ARE ASSUMED DIFFERENCES IN DELAY DISCOUNTING AND DELAYED GRATIFICATION DUE TO PROCEDURAL VARIANCE?

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A thesis submitted in partial fulfillment of
the requirements for the degree of
Master of Arts

Department of Psychology

Central Michigan University
Mount Pleasant, Michigan
November 2014

ACKNOWLEDGMENTS

There are several people who have supported me throughout the undertaking of my thesis project. I wish to Dr. Reid Skeel, Thesis Committee Chair, whose level of support has been invaluable. He provided vital expertise and emotional support during both the highs and lows of my project's progression. Dr. Mark Reilly assisted me both in analyzing the data and providing resources when I needed additional techniques; without his support, this project would not have been completed. Finally, I want to thank Dr. Stuart Quirk for reminding me to think of the "bigger picture" when formulating my conclusions, and for offering numerous suggestions throughout this process.

In addition, many other individuals contributed to the completion of this project. Several undergraduate students in the Neuropsychology Lab assisted in data collection and provided much needed support when the operant measures were not running smoothly. Without the continuous technical assistance provided by Jason Reed from the Empirisoft Corporation, this project would have never become a reality.

Finally, my gratitude for my family and friends is immeasurable. My parents are an amazing source of encouragement and strength; their continued support allowed me to persevere when obstacles seemed insurmountable. My fiancé and friends provided the emotional support and insight that allowed me to focus on my education while keeping what's important in mind. I want to thank all of you for making this project possible.

ABSTRACT

ARE ASSUMED DIFFERENCES IN DELAY DISCOUNTING AND DELAYED GRATIFICATION DUE TO PROCEDURAL VARIANCE?

by Rachael Goldsworthy

Delay discounting refers to the subjective evaluation of reward values: a reward's value will subjectively decrease as the delay between when it is selected and when it is awarded becomes longer (Bickel & Marsch, 2001). Delayed gratification is the inclination to refrain from immediate satisfaction for the promise of a forthcoming larger reward (Hoerger et al., 2011; Mischel et al., 1972). Although both sound conceptually similar, the literature has taken divergent paths in regards to what the two concepts are measuring, and whether they represent the same underlying construct. The current study sought to make direct comparisons between these procedures using two novel operant procedures. Eighty-five participants were randomly assigned to one of three conditions: operant delay discounting, operant delayed gratification, or hypothetical delay discounting. In the two operant procedures, participants chose between watching relatively neutral-rated videos immediately, and watching highly-rated videos after variable delays. The hypothetical condition was a questionnaire version of the operant procedure. In addition, all participants completed the Hypothetical Monetary Reward questionnaire, the Barratt Impulsivity Scale, and the Delayed Gratification Inventory. Both of the operant conditions suggested the novel task was valid: the effect of the delay significantly affected participants' responses. Area under the curve analyses indicated that the choices made in the two operant procedures were not significantly different from one another. The current study supports models of delay discounting and delayed gratification that treat them as similar or identical processes. Limitations of the current study are also discussed.

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CHAPTER I

INTRODUCTION

Delay discounting and delayed gratification are operationally defined concepts that attempt to measure the underlying construct of impulsivity. Rachlin and Green (1972) described impulsivity as the act of choosing a smaller immediate reward as opposed to a larger delayed reward; this definition of impulsivity will be used in the present study. Both delay discounting and delayed gratification are studied as measures of impulsive behavior and the ability to resist prepotent responses. Delay discounting refers to the subjective evaluation of reward values: a reward's value will subjectively decrease as the delay to its receipt becomes longer (Bickel & Marsch, 2001). The act of discounting delayed rewards is typically measured by having participants repeatedly choose between immediate and delayed rewards; the delay for the large award is adjusted until the value of the two rewards are judged to be relatively equal (Green, Myerson, & Macaux, 2005). Delayed gratification has been defined as the inclination to refrain from immediate satisfaction for the promise of a forthcoming larger reward (Hoerger et al., 2011; Mischel et al., 1972). In the delayed gratification paradigm, the participant is typically presented with a lesser reward immediately (usually a food item), or a larger reward if the participant is able to refrain from consuming the lesser reward during the delay period (Metcalfe & Mischel, 1999). In other words, the participant is constantly provided the option of consuming the lesser reward while waiting for the preferred, larger reward.

Although delay discounting and delayed gratification sound conceptually similar, the literature has taken divergent paths in regards to what the two concepts are measuring, and whether the two represent the same underlying construct. Reynolds and Schiffbauer (2005) argued that delay discounting and delayed gratification are fundamentally different processes, because delay discounting measures the “initial choice preference” between two rewards, and delayed gratification measures an individual’s ability to *sustain* their choice during the delay. Alternatively, Rachlin (2002) alleged that the concepts are fundamentally similar by stating that, “waiting time in delay-of gratification experiments depends on delay discount functions” (p. 47). Several authors also use the concepts interchangeably (e.g., Green, Fry & Myerson, 1994; Anokhin et al., 2011; Epstein et al., 2010; Caswell, Morgan & Duka, 2013).

As stated previously, delay discounting is assessed by asking participants to choose between a series of a smaller rewards available immediately versus higher rewards available after a delay (Green, Myerson & Macaux, 2005). When delayed gratification is assessed, participants are presented with two rewards; they are told to wait for a period of time for the larger (often preferred) reward, or that they may consume the smaller reward at any time (Mischel, Ebbesen & Zeiss, 1972). In other words, traditional delay discounting procedures assess the initial choice involved in the decision, whereas delayed gratification assesses one’s desire to maintain that decision during the delay while resisting the temptation of the smaller reward (Reynolds & Schiffbauer, 2005). The present study proposes that procedural variance may account for much of the argued theoretical differences between delay discounting and delayed gratification. It is possible that both represent the same underlying processes, but appear different due to the methodologies used to assess them. As such, there is a need to combine both delayed gratification and delay discounting procedures into one study in which the two may be directly compared in humans. In addition, it is necessary to develop an operant procedure that allows for the experience of each delay.

Research Utilizing Delay Discounting Tasks

Delay discounting originated from animal research, and has been considered a measure of impulsive behavior in behavior analysis literature (Reynolds & Schiffbauer, 2005). Discounting refers to the diminishing value of a reward as a function of an increasing delay time (McKerchar et al., 2009). Exponential discounting models have been used to model the rate of discounting, but tend to over predict the subjective value on items with shorter delays, and do not predict preference reversals (Rachlin, 2002). As such, Mazur (1987) proposed this alternative hyperbolic model of discounting:

$$V = A/(1 + kd)$$

In the above equation, V is the subjective value of a delayed reward, d is the delay, A is the amount of the delayed reward, and k is a free parameter. A higher k value indicates a greater rate of discounting. The hyperbolic equation proposed by Mazur (1987) will be used in the present study.

An alternative approach proposed Myerson, Green, and Warusawitharana (2001) utilizes area under the curve (AUC) to measure the level of discounting. This procedure analyzes the area under the empirical discounting function to estimate the level or amount of discounting for each individual. The distribution of AUC values resembles normality, unlike traditional discounting parameter estimates that tend to be positively skewed (Myerson, Green, & Warusawitharana, 2001). One limitation of this technique is the possibility that two individuals can have different discounting rates, but derive the same area underneath that curve. With the AUC approach, these two individuals would be given identical discounting values (Myerson, Green, & Warusawitharana, 2001).

Studies with novel delay discounting measures typically use drug-dependent groups as a way of validating that their measure is assessing the underlying construct of impulsivity. Logue (1995) expanded upon Rachlin and Green's (1972) definition of impulsivity, stating that the construct includes all choices that result in smaller, immediate rewards that have delayed, negative consequences**.** It is possible that drug-dependent individuals are more likely to discount the value of delayed rewards. When a delay discounting measure yields higher *k* values for these individuals, the measure is determined to be an adequate method of measuring impulsive behavior. As a result, many studies validate delay-discounting procedures using substance abuse populations.

The following two studies demonstrate the traditional approach to measuring impulsivity through the use of delay-discounting questionnaires. Madden et al. (1997) utilized the delay discounting procedure for both an opioid-dependent and a control group. Hypothetical values of both money and heroin were used; however, the subjective value of heroin was only studied with the experimental group. Index cards were used to display both the rewards and delays, and subjects were to make choices about which hypothetical reward they would rather receive. The delayed reward value was fixed at $1,000, and the immediate reward was adjusted until the participant indicated indifference between the two reward values. This procedure was used to assess indifference between the two reward values for seven delays (1 week, 2 weeks, 2 months, 6 months, 1 year, 5 years, and 25 years). The experimental condition was also asked to make choices between differing amounts of heroin using the same procedure (the delayed value was roughly equivalent to $1,000 worth of the drug). The choices for the monetary and heroin rewards were then compared for the experimental group, which allowed for within-subject comparisons between reinforcers. It was found that the opioid-dependent group discounted monetary rewards significantly more than the control, and discounted the heroin rewards to an even greater extent (Madden et al., 1997).

Coffey et al. (2003) presented both a crack/cocaine dependent and a matched control group with hypothetical monetary rewards using a similar procedure utilized by Madden et al. (1997). Once again, the experimental group was presented with hypothetical crack/cocaine reward choices in addition to the monetary rewards. Choices were presented on index cards, and the reward amounts ranged from $1 to $1,000; the crack/cocaine choices were roughly equivalent to these values. The indifference point between the immediate and delayed reward was assessed for the same seven delay periods used in the Madden et al. (1997) procedure outlined above. The delays for the hypothetical crack/cocaine reward choices were reduced to minutes and hours to prevent a floor effect (i.e., always preferring the immediate cocaine reward). As predicted, the crack/cocaine dependent group discounted the value of money at a faster rate than the controls. In other words, the experimental group tended to choose the smaller, immediate reward, whereas the control group demonstrated a preference to wait for the larger reward. In addition, the substance-dependent group discounted crack/cocaine reward at a higher rate than monetary rewards (Coffey et al., 2003).

Delay discounting is a procedure often used in conjunction with self-report scales and other measures of impulsivity. For example, Baumann and Odum (2012) assessed delay discounting in addition to time perception, and hypothesized that people who judge time as passing more quickly were more likely to be impulsive. It was theorized that different aspects of impulsivity and time perception were related, and that a higher rate of discounting would be associated with riskier behavior. Participants sat at a computer and were shown an image of a circle that was present on the screen. The trials had varying durations of time that the circle was present, which ranged from 2-4 seconds. The participants were instructed to indicate how long they thought the circle was displayed on a screen by classifying each trial as “short” or “long.” The proportion of “long” responses was assessed to indicate time perception. The delay discounting procedure assessed indifference for seven delays (1 day, 2 days, 1 week, 2 weeks, 1 month, 2 months, and 6 years). The larger hypothetical reward was $100, and the immediate reward was adjusted from $50 until the participant indicated indifference between the two rewards. This process was repeated for each of the seven delays. Results indicated a positive correlation between the degree of discounting and the time perception measure. As such, Baumann and Odum (2012) concluded that people who perceive time as passing more quickly discount rewards at a greater rate.

Operant Measures of Delay Discounting

Although many studies assess the rate of discounting by asking participants to make choices between hypothetical rewards, this method has several limitations. Individuals are asked to make a choice between two rewards with the knowledge that these rewards will not be obtained. This method may affect the validity of the responses, in that responses differ for real and hypothetical rewards (Johnson, 2002; Kirby, 1997). Secondly, the procedure acts as a self-report of delay discounting; participants are not required to actually wait for the larger, delayed reward if they have indicated that they would be willing to do so. It becomes difficult to create a behavioral measure for delay discounting because many of the choices involve large amounts of money and delays of several weeks or longer—asking participants to experience these delays would be unreasonable and expensive. Finally, delay discounting procedures typically use hypothetical amounts of money to assess the rate of discounting (e.g., Baumann & Odum, 2012; Coffey et al., 2003; Green, Myerson & Macaux, 20005; Madden et al., 1997;. Money is not a primary reinforcer, and has a subjective value for each individual depending on socioeconomic status, and affect, among other characteristics (Raghubir, 2006). It becomes difficult, then, to measure monetary discounting if the values are not stable across the participants.

In order to compensate for the limitations the traditional hypothetical procedure poses, many studies have implemented a random drawing, wherein one of the participants' choices from the delay discounting procedure is randomly selected. That participant then receives the amount they have chosen for a particular response. Johnson and Bickel (2002) conducted a study that involved two monetary reward procedures, one involving the random drawing component. Participants were informed that some of their answers would be potentially real, while others would be purely hypothetical. On each trial, the computer specified whether the participants' choices on the trial would be potentially real or hypothetical. All participants then completed a computerized delay discounting task that utilized a choice algorithm, which adjusted the value of both rewards based upon prior responses. The larger rewards began at $10, $25, $100, and $250, and were adjusted until an indifference point as estimated. For all but one participant, there were no systematic differences in the rate of discounting between the trials that incorporated a random drawing and the traditional (i.e., purely hypothetical) trials. The log-transformed *k* values for the random drawing trials were positively correlated with the log-transformed *k* values in the purely hypothetical trials. Although this study appears to demonstrate the validity for the use of hypothetical questionnaires, there were only six participants included in the study; in other words, there was a systematic difference between the trials for 16% of the participants. As such, although a random drawing encouraged participants to respond more truthfully, Warren and Bickel (2002) cautioned against assuming that hypothetical rewards are a sufficient proxy for all individuals.

Kirby (1997) was also interested in the possible discrepancy between hypothetical and real rewards associated with delay discounting procedures. Hyperbolic discounting rates from nine prior studies were compiled, which included both real and hypothetical delay discounting procedures. Results indicated that the mean slope for the hypothetical reward studies was -0.24; the mean slope for the "real reward" studies was -0.71. Also, the rate of discounting in the real reward conditions declined more severely the hypothetical conditions. Kirby (1997) theorized that real rewards might be discounted more than hypothetical rewards. Kirby (1997) noted the fact that smaller delayed reward values are discounted more than larger delayed reward values, which constitutes a "magnitude effect," and may be more pronounced in real reward situations. However, Kirby (1997) argued that the different levels of rewards used in the hypothetical and real procedures likely explain this magnitude effect. Operant procedures typically employ smaller delayed rewards due to financial limitations (e.g., $.80 versus $1,000). As a result, studies that use real rewards may observe larger rates of discounting due to this magnitude effect, which gets weaker with increasing reward values (Kirby, 1997).

Although Kirby (1997) found evidence to suggest that magnitude effects are more pronounced in real procedures, later research in this area has found conflicting results. Lagorio and Madden (2005) conducted a study in which six subjects participated in both hypothetical and real reward delay discounting procedures. Participants completed the hypothetical sessions first, and were instructed to make choices between two hypothetical amounts of money, which ranged from $.10 to $1.00. The delays were 1 day, 3 days, 1 week, 1 month, 2 months, 6 months, and 1 year. These sessions were continued until the participants' choices were assumed to be stable (*M* = 5.4 sessions). The participants were then told that they would be making choices between real reward amounts, which could only be redeemable for snack and beverage items in the laboratory.

The delays for the real choice sessions were 1 day, 1 week, and 1 month; if the participant chose to receive $1 in 1 week, for example, they would receive the money in one week's time and could then purchase snack items from the laboratory. Results indicated that the area under the curve values were not significantly different based upon reward type (i.e., real vs. hypothetical). As such, Lagorio and Madden (2005) concluded there were no significant differences between hypothetical and real reward procedures. Although this study allows for comparison between both measures, the methodology has limitations. Participants were told they could not save up the money they have received. All rewards, including delayed rewards, could only be redeemed for store items in the laboratory. It can be argued that the rationale behind choosing a larger, delay reward in real life includes a "saving up" component; this motive was not an option in this study and may affect the validity of the results.

Millar and Navarick (1984) produced an operant measure of delay discounting that involved real choices between primary reinforcers. Prior to this date, only two studies of this nature had been conducted with humans (Navarick, 1982; Solnick et al., 1980), both of which used negative reinforcement. Millar and Navarick (1984) wished to find a positive reinforcer that produced enough motivation to induce impulsive behavior, or delay discounting effects, in humans. The first experiment explored whether video game playing was reinforcing to the participants. Participants made several different choices in which only the delay was manipulated (i.e., playing the video game immediately or after a certain amount of time), only reinforcer properties were manipulated (i.e., the amount of time participants could play the game was manipulated), or both were manipulated simultaneously (i.e., the delay preceding the larger reinforcer and the amount of gaming time). Millar and Navarick (1984) hypothesized that, if video games were reinforcing, participants would prefer the immediate reinforcer to a delayed one, and a large reinforcer to a small one. Data from the first group of participants supported this hypothesis, whereas the third group did not provide significant evidence for either the immediate reinforcer or the larger, delayed reinforcer. For 40% of the participants, imposing delays before the large reinforcer resulted in a preference for the smaller, immediate reinforcer. Although video gaming time did not provide evidence of impulsive behavior in all three conditions, Millar and Navarick (1984) concluded that these results show promise for impulsivity research, and provide important insight into the nature of operating delay discounting measures.

As stated previously, the question of whether there are significant differences between real and hypothetical choices continues to exist, and thus motivates researchers to continue investigating additional operant procedures. Navarick (1998) sought to validate another operant measure to assess delay discounting through the utilization of cartoon video clips. College students chose between two animated cartoon schedules: 15 seconds of cartoon viewing time followed by a delay of 75 seconds (immediate, smaller reward), or a delay of 55 seconds followed by 25 seconds of viewing time (delayed, larger reward). A second group of participants made similar choices, only the immediate reinforcer was 10 seconds in length. If individuals chose the smaller reward on at least 70% of the trials, their behavior was considered impulsive. Conversely, if the smaller reward was chosen less than 30% of the time, the behavior was viewed as self-controlled. Results indicated that 40% of the participants were considered impulsive, 40% were considered self-controlled, and the remaining were undetermined (Navarick, 1998). Although this study shows promise for the use of operant measures, there are some potential confounds. Participants were not informed about the length of the delay preceding the larger reward, nor how long the video clip would play on each trial. In addition, the reinforcer is the amount of time the video clip is shown; in other words, the cartoon is simply cut short after 15 or 25 seconds, which likely interferes with its reinforcing properties.

Measures that impose delays on the order of seconds have also been shown to produce discounting (Navarick, 2001). Johnson (2012) created a coin delivery operating system that rewards participants after each choice trial. Participants included 20 cocaine dependent individuals and 20 individuals who were not cocaine dependent. There were 20 total trials with 5 delays (5, 10, 20, 40, and 80 seconds); the larger reward was kept constant at $.80. The smaller immediate reward started at $.40, and was adjusted on subsequent trials depending on the participants' prior choices. When participants chose the smaller immediate reward, the amount was dispensed and could be kept as money earned. If the larger delayed reward was chosen, participants observed a timer on the computer screen that counted down each delay, and received the $.80. This experimental task, also known as the Quick Discounting Operant Task, produced effects of delay discounting that fit the hyperbolic function adequately. Results indicated that the cocaine-dependent participants discounted rewards significantly more than the control group (Johnson, 2012).

It is tempting to use monetary rewards as reinforcement in delay discounting procedures: money facilitates reward value manipulation, and operates as a reinforcer for each participant. As stated previously, however, money has a different subjective value for each individual. As observed by Madden et al. (1997) and Coffey et al. (2003), substance users discount drugs of abuse more steeply than monetary rewards. Odum and Rainaud (2003) investigated the reinforcing properties of other primary reinforcers by assessing delay discounting of food and alcohol rewards with participants who were not drug-dependent. The purpose of the study was to determine if a primary reinforcer, such as food, would be discounted in the same way that alcohol and money are discounted. Twenty participants were interviewed about their favorite foods, and subsequently chose between hypothetical amounts of food, money, and alcohol in separate conditions. For each reinforcer, the immediate option started at a value of $100 (e.g., $100 in cash, 10 pizzas, or 20 six-packs of beer) and decreased after the first trial. The delayed reward was held constant at a $100 value. For each condition, the smaller reward was always available immediately, and the larger reward was available after a delay (1 week, 2 weeks, 1 month, 6 months, 1 year, 5 years, and 25 years). Mean areas under the curve showed that participants discounted money less steeply than food or alcohol, but the primary reinforcers produced similar discounting patterns of behavior (Odum & Rainaud, 2003). One limitation of this study is the use of large amounts of food or alcohol. For example, participants were asked to make hypothetical choices involving large sums of their favorite foods (e.g., ten pizzas after two weeks). This strategy was utilized to provide variation in the amount of rewards available, but the mere amount of food or alcohol available does not have a larger reinforcement value per se.

In response to the possible discrepancy between hypothetical questionnaires and real choice procedures, Navarick (2004) asserted that hypothetical questionnaires yield discounting values that are too low to explain the impulsive behavior seen in operant measures. By using a comparison of hypothetical questionnaires and operant measures, Navarick (2004) found that hypothetical measures produce a slower discounting curve. It was theorized that hypothetical measures produce a low rate of discounting because they don't allow the participant to experience the reinforcer. Navarick (2004) referenced Johnson and Bickel's (2002) hypothetical questionnaire data, and noted that k (rate of discounting) increased as the amount of the larger, delay reward decreased. However, when the reinforcement values of Johnson and Bickel's (2002) questionnaire were compared to Millar and Navarick's (1984) cartoon study, the k values associated with the hypothetical procedure are much lower. In other words, if the *k* values derived from the hypothetical questionnaire were applied to operant procedure, the *k* values from the questionnaire would predict no discounting in the operant procedure. Navarick (2004) concluded that these differences result in the actual experience of the delay and consumption of the reward; only in operant procedures are subsequent choices sufficiently dependent upon prior experiences.

Research Utilizing the Delayed Gratification Paradigm

Delayed gratification refers to the act of abstaining satisfaction associated with an immediate reward while waiting for a larger reward (Hoerger, Quirk, & Weed, 2011). The study of delayed gratification as a measure of self-control has traditionally been operant in nature. Research utilizing the delayed gratification paradigm typically present the participant with a small reward that's available at any time, and a larger reward available later (Mischel, Ebbesen, & Zeiss, 1972). The dependent variable under question is the amount of time the participant refrains from deferring to the smaller reward while experiencing the delay associated with the larger reward. Delay discounting, on the other hand, is the rate at which one discounts the value of a reward that is not immediately available (Johnson & Bickel, 2002).

Metcalfe and Mischel (1999) proposed a hot/cool system in an attempt to understand the dynamics of willpower and decision-making. The cool system is cognitive in nature, and actions are premeditated. Conversely, the hot system is thought to give rise to emotions, fears, and impulsivity. The balance between these two systems is dependent upon stress, individual differences, and the ability of an individual to self-regulate their behavior (Metcalfe & Mischel, 1999). When applying the hot/cool system framework to the delayed gratification paradigm, the cool system monitors progress and allows the participant to "keep their eye on the prize," or the larger, forthcoming reward. The hot system is largely driven by external stimuli (e.g., the immediate availability of the smaller reward) and is prone to impulsiveness (Metcalfe & Mischel, 1999). Current studies on delay discounting and impulsivity continue to refer to this two-system framework when describing differences in impulsive behavior.

Due to the nature of the delayed gratification design, research in this area has typically employed children as research subjects. A study by Mischel, Ebbesen and Zeiss (1972) asked 162 elementary school children to make choices about two reinforcers (a marshmallow or a pretzel). Whichever snack was chosen to be the child's favorite became the delayed reward. The children were instructed to sit and wait for the delayed reward; they could ring a bell at any time to signal their preference for the other, less-preferred snack. In addition, Mischel et al. (1972) told some of the children to either play with a toy or to think of pleasant thoughts to test the effects of attention on delaying gratification. In the control group, the children were not instructed to engage in another activity while they waited for the larger reward. The dependent variable in this study was the amount of time the child waited before ringing a bell. As expected, children were able to delay gratification much longer when they were engaging in a distracting activity: the delay time (expressed in minutes) for the control group ($M = 0.5$) was much shorter than the toy group ($M = 8.6$) and the pleasant thoughts group ($M = 12.1$).

The results of Mischel, Ebbeson and Zeiss's (1972) study brought to light several mechanisms that affect the ability to delay gratification. First, when the child can see the anticipated reward, it becomes much more difficult to withstand the delay time. When children were asked to think about distracting thoughts, the average delay became longer; however, thinking about the anticipated reward resulted in shorter average delay times (Mischel, Ebbeson, and Zeiss, 1972). In short, providing the participant with a constant reminder of the anticipated reward has been shown to result in shorter delay times, and allowing the participant to distract themselves will likely result in longer delay times.

Delayed gratification has also been studied in adult populations. Rosenbaum and Smira (1986) studied the factors associated with delaying gratification using fifty-three dialysis patients who were constantly required to comply with a strict fluid-intake regimen. Unfortunately, the diet is accompanied by a constant source of frustration for the patients, who must constantly avoid drinking too many fluids. In other words, the immediate satisfaction of satisfying one's thirst must be overcome in order to delay gratification (i.e., stay healthy). It was hypothesized that self-evaluations of past compliance with the strict diet, as well as expectations about their ability to stick to the fluid regime would be associated with delayed gratification outcomes. It was found that learned resourcefulness, a set of self-control abilities measured by Rosenbaum's Self-Control Scale, was correlated with the patient's ability to adhere to the strict diet. These self-control abilities included strategies such as problem solving, coping with both emotional and physical responses, and evaluating alternatives. Interestingly, many similar factors between Mischel et al.'s (1972) study and the present study emerged: participants who were better able to distract themselves were more likely to delay gratification. Rosenbaum and Smira (1986) expanded upon Mischel's previous research, and concluded that the ability to delay gratification is dependent upon both behavioral abilities and resourcefulness.

Research on both the hot/cool systems and self-control likely prompted researchers to study the manipulation of these processes on delaying gratification. Gino et al. (2011) conducted a study that depleted subjects of their self-control resources, and subsequently measured their unethical behavior on a separate task. Self-control is theorized to be a finite resource (Baumeister & Heatherton, 1996); when an individual uses self-control for one task, fewer resources are available for consequent tasks. In the present study, participants first completed an attentional task that required self-control resources: participants were instructed to watch a video clip and ignore the words that appeared below the screen. The control condition also watched the video clip, but was given no instructions regarding the accompanying words. Participants were then presented with a problem-solving task; they had the opportunity to "cheat" by reporting higher scores than they had actually earned on this task. Results indicated that a larger portion of participants cheated in the manipulation condition than the control condition, showing support for the self-regulation hypothesis. It is important to note, however, that the manipulation condition was given instructions about the attention task (i.e., ignoring words on the screen) in which compliance could not be validated by the experimenter.

Although the above studies contributed to the understanding of delayed gratification, frustrations with methodological errors, construct validity, and reliability threats have led to the need for more concrete measures of delayed gratification (Hoerger et al., 2011). A study conducted by Hoerger et al. (2011) sought to develop a new measure that assessed individuals on the five domains typically addressed in delayed gratification research: food, social interactions, achievement, money, and physical pleasure. It is important to note that the authors give considerable mention to the inconsistencies of operational definitions in self-control literature, stating that many constructs have been interchanged and subtle distinctions ignored. However, when conceptualizing delayed gratification as an area of research, Hoerger et al. (2011) considered delay discounting tasks to measure equivalent processes as the delayed gratification measures. This integration of delay discounting and delayed gratification into a unifying construct is a crucial area of concern for the proposed study.

The Discrepancy between Delay Discounting and Delayed Gratification

After conducting a literature review on delay discounting and delayed gratification, three patterns emerged: the two procedures are assumed to refer to the same underlying process, the two are explicitly stated to be different, or there is a strict focus on only one of the procedures. Reynolds and Schiffbauer (2005), for example, assert that while both procedures measure impulsive behavior, they are not measuring the same processes. “The DG [delayed gratification] procedure is a measure of ability to *sustain* [italics in original] a choice for a delayed reward while a smaller immediate reward is continually available... In contrast to DG measures, DD [delay discounting] procedures focus on initial choice responses” (Reynolds & Schiffbauer, 2005). The argument for this distinction relies upon the methodologies typically used to study delay discounting and delayed gratification. Reynolds and Schiffbauer (2005) stressed that future researchers should not assume that the two constructs are measuring the same processes nor treat them as equivalent, because the procedures used to measure them are discretely different. The authors continue their argument by stating that no measure has been studied that allows a direct comparison between the two procedures (Reynolds & Schiffbauer, 2005). The proposed study aims to address this distinction by allowing for the direct comparison of these two procedures.

Angott (2010) also discusses the distinction between delay discounting and delayed gratification, and refers to Reynolds and Schiffbauer (2005) argument when doing so. Angott (2010) argues that delay discounting research studies how people make certain choices, while delayed gratification research studies how people sustain these choices. In studies of delay discounting, the participant does not exert the continuous self-control that is prevalent in delayed gratification research. However, the distinction between these procedures (e.g., allowing someone to sustain their reward preference versus not allowing for this opportunity) is not sufficient to conclude that they represent different underlying components of impulsivity. The curiosity of this distinction is illustrated more clearly when one considers a typical operant delay discounting procedure: the participant makes several choices between rewards, and experiences the delay prior to receiving the larger reward. When making the initial choice between a smaller immediate reward and a larger delayed reward, does this part of procedure represent delay discounting or delayed gratification? After the choice is made and the participant waits for the reward, does the procedure now become “delayed gratification,” or is it still part of the delay discounting procedure?

A study conducted by Reynolds, de Wit and Richards (2002) demonstrates the controversy surrounding differences between delay discounting and delayed gratification. Due to the fact that the two procedures are often viewed as reflecting different processes, the procedures were directly compared using rats. For both the delay discounting and delayed gratification conditions, two water dispensers were placed in the chambers; the left water bottle (larger reward) dispensed 250 μl water after a variable length of time (0, 4, 8, 16, and 32 seconds). The right water bottle dispensed a variable amount (which was usually less than 250 μl) of water immediately (smaller reward). If the rat chose the larger reward, the amount of water dispensed by the other water bottle would increase by 15% until an indifference point could be obtained. Half of the rats were placed under the delay discounting condition; after indicating a preference for the larger reward, the rats could not dispense water from the other bottle during the delay period. The other half of the rats were placed into the delayed gratification condition; after indicating a preference for the larger reward, these rats *were* able to dispense water from the other bottle during the delay, which indicated a preference reversal. The main difference between the two groups was the availability to switch alternatives in the delayed gratification condition.

Results indicated that both groups were similar in their adjustment towards an indifference point, and that both groups produced similar indifference points for each of the delays. There were no significant differences in *k* values (rate of discounting) between the two groups. One difference did emerge: the delayed gratification group had fewer preference reversals for longer delay periods. Despite this discrepancy, the differences in the rate of discounting between the two groups remained insignificant. Most importantly, the two groups did not significantly differ in discounting rates as a function of the delay. Reynolds, de Wit and Richards (2002) concluded that “the finding of no group differences in the rate of discounting between the two different procedures supports arguments that the processes measured by DD and DG procedures are the same... at least in rats.” (Reynolds, de Wit & Richards, 2002, p. 165)

A meta-analysis conducted by Duckworth and Kern (2011) analyzed the convergent validity among different studies of self-control, including both delay discounting and delayed gratification. In the meta-analysis, delay discounting and delayed gratification were both subsumed under “delay task” procedures. Real choice delay tasks (e.g., delay discounting tasks) and delay tasks as a whole yielded a correlation of r = .23. Sustained delay tasks (e.g., delayed gratification) and delay tasks as a whole yielded a correlation of r = .20. Duckworth and Kern (2011) concluded that there is a need to assess impulsivity as though it contained multiple domains. Although the correlations between delay discounting tasks are relatively low, it is important to note that several procedures were included in “delay task” category. The different methodologies considered to be “delay tasks” allow for variability in the way impulsivity processes are construed. This illustrates the need for a direct comparison between delay discounting and gratification that relies upon consistent methodology between the two groups.

The Current Study

The present study developed and evaluated two operant measures that directly compared delay discounting and delayed gratification procedures in humans. These operant measures were also compared with two self-report measures of impulsivity and a hypothetical monetary delay discounting questionnaire. In addition, the present study developed an additional delay discounting questionnaire that used the same set of choices in the operant measures, only these choices were hypothetical.

The novel delay discounting and delayed gratification operant procedures were nearly identical; the only differences between the two were made to conform to the current methodology used in the literature. In the Delay Discounting Condition (Condition 1), participants made choices between two rewards: one available immediately, and one after a delay. After making his or her choice, the participant was unable to make a preference reversal during the delay. In other words, the Delay Discounting Condition assessed the initial choice preference for each trial, and the participant then experienced each delay (if applicable). In the Delayed Gratification Condition (Condition 2), participants made the same set of choices between the same set of rewards and delays as the Delay Discounting Condition. In this condition, however, the participants were given the option to make a preference reversal at any time during the delay and obtain the smaller reward immediately. In addition, a Hypothetical Delay Discounting Condition was used (Condition 3), in which participants made the same set of 20 choices used in the Delay Discounting and Delayed Gratification Conditions. In this third condition, participants made purely hypothetical choices, and did not experience the delays or the rewards associated with each choice.

The novel procedures described above consisted of a compilation of YouTube Internet video clips and their online popularity. The video clips were chosen based upon overall positive ratings by Internet viewers. The average number of positive and negative ratings, as well as the total number of views, determined the star rating for each video. Video clips that were highly rated (i.e., at least 95% positive ratings) were given a “10 Star” rating, and were conceived as a large reward. Consequently, video clips that had a relatively equal number of positive and negative YouTube ratings were given a “5 Star” rating, and were conceived as a small reinforcer. All videos used in the present study had at least 10,000 views by Internet users. Participants were asked to make choices between watching a lower-rated video immediately and a higher-rated video after a delay. Video clip length was approximately 30 seconds for each clip, and each trial was 90 seconds in length (which included the delay, video clip duration, and post-trial time). Participants made a total of 20 video clip preference choices; the choice options were identical in the three conditions.

Conceptually, the delay that preceded each 10 Star video clip is analogous to the advertisements that precede many video clips on the Internet in everyday life. As such, the question, “Would you rather wait 60 seconds for a 10 Star video or watch a 5 Star video immediately?” has considerable external validity. Participants in the Delay Discounting and Delayed Gratification Conditions made decisions identical to the question posed above, but with varying delay amounts. After indicating his or her choice, the participants in both groups experienced the delay if the larger reward was chosen. Participants in the Delayed Gratification Condition were given the opportunity to watch a 5 Star video at anytime during the delay if they no longer wanted to wait for the 10 Star video. Participants in the Delay Discounting Condition were not given this option in order to reflect the differences between delay discounting and delayed gratification methodology.

Hypotheses

Previous research on delay discounting and delayed gratification has used distinct methodologies to measure facets of impulsivity (Reynolds & Schiffbauer, 2005). It is hypothesized that delay discounting and delayed gratification represent equivalent underlying processes, but that subtle differences between the two are due to the procedural variance associated with measuring them. Delay discounting procedures assess the beginning "choice" processes of the same construct involved in delayed gratification. Delayed gratification procedures, on the other hand, allow for the experience of the delay after the choice is made, as well as allowing the individual to defer back to the smaller reward during this delay. The present study hypothesized that the differences between delay discounting and delayed gratification result from procedural differences, which are due the permission to experience each choice and the permission to change one's choice during the delay. To date, there have been no direct comparisons between delay discounting and delayed gratification in humans that can substantiate these processes as being equivalent.

It was hypothesized that the discounting rates for both the delay discounting and delayed gratification conditions would be adequately explained by the delay discounting model ($V = A/(1 + kd)$). In other words, the present study hypothesized that the two conditions were measuring similar underlying processes of impulsivity, and that both groups would be sufficiently explained by the traditional hyperbolic model used to assess delay discounting. In addition, comparisons were made between the operant delay discounting procedure (Condition 1) and the hypothetical delay discounting procedure (Condition 3). It was hypothesized that the rate of discounting would be significantly higher in the operant condition than in the hypothetical condition because the participants in the operant condition had to experience each delay after indicating their choice. In addition, it was hypothesized that the two self-report measures of impulsivity would correlate more strongly with the hypothetical delay discounting procedure than with the operant measures.

CHAPTER II

METHOD

Participants and Design

A total of 85 participants were recruited for the current study through Central Michigan University's SONA psychology subject pool. Participants obtained SONA credits, which were awarded for extra credit in undergraduate courses. Participants were assigned to one of the three conditions: the Delay Discounting Condition, the Delayed Gratification Condition, or the Hypothetical Delay Discounting Condition. Regardless of condition assignment, all participants completed a hypothetical delay discounting questionnaire involving monetary rewards. In addition, all participants completed two self-report impulsivity questionnaires and a demographic questionnaire. Participants were informed that the information used in the study would be de-identified through the use of subject numbers, and that any identifiable information would be kept in a locked cabinet in the laboratory. The Delay Discounting and Delayed Gratification Conditions took approximately 45 minutes to complete, and the Hypothetical Delay Discounting Condition took 10 minutes to complete. Two undergraduate researchers and the author conducted the experiment.

Materials

Delay Discounting Task

Participants in the Delay Discounting Condition (Condition 1) completed the Delay Discounting Task. Participants were shown an example of both a 5 and 10 Star video clip prior to the choice trials (sample clips were identical across conditions). Video clips for each trial were approximately 30 seconds in length, and each trial was 90 seconds long (including the delay, video clip length, and post-trial time). For each of the 20 trials, participants between watching a 5 Star video immediately, or a 10 Star video after a variable amount of time. There were five delays across 20 trials: 0 seconds, 20 seconds, 30 seconds, 45 seconds, and 60 seconds. The delays were presented twice in ascending order, and twice in descending order. Participants were told how long the delay would last for each trial, and watched a blank screen during each delay. Once the participant indicated their choice by clicking “watch 5 star video” or “watch 10 star video,” they experienced the delay (if applicable) and watched the chosen video clip. The trials were identical for all participants regardless of prior choices. At the beginning of the session, participants were notified that their responses would not affect the length of the task, which took 30 minutes to complete. The Delay Discounting Task was made using MediaLab version 2012 software (Empirisoft Corporation, 2012b).

Delayed Gratification Task

Participants in the Delayed Gratification Condition (Condition 2) completed the Delayed Gratification Task. Participants were presented with an example of both a 5 and 10 Star video clip. Each trial was identical to the Delay Discounting Task. For each of the 20 trials, participants made choices between watching a 5 Star video immediately, or a 10 Star video after a varying amount of time. There were five delays across 20 trials: 0 seconds, 20 seconds, 30 seconds, 45 seconds, and 60 seconds. The delays were presented twice in ascending order, and twice in descending order. Once the participant indicated their choice (i.e., pressing F5 to watch the 5 star video or pressing F10 to watch the 10 star video), they experienced the delay (if applicable) and watched the video clip. In this condition, however, participants were told they could press the space bar at any time during the delay to watch a 5 Star video immediately. Participants were given information on the delay time for each trial, and watched a screen during each delay that stated, “The 10 Star video will play after XX seconds. If you’d like to watch a 5 Star video immediately, press the space bar.” This statement only informed them of the total delay time and did not function as a countdown. Once the delay had passed and the participant had refrained from pressing the space bar, the 10 Star video clip immediately started playing. The video clips and delay times for each of the 20 trials were identical for all participants regardless of prior choices. Each trial was 90 seconds in length regardless of the participant’s choice. If the participant deferred to a 5 Star video during the delay (i.e., pressing the space bar), this was treated as a preference for the 5 Star video for that trial. The Delayed Gratification Task was made using DirectRT version 2012 software (Empirisoft Corporation, 2012a).

Hypothetical Delay Discounting Task

Participants in the Hypothetical Delay Discounting Condition (Condition 3) completed a hypothetical questionnaire concerning choices about viewing video clips. Participants were presented with the same examples of both a 5 and 10 Star video clip used in the Delay Discounting and Delayed Gratification Conditions. Participants were presented with the same 20 choices used in the operant conditions, only in a hypothetical format. For each of the 20 trials, participants were asked whether they’d rather watch a 5 Star video immediately, or a 10 Star video after a varying amount of time. There were five delays across 20 trials: 0 seconds, 20 seconds, 30 seconds, 45 seconds, and 60 seconds. The delays were presented twice in ascending order, and twice in descending order. Participants were instructed to complete the questionnaire as though the choices they made were real. The Hypothetical Delay Discounting Task was made using MediaLab version 2012 software (Empirisoft Corporation, 2012b).

Hypothetical Monetary Reward Questionnaire

All participants, regardless of condition, completed a 21-item questionnaire developed by Kirby and Marakovic (1996) that involves choices about monetary rewards. Delay rewards are categorized into small ($30-35), medium ($55-65), and large ($70-85) amounts. The questionnaire was presented in a computerized format. Participants indicated which amount they would rather receive for each item by clicking on the respective reward amount.

Barratt Impulsivity Scale

The BIS is a 30-item questionnaire designed to measure the personality and behavioral aspects of impulsivity. The BIS-11 is the current version. Items involve questions describing typical impulsive/non-impulsive behaviors, and are scored on a 4-point scale: *Rarely/Never = 1, Occasionally = 2, Often = 3, Almost Always/Always = 4.* Results yield six 1^{st} order factors, which include cognitive complexity, perseverance, attention, motor, and self-control. In addition, items yield three 2^{nd} order factors: attention, motor, and non-planning impulsiveness (Patton, Stanford & Barratt, 1995). All participants completed the BIS questionnaire.

Delaying Gratification Inventory

The 35-item questionnaire was developed in 2011 as a means to measure five domains of the delayed gratification construct. These domains include: social interactions, achievement, money, food, and physical pleasures. These areas have received considerable attention in the delayed gratification literature, and this questionnaire allows for the assessment of individual differences in each domain. Items are scored from 1 (*never*) to 5 (*always*). Higher scores indicate a higher level of adaptive functioning (Hoerger et al., 2011). All participants completed the Delaying Gratification Inventory.

Demographic Questionnaire

All participants also completed a short questionnaire that included age, gender, years of education completed, handedness, and native language.

Procedure

Data Collection

This project was approved by the Institutional Review Board at Central Michigan University. Subjects were informed of voluntary consent and any potential risks associated with the experiment. After consent was obtained, participants completed the demographic questionnaire. Participants were randomly assigned to one of the three conditions: the Delay Discounting Condition, the Delayed Gratification Condition, or the Hypothetical Delay Discounting Condition. In the two operant conditions, participants were informed that they would be making choices about video clips and watching whichever choice they had indicated. Participants were told that videos were roughly the same length, and that the choices made would not influence the length of the experiment. In the Hypothetical Delay Discounting Condition, participants were instructed to complete the task as though they were making each choice in real life. Following the completion of these tasks, all participants completed the Hypothetical Monetary Reward questionnaire, the Barratt Impulsivity Scale, and the Delayed Gratification Inventory.

CHAPTER III

RESULTS

Sample Characteristics

The demographic information is presented in Table 1.

Table 1. *Demographic Information*

Statistics	Sample
N	85
Males (%)	17 (19.8%)
M Age (*SD*)	20.25 (2.27)
Age Range	18-36
M Education (*SD*)	14.39 (1.20)
Caucasian (%)	67 (77.9%)
African American (%)	7 (8.1%)
Latino (%)	2 (2.3%)
Asian (%)	3 (3.5%)
Native American (%)	2 (2.3%)
Other (%)	4 (4.7
Native Language: English	84

Note. *M* = Mean. *SD* = Standard Deviation.

Delay Discounting Task

Thirty-one participants were assigned to the Delay Discounting Condition. Three participants chose the 10 star video rewards for all twenty trials; in other words, these participants did not display a preference for the 5 star videos as the delays became longer. Although these participants did not display a preference reversal, they were included in analyses.

Delayed Gratification Task

Thirty participants were assigned to the Delayed Gratification Condition. One participant chose the 10 star video rewards for all twenty trials; although this participant did not display a preference reversal, the data were included in analyses. In the Delayed Gratification Condition, participants were given the option to press the space bar if they no longer wished to wait for the 10 star video. This action would immediately play a 5 star video instead. Only 5 (17%) participants utilized this option: three participants pressed the space bar once during the task, and two participants pressed the space bar twice. This action was analyzed as a preference for the 5 star video for that trial.

Hypothetical Delay Discounting Task

Twenty-four participants were assigned to the Hypothetical Delay Discounting Condition. Nine participants chose the 10 star video rewards for all twenty trials. Although these participants did not display a preference reversal, the data were included in analyses.

Results of the Novel Impulsivity Measures

Participants in the three conditions completed twenty trials: each of the five delays was presented twice in both ascending and descending order. The responses for each delay were then transformed into a proportion of the larger reward. For example, if a participant chose to watch a 10 star video on both ascending twenty-second trials, the proportion for the ascending twenty-second trial would be 1.0. If the participant chose to watch a 10 star video on the first ascending twenty-second trial, but chose to watch a 5 star video on the second ascending twenty-second trial, the proportion for the ascending twenty-second delay would be 0.5. These proportions were then examined across ascending and descending trials for each delay. The descriptive statistics for proportion of 10 star videos chosen by condition are presented in Table 2.

Table 2. *Descriptive Statistics for Ascending and Descending Trials*

	Delay Discounting Task		Delayed Gratification Task		Hypothetical Delay Discounting Task	
Trial Presentation	**Mean**	***SD***	**Mean**	***SD***	**Mean**	***SD***
Ascending Trials						
0 Seconds	.960	.093	.933	.130	.979	.102
20 Seconds	.903	.139	.858	.157	.958	.120
30 Seconds	.798	.176	.783	.194	.906	.162
45 Seconds	.774	.208	.667	.211	.833	.204
60 Seconds	.790	.215	.750	.227	.781	.248
Descending Trials						
0 Seconds	.984	.062	.950	.121	.969	.112
20 Seconds	.936	.129	.933	.145	.948	.147
30 Seconds	.895	.180	.842	.191	.917	.175
45 Seconds	.815	.182	.733	.217	.813	.236
60 Seconds	.774	.187	.667	.178	.781	.237
Ascending and Descending Combined						
0 Seconds	.972	.062	.942	.108	.974	.104
20 Seconds	.919	.105	.896	.114	.953	.115
30 Seconds	.847	.143	.813	.134	.911	.150
45 Seconds	.794	.169	.700	.163	.823	.211
60 Seconds	.782	.177	.708	.178	.781	.236

Note. N = 31 for the Delay Discounting condition, 30 for the Delayed Gratification condition, and 24 for the Hypothetical Delay Discounting condition. M = mean proportion of 10 star videos chosen for each delay. SD = Standard deviation. Twenty trials were presented as follows: ascending (0, 20, 30, 45, 60 seconds), ascending (0, 20, 30, 45, 60 seconds), descending (60, 45, 30, 20, 0 seconds), descending (60, 45, 30, 20, 0). "Ascending and descending combined" displays the average proportion of 10 star videos chosen for both ascending and descending trials.

A three-way mixed between-within subjects analysis of variance was conducted to assess the impact of trial direction (ascending vs. descending), condition (Delay Discounting, Delayed Gratification, or Hypothetical Delay Discounting) and delay times (0, 20, 30, 45, and 60 seconds) on the proportion of 10 star videos chosen. There was not a significant interaction between trial direction, condition, and delay times, Wilks Lambda = .90, F (8, 156) = 1.19, p = .31, partial eta squared = .06. In addition, there was not a signification interaction between trial direction and condition (Wilks Lambda = .96, *F* (2, 81) = 1.73, *p* = .18, partial eta squared = .04), between delays and condition (Wilks Lambda = .89, *F* (8, 156) = 1.14, *p* = .34, partial eta squared = .06), or between trial direction and delays (Wilks Lambda = .90, *F* (4, 78) = 2.21, *p* = .08, partial eta squared = .10). There was a significant main effect for condition, *F* (2, 81) = 4.85, *p* < .05, partial eta squared = .11. The main effect for trial direction on the proportion of 10 star videos chosen, Wilks Lambda = .95, *F* (1, 81) = 3.95, *p* = .05, partial eta squared = .05, was significant. There was also a significant main effect for the delay times, Wilks Lambda = .47, *F* (4, 78) = 22.22, *p* < .001, partial eta squared = .53. The average discounting functions for each of the three conditions are displayed in Figures 1, 2, and 3.

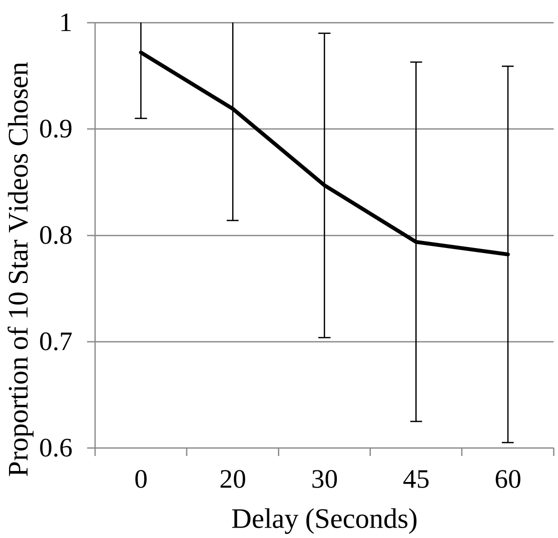

Figure 1. *Average Discounting Function for the Delay Discounting Condition*

Note. Proportion of 10 star videos chosen is calculated based upon each delay presented four times, for a total of 20 trials. Data include both ascending and descending trials. Error bars represent 1 *SD* for each condition.

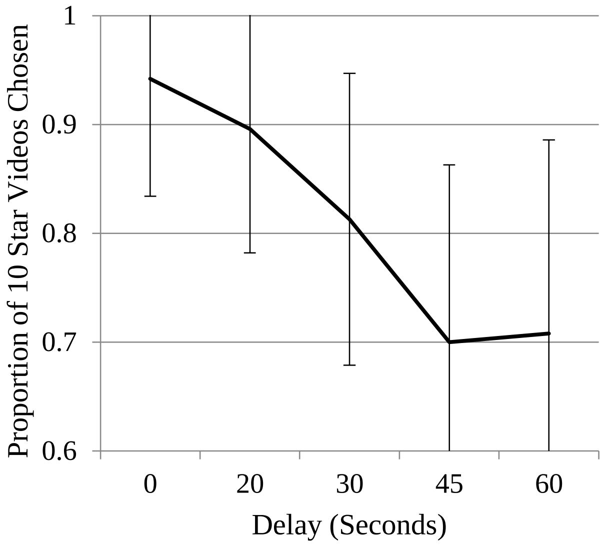

Figure 2. *Average Discounting Function for the Delayed Gratification Condition*

Note. Proportion of 10 star videos chosen is calculated based upon each delay presented four times, for a total of 20 trials. Data include both ascending and descending trials. Error bars represent 1 *SD* for each condition.

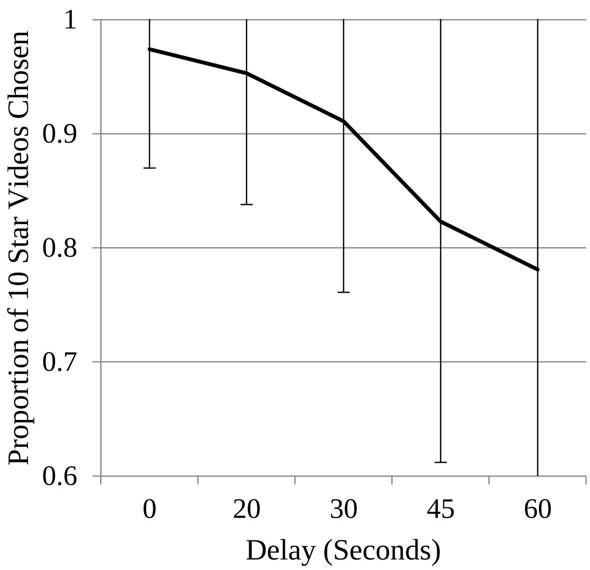

Figure 3. *Average Discounting Function for the Hypothetical Delay Discounting Condition*

Note. Proportion of 10 star videos chosen is calculated based upon each delay presented four times, for a total of 20 trials. Data include both ascending and descending trials. Error bars represent 1 *SD* for each condition.

The responses were then examined for differences between the ascending and descending trials. Three separate within-subject analyses of variance with two factors (ascending vs. descending and the 5 delays) were conducted to assess which conditions were significantly affected by trial direction. For the Delay Discounting Task, there was no significant interaction between trial presentation and delay times, Wilks Lambda = .87, F (4, 27) = 1.06, p = .40, partial eta squared = .14. There was a significant main effect for trial presentation direction (ascending vs. descending), with descending trials producing a higher proportion of 10 star videos chosen, Wilks Lambda = .81, F (1, 30) = 7.1, p < .05, partial eta squared = .19. There was also a significant main effect for delay times, Wilks Lambda = .35, F (4, 27) = 12.80, p < .001, partial eta squared = .66, with participants showing a decrease in 10 star video responses as the delays became longer. For the Delayed Gratification Task, the interaction between trial presentation and delay times almost reached significance, Wilks Lambda = .71, F (4, 26) = 2.70, p = .053, partial eta squared = .29. This was likely due to the fact that the last two ascending trials in the Delayed Gratification Condition (*M* 45 seconds = .66, *M* 60 seconds = .75) produced an increase in the proportion of 10 star videos chosen. There was a significant main effect for delay times, Wilks Lambda = .35, F (4, 26) = 12.35, p < .001, partial eta squared = .66, with participants showing a decrease in 10 star video responses as the delays became longer. There was not a significant main effect for trial presentation direction, Wilks Lambda = .94, F (1, 29) = 1.75, p = .20, partial eta squared = .06. For the Hypothetical Delay Discounting Task, there was no significant interaction between trial presentation and delay times, Wilks Lambda = .96, F (4, 20) = .22, p = .93, partial eta squared = .04. The main effect for delay times was nearly significant, Wilks Lambda = .64, F (4, 20) = 2.82, p = .053, partial eta squared = .36, with participants showing a decrease in 10 star video responses as the delays for this reward became longer. There was not a significant main effect for trial presentation direction, Wilks Lambda = .98, F (1, 23) = .35, p = .56, partial eta squared = .02.

Initially, data from the three conditions were to be fitted to the discounting formula ($V = A/(1 + kd)$) proposed by Mazur (1987). The model was estimated based upon the average ascending values from Delay Discounting Task for each of the five delays, and was calculated using Prism Graphpad. The hyperbolic best-fit values for the discounting formula ($V = A/(1 + kd)$) indicated a relatively poor fit at the individual level and at the group level: A = .96, k = .0044, R^2 = .13. As such, data were instead analyzed by calculating the area under the curve (AUC) for each participant as outlined by Myerson, Green and Warusawitharana (2001). This method separates the area under the empirical discounting function (the observed values as a function of the delays) into a series of trapezoids and calculates the total area under the curve for each participant. For a detailed description of how to calculate the area under the curve, refer to Myerson, Green and Warusawitharana (2001). The delay times (0, 20, 30, 45 and 60 seconds) were normalized, so that each delay was transformed into a proportion of the 60-second delay. The proportion of 10 star videos chosen was used for the normalized dependent variable. The ascending and descending proportions were combined into one proportion for each delay time. These five data points created five imaginary lines that connect the x axis to each data point, which created four trapezoids. For each participant, the area under the curve was calculated by summing the area of these trapezoids. Since both variables were normalized, area under the curve values ranged from 0.0 (greatest amount of discounting; 5 star videos chosen each time) to 1.0 (no discounting; 10 star videos chosen each time). An area under the curve boxplot is presented in Figure 4, and descriptive statistics are presented in Table 3.

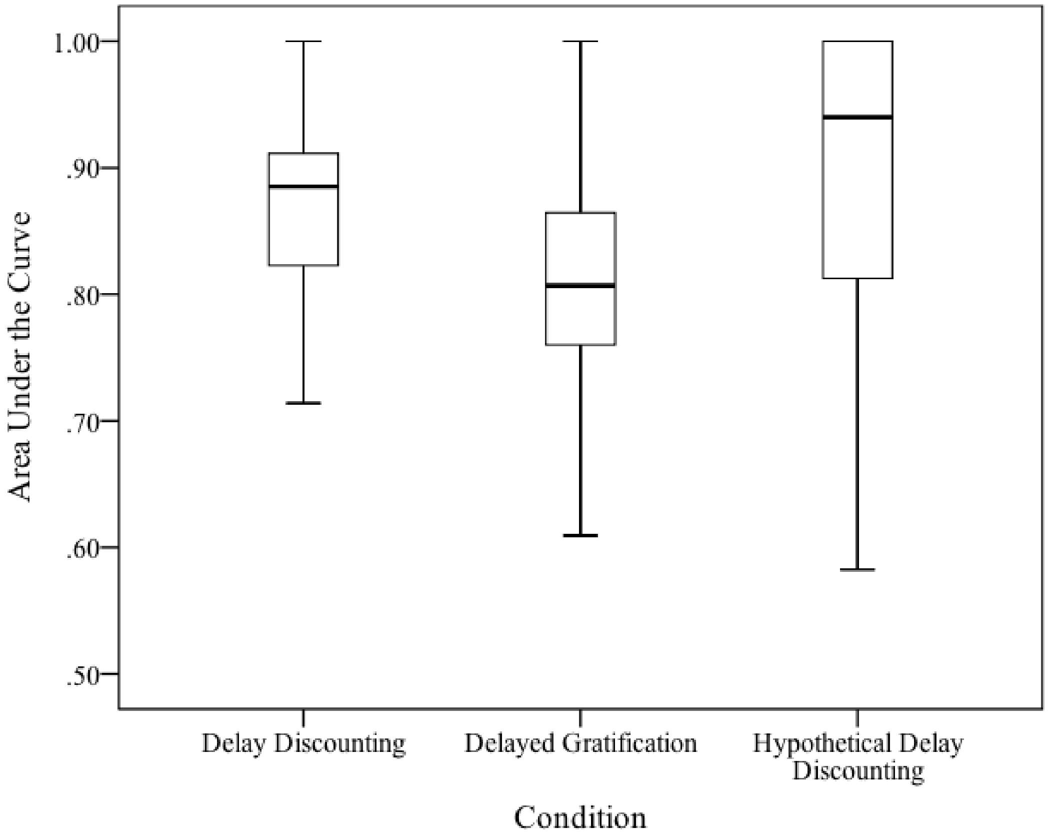

Figure 4. *Area Under the Curve Boxplot*
Note. N = 31 for the Delay Discounting Condition, 30 for the Delayed Gratification Condition, and 24 for the Hypothetical Delay Discounting Condition. Possible area under the curve values range from 0.0 (steepest discounting) to 1.0 (no discounting). The top and bottom of each box represents the first and third quartiles; the band inside the box represents the median. Whiskers represent minimum and maximum values.

Table 3. *Descriptive Statistics for Area under the Curve Values*

	Delay Discounting Task		Delayed Gratification Task		Hypothetical Delay Discounting Task	
	Mean	***SD***	**Mean**	***SD***	**Mean**	***SD***
Area Under the Curve	.864	.097	.814	.092	.894	.118

Note. N = 31 for the Delay Discounting condition, 30 for the Delayed Gratification condition, and 24 for the Hypothetical Delay Discounting condition.

A one-way between-groups analysis of variance was conducted to assess the impact of condition (Delay Discounting, Delayed Gratification, or Hypothetical Delay Discounting) on area under the curve values. There was a significant difference in AUC values for the three conditions, F (2, 82) = 4.39, $p < .05$. The effect size, calculated using partial eta squared, was .09. Post-hoc comparisons utilizing the Tukey HSD test indicated that the mean AUC for the Delay Discounting condition was not significantly different from the Delayed Gratification condition (*M* difference = .05), $p = .13$. In addition, the mean AUC for the Delay Discounting Condition (*M* = .86, *SD* = .09) was not significantly different from the Hypothetical Delay Discounting Condition (*M* difference = -.03), $p = .13$. The Delayed Gratification Condition and the Hypothetical Delay Discounting Condition were significantly different from one another (*M* difference = .09), $p = .01$.

Comparisons with Other Measures of Impulsivity

In addition to completing the novel impulsivity tasks, subjects in all conditions completed three additional impulsivity questionnaires: the Delaying Gratification Inventory (DGI) (Hoerger et al., 2011), the Barratt Impulsivity Scale (BIS) (Patton, Stanford & Barratt, 1995), and the Hypothetical Monetary Reward Questionnaire (HMRQ) (Kirby & Marakovic, 1996). The HMRQ estimates a k value, which serves as an estimate of discounting for each participant. This k value was log 10 transformed to improve normality. A one-way between subjects analysis of variance indicated that participants did not differ significantly by condition on the Barratt Impulsivity Scale, F (2, 82) = 1.03, $p = .36$, the Hypothetical Monetary Reward Questionnaire, F (2, 80) = 0.23, $p = .80$, or the Delaying Gratification Inventory, F (2, 79) = 0.21, $p = .81$. For each questionnaire, the average score represents the average obtained by combining scores from all three conditions. The mean score for the DGI was 139.28 (*SD* = 11.46); higher scores indicate a higher level of adaptive functioning in delaying gratification. The mean score for the BIS was 61.88 (*SD* = 8.74); higher scores indicate higher levels of impulsivity. The 3 second-order factors of the BIS were also examined, which included Attention (*M* = 17.39, *SD* = 3.54), Motor (*M* = 21.80, *SD* = 3.84), and Nonplanning (*M* = 22.69, *SD* = 4.07). The mean *k* value estimated from the HMRQ was -1.96 (*SD* = .11); prior to log 10 transformation, the mean *k* value was .016 (*SD* = .016). Two participants did not display a preference reversal for the delayed reward the HMRQ, and their *k* values could not be estimated. The descriptive statistics for these measures are displayed in Table 4.

Table 4. *Descriptive Statistics for Impulsivity Questionnaires*

Measure	**Mean**	***SD***
Delaying Gratification Inventory	139.28	11.46
Barratt Impulsivity Scale	61.88	8.74
Attention	17.39	3.54
Motor	21.80	3.84
Nonplanning	22.69	4.07
Hypothetical Monetary Reward Questionnaire	-1.96	0.11

Note. N = 82. Three cases were excluded due to missing questionnaire data. The *k* values derived from the Monetary Delay Discounting Questionnaire were log 10 transformed to improve normality. Higher DGI scores indicate a greater level of adaptive functioning. Higher BIS scores indicate higher impulsivity.

Bivariate Pearson's product-moment coefficients were utilized to investigate the relationship between the AUC values and the impulsivity questionnaires. The relationships between the AUC and the DGI (*r* = .07, *p* > .05) and the HMRQ (*r* = -.04, *p* > .05) were not significant. The relationships between the AUC and BIS Attention (*r* = -.08, *p* > .05), Motor (*r* =

.05, $p > .05$), and Nonplanning ($r = -.03$, $p > .05$) subscales were also not significant. There were medium negative relationship between the DGI and the BIS Attention ($r = -.32$, $p < .01$), Motor ($r = -.50$, $p < .01$), and Nonplanning ($r = -.40$, $p < .01$) subscales, which were significant. The BIS Motor subscale was significantly correlated with the Attention ($r = .34$, $p < .01$) and Nonplanning ($r = .35$, $p < .01$) subscales. The BIS Attention subscale was also significantly correlated with the Nonplanning subscale ($r = .43$, $p < .01$). No other correlations were statistically significant, as shown in Table 5. In addition, separate correlations were conducted to investigate whether the relationships would be more pronounced in the Hypothetical Delay Discounting Condition. The relationships between the AUC values and the DGI ($r = .11$, $n = 24$, $p > .05$) and the HMRQ ($r = .05$, $n = 24$, $p > .05$) were not significant. The relationships between the AUC and BIS Attention ($r = -.32$, $n = 24$, $p = .13$), Motor ($r = -.19$, $n = 24$, $p > .05$), and Nonplanning ($r = -.31$, $n = 24$, $p = .15$) subscales were also not significant.

Table 5. *Correlations between impulsivity measures and AUC values*

Measure	1	2	3	4	5	6
1. Delayed Gratification Inventory	1	--	--	--	--	--
2. Hypothetical Monetary Reward Questionnaire	-.05	1	--	--	--	--
3. Area Under the Curve	.07	-.04	1	--	--	--
4. BIS Attention	-.32**	-.01	-.08	1	--	--
5. BIS Motor	-.50**	-.18	.05	.34**	1	--
6. BIS Nonplanning	-.40**	.13	-.03	.43**	.35**	1

Note. $N = 82$. Three cases were excluded due to missing questionnaire data. The k values derived from the Monetary Delay Discounting Questionnaire were log 10 transformed to improve normality. Higher DGI scores indicate a greater level of adaptive functioning. Higher BIS scores indicate higher impulsivity. *$p < .05$. **$p < .01$.

CHAPTER IV

DISCUSSION

To date, there have been no direct comparisons between delay discounting and delayed gratification in humans using identical rewards with choice points. The current study developed and evaluated two operant measures that allowed for the comparison of delay discounting and delayed gratification procedures using video clips as reinforcers. The relationships between these operant measures and self-report questionnaires of impulsivity were also investigated.

For both the Delay Discounting and Delayed Gratification Tasks, the five delays significantly affected the proportion of 10 star videos chosen by participants. In other words, the novel operant procedures were able to generate discounting effects for the larger reward as a function of the delay. Although this rate of discounting was small, the effect was significant. In both the Delayed Gratification and Hypothetical Delay Discounting Conditions, the presentation of ascending versus descending trials did not significantly impact the proportion of 10 star videos chosen. The Delay Discounting Condition was significantly impacted by trial presentation, however. Since the trials were presented twice in ascending order and twice in descending order, it is difficult to conclude whether the trial direction or the second half of the procedure affected participants' responses. Future studies utilizing the operant Delay Discounting Task should take care to disentangle which variables contribute to these differences in responding.

The present study hypothesized that delay discounting and delayed gratification represent equivalent underlying processes, and that assumed differences between them are associated with procedural variance used to measure the two. Traditional delay discounting procedures only assess the beginning "choice" process that is also present in the delayed gratification construct. Operant delay discounting procedures allow the participant to experience the delay after indicating their choice, but don't allow the participant to defer back to the smaller reward after the initial choice has been made. Conversely, delayed gratification procedures *do* allow for the participant to defer back to the smaller reward during the delay. Consistent with current procedures, the defining feature that distinguished the Delayed Gratification Task from the Delay Discounting Task was the ability to change one's choice during the delay preceding the 10 star video. Only 17% participants only utilized this feature; three participants pressed the space bar once during the task, and two participants pressed the space bar.

To test whether the two processes were equivalent (and thus produced similar rates of discounting), it was hypothesized that the group discounting functions for both the Delay Discounting and Delayed Gratification Conditions would be adequately explained by the discounting model ($V = A/(1 + kd)$) proposed by Mazur (1987). In other words, it was hypothesized that both the Delay Discounting and Delayed Gratification Conditions were measuring similar underlying processes of impulsivity as evidenced by their fit to the discounting model. Analyses of the Delay Discounting Condition showed that the group fit to the discounting model was significant, but not representative of the participants' choices at an individual level. The relatively poor fit was likely due to the use of only two reward values (i.e., 10 star versus 5 star choices) and the largest delay only producing a 29% decrease in preference for the larger reward. Although parameter estimation is a method commonly used to estimate the rate of discounting in the literature, this technique tends to produce large confidence intervals at the individual level, and skewed parameter estimates at the group level (Myerson, Green & Warusawitharana, 2001).

As an alternative to parameter estimation, the area under the empirical discounting function was instead calculated for each participant. Post-hoc comparisons between the Delay

Discounting and Delayed Gratification Condition indicated that the AUC values were not significantly different from one another. In other words, forcing the participant to sustain their choice during the delay without pressing the space bar (as was the case in the Delayed Gratification condition) did not produce significant changes in responding that would differentiate AUC values from the Delay Discounting Condition. Although relative fit to the discounting model was not ultimately used as a measure of equivalence between the Delay Discounting and Delayed Gratification conditions, these results provide initial support for the negligible differences between these procedures, and further research is needed to replicate and expand upon these findings.

In addition, comparisons were made between the Delay Discounting Condition and the Hypothetical Delay Discounting Condition. It was hypothesized that the rate of discounting would be significantly higher in the operant condition than in the hypothetical condition because the participants in the operant condition had to experience each delay after indicating their choice. Analyses utilizing both the AUC values and the proportion of 10 star videos chosen for each delay indicated that the two conditions were not significantly different from one another in responding. Interestingly, the effect size for the delay times was larger in the Delay Discounting Condition (partial eta squared = 0.66) than in the Hypothetical Delay Discounting Condition (partial eta squared = 0.36), providing evidence that the delays had a stronger effect on choices in the operant condition. Insufficient power, particularly in the Hypothetical Delay Discounting Condition, was likely the reason for this insignificant result.

It was also hypothesized that the two self-report measures of impulsivity would correlate more strongly with the Hypothetical Delay Discounting Task than with the operant tasks. Results revealed insignificant correlations between the AUC values and the impulsivity questionnaires, both for the Hypothetical Delay Discounting Condition and the sample as a whole. The only significant correlation was between the Delaying Gratification Inventory and the Barratt Impulsivity Scale. Previous research on the construct of impulsivity, however, has indicated that self-report and behavioral measures tend to have small relationships (e.g., Cyders & Coskunpinar, 2011), which may in part explain these null results.

Limitations

The current study has several limitations. Although preliminary evidence provides support for the two operant procedures, the tasks were novel, and it is possible that the present study was not an accurate representation of delay discounting and delayed gratification procedures. The Delay Discounting and Delayed Gratification group had 31 and 30 participants, respectively, limiting the power to detect small effects. One of the principal limitations of the current study was the limited conclusions that can be drawn from an insignificant difference between the Delay Discounting and Delayed Gratification groups—although this provides initial support for the equivalence of the two procedures, more research is clearly needed. The limited statistical power in the present study makes it difficult to find evidence of small differences that may exist between the Delay Discounting and Delayed Gratification Conditions.

There are several plausible explanations why the largest delay (60 seconds) only resulted in a 29% decrease in the reward value. Previous research has theorized that self-control is a finite resource, and that demanding tasks will exhaust these resources (Gino et al., 2011; Baumeister & Heatherton, 1996). The Delay Discounting and Delayed Gratification Tasks consisted of 20 trials and lasted roughly 30 minutes in length. It is plausible that the operant tasks were not long enough to induce impulsive decision-making, and that the majority of the participants were able to endure the task without depleting their self-control resources. It is also plausible that the act of sustaining one's choice through the delay period was not a difficult task, and did not require much self-control. Finally, it is possible that the post-trial delay time affected participants' responses. Since each trial was 90 seconds in length, choosing to watch a 5 Star video immediately resulted in 60 seconds of post-trial delay time for the participant once the 30-second clip had ended. As such, a shorter post-trial delay time may have motivated participants to wait for the 10 Star Video.

It is also possible that use of videos as reinforcers may have not been adequate to induce steep discounting rates in participants. In other words, the difference between a "5 star" video and a "10 star" video may have not been substantial enough to create a steep discounting curve. The use of a "1 star" video as an alternative may have resulted in less discounting, however, as a video rated this poorly is unlikely to have any reinforcing qualities. The use of video clips as a reinforcer has been used in previous delay discounting research (e.g., Navarick, 1998), but the value of a video reward is difficult to quantify.

Although the operant measures produced a significant decrease in the proportion of 10 star videos chosen as a function of the delay time, it is difficult to conclude whether the novel measures are adequately assessing impulsivity as a construct. Providing evidence for convergent validity is difficult, as previous research has shown that behavioral lab measures tend to have small relationships with one another (Reynolds et al., 2006; Duckworth & Kern, 2011). Self-report measures of impulsivity tend to have weak correlations with behavioral lab measures as well (Cyders & Coskunpinar, 2011), which is consistent with the current study's findings. Evidence for the use of the Delay Discounting and Delayed Gratification Tasks will likely need to be validated through the use of specific populations (e.g., substance-dependent individuals).

Finally, there were limitations with the operant tasks, both in design and implementation. The participants were told they would be seated at the computer for roughly 30 minutes regardless of the choices they made on the task. Although these instructions were intended to promote the fact that choosing all “5 star” videos would not result in the study ending prematurely, this may have had an effect on the participants’ choices. The video clips were not randomized for each participant; in other words, every participant was given the same set of video clips for the first trial, the second trial, and so on, regardless of the participants’ responses. This is potentially problematic, as it may have resulted in systematic variations in responding. For example, if many participants disliked the 10 star video on trial 14, they would be more likely to pick the 5 star video on trial 15, and so on. In addition, technical difficulties with the Delayed Gratification Task resulted in a quasi-random assignment for a portion of the experiment, in which some of the participants were automatically assigned to the Delay Discounting Condition while the technical issues were resolved. Although there appear to be no significant differences between groups, the assignment to the operant conditions was not consistently random throughout the experiment.

Conclusions

The results of the present study provide initial support for the hypothesis that delay discounting and delayed gratification procedures do not result in marked differences in discounting. In other words, participants in both operant conditions made roughly the same decisions for each delay, and those in the Delayed Gratification Condition did not defer back to the smaller reward regularly, even though it was constantly available. The goal of the present study was to identify whether sustaining one’s choice during the delay (Delayed Gratification Condition) would be significantly different from simply experiencing the delay after the choice was made (Delay Discounting Condition). Although the participants in the Delay Discounting Condition were not given the option to defer back to the smaller reward during the delay period, there were insignificant differences between the two groups' responses. In other words, the option to use a "Delay Discounting" procedure or a "Delayed Gratification" procedure may make little difference in how people respond on behavioral tasks. Furthermore, the hypothetical AUCs were not significantly different from the operant delay discounting AUCs, providing additional evidence for the equivalence of the two procedures. The present study provides initial support for studies that treat delay discounting and delayed gratification as similar or identical underlying processes. Future research is needed to expand upon these conclusions and validate the use of these operant tasks as a behavioral measure of impulsivity.

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