effortful reinforcer, and control selections during the Choice Effort Task (CET).

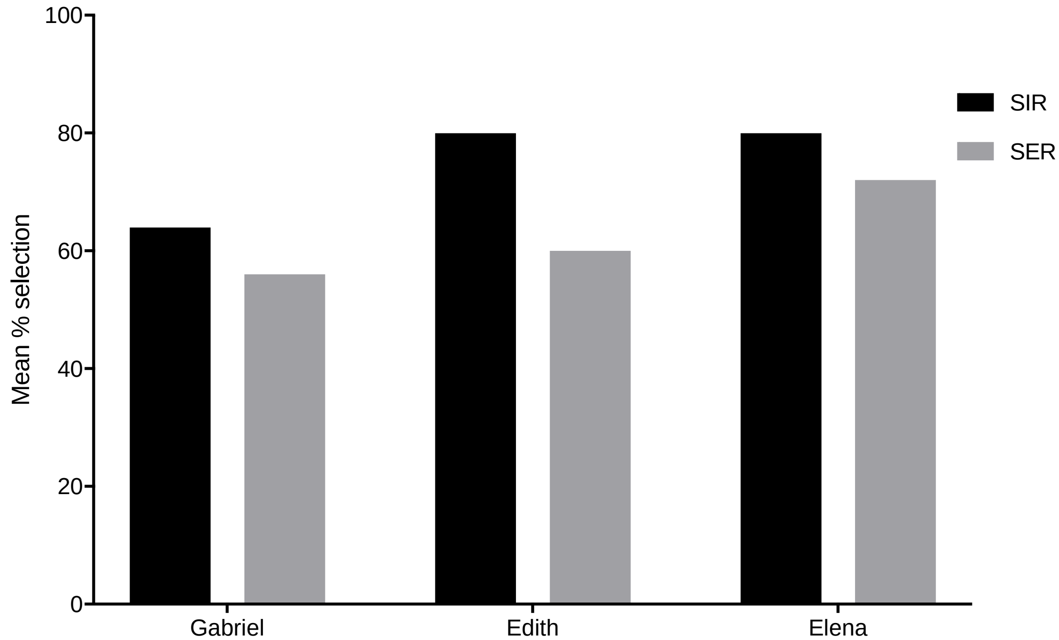

Figure 6. Mean percentage of smaller immediate reinforcer and smaller effortless reinforcer selections during the CDT and CET, respectively.

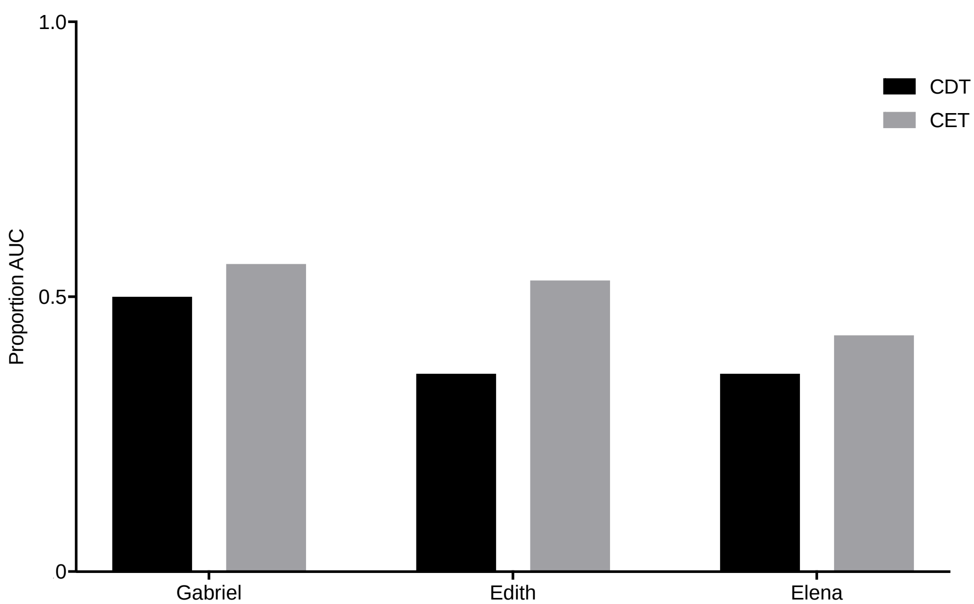

Figure 7. Mean proportion area under the curve (AUC) values from the CDT and CET.

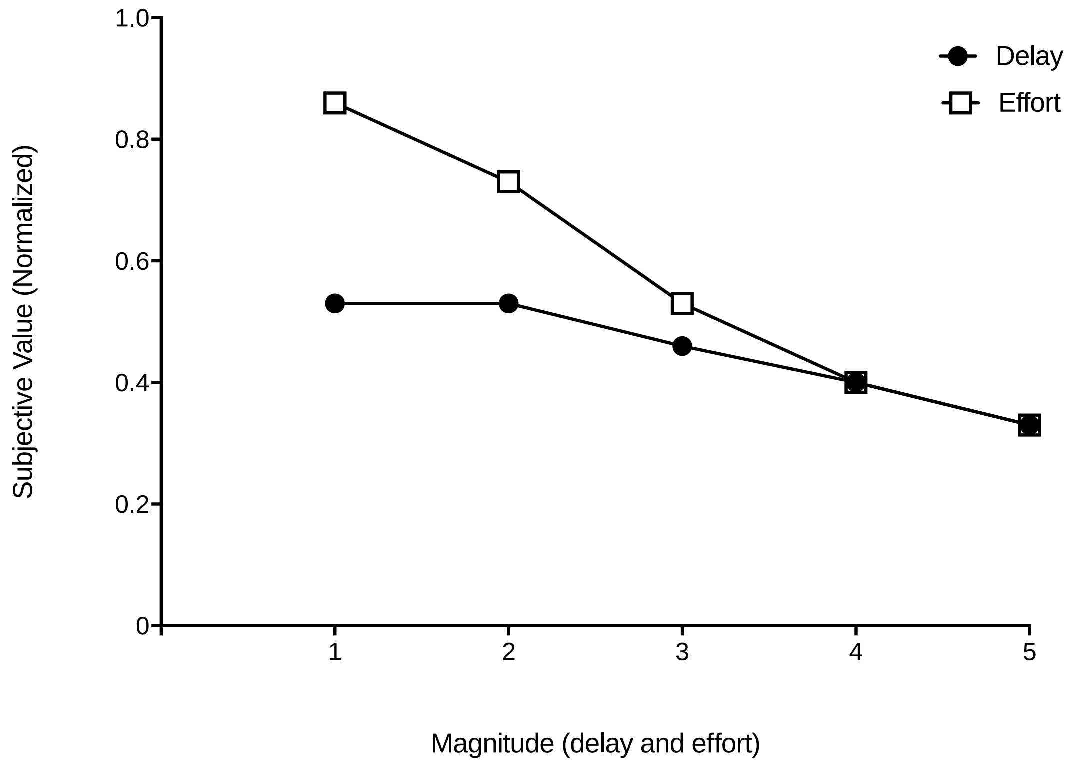

Figure 8. Mean subjective values of delayed and effortful rewards.

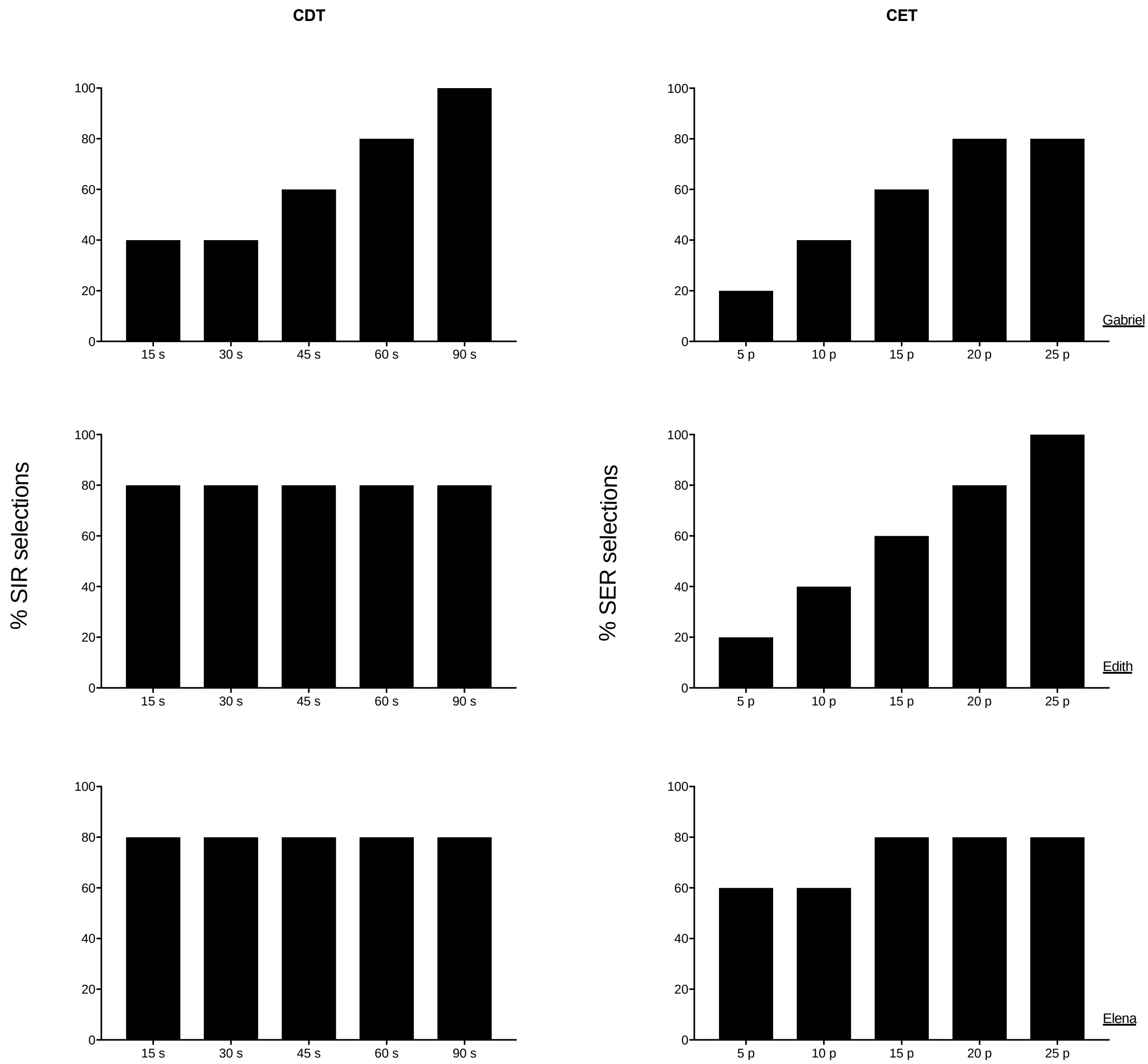

Figure 9. Side-by-side comparisons of the percentage of SIR selections across each delay (left-side graphs), and the percentage of SER selections across each effort requirement (right-side graphs) for each participant.