Temporal Discounting Preferences as an Index of Rational Thinking

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Abstract

Temporal discounting refers to a preference for smaller sooner rewards over larger delayed rewards. We explored temporal discounting in a set of two studies as a construct of rational thinking in emerging adults. In Study One, we examined temporal discounting preferences using three different paradigms. The first paradigm used a classic staircase presentation of items, the second paradigm used a mixed presentation of items, and the third paradigm assessed response consistency across choices. Associations with individual differences in cognitive ability and thinking dispositions related to rational thinking were examined. In Study Two, we examined whether providing explanations to wait for delayed rewards and to respond consistently across items would result in more willingness to wait for larger delayed rewards and greater response consistency. Willingness to wait for larger delayed rewards was found to be associated with higher intellectual ability and various thinking dispositions, especially during choices that consisted of high rates of return (Study One). When provided with a reason to choose the delayed reward, a significant number of individuals who initially chose smaller sooner rewards switched their preferences and chose the larger delayed rewards instead (Study Two). Similarly, when provided with a reason to choose consistently, a significant number of individuals who initially displayed inconsistent reward preferences later switched preferences and chose consistent rewards preferences instead. Our results suggest that temporal discounting preferences may be a useful index of rational decision-making. Broader theoretical and practical implications of our results are discussed.

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Introduction

Do you prefer $100 now or $150 in one year? This represents a 50% annual rate of return, which is an outstanding gain for any investor. However, many individuals will prefer the smaller immediate gain to the larger delayed benefits (e.g., Myerson & Green, 1995; Green et al., 1997). This preference for smaller sooner rewards over larger delayed rewards is referred to as temporal discounting and it is assessed using temporal discounting paradigms. All individuals devalue increasingly delayed rewards, but there are considerable individual differences in how rapidly people devalue future amounts of money. For example, while some individuals will forsake $150 in one year for $50 now, others will be willing to wait for $150 reward in one year even if they are offered $70 now. Unusually strong preferences for smaller sooner rewards have been shown to be an indicator of impulsive decision-making (Ostaszewski, 1996; Coffey, Gudleski, Saladin, & Brady, 2003; Zhong & DeVoe, 2010). People who are less willing to wait for larger delayed rewards are more likely to display low self-control (Ostaszewski, 1996; Coffey, Gudleski, Saladin, & Brady, 2003; Zhong & DeVoe, 2010) and less future oriented thinking (Steinberg, Graham, & O'Brien et al., 2009). They are also more likely to display substance abuse (Reynolds, 2006; Bickel, Odum, & Madden, 1999), gambling problems (Holt, Green, & Myerson, 2003; Alessi & Petry, 2003), and risky sexual behaviors (Chesson, Leichliter, & Zimet, 2006). The negative long-term outcomes associated with a greater preference for smaller sooner rewards make temporal discounting a potentially useful construct for operationalizing reward preferences over time and studying human decision-making.

In two studies, we examined temporal discounting as an index of rationality. In Study One, we examined temporal discounting choices using three different paradigms and associations with individual differences in intellectual ability and thinking dispositions. In Study Two, we examined whether a rational explanation would provoke participants to modify temporal discounting decisions. Specifically, in Study One, we examined whether intellectual abilities and thinking dispositions would correlate with more willingness to wait for larger delayed rewards and response consistency. This was done in order to determine whether more willingness to wait for larger rewards and high response consistency could be conceptualized as more rational than not waiting for larger delayed rewards and low response consistency. In Study Two, we examined whether compelling people to think more analytically about their temporal discounting choices would result in more rational decisions. This was done in order to determine whether participants could understand that waiting for larger delayed rewards and high response consistency represents rational behavior.

What Is Temporal Discounting?

Humans have been shown to undervalue future rewards (Green, Fry & Myerson, 1995; Chapman & Elstein, 1995; Green, Myerson & McFadden, 1997). For example, you might decide that $100 now is more valuable than $100 in one week. If you are a smoker, you might decide that a cigarette now is more valuable than a cigarette in two days. You might also decide that $85 now is more valuable than $100 in three months (Green, Fry & Myerson, 1995; Green et al., 1997) or that one cigarette now is more valuable than two cigarettes in two days (Bickel, Odum, & Madden, 2007). Discounting the value of future rewards is referred to as *temporal discounting* (Green, Fry & Myerson, 1995; Rachlin, Raineri, & Cross, 1991; Takahashi, Taiki, Hadzibeganovic, Tarik, Cannas, Sergio, Makino et al., 2009)

Psychologists and economists have developed a paradigm to evaluate temporal discounting. The temporal discounting paradigm typically offers the hypothetical choice between smaller rewards available immediately (e.g., $50 now) and larger rewards available in the distant future (e.g., $100 in 3 months). These paradigms have revealed three important findings that define temporal discounting.

First, temporal discounting paradigms have shown that many people tend to choose smaller sooner rewards over larger delayed rewards (Rachlin, Raineri, & Cross, 1991; Ainslie & Haslam, 1992; Green, Fry & Myerson, 1995; Green et al., 1997). For example, a preference for smaller sooner rewards over larger delayed rewards was demonstrated in a notable experiment conducted by Green et al., (1997). Participants were provided with a series of hypothetical choices that consisted of two options: 1) an immediate monetary reward that ranged from $0 to $99 and 2) $100 in three months. On average, participants preferred anywhere between $82 and $99 now over $100 in three months. Most participants judged $82 to $99 available now to be more valuable than and thus preferable to $100 available in three months.

Second, temporal discounting paradigms have shown that the longer a person has to wait for a reward the more likely a person will be to settle for smaller sooner rewards (Green et al., 1997). In the study described above, Green et al. (1997) also provided participants with the same series of choices, but the delayed reward varied from $100 in three months, six months, one year, three years, five years, ten years, and 20 years. On average, participants were willing to settle for $78 now over $100 in 6 months, $40 now over $100 in 5 years, and $20 now over $100 in 20 years. Presumably, the longer participants had to wait to receive the $100 reward, the less valuable that $100 became. Rewards become less subjectively valuable the longer a person has to wait to receive them.

Third, temporal discounting paradigms have shown that the effect of time on temporal discounting preferences eventually becomes diminished (Ainslie, 1978; Rachlin et al., 1991;

Green et al., 1994). When given the choice between $100 now and $110 in seven days, most people will prefer $100 now to $110 in seven days. However, when given a choice between $100 in 30 days and $110 in 37 days, *fewer* people will prefer $100 in 30 days to $110 in 37 days. Most people will reverse preferences and choose to wait for the larger reward. Most people would prefer to wait an extra seven days for $10, only if the wait occurs a month into the future and not in the immediate present. As such, temporal discounting is best represented by a hyperbolic curve (Ainslie & Herrnstein, 1978; Rachlin et al., 1991; Green et al., 1994). Traditional models of temporal discounting assumed that people's reward preferences were consistent over time, which would be described by an exponential curve. Reward preferences are not consistent over time; humans tend to exhibit less patience in the present while thinking that they will be more patient if confronted with today's choice in the future.

To summarize, temporal discounting can be thought of as a decrease in the *subjective* value of a reward as the delay to its receipt increases (Green et al., 1995; Green et al., 1997). Temporal discounting is demonstrated in a preference for smaller sooner rewards over larger delayed rewards. This preference is best modeled by a hyperbolic function. Temporal discounting preferences are measured using temporal discounting paradigms that offer the choice between smaller sooner rewards and larger delayed rewards.

It has been proposed that choosing smaller immediate rewards over larger delayed rewards is a normal, adaptive process (Kagel, Green, & Caraco, 1986; Green, Fry, & Myerson, 1995). Immediate rewards are certain, but delayed rewards are risky and less certain. Humans may have evolved to accept smaller rewards that are certain instead of risking loss by waiting for larger rewards that might not be received. If humans have evolved to prefer smaller sooner rewards over larger delayed rewards, then waiting for delayed rewards may be a process that goes against a human’s natural or intuitive response. Research has shown that a strong preference for smaller sooner rewards is associated with high impulsivity (Ostaszewski, 1996; Coffey, Gudleski, Saladin, & Brady, 2003; Zhong & DeVoe, 2010). In contrast, choosing to wait for a larger delayed reward may be a hard decision that requires cognitive effort and control.

Waiting is More Cognitively Effortful than not Waiting

There is converging evidence to suggest that a preference for a larger delayed reward is associated with a) more effortful cognitive processing in neural studies (McClure, Laibson, Loewenstein, and Cohen, 2004), b) higher cognitive abilities (Shamosh and Gray, 2008), and c) thinking dispositions related to future oriented thinking (Steinberg et al., 2009).

Effortful Processing and Neural Studies. Neuroimaging studies have provided evidence to support the association between cognitive control and a greater willingness to wait for larger delayed rewards. McClure, Laibson, Loewenstein, and Cohen (2004) examined the neural correlates of temporal discounting while participants made choices between smaller sooner rewards and larger delayed rewards. When participants decided to choose smaller immediate rewards, parts of the limbic system that are associated with the midbrain and known to be rich in dopaminergic activity were preferentially activated. The limbic system has appeared to be involved in emotional processing (see Morgane, Galler, & Mokler, 2005 for a review) and reward processing including motivation (Elliot, Friston, Dolan, 2000). The limbic system has frequently been implicated in impulsive behavior and addiction. Accordingly, decisions involving smaller sooner rewards may be governed by emotional processes associated with reward seeking and expectations of pleasure (Berridge & Robinson, 1998; Kelley & Berridge, 2002; Sharot, Shiner, Brown, Fan, & Dolan, 2009). When participants decided to choose larger delayed rewards, parts of the prefrontal and parietal cortex were preferentially activated. The prefrontal and parietal cortex has been implicated in planning, deliberative cognition, problem solving including numerical operations, and controlled decision-making including prediction of outcomes (Smith & Jonides, 1991; Miller & Cohen 2001; Miller, Freedman, & Wallis, 2002; McClure et al., 2004). The relatively higher levels of activation in the prefrontal cortex during decisions that involve larger delayed rewards suggest that participants are investing more cognitive effort into deliberately evaluating their choices.

McClure et al., (2004) also demonstrated higher levels of activation in the prefrontal cortex during decisions for delayed rewards when temporal discounting items were more challenging to calculate (i.e., when the difference between the immediate and delayed reward was less than 25%). Brain regions engaged in decision-making would be engaged to a greater degree by more difficult decisions. Relative increases in prefrontal activation during more difficult choices suggests that participants invest more cognitive effort into making the decision to choose the larger delayed reward when that decision is more difficult to make. These findings may generalize to other situations in which people must engage in more effortful processing in order to make decisions involving larger delayed benefits. For example, it has been shown that the prefrontal cortex is more strongly activated when dieters choose healthy food over tasty food (Hare, Camerer, & Rangel, 2005).

Intellectual Abilities and Temporal Discounting. In a meta-analysis conducted by Shamosh and Gray (2008), higher intellectual ability was significantly related to more willingness to wait for larger delayed rewards across numerous studies. These studies demonstrate that people who display higher intelligence (i.e., as measured by tests of IQ) are significantly more likely to wait for larger delayed rewards (e.g., de Wit, Flory, Acheson, McCloskey, & Manuck, 2007, Shamosh, DeYoung, Greene, et al., 2008; Dohmen, Falk, Huffman, & Sunde, 2007).

Working memory has also been implicated in temporal discounting choice performance (Bickel, Yi, Landes et al., 2011), where a preference towards sooner rewards has been associated with impaired working memory and low neural activation in brain areas responsible for working memory (Shamosh, DeYoung, Green et al., 2008). Working memory is used to maintain active representations of goal relevant information, especially when faced with conflicting sources of arousal (e.g., Engle et al., 1999). Accordingly, when distractions have been introduced during experimental paradigms, people have been shown to be more likely to discount the value of a delayed reward and to prefer smaller, sooner rewards (Hinso, Jameson, & Whitney, 2003).

Thinking Dispositions and Temporal Discounting. In Norris's (2004) words: "a person with an *ability* to think critically under certain conditions will do it, only if so disposed". High intellectual ability does not always guarantee that a person will use those abilities when making decisions (Stanovich, 2009; Kahneman, 2011). Certain thinking dispositions, or a person's tendency to think in a certain way under certain conditions (Norris, 1994), can impact whether or not that person will think critically and flexibly in real world situations (Facione. 1998; Facione, Sanchez, Facione et al., 1995). In other words, certain ways of thinking can have an impact on whether or not an individual will invest time and effort into thinking hard and critically about a given choice.

People who decide to wait for larger delayed rewards have been shown to display certain thinking dispositions. For example, Steinberg et al. (2009) show that individuals who are more willing to wait for larger delayed rewards tend to demonstrate high orientation to the future. In other words, people who discount the value of a delayed reward may be less likely to extend their thinking into the future and less likely to evaluate present options according to their future implications. Similarly, Basile and Toplak (in preparation) found that participants who showed a greater willingness to wait for larger rewards tended to demonstrate greater consideration for future consequences. High orientation to the future and more consideration for future consequences reflect the disposition to be strategic, which includes the tendencies to envision future outcomes, set goals, and implement plans (Perkins et al., 1992).

That a preference for larger delayed rewards has been associated with more effortful cognition, higher intellectual ability, and more orientation to the future, does not necessarily mean that all preferences for smaller sooner rewards are necessarily poor choices. However, certain temporal discounting choices may be more beneficial than others.

Certain Temporal Discounting Choices are Better than Others

Some temporal discounting decisions may be considered better choices than others. For example, if you are given the option to choose between $100 now and $101 in one year, you might decide that it is not worth waiting one year for an additional $1, which would only amount to a 1% annual return. However, if you are given the option to choose between $100 now and $110 tomorrow, you might decide that it is worth waiting one day for an extra $10 which would amount to 3650% annual return. Deciding when to wait or not to wait may be characterized as a type of instrumental rationality.

Among the most important areas of study in cognitive science is how humans come to make good judgments and decisions. Human rationality has been defined as what is true and what to do (Stanovich, 2009; 2011). Epistemic rationality is concerned with what is true and refers to holding unbiased beliefs that accurately reflect the world. Instrumental rationality is concerned with what to do or how to act and refers to adopting appropriate goals and behaving in a way that is conducive to achieving those goals. In other words, instrumental rationality refers to how good one is at getting what one wants. In some cases, a preference for smaller sooner rewards over larger delayed rewards may reflect a failure in instrumental rationality (Stanovich, West, & Toplak, 2011).

To make optimal decisions, one should assess the potential gains and costs in making a choice (Delgado & Tricomi, 2011). By choosing to pass on the current $1500 reward and to wait for the $2000 reward in one year, one would gain an extra $500 a year, which would amount to a 33% interest rate (compounded annually). A 33% annual interest rate is greater than can be earned by holding one's investments in banks, which currently offer interest rates lower than 2% (CIBC, 2014; RBC, 2014). If one wants to adopt the appropriate goal of maximizing gains and behave in a way that serves that goal despite immediate desires, it would be more rational in this circumstance to wait for the larger reward instead of choosing the more appealing but less beneficial sooner smaller reward. In such instances, temporal discounting preferences may be conceptualized as a measure of instrumental rationality.

Consistent with the idea that temporal discounting preferences may be associated with instrumental rationality, willingness to wait for larger delayed rewards has been shown to predict more positive long-term outcomes (Shoda & Mischel, 1990; Mischel, Shoa, & Peake, 1988). Children's ability to delay gratification was studied in a classic experiment conducted by Mischel, Ebbesen, and Raskoff (1972). In a series of studies, children were offered the choice between one marshmallow now and two marshmallows in 15 minutes. Follow-up studies showed that children who were able to delay gratification and wait for 2 marshmallows also tended to have higher Scholastic Aptitude Test (SAT) scores (Shoda & Mischel, 1990), parental ratings of competencies including ability to plan, concentrate, and handle stress (Mischel, Shoa, & Peake, 1988), and education (Ayduk, Mendoa-Denton, Mischel, et al., 2000). These results suggest that having the ability to make rational temporal discounting decisions is associated with better long-term outcomes related to academic performance, planning, and coping.

Temporal Discounting Preferences as an Index of Rationality

We propose that a willingness to wait for larger delayed rewards in some cases is indicative of instrumental rationality, or the ability to set appropriate goals and to behave in a way that is conducive to reaching those goals. There is an abundance of evidence to show that more effortful processing, higher intellectual ability, higher orientation to the future, and positive long-term outcomes are all associated with more willingness to wait for larger delayed rewards. When is it definitely not rational to forsake larger delayed rewards for smaller sooner rewards?

Current temporal discounting measurement paradigms are on a continuous scale and do not differentiate between more and less rational choices. Typical temporal discounting tasks offer a hypothetical choice between a smaller sooner reward (e.g., $50 now) and a larger delayed reward (e.g., $100 in 1 week). In most studies, these items are presented in a staircase method, with immediate rewards in consecutive order from high to low (or low to high) and a larger delayed reward that is fixed in magnitude and delay (e.g., Green et al., 1995; Green et al., 1997). Performance on these tasks is typically measured in one of three ways: 1) the indifference point 2) area under the curve and 3) the k-value (see Basile & Toplak, in preparation for a critical comparison of these three measurement techniques). These three measurement techniques yield a value that represents one's rate of discounting. For example, the indifference point represents the point at which the value of an immediate reward in a staircase temporal discounting task is *subjectively* equivalent in value to the larger delayed reward. A person may be willing to forsake $2000 in 1 year for $1900 now, $1800 now, and $1700 now. Their point of indifference is when they switch preferences and prefer $2000 in 1 year to $1600 now. It is implied in their pattern of choices that they are roughly indifferent to $2000 in 1 year and $1600 now. The indifference point is then converted using mathematical modeling into a discount rate. The area under the curve and the k-value are also estimates of the discount rate that are based on mathematical models. Discount rates do not provide us with a way to clearly differentiate non-rational temporal discounting preferences from rational temporal discounting preferences.

We examined temporal discounting preferences as an index of rational-thinking in three ways: 1) annual return rates (Study One), 2) response consistency (Study One), and 3) understanding/acceptance (Study Two). These methods are described in further detail below.

1) Return Rates as an Indicator of Rational Preferences. There is no definite or objective distinction between incorrect or correct reward choices during temporal discounting tasks. However, in a temporal discounting task, the difference between the smaller sooner rewards and the larger delayed rewards are often blatantly high or low if conceptualized in terms of percent rate increases and long term financial gain. Consider being offered a choice between receiving $600 now or $2000 in one year. Waiting a year for the delayed reward results in a 233% annual interest rate. On the other hand, choosing to wait one year for a $2000 reward over a $1900 reward offered now results in only a 5% annual interest rate. Stated in these terms clearly depicts the advantages to waiting for some rewards and not waiting for others. While previous studies have relied on mathematical modeling of the discounting function as a measure of temporal discounting, we used differences in interest rates to distinguish between varying degrees of optimal temporal reward preferences. In doing so, we may be able to separate more rational temporal discounting choices from ones that are less rational.

We used two different versions of the temporal discounting paradigm in order to examine return rates as a potential differentiator between rational and non-rational temporal discounting preferences: a) the staircase method and b) a mixed method.

In the staircase method, we provided participants with a typical temporal discounting task. Temporal discounting items were presented in a fixed order. The smaller sooner reward ranged from \$0 to \$1980. The larger, delayed reward was held constant at \$2000 with a constant delay of one year. The indifference point was calculated for each participant. The staircase method was meant to provide us with a measure of temporal discounting that has been used conventionally in the literature (e.g., Green et al., 1995; Green et al., 1997).

In the mixed method, temporal discounting items were presented in random order. We calculated the annual return rates for each of the items. When scoring performance using the mixed method, we divided items into one of three categories: low annual return, medium annual return, and high annual return. We compared temporal discounting preferences across these three levels of return.

We also examined associations with intellectual ability and thinking dispositions. Following past research (Basile & Toplak, in preparation), we examined whether participants who show strong consideration of future consequences would also be more likely to prefer smaller sooner rewards in our staircase and mixed methods. There are several thinking dispositions that are often examined in the rational-thinking literature that may contribute to whether a person will invest cognitive effort into evaluating their temporal discounting choices. These dispositions relate to one's *desire* to act according to reason (Stanovich, 2008) and to the tendency to be open-minded and flexible (Sa, Stanovich, & West, 1997; Stanovich & West, 1997; 2007), to be cognitively persistent and to enjoy effortful thinking (Cacioppo & Petty, 1982;

Cacioppo, Petty, & Kao, 1984; Nair & Ramnayaran, 2000), and to be resistant to superstitious thinking (Stanovich & West, 1997; Stanovich, 2005). We examined whether these thinking dispositions would associate with decisions to wait for larger delayed rewards.

2) Response Consistency as an indicator of Rational Temporal Discounting Preferences. Evaluating the consistency in one's preference across temporal discounting choices is another index we used to assess one's tendency to behave rationally, irrespective of one's contextual influences. Some people provide two contrasting answers to the same question depending on context, namely how the question is worded (Tversky & Kahneman, 1986). Responding in a way that is consistent with beliefs, in a consistent manner across contexts, is suggested to reflect rational thinking. Alternatively, showing variations in choice preferences depending upon how those choices are presented is therefore considered less rational. This effect has been termed a failure of invariance (Tversky & Kahneman, 1986).

An interesting and related phenomenon that has been shown to occur in temporal discounting studies is a *preference reversal.* When given the choice between $50 today and $100 in one week, a person may choose $50 today. However, when given a choice between $50 in one week and $100 in two weeks, this same person is likely to switch preferences and prefer the $100 in two weeks (Greene, 1994). This preference reversal may not be rational because both scenarios are equivalent and should be treated equivalently. As previously explained, this pattern of responding is best described by hyperbolic discounting, which assumes that preferences are *not* consistent over time. Thus, according to Tversky and Kahnmeman's (1986) theory, preference reversals and hyperbolic discounting represent response inconsistency and are thus not rational. Should you decide to take $50 now over $100 in one week, then rationally you should also decide that in one week from now you will still take $50 over $100 in two weeks from now. If you decide that you are not willing to wait one week for an extra $50 right now, then you should also decide that in one week you would still not be willing to wait one week for an extra $50.

In order to study response consistency across temporal discounting items, we used a third version of the temporal discounting paradigm, which we referred to as the Invariance task. In the Invariance task, we sought to invoke preference reversals. The more people reversed preferences, the more their responses were considered to be inconsistent and less rational.

3) Understanding/acceptance as an indicator of Rational Temporal Discounting Preferences. Another way to examine temporal discounting from a rational thinking perspective is to determine whether participants will make better choices after we explain to them why waiting for larger delayed rewards is rational. We need to be able to distinguish between deviations from optimal performance that result due to a rejection of a particular reasoning axiom from those deviations that result from a failure to understand the axiom (Slovic & Tversky, 1974). Consider the following analogy. A pedestrian is in a rush to get to the mall and thus crosses the street when the "do not walk" sign is lit. This pedestrian may be irrational for endangering his/her life. A second pedestrian may not be as irrational for endangering his/her life if they are from a foreign country and did not know that the "do not walk sign" was a warning when he/she crossed the street. However, if we teach both pedestrians that the "do not walk" sign is a warning not to be ignored, the pedestrian who still crosses the street may then be considered not rational.

We evaluated whether explaining to participants: 1) why larger delayed rewards are a better choice and 2) why it is rational to respond consistently across temporal discounting items will impact response choices. Slovic and Tversky (1974) suggest that ''the deeper the understanding of the axiom, the greater the readiness to accept it'' (pp. 372–373).

Accordingly, participants who prefer smaller immediate rewards should alter preferences if they were made to better understand, or to consciously consider, the logic of return rates and percent increases over time (Stanovich & West, 1999). If evaluating annual interest rates is an effective method for determining the normative reward preference, then helping participants to understand or to use this axiom should alter participant responding. That is, participants should shift towards waiting after receiving an explanation for why waiting is a better choice. Similarly, participants who are initially inconsistent in their reward preferences should become more consistent after the axiom of consistency is explained.

We developed a fourth version of the temporal discounting paradigm in order to study the impact that providing a good reason to participants will have on responding. This version was referred to as the Understanding/Acceptance task. Benjamin et al., (2006) have shown that temporal discounting decreases when people are asked to provide reasons for their responses. This suggests reflective reasoning elicits more willingness to wait for larger delayed rewards. In the Understanding/Acceptance task, we sought to evaluate whether giving participants good reasons to make more rational temporal discounting choices will also have a positive impact on temporal discounting performance. If people change their preferences in the normative direction, then this would suggest that temporal discounting may be used as a measure of rational thinking (Slovic and Tversky, 1974; Stanovich & West, 1999).

In Study One, we examined individual differences in relation to performance on Staircase and Mixed methods and the Invariance task. This was done in order to determine whether more willingness to wait for rewards that yield relatively high annual return and high response consistency could be conceptualized as more rational than not waiting for rewards that yield high annual return and low response consistency. In Study Two, we examined the

Understanding/Acceptance task in order to determine whether participants would understand and accept waiting for larger delayed rewards and high response consistency as rational behavior.

Study One

The goal of Study One was to operationalize temporal discounting preferences as indices of rational thinking. Are people with higher intellectual ability and stronger critical thinking dispositions a) more likely to prefer larger delayed rewards especially when the long terms gains are relatively high, and b) to show response consistency across temporal discounting items? First, we hypothesized that a greater willingness to wait for larger delayed rewards on the Staircase and Mixed tasks would be associated with stronger intellectual ability and thinking dispositions that have been associated with better rational thinking. Participants who choose to wait on items with relatively high annual rates of return are predicted to display higher intellectual ability and critical thinking dispositions. Second, we hypothesized that greater response consistency in the Invariance task would be associated with higher intellectual ability and stronger critical thinking dispositions. Third, we hypothesized that both intellectual ability *and* critical thinking dispositions would predict a) more willingness to wait for larger delayed rewards in the Staircase and Mixed tasks and b) higher response consistency in the Invariance task.

Methods

Participants. One-hundred sixty-eight undergraduate students (111 females, 67 males) from York University participated in this study. The average age was 20.09 (SD= 2.50). Fourteen of these participants were of African ethnicity, 14 of Asian, seven of Caribbean, 23 of European, 44 of South Asian, 16 of Middle Eastern, two of Latin, three of Latin/American, and 45 self identified as Other. Participants were required to speak English fluently or for a minimum of six years. Each volunteer participated in exchange for minimal course credit.

Measures. Refer to Appendix A for all of the items included in each of the tasks and scales described below.

Temporal Discounting Tasks.

Staircase Method. This task was based on previous temporal discounting tasks that have been studied in the literature (e.g., Raineri & Rachlin, 1993; Green et al., 1997). It was intended to measure one's tendency to prefer smaller sooner rewards to larger delayed rewards. It included 25 items. Participants were asked to choose between $2000 in 1 year and various smaller immediate monetary rewards. The immediate reward started at $1980 and with each subsequent trial decreased in increments of $20. Performance was scored in two ways. First, we calculated the indifference point for each subject. The indifference point is the point at which a participant is thought to be indifferent to whether he/she prefers the smaller sooner reward or the larger delayed reward, as both options become equal in subject value. The indifference point, or the amount of the immediate reward judged equal in subjective value to the delayed reward, was calculated as the average of the last immediate amount preferred over the delayed reward and the next immediate amount (e.g., Green et al., 1997). The point of indifference typically serves as an anchor. Once participants switch, they rarely switch back to preferring the smaller sooner reward. However, seven of our participants switched back and forth between preferring the smaller sooner reward and the larger delayed reward in this task. As a reliable estimate of their indifference point could not be calculated, these seven participants were excluded from analyses that included the indifference point. The mean indifference point was 1541.43 (SD= 417). The distribution of scores was not normal but this variable was only used in a correlational analysis, which does not assume normality. Higher points of indifference represent *less* discounting of the $2000 reward.

Second, to enable parallel comparisons with the Mixed task, we also scored performance based on the number of decisions to wait for the larger delayed rewards. Each time a participant chose to wait for a delayed reward, he/she was allocated one point. Not waiting for the delayed reward was scored zero. Scores were summed for a composite Staircase score out of 25. The mean score was 20.58 with a standard deviation of 4.40. Scores were not normally distributed and could not be transformed to normal. However, the skewness (-0.631) and kurtosis (.340) values for this task were acceptable. Higher scores indicate a greater willingness to wait for larger rewards.

Mixed Method. This task was also intended to measure one's tendency to prefer smaller, sooner rewards to larger delayed rewards except the items were presented in a random order instead of a descending order. It included 27 items. The items were presented in a fixed, random order for all participants.

When scoring this task, the 27 items were divided into three groups of nine items. The three groups were: 1) Low Return, 2) Medium Return, and 3) High Return based on the annual rate of return on these items. Items were categorized into the Low Return group if the delayed reward yielded less than a 35% annual return, the Medium Return group if the delayed reward yielded between a 90% and a 600% annual return, and High Return if the delayed reward yielded between a 1400% and a 9100% annual return. While these rates of return are systematically higher than the current interest rates, the purpose of these groupings in the current study was to contrast considerably different levels for comparison. Each time a participant chose to wait for the larger reward, he/she was allocated one point. Not waiting for the larger reward was scored zero. Scores were summed in each of the three groups yielding three separate total scores.

The scores for the Low Return category (M=5.18, SD=2.63), the Medium Return category (M=6.25, SD=3.07), and the High Return category (M=8.19, SD= 2.22) were not normally distributed and the data could not be transformed to a normal distribution. However, the skewness (0.57) and kurtosis (-.95) values for the Medium Return were acceptable. The High Return total scores were skewed (-1.62) with a greater number of high scores, which was expected since higher return rates should provoke greater waiting. Scores for the Low Interest Rates were skewed (1.897) with a greater number of low scores, which was also expected since lower return rates should provoke less waiting. Higher scores indicate a greater willingness to wait for larger rewards. The data could not be transformed to normal.

Invariance Task. We developed a temporal discounting task intended to measure whether participants would select consistent discounting choices with the same delay and reward magnitudes within each choice. This task included a total of 13 items and each item consisted of two-paired questions. In one pair, participants were asked to choose between a specific smaller reward offered today or a larger reward offered weeks or months later. In the other pair, participants were asked to choose between a specific smaller reward offered weeks or months from today, and a larger delayed reward offered even later. The two pairs complimented each other so that each item in one group was matched to one of the items in the second group in equivalent wait times, immediate reward values, and delayed reward values; the only difference was that for the second group of items, participants were required to wait for both smaller and larger rewards. The following is a sample item:

1. If you had a choice, would you prefer $180 now OR $200 in 2 weeks?

   1. Very strongly prefer $180 now
   2. Strongly prefer $180 now
   3. Prefer $180 now
   4. Prefer $200 in 2 weeks
   5. Strongly prefer $200 in 2 weeks
   6. Very strongly prefer $200 in 2 weeks

2. If you had a choice, would you prefer $180 in 10 weeks OR $200 in 12 weeks?

   1. Very strongly prefer $180 in 10 weeks
   2. Strongly prefer $180 in 10 weeks
   3. Prefer $180 in 10 weeks
   4. Prefer $200 in 12 weeks
   5. Strongly prefer $200 in 12 weeks
   6. Very strongly prefer $200 in 12 weeks

Participants who chose the same reward preference for both items (i.e., "very strongly prefer", "strongly prefer" or "prefer" $180 for both items *or* "very strongly prefer", "strongly prefer" or "prefer" $200 for both items) were scored as *invariant* or *consistent* and were allocated one point. Participants who chose two different reward preferences for both items were scored as *variant* or *inconsistent* performance and were allocated zero points. Scores were summed for a total score of performance out of 13. Scores were not normally distributed (M= 8.19, SD= 2.11). However, the skewness value was acceptable (0.41). Higher scores represented less invariance and greater response consistency. This variable was referred to as the Invariance Score.

We also evaluated performance on this task as a typical measure of *temporal discounting* irrespective of response consistency. First, we split the items in the Invariance task into two groups. Group one included the 13 items that had smaller rewards available *now* and was referred to as the Now, Later group. Group two included the 13 items that consisted of smaller rewards with a delay and was referred to as the Later, Even Later group. In each group, preferences for smaller sooner rewards were scored zero and preferences for larger delayed rewards were scored one. Scores in each group were summed for a composite *temporal discounting* score. This was done in order to ensure that Invariance task items elicited similar degree of temporal discounting as our Staircase and Mixed items. The mean temporal discounting score for group 1 (now, later) was 5.55 with a standard deviation of 3.61. This variable was referred to as the Group One: TD score. The mean temporal discounting score for group 2 (later, even later) was 6.3 with a standard deviation of 3.61. This variable was referred to as the Group 2: TD score. Higher scores represented more willingness to wait for larger, delayed rewards.

Intellectual ability. Participants completed an 18-item version of Raven's Advanced Progressive Matrices (Set II, Raven 1962) and a 60-item Vocabulary measure that uses a checklist-with foils format. The Matrix reasoning items were used to measure nonverbal ability and analytic thinking (Carpenter, Just, & Shell, 1990). The inter-item correlations showed sufficient reliability of test scores in this subtest (Cronbach's alpha =.70). Participants also completed a Vocabulary subtest that included 40 words and 20 non-words used to measure individual differences in vocabulary knowledge (Anderson & Freebody, 1983). These items have been considered to be a strong measure of verbal ability (Cooksey & Freebody, 1987; Zimmerman, Broder, Shaughnessy, & Underwood, 1977). The inter-item correlations showed sufficient reliability of test scores in the verbal ability subtest (Cronbach's alpha =.78).

Raven's Matrices and the Vocabulary test items combined have been thought to provide a strong index of general intellectual ability and fluid intelligence (Toplak et al., 2011; Toplak & Stanovich, 2002). Furthermore, other studies have shown that Raven's Matrices tests are especially strongly correlated with full-scale intelligence scores (FSIQ) of the Wechsler intelligence tests (Watson & Klett, 1974; Wechsler, 2002).

Verbal reasoning scores had a mean of 18.0 and a standard deviation of 8.2. Non-verbal reasoning scores had a mean of 5.2 and a standard deviation of 3.1. Verbal and non-verbal reasoning scores were standardized (z-scores) and summed for a composite score of intellectual ability. Higher z-scores represent higher intellectual ability.

Thinking Dispositions Questionnaire. Participants completed a self-report questionnaire that included five intermixed scales to measure thinking dispositions that have been associated with rational thinking and good decision-making (Perkins, Jay and Tishman,1992; Nair & Ramnayaran, 2000; Stanovich, 2002; Stanovich & West, 2007; Stanovich, 2008). Participants were asked to rate their agreement with each question using the following six-point scale: Strongly Disagree (1), Disagree Moderately (2), Disagree Slightly (3), Agree Slightly (4), Agree Moderately (5), Strongly Agree (6). Questions were presented in mixed order so that the target scales of interest would be less transparent to participants. The following thinking disposition scales were included:

Actively Open-minded Thinking (AOT). This 41-item scale developed by Stanovich and West (2007) is intended to measure tendency toward open-minded thinking (Sa, Stanovich, & West, 1997; Stanovich & West, 1997; 2007). Sample items were, "People should always take into consideration evidence that goes against their beliefs" and, "Changing your mind is a sign of weakness" (reverse scored). Scores were summed for a total score of AOT. The total scores were normally distributed with a mean of 2.20 and a standard deviation of 0.05. The inter-item correlations showed sufficient reliability of test scores with a Cronbach's alpha of .82 and split-half reliability of .81. Higher scores represented higher tendency towards actively open-minded thinking.

Master Rationality Motive (MRM). This 13-item scale is intended to measure the degree to which an individual *desires* to make decisions that are based on reason (Stanovich, 2008).

Sample items were, “I like to have reasons for what I do”, and “I like to gather many different types of evidence before I decide what to do”. Scores were summed for a total MRM score. Scores were normally distributed with a mean of 52.35 and standard deviation of 8.11. The inter-item correlations showed sufficient reliability with a Cronbach’s alpha of .77 and split-half reliability of .76. Higher scores represented a greater desire to make decisions based on reason.

Consideration of Future Consequences (CFC). This 12-item scale assesses the extent to which one considers distant outcomes when choosing one’s present behavior (Strathman, Gleicher, Boninger & Edwards, 1994). A sample item was, “I only act to satisfy immediate concerns, figuring the future will take care of itself” (reverse scored). Scores were summed to create a total score of CFC. The total scores were normally distributed (M=46.36, SD=6.60). In the current study, inter-item correlations show sufficient reliability with a Cronbach’s alpha of 0.66 and split-half reliability of 0.75. Higher scores represented a higher consideration of future consequences.

Need for Cognition Scale (NFC). This 18-item scale, originally developed by Cacioppo et al. (1996) is intended to assess one’s tendency toward engaging in and enjoying effortful thinking. Sample items were: “I really enjoy a task that involves coming up with new solutions to problems”, and “It is enough for me that something gets the job done; I don’t care how or why it works” (reverse coded). Scores were summed for a total score of NFC. Scores were normally distributed (M=65.28, SD=10.25). A previous study reported a split-half reliability of .81 for this scale and a Cronbach’s alpha of .88 (West, Toplak, & Stanovich, 2008). The inter-item correlations among scores in the present study showed sufficient reliability with a Cronbach’s alpha of .79 and split half reliability of .77. Higher scores represented a higher need for cognition.

Superstitious Thinking (ST). This 13-item scale was composed of two items from a paranormal scale used by Jones, Russell and Nickel (1977), four items from a luck scale used by Stanovich and West (1998c), four items from an ESP scale used by Stanovich (1989), and three items from a superstitious thinking scale published by Epstein and Meier (1989). Sample items include: "Astrology can be useful in making personality judgments," "The number 13 is unlucky," and "I do not believe in any superstitions" (reverse scored). The score on the scale was obtained by summing the responses to the 13 items. The mean score was 35.52 and the standard deviation was 10.17. The inter-item correlations show sufficient reliability with a Cronbach's alpha of .81 and split-half reliability of .78. Higher scores represented higher superstitious thinking.

Thinking Dispositions Composite. The thinking disposition scales were all significantly inter-correlated with Pearson values ranging from 0.27 to 0.59 ($p < 0.001$). Total scores for each of the thinking disposition scales were transformed into z-scores. The z-scores for AOT, NFC, MRM, and CFC were summed. The z-scores for ST were subtracted from this sum in order to yield a total composite score that reflects dispositional tendencies towards actively open-minded thinking, persistence in thinking, desire to act according to rational motives, consideration of future consequences, and superstitious thinking.

Procedure. Questionnaires were distributed and data was collected using Qualtrics, an online survey site. The Questionnaire took approximately 1.5 hours to complete. The questionnaire was organized such that a participant could not proceed to the next item before submitting a response to the current one. Once submitted, a response could not be changed.

Results

Temporal Discounting Task Frequencies.

Staircase and Mixed Methods. Table 1 includes a frequency distribution of the number of later choosers for each item on the Staircase and the Mixed tasks. The annual rate of return for each item is also indicated in Table 1. From the pattern of frequencies in Table 1, it is clear that as the annual rate of return increased with each subsequent item presented in the Staircase and Mixed task, the number of participants who chose the larger delayed reward also generally increased. However, the number of participants who decided to wait for the larger delayed rewards for a particular level of return tended to be larger in the Staircase task than in the Mixed task. For example, 99 participants chose the delayed reward when it yielded 33 percent return in the TD Staircase, but only 38 people chose the delayed reward when it yielded 36 percent return in the TD Mixed task. From the perspective of annual rate of return, considerably fewer participants chose to wait for the delayed option in the Mixed than in the Staircase task. The frequencies of total scores for the TD Staircase (M= 20.58, SD= 4.40) and TD Mixed Low (M=5.18, SD=2.63), TD Mixed Medium (M=6.25, SD=3.07), and TD Mixed High (M=8.19, SD= 2.22) tasks are displayed in Appendix B.

Table 1.
Annual Return Rates Yielded by Choosing the Delayed Reward for each Item in the Staircase and Mixed Task, and the Number of People who chose to wait for the Delayed Reward.

Item	Return Rate (%)	Later Choosers (n/168)
TD Staircase Task		
$1,990 now or 2000 in 1 year	0.6	17
$1,980 now or 2000 in 1 year	1.0	16
$1,950 now or 2000 in 1 year	2.6	27
$1,900 now or 2000 in 1 year	5.3	37
$1,850 now or 2000 in 1 year	8.1	50
$1,800 now or 2000 in 1 year	11.1	57
$1,700 now or 2000 in 1 year	17.7	79
$1,600 now or 2000 in 1 year	25.0	90

$1,500 now or 2000 in 1 year	33.3	99
$1,400 now or 2000 in 1 year	42.9	114
$1,300 now or 2000 in 1 year	53.9	119
$1,200 now or 2000 in 1 year	66.7	127
$1,000 now or 2000 in 1 year	100.0	137
$900 now or 2000 in 1 year	122.2	159
$800 now or 2000 in 1 year	150.0	159
$700 now or 2000 in 1 year	185.7	158
$600 now or 2000 in 1 year	233.3	161
$500 now or 2000 in 1 year	300.0	160
$400 now or 2000 in 1 year	400.0	162
$300 now or 2000 in 1 year	566.7	162
$200 now or 2000 in 1 year	900.0	164
$150 now or 2000 in 1 year	1233.3	164
$100 now or 2000 in 1 year	1900.0	163
$50 now or 2000 in 1 year	3900.0	164
$20 now or 2000 in 1 year	9900.0	165
TD Mixed: Low Return Rate		
$34 now or $35 in 186 days	5.8	22
$54 now or $55 in 117 days	5.8	15
$75 now or $80 in 162 days	5.8	29
$80 now or $85 in 157 days	14.5	25
$47 now or $50 in 160 days	14.6	26
$28 now or $30 in 179 days	14.6	26
$67 now or $75 in 119 days	36.6	38
$54 now or $60 in 111 days	36.5	28
$22 now or $25 in 136 days	36.6	21
TD Mixed: Med Interest Rate		
$69 now or $85 in 91 days	93.0	64
$49 now or $60 in 89 days	92.1	50
$25 now or $30 in 80 days	91.3	34
$55 now or $75 in 61 days	217.5	66
$19 now or $25 in 53 days	217.6	46
$40 now or $55 in 62 days	220.7	45
$24 now or $35 in 29 days	576.9	66
$34 now or $50 in 30 days	572.6	96
$54 now or $80 in 30 days	585.8	119
TD Mixed: High Interest Rate		
$14 now or $25 in 19 days	1509.4	109
$27 now or $50 in 21 days	1480.6	123
$41 now or $75 in 20 days	1513.4	132
$25 now or $60 in 14 days	3650.0	135

$15 now or $35 in 13 days	3743.6	143
$33 now or $88 in 14 days	3713.2	143
$31 now or $85 in 7 days	9058.1	147
$11 now or $30 in 7 days	9006.5	152
$20 now or $55 in 7 days	9125.0	157

Invariance Methods. Table 2 includes the frequency of later choosers on each item and of *in*variant responders on each pair of items in the TD Invariance task. Participants could have shown two types of response *in*variance on this task. First, participants could have shown invariance by choosing the smaller sooner rewards in both pairs of matched items. Second, participants could have shown invariance by choosing the larger delayed rewards in both pairs of matched items. The number of participants who showed invariance on each pair of items ranged from 72 to 137. Note that for some of these items, many participants showed invariance by selecting the smaller sooner rewards for both pairs of items. For example, for the first pair of items 61 out of 72 invariant responders chose the delayed rewards while 11 out of 72 invariant responders chose the smaller sooner rewards. For the second pair of items, 40 out of 130 invariant responders chose the larger delayed rewards while 90 out of 130 invariant responders chose the smaller sooner rewards.

Participants could have shown two types of response variance for each pair of items in this task. First, participants could have shown response variance by choosing the smaller sooner reward in the first item and then the larger delayed reward for the second item. This pattern of responding would have been a preference reversal in the expected direction (Green, 1994). Fourth, participants could have shown variance by choosing the larger delayed reward in the first item and then the smaller sooner reward for the second item, which would have been a preference reversal in the unexpected direction. Contrary to prior research, fewer participants than expected displayed preference reversals on each pair of items. For example, 72 participants answered consistently on our first pair of items, meaning only 57% of our participants showed response *in*consistency on this pair of items. For a second example, 130 participants answered consistently on our second pair of items, meaning only 23% of our participants showed response *in*consistency on this pair of items.

Additionally, of the preference reversals displayed by participants, some were in the unexpected direction. For example, in the first pair of items, participants were offered the choice between $340 now and $400 in 4 months. Of our participants, 112 chose to wait for the $400 reward. We later offered the choice between $340 in 10 months and $400 in 14 months. Of our participants, 61 people chose to wait for the larger delayed rewards. This means that 51 people switched preferences in the unexpected direction. This number was lower, ranging from 0 – 13, for the other pair of items. We would expect participants to choose the smaller reward when it is offered *now*, and to switch preferences to preferring the larger delayed rewards when a delay is added to the smaller reward (Green, 1994).

Table 2.
Number of Participants who Chose the Later Reward and number of Invariant Responders in the Invariance Task.

Matched-Pairs	Number of Later Choosers /168	Number of Invariant Responders /168
$340 now or $400 in 4 months	112	72
$340 in 10 months or $400 in 14 months	61	
$110 now or $120 in 4 weeks	42	130
$110 in 8 weeks or $120 in 12 weeks	40	
$65 now or $70 in 3 weeks	37	124
$65 in 20 weeks or $70 in 23 weeks	53	

$60 now or $90 in 3 months	95	110
$60 in 10 months or $90 in 13 months	105	
$300 now or $315 in 1 week	127	133
$300 in 20 weeks or $315 in 21 week	116	
$150 now or $160 in 4 weeks	31	137
$150 in 20 weeks or $160 in 24 weeks	46	
$180 now or $200 in 2 weeks	117	126
$180 in 10 weeks or $200 in 12 weeks	104	
$95 now or $105 in 2 weeks	82	113
$95 in 10 weeks or $105 in 12 weeks	98	
$75 now or $80 in 1 week	99	124
$75 in 10 weeks or $80 in 11 weeks	109	
$70 now or $110 in 6 months	85	121
$70 in 12 months or $110 in 16 months	116	
$235 now or $270 in 4 months	79	90
$235 in 12 months or $270 in 16 months	66	
$45 now or $50 in 4 weeks	34	139
$45 in 10 weeks or $50 in 14 weeks	39	
$210 now or $220 in 3 weeks	43	123
$210 in 20 weeks or $220 in 23 weeks	56	

Table 3 includes the frequency of *total invariance* scores in the Invariance task. Higher scores represent greater response consistency. Many participants showed relatively high response consistency. Less than 25% percent of our participants scored lower than 50% consistency across items on this task. More than 45% of our participants scored higher than 80% consistency across items on this task.

Table 3.
The Number of Times and Proportion of Participants Who Answered Consistently to Two Different, but Equivalent, Temporal Discounting Items

Score	n	Percentage of N (%)
13	0	0
12	9	5.4
11	13	7.7
10	27	16.1
9	27	16.1
8	29	17.3
7	28	16.7
6	19	11.3
5	10	6.0
4	3	1.8
3	2	1.2
2	0	0
1	0	0
0	1	.6

Note: A lower score represents less consistency and greater variance, while a higher scores represents greater consistency and less variance

Temporal Discounting Task Inter-correlations. Table 4 includes the Pearson correlations among the three temporal discounting tasks. Choices on the Staircase task were significantly associated with choices on the Mixed task, particularly for the medium and high levels of annual return. Choices on the Staircase task were also significantly associated with a preference for larger delayed rewards (i.e., the *temporal discounting* scores) on all items in the Invariance task, but not on the index of response consistency (i.e., the invariance scores) in the Invariance task. Choices on the Mixed task were significantly associated with more willingness to wait for larger delayed rewards (i.e., temporal discounting scores) on all items in the Invariance task. However, choices on the Mixed task were not associated with the index of response consistency (i.e., invariance scores) in the Invariance task. Temporal discounting preferences in the TD Invariance task were significantly related to TD Invariance scores, which represent response consistency, *only* when the items consisted of smaller rewards *with a delay* (i.e., Group 2: Later, Even Later).

Table 4
Pearson Correlations Among the Staircase, Mixed, and Invariance Tasks.

Temporal Discounting Tasks	1a	1b	2a	2b	2c	2d	3a	3b	3c
1. Staircase Version									
a. Indifference Score	----								
b. Total Score	.95**	----							
2. Mixed Version									
a. Total Score	.57**	.59**	----						
b. Low Return	.29**	.28**	.77**	----					
c. Medium Return	.57**	.59**	.93**	.66*	----				
d. High Return	.49**	.50**	.59**	.03	.43**	----			
3. Invariance Task									
a. Group 1 (now, later): Total	.39**	.42**	.45**	.25**	.48**	.29**	----		
b. Group 2 (later, even later): Total	.38**	.42**	.45**	.30**	.46**	.27**	.77**	----	
c. Invariance Score	-.002	.30	.02	.05	.07	.00	.08	.16*	----

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

Inter-correlations between Temporal Discounting Tasks and Individual Differences in Intellectual Abilities and Thinking Dispositions. Table 5 includes the Pearson correlations among performance on the temporal discounting tasks, intellectual ability measures, and individual thinking disposition scales. Choices on the Staircase task were significantly associated with all of the thinking dispositions and with intellectual ability, except the indifference point was not significantly related to intellectual ability (*r=0.15, p=.058*). In other words, participants who showed greater preferences for larger delayed rewards were more likely to display high intellectual ability, Need for Cognition, Actively Open Minded Thinking, Master Rationality Motive, and Consideration for Future Consequences, and lower Superstitious Thinking.

Intellectual ability and thinking dispositions were *not* significantly related to total performance on the Mixed task when items were presented in random order. Choices on the Mixed Task were associated with intellectual ability and all of the thinking dispositions (except for Superstitious Thinking) *only* when the temporal discounting items consisted of *high* annual return rates. Choices on the Mixed task were not significantly correlated with intellectual ability or thinking dispositions when items consisted of low or medium return rates.

Response consistency on the Invariance task was not significantly associated with intellectual ability or critical thinking dispositions. A preference for larger delayed rewards on the Invariance task, irrespective of response consistency, was significantly correlated with intellectual ability, AOT, and CFC in both groups of items, but only group two scores (i.e., later, even later items) correlated with the thinking disposition composite. Response consistency as measured by performance on the Invariance task was not significantly correlated with any of the individual differences measures. Intellectual ability and thinking dispositions were related to response consistency when participants *consistently* chose later rewards for both pairs of matched items ($r = .238, p < .01$; $r = .211, p < .01$ respectively). This relationship was stronger than the association between intellectual ability and a preference for later rewards irrespective of response consistency ($r = .221, p < .01$; $r = .208, p < .01$).

Table 5.
Correlations between Performance on the Temporal Discounting tasks, Thinking Disposition Scales, the Thinking Disposition Composite, and Intellectual Ability Measure.

Temporal Discounting Tasks	Intellectual ability	NFC	AOT	CFC	MRM	ST	Thinking Disposition Composite
Staircase Task							
a. Indifference score	.15	.19*	.25**	.19*	.20*	-.30**	.31**
b. Total Score	.17*	.19*	.22**	.19*	.18*	-.30**	.29**
Mixed Task							
a. Total Score	.09	.07	.13	.09	.08	-.12	.13
b. Low Return	-.08	-.01	-.08	-.07	-.13	.08	.10
c. Medium Return	.04	.05	.07	.06	.03	-.10	.08
d. High Return	.30**	.16*	.37**	.25**	.31**	-.29	.37**
Invariance Task							
b. Group 1: TD Score	.18*	.027	.16*	.16*	.04	-.14	.14
c. Group 2: TD Score	.21**	.08	.25**	.20**	.12	-.17	.22**
a. Invariance Score	.07	.04	.05	.02	.05	-.08	.01
	Intellectual Ability	NFC	AOT	CFC	MRM	ST	Thinking Disposition Composite

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

Predicting the Preference to Wait for Larger Rewards. The next set of analyses were concerned with determining whether intellectual ability *and* thinking dispositions would predict the willingness to wait for larger, delayed rewards. Intellectual ability was significantly associated with all of the thinking dispositions. The thinking disposition scores were moderately to strongly associated with each other. (Refer to Table 3 in the appendix for correlation and significance values). Given that intellectual ability and thinking dispositions were significantly correlated, hierarchical regression analyses were conducted to determine whether thinking dispositions would uniquely explain significantly more of the variance in temporal discounting choices than intellectual abilities alone. Two hierarchical regressions were conducted: first with the Staircase task as an outcome variable and second with the Mixed: High Return as an outcome variable. Since intellectual abilities and thinking dispositions were not significantly related to a preference for larger delayed rewards in the Mixed task for Low and Medium levels of annual return or response consistency in the Invariance task, the regression analysis were not conducted for either of these tasks.

Results of the variance inflation factor (all less than 2.0), and collinearity tolerance (all greater than .76) suggest that intellectual ability and the thinking disposition composite are not collinear and that the estimated βs are well established in all of the following hierarchical regression analyses. An examination into outliers reveals one case with an extremely low score for the first regression analysis, and three cases with extremely high scores for the second. However, no justification could be found for the elimination of these outliers, and thus the cases were retained. Results of the hierarchical regression analyses are displayed in Table 6 below.

Table 6.
Regression Results.

	R^2	ΔR^2 (N)	ΔF	Unique Variance	Standardized β
Criterion Variable = Staircase Task					
1. Intellectual ability Block: Composite	.03	.03*	5.67*	.0015	.04
2. Thinking Disposition Block: Composite	.08	.06**	9.82**	.055	.26***
Criterion Variable = Mixed High Annual Return					
1. Intellectual ability Block: Composite	.09	.09***	16.80***	.023	.17*
2. Thinking Disposition Block: Composite	.16	.07***	12.85***	.066	.29***

***, P <.001; **. P <.01; *. P <.05

The first analysis included performance on the Staircase task as an outcome measure with intellectual ability entered into the first block and thinking dispositions entered into the second. The general model was significant (*R^2=0.08, F(1, 164)=7.37, p= 0.001*). Thinking dispositions was a significant predictor of Staircase performance *(β = 0.32, p< .01*). Intellectual ability was found to significantly predict a preference for larger delayed reward in the Staircase task when it was entered into the first model alone (*β=.45, p< .05*) but it was no longer a significant contributor (*β =.118, p=.603*) when thinking dispositions was added to the model. Results of block one indicated that intellectual ability accounted for 2.8% of the performance on the Staircase task, which was significantly different from zero ($F_{(1, 165)}$=5.67, p<.05). The results of block two indicated that thinking dispositions accounted for an additional 5.5% of the variance in Staircase, which was a significant change from block one ($F_{(1, 164)}$=9.82, p<.001). According to this analysis, thinking dispositions accounted for 5.5% of the unique variance in Staircase performance. Thus, a general disposition towards thinking critically uniquely predicted 5.5% of the variability in a preference for larger delayed rewards.

The second analysis included the Mixed task with High levels of annual return as an outcome measure with intellectual ability entered into the first block and the thinking dispositions composite entered into the second block. The general model was significant (R^2=0.40, F(1, 164)=15.42, p= <0.001). Intellectual ability was a significant predictor of performance on the Mixed task for High levels of annual return (β =.232, p< 0.05), as was the thinking dispositions composite (β =.176, p< 0.001). The results of block one indicated that intellectual ability accounted for 9.2% of the performance on the Mixed task for High levels of annual return, which was significantly different from zero ($F_{(1, 165)}$=16.80, p<.001). The results of block 2 indicated that thinking dispositions accounted for an additional 6.6% of the unique variance in the Mixed task for High levels of annual return, which was a significant change from block one ($F_{(1, 164)}$=12.85, p<.001). According to this analysis, thinking dispositions accounted for 6.6% of the unique variance in performance on the Mixed task for High levels of annual return.

Study Two

Results of Study One have indicated that preferences for larger delayed rewards are associated with high intellectual ability and critical thinking dispositions, especially with higher annual rates of return. Results of Study One have also indicated that response consistency in temporal discounting choices is not necessarily associated with high intellectual ability or critical thinking dispositions. Would people be more likely to make better choices if it is explained to them why waiting for larger delayed rewards and responding consistently across temporal discounting choices reflects more rational decision-making? In Study Two, we examined whether people would shift their immediate choice to a later choice after being given an explanation for why waiting would be beneficial. We also examined whether fewer people would show preference reversals after being given an explanation to respond consistently across temporal discounting choices. This method was used as a further converging method to assess temporal discounting as an indicator of rational choice (Stanovich & West, 1999).

First, we hypothesized that giving participants a good explanation to choose the larger delayed reward would impact their initial responses. Second, we hypothesized that giving participants a good explanation to respond consistently would also impact their initial responses. If people change their preferences in the normative direction, then this would suggest that using return rates as a rational to make good temporal discounting preferences is an axiom that is understood and accepted. It also suggests that our Understanding/Acceptance paradigm may be an effective measure of rational thinking (Slovic and Tversky, 1974; Stanovich & West, 1999).

Methods

Participants. Participants who completed the tasks in Study One also participated in Study Two. Each volunteer participated in exchange for minimal course credit.

Measures.

Understanding/Acceptance-Reason To Wait Task. This task was adapted and based on methods used by Slovic and Tversky (1974) and Stanovich and West (1999). It was used to measure whether evaluating temporal discounting choices according to yearly percent rate increases was an axiom that was commonly accepted. The Understanding/Acceptance-Reason To Wait Task was comprised of two items, and each item included two parts.

Item 1. In the first part, participants were asked to choose between a specific, smaller award that was available immediately and a larger, delayed reward that would have available at a later time. The normative response would be to select the larger delayed reward. This part appeared as follows:

"If you had a choice, would you prefer $75 now OR $80 in 1 week?"

1. Very strongly prefer $75 now
2. Strongly prefer $75 now
3. Prefer $75 now
4. Prefer $80 in 1 week
5. Strongly prefer $80 in 1 week
6. Very strongly prefer $80 in 1 week

At a later point in time during the study, the second part of Item One was presented to participants. The normative response would be to select the larger delayed reward. This part appeared as follows:

"Let's consider the choice between $75 now VERSUS $80 in 1 week.

There would be a good reason to wait 1 week for $80 instead of taking $75 right now. Waiting for an extra $5 is getting a 7% return for just waiting 1 week. This would amount to a 347% return based on an annual interest rate. This is an extraordinarily higher return than most banks or investment firms would give you. They would give you less than a 5% annual interest rate.

Based on this information, what would you prefer?"

1. Very strongly prefer $75 now
2. Strongly prefer $75 now
3. Prefer $75 now
4. Prefer $80 in 1 week
5. Strongly prefer $80 in 1 week
6. Very strongly prefer $80 in 1 week

Participants who preferred any of the "$75 now" options were considered "Now Choosers", while those who preferred any of the "$80 in 1 week" options were considered "Later Choosers". Participants within each group were further divided into one of two groups based on their choices for the second part: Switchers and Non-Switchers. Switchers were those who had changed their reward preferences when they were provided with a reason to choose $80 in 1 week over $75 now. Refer to Figure 1 for an illustration of the resulting categories.

		Part 1	
		$75 Now	Wait for $80
Part 2	$75 Now	Non-Switcher	Switcher (non-normative)
	Wait for $80	Switcher (normative)	Non-Switcher

Figure 1. Between-Subject grouping categories for Item One in the Understanding/Acceptance: Reason to wait task.

Given that our scale provided participants with the opportunity to rate their preferences from 1-3, those who had preferred smaller, immediate rewards were not considered switchers unless they had changed their answers from preferring, strongly preferring, or very strongly preferring $75 now, to preferring, strongly preferring, or very strongly preferring $80 in 1 week. The same criterion applied to those who preferred larger, delayed rewards; switchers were those who changed their reward preferences from preferring, strongly preferring, or very strongly preferring $80 in 1 week, to preferring, strongly preferring, or very strongly preferring $75 now. A switch in the normative direction referred to switches from preferring the $75 now to preferring the $80 later. A switch in the non-normative direction referred to switches from preferring $80 later to preferring $75 now.

Item 2. The format of this item followed that of Item 1. The first part appeared as follows:

"If you had a choice, would you prefer $60 now OR $90 in 3 months?"

1. Very strongly prefer $60 now
2. Strongly prefer $60 now
3. Prefer $60 now
4. Prefer $90 in 3 months
5. Strongly prefer $90 in 3 months
6. Very strongly prefer $90 in 3 months

The second corresponding part appeared as follows at a later point in time during the experiment:

"Let's consider the choice between $60 now VERSUS $90 in 3 months.

There would be a good reason to wait 3 months for $90 instead of taking $60 right now. Waiting for an extra $30 is getting a 50% return for just waiting 3 months. This would amount to a 200% return based on an annual interest rate. This is an extraordinarily higher return than most banks or investment firms would give you. They would give you less than a 5% annual interest rate.

Based on this information, what would you prefer?"

1. Very strongly prefer $60 now
2. Strongly prefer $60 now
3. Prefer $60 now
4. Prefer $90 in 3 months
5. Strongly prefer $90 in 3 months
6. Very strongly prefer $90 in 3 months

Participants who preferred any of the "$60 now" options for the first item were considered Now Choosers, while those who preferred any of the $90 in 3 months options were considered Later Choosers. Participants within each group were further divided into one of two groups based on their performance during the second item: Switchers and Non-Switchers. Switchers were those who changed their reward preferences when subsequently provided with a reason to choose $90 in 3 months over $30 now. Refer to Figure 2 for a depiction of the resulting categories.

		Part 1	
		$60 Now	Wait 3 months for $90
Part 2	$60 Now	Non-Switcher	Switcher (Not Ideal)
	Wait 3 months for $90	Switcher (Ideal)	Non-Switcher

Figure 2. Between-Subject grouping categories for Item 2 in the Understanding/Acceptance: Reason to wait task.

Each of the temporal discounting questions in the Understanding/Acceptance-Reason To Wait tasks were characterized with delayed rewards that yielded annual interest rates greater than 200%. Thus waiting for the delayed reward was considered the rational, normative (ideal), choice.

Understanding/Acceptance-Invariance Task. This task included three parts. The first part asked participants to choose between $70 now and $110 in 6 months, and the second part asked participants to choose between $70 in 12 months and $110 in 18 months. Participants were divided into two groups based on their answers to these questions: Consistent Responders and Inconsistent Responders. Consistent Responders chose the same reward preference for both parts. Inconsistent responders chose different reward preferences for both parts. The normative response would have been to choose the same reward preference for both, because waiting for the delayed reward in each of the choices yields the same return. These two parts appeared as follows:

"If you had a choice, would you prefer $70 now OR $110 in 6 months?"

1. Very strongly prefer $70 now
2. Strongly prefer $70 now
3. Prefer $70 now
4. Prefer $110 in 6 months
5. Strongly prefer $110 in 6 months
6. Very strongly prefer $110 in 6 months

"If you had a choice, would you prefer $70 in 12 months OR $110 in 18 months?"

7. Very strongly prefer $70 now
8. Strongly prefer $70 now
9. Prefer $70 now
10. Prefer $110 in 18 months
11. Strongly prefer $110 in 18 months
12. Very strongly prefer $110 in 18 months

At a later point in time, participants were presented with a third part that included these two temporal discounting items again *and* it was explained to them that both items consist of equal wait times and yield equivalent return rates. This item provided an explanation as to why it would be rational, and thus normative, to respond in the same way to each item and appeared as follows:

"Consider the following two situations:

Situation 1 offers a choice between $70 now <u>or</u> $110 in 6 months.

Situation 2 offers a choice between $70 in 12 months <u>or</u> $110 in 18 months.

In 12 months, you will be in exactly the same situation as in the first choice – you could be receiving $70 now or $110 in 6 months.

Based on this information, please make your choices below"

Participants were further divided into groups based on their reward preferences. Non-switchers were those participants whose temporal discounting preferences for the two situations were *not* impacted by our explanation. Switchers were those participants whose temporal discounting preferences for these two temporal discounting situations *were* impacted by our explanation. Refer to Figure 3 for a depiction of the resulting categories.

a)

		Part 2	
		$70 in 12 months	$110 in 18 months
Part 1	$70 now	Consistent Responders	Inconsistent Responders
	$110 in 6 months	Inconsistent Responders	Consistent Responder

b)

		Part 3	
		Consistent Responders	Inconsistent Responders
Part 1 and 2	Consistent Responders	Non-Switchers	Switchers (non-normative)
	Inconsistent Responders	Switchers (normative)	Non-switchers

Figure 3. Between-Subject grouping categories for Item 3 in the Understanding/Acceptance-Reason to wait task.

Procedure. The procedure in Study Two followed that of Study One.

Results

Understanding/Acceptance- Reason To Wait Task. As previously explained, the Understanding Acceptance-Reason to Wait Task included two items. The two items included two parts each: 1) a temporal discounting item that asked participants to choose between a smaller, sooner reward and a larger, delayed reward, and 2) a subsequent item that provided participants with the same choice *and* a compelling reason to prefer the larger, delayed reward. The number of participants who respond non-normatively (or not optimally) across the three parts of this task *prior* to being given our reasons to is displayed in Table 1 below.

Table 1.
Number of Participants who Chose the Non-normative Response for Each Item in the Understanding/Acceptance-Reason to Wait Task.

Understanding/Acceptance Item	N	Non-normative Response (n)	Normative Response (n)
Item 1) $75 now or $80 in 1 week	168	$75 now (n= 69)	$80 in 1 week (n=99)
Item 2) $60 now or $90 in 3 months	168	$60 now (n=74)	90 in 1 week (n=94)

Separate analysis were conducted on Items 1 and 2 of the Understanding/Acceptance-Reason to Wait Task in order to determine whether providing participants with a compelling reason to prefer larger, delayed rewards will improve decision-making towards preferring larger, delayed rewards in either Items.

Understanding/Acceptance-Reason to Wait Item 1. Table 2 describes the proportion of participants who initially chose $75 dollars now and switched their temporal discounting preferences after being provided with an argument to choose $80 in 1 week, and the proportion of participants who initially chose $80 in 1 week and changed their answer to $75 now. Upon being given our reason to choose $80 in 1 week over $75 now, 31 (44.9%) Now Choosers switched their answers while 38 (55.1%) Now Choosers again chose $75 now; while 74 (27%) of the

Later Choosers continued to prefer \$80 in 1 week, 25 (25%) of the Later Choosers who initially chose \$80 in 1 week switched to choosing \$75 now.

The proportion of participants who chose \$70 now and switched their answers to \$80 in 1 week was significant X^2 (1, N=168)=0.07, p< .01. This proportion was also significantly greater than the number of participants who initially chose \$80 in 1 week and then switched their answers in the negative direction towards preferring \$75 now (refer to Table 2).

Table 2.
Test Statistics and Percentage of Participants who Changed their Responses on the Second Administration of Item One in the Understanding/Acceptance- Reason to Wait Task.

Initial Response	n	% Who Switched Preferences (n)	Chi-Square
Not Ideal: \$75 Now	69	44.9% (31)	X^2 (1, N=168)= 0.71**
Ideal: \$80 Later	99	25.3% (25)	Phi= -.21, Cramer's V= .21

**. significant at the 0.01 level (2-tailed).

Understanding/Acceptance- Reason to Wait Item 2. The first part asked participants to choose between \$60 now and \$90 in 3 months. The second part asked participants to choose between \$60 now and \$90 in 3 months, but it also included an explanation that explained why participants should choose \$60 in 3 months. Participants were divided into two groups: \$60 Now Choosers (n=37, 44%) and \$90 Later Choosers (n=77, 56%). Upon being given our reason to choose \$90 in 3 months over \$60 now, 37 (50%) Now Choosers switched their answers while 37 (50%) Now Choosers again chose smaller, sooner rewards; while 77 (81.9%) Later Choosers continued to prefer \$90 in 3 months, 17 (18.1%) of the Later Choosers who initially chose \$90 in 3 months switched to choosing \$60 now. Table 3 displays the proportion of participants who changed their temporal discounting preferences after being provided with a rational reason to choose the larger delayed reward for the temporal discounting choice in Part 2.

The proportion of participants who chose \$60 now and switched their answers to \$90 in 3 months was significant X^2 (1, N=168) = 19.37, $p < .001$. This proportion was also significantly greater than the number of participants who initially chose \$90 in 3 months and then switched their answers in the negative direction towards preferring \$60 now (refer to Table 3).

Table 3.
Test Statistics and Percentage of Participants Who Changed Their Responses on the Second Administration of Item Two in the Understanding/Acceptance- Reason to Wait Task.

Initial Response	n	% Who Switched Reward Preferences (n)	Chi-Square
Not Ideal: \$60 Now	74	50% (37)	X^2 (1, N=168)= 19.37***
Ideal: \$90 Later	94	18.1% (17)	Phi= -.34 Cramer's V= .34

***.significant at the 0.001 level (2-tailed).

Understanding/Acceptance- Invariance. The Understanding/Acceptance-Invariance Task included 3 parts: 1) a part that required participants to choose between \$70 now and \$110 in 6 months, 2) a part that required participants to choose between \$70 in 12 months and \$110 in 18 months, and 3) a part that presented participants with *both* of these items at once *and* explained to participants that both items are similar in that they yield equivalent wait times and annual return. The goal was to determine whether providing participants with a reason to make consistent decisions would improve decision-making towards choosing the same reward preference across similar temporal discounting situations.

Participants were divided into two groups based on their answers to the first two parts (1. between \$70 now and \$110 in 6 months, and 2. between \$70 in 12 months and \$110 in 18 months): Consistent responders chose the same reward preference for both parts whereas Inconsistent responders chose different reward preferences for both parts. At a later point in the battery, participants were presented with the third part, which presented them with these two temporal discounting choices again and it was explained to them that both choices consist of equal wait times and yield equivalent return rates. Non-switchers were those participants whose temporal discounting preferences for these two items were not changed by our explanation. Switchers are those participants whose temporal discounting preferences for these two items were changed by our explanation. Table 4 indicates the proportion of participants who initially chose two inconsistent preferences for each part and changed their answers following our explanation in part three.

Table 4.
Test Statistics and Percentage of Participants who Changed their Responses After being Given a Reason to Make Consistent Reward Choices in the Understanding/Acceptance-Invariance Task.

Initial Response	n	% Who Switched Responses (n)	Chi-Square
Consistent Responders	121	24.0% (29)	X^2 (1, N=168)= 15.11***
Inconsistent Responders	47	55.3% (26)	Phi= .30, Cramer's V= .30

***.significant at the 0.001 level (2-tailed).

Of the 47 inconsistent responders who initially chose two different answers to the equivalent temporal discounting items, 55.3% switched their answers to preferring the same reward preference subsequent to evaluating our argument. This proportion was significantly different from the percentage of inconsistent responders that did not switch their answers, X^2 (1, N=168)= 15.11, p<.001. This proportion was also significantly greater than the percentage of consistent responders who switched their answers in the non-normative direction towards preferring two different rewards for the equivalent temporal discounting items (refer to Table 5).

General Discussion

In Study One, we found that more willingness to wait for larger delayed rewards was associated with higher intellectual ability and stronger critical thinking dispositions. As predicted, more willingness to wait for larger delayed rewards on the Mixed temporal discounting task was significantly correlated with stronger intellectual ability and thinking dispositions for items in the high annual return category. Furthermore, critical thinking dispositions significantly predicted more willingness to wait for larger delayed rewards in the Staircase and Mixed tasks even after controlling for intellectual ability. These results provide evidence to support decisions to wait for larger delayed rewards may involve more effortful thinking and consideration (McClure et al., 2004), especially when the long-term gain is relatively high. In Study One, we did not find that response consistency across temporal discounting choices was significantly associated with higher intellectual ability or stronger critical thinking dispositions. Contrary to predictions, response consistency in the Invariance task did not correlate with intellectual ability or thinking dispositions. These results indicate that choosing two inconsistent reward preferences for two parallel temporal discounting items is not a decision that is necessarily void of effortful thinking or consideration.

In Study Two, we found that giving participants explanations to select larger delayed rewards and to choose consistent reward options lead participants to alter their initial rewards preferences. Consistent with our first prediction, a significant proportion of participants who initially chose the smaller sooner rewards, switched preferences after giving them an explanation to select the larger delayed rewards. Consistent with our second prediction, a significant proportion of participants who initially chose inconsistent reward preferences also altered preferences after giving them an explanation to make consistent choices. These results suggest participants who do not switch preferences after being given explanations to choose larger delayed rewards and to choose consistent reward preferences may not be engaging in good decision-making.

These findings all converge to suggest that some temporal discounting choices are better than others. These findings are discussed in further detail below with respect to using 1) annual return rates as an index of rational temporal discounting preferences (Study One), 2) response consistency as an index of rational temporal discounting preferences (Study One), and 3) the understanding/acceptance principle as an index of rational temporal discounting preferences (Study Two).

Annual Return Rates as an Index of Rational Temporal Discounting Preferences

Results in Study One indicate that annual rates of return may be used to operationalize temporal discounting items as an index of rationality. Our results suggest that waiting for larger delayed rewards when the potential for long-term gain is relatively high (i.e. high annual return) may be considered a rational choice. Consistent with our first hypothesis, we found that higher intellectual ability and stronger critical thinking dispositions associated with more willingness to wait for larger delayed rewards in the Staircase task and Mixed task when the annual return was high. We demonstrated that decisions to wait for larger delayed rewards in the Staircase task and the Mixed task (for high levels of annual return) were significantly related to higher intellectual ability. We also demonstrated that decisions to wait for larger delayed rewards in the Staircase and Mixed task (for high levels of annual return) were significantly related to stronger thinking dispositions linked to cognitive persistence and flexibility, and that people who were more *disposed* to effortful thinking were more likely to wait for larger delayed rewards. We assessed dispositions towards actively open-minded thinking, intellectual curiosity and enjoyment, motive to act according to reason, consideration of future consequences, and superstitious thinking. It has been thought that people who tend to be open-minded, intellectually curious, motivated to act according to reason, considerate of future consequences, and resilient to superstitious thinking are more inclined to engage in more effortful decision-making that involves planning, reasoning, and analytical evaluation (Perkins, Jay & Tishman, 1992; Stanovich, 2008; Stanovich, 2009).

In the Mixed task, *more* participants tended to select larger delayed rewards when the annual rates of return were relatively high. As the annual returns increased with each item, the number of participants that chose the larger delayed rewards also generally increased (refer to column three in Table 1). Participants recognized that they should choose the larger delayed rewards when the long-term gains were relatively high. Additionally, higher intellectual ability and stronger critical thinking dispositions were significantly correlated with more willingness to wait for larger delayed rewards on items that yielded high annual return. Intellectual ability and critical thinking dispositions were *not* significantly correlated with more willingness to wait for larger delayed rewards on items that yielded relatively low or medium annual return. In other words, participants that were more willing to wait for larger delayed rewards when the long-term gain was relatively high, were also more likely to display higher intellectual ability and stronger critical thinking dispositions. Participants that were more willing to wait for larger delayed rewards when the gains were relatively low were *not* necessarily more likely to display higher intellectual ability or stronger critical thinking. This pattern of results suggests that making the decision to wait for larger delayed rewards when the potential for gain is relatively low (i.e., low or medium annual return) does not necessarily require effortful thinking or consideration. In contrast, making decisions to wait for larger delayed rewards when the potential long-term gain is relatively high (i.e., high annual return) requires more effortful thinking and consideration. Thus not waiting for larger delayed rewards when the potential for long-term gain is relatively low, may not *necessarily* be considered a non-rational decision. However, not waiting for larger delayed rewards when the potential for long-term gain is relatively high may be considered a non-rational decision.

Staircase Versus Mixed Methods. In Study One, the number of participants that selected the larger delayed reward for a specific level of annual return tended to be larger in the Staircase task (e.g., when the annual return was 33%, 99 participants chose the larger delayed reward) than in the Mixed task (e.g., when the annual return was 36%, 38 participants chose the larger delayed reward). This finding is important because it suggests that the order in which items are presented in a temporal discounting task can impact overall reward preferences. In the Staircase task, where items are presented in decreasing order, a participant's point of indifference likely served as an anchor. In decision-making, the anchoring effect occurs when people rely on an initial piece of information to make all subsequent decisions (see Tversky & Kahneman, 1984). In the Staircase task, once participants decided to prefer the larger delayed reward to the smaller sooner reward, very few of them went back to preferring the smaller sooner rewards. In the Mixed task, items were presented in random order and thus one's point of indifference is not easily perceivable. Thus the indifference point cannot serve as an anchor. However, decisions in the Mixed task may be related to one another in that participants may eventually recognize that some items yield relatively larger long-term gain (e.g., high annual returns of 9000%) than others (e.g., low annual returns of 33%).

These results are consistent with prior research. Robles and Vargas (2007) showed that Staircase and Mixed methods are highly correlated but that they result in different degrees of temporal discounting overall. Robles and Vargas (2007) concluded that these differences do not threaten interpretation of data. However, in the Staircase task, items prior to one's indifference point likely invoke qualitatively different thought processes than items after one's indifference point. This would not apply to items in the Mixed task, which are presented in random order. Thus performance on the Staircase task may not always be directly comparable to performance on the Mixed task.

Response Consistency as an Index of Rational Temporal Discounting Preferences

Results of Study One indicated that response consistency in temporal discounting preferences was not associated with more effortful thinking. It has been suggested that rational thinkers are more likely to respond in a consistent manner across similar situations (Tversky & Kahneman, 1986), and that preference reversals in temporal discounting choices are reflective of non-rational behavior (Greene, Festoe, & Myerson, 2004). Contrary to our second hypothesis, intellectual ability and critical thinking dispositions did not correlate with greater response consistency in the Invariance task. In other words, participants that responded consistently across two parallel temporal discounting items (e.g., "Do you prefer $50 now or $100 in One week" and "Do you prefer $50 in one week or $100 in two weeks") were *not* more likely to display higher intellectual ability or stronger critical thinking dispositions. If intellectual ability and critical thinking skills do not differentiate between people who respond consistently and people who reverse preferences, then it is possible that preference reversals may not always be entirely indicative of non-rational decision-making.

There may be various explanations why participants were more or less consistent when making temporal discounting choices in the Invariance task that are not strongly related to intellectual ability or thinking dispositions. First, some participants might have the general tendency to wait for larger delayed rewards regardless of the choice offered and thus would have scored high response consistency in the Invariance task. In contrast, some participants might have the general tendency to prefer smaller sooner rewards to larger delayed rewards regardless of the choices offered and thus would have also scored high consistency in the Invariance task. These response patterns may be less reflective of rational and effortful thinking, and more attributable to general habits. Second, it has been suggested that humans prefer to plan for the future but that they tend to behave non-rationally today (e.g., McClure, 2004). For example, dieters may make non-rational decisions today even though they do not plan to make those decisions in the future. When given the choice between $50 today and $100 in one week, a person may choose the $50 today, which would result in less potential for long term gain. When given a choice between $50 in one week and $100 in two weeks, this same person is likely to switch preferences and prefer the $100 in two weeks, which would result in more potential for long term gain. This preference reversal may be less indicative of non-rational thinking, and more indicative of the human tendency to rationally plan for the future while behaving non-rationally in the moment. Third, in the Invariance task, there are two competing indices of rational choice: responding consistency and choosing larger delayed rewards. It is possible that some participants were more focused on deciding when to or not to wait for the larger delayed reward and less concerned with whether or not their choices were consistent across temporal discounting items.

In Study One, intellectual ability and thinking dispositions were related to response consistency in the Invariance task, *only* when participants *consistently* chose *larger later* rewards for two parallel items (e.g., preferred the $100 reward when offered 1) the choice between $50 now or $100 in one week and $2) 50 in one week and $100 in 2 weeks). This relationship was stronger than the association between intellectual ability and a preference for later rewards irrespective of response consistency. This pattern of results suggests that while response consistency may not be a clear indicator of rational decision-making on temporal discounting tasks, response consistency paired with a preference for larger delayed rewards may reflect better decision-making than response consistency paired with smaller sooner rewards.

Understanding/Acceptance as an Index of Rational Temporal Discounting Preferences

In Study Two, we found that reward preferences changed significantly after participants were given an explanation to prefer larger delayed rewards. We also found that a significant proportion of participants switched from two inconsistent reward preferences to two consistent reward preferences after being given an explanation to respond consistently.

Understanding/Acceptance- Reason to Wait. Consistent with our first hypothesis, a significant proportion of participants who initially chose the smaller sooner rewards in our Understanding/Acceptance task, switched preferences after being given an explanation to select the larger delayed rewards. This suggests that evaluating temporal discounting choices based on annual return rates is an axiom that was understood and accepted by a significant proportion of participants. Based on methods used by Slovic and Tversky (1974) and Stanovich and West (1999), it was inferred that the significant proportion of Now Choosers who switched their preferences on the second administration of the temporal discounting item, understood, accepted, and used the reason we gave them to prefer larger delayed rewards. We may thus claim, according to the understanding/acceptance principle (Slovic and Tversky, 1974; Stanovich &

West, 2000), that our explanation was rational as it presumably lead to a significant number of switches in the normative direction. This finding is important for two reasons.

First, if a significant proportion of participants understood and accepted our explanation to choose larger delayed rewards based on the annual return rates, then further support is given to using return rates as a way to score temporal discounting preferences in our Mixed task in Study One. Temporal discounting decisions that involve relatively higher rates of return should be more likely to invoke more optimal responses (i.e., more willingness to wait for larger delayed rewards). In Study Two, people accepted 347% and 200% annual returns as rational reasons to wait for the larger delayed rewards. Results of Study One indicated that in the Mixed task, items that yielded interest rates between 1500 percent and 9125 percent, may be especially useful for distinguishing between rational and non-rational preferences *when pitted against items that yielded lower interest rates between five percent and 585 percent*.

Second, these results suggest that initial preferences for smaller sooner rewards were not based on strong rational reasons. Benjamin et al., (2006) found that asking participants to provide reasons for their temporal discounting choices lead to significant increases in choices for larger delayed rewards. This finding suggests that encouraging participants to think more about their temporal discounting choices leads to a greater willingness to wait for larger delayed rewards, which may thus be conceptualized as a more rational choice. Similarly, by providing participants in Study Two with a reason to choose larger delayed rewards, we may have provoked participants to think more rationally about their reward preferences. We can infer from the significant increase in choices for larger delayed rewards, that our reason for choosing larger delayed rewards was more rational than a participant's initial reason for choosing smaller sooner rewards. According to the understanding/acceptance principle, it may be assumed that people whose preferences continued to deviate from normative standards on the second administration of our understanding/acceptance items did not behave rationally (Slovic and Tversky, 1974; Stanovich & West, 1999). Our results suggest that the proportion of people who used our reason to choose delayed rewards based on return rates was significantly greater than the proportion of people who did not. As previously explained, this is evidence to support that high return rates are a rational reason to wait for larger delayed rewards. Yet some participants a) continued to choose smaller sooner rewards or b) switched from preferring later delayed rewards to preferring smaller sooner rewards *despite* having a rational reason to choose larger delayed rewards. As such, it may be assumed that people who did not perform normatively on the second administration of our understanding/acceptance items may not have been engaging in rational-thinking (Stanovich & West, 1999).

Understanding/Acceptance- Invariance. Consistent with our second hypothesis, a significant proportion of participants who initially chose inconsistent reward preferences also altered preferences after being given an explanation to make consistent choices. We were able to influence a significant proportion of inconsistent choosers to choose more consistently by explaining to them that the two temporal discounting items provide to them are actually highly similar in that they yield equivalent annual returns. Thus responding consistently across two parallel temporal discounting items based on our explanation that both items yield the same annual returns was an axiom that was understood and accepted by a significant proportion of participants. It follows that using this axiom to make more normative decisions reflects rational behavior. In contrast, continuing to make inconsistent choices despite being aware of this axiom is reflective of non-rational behavior (Stanovich & West, 1999).

It is important to highlight that we cannot conclude that response inconsistency during temporal discounting tasks necessarily reflects poor rational thinking, as this relationship was not entirely supported by our findings in Study One. Results of Study One suggested that even those participants who display higher intellectual ability and stronger critical thinking dispositions may not have been aware that response consistency is more rational than response inconsistency. However, results in Study Two suggested that we might able to use the Understanding/Acceptance principle as a way to gage whether participants will make better decisions once all are made aware of why response consistency is more rational than response inconsistency. If our reason to respond consistently is one that is accepted and used as a rational axiom for making temporal discounting choices, then it may be assumed that people whose preferences continued to be inconsistent despite being aware of this axiom were not behaving rationally. Response consistency may then be useful for measuring temporal discounting preferences while minimizing the influence of contextual factors that may make a participant more apt to select smaller sooner rewards over larger delayed rewards.

Summary of Main Findings

By considering relative long-term gains (i.e., annual rates of return), associations with intellectual ability and thinking dispositions, and understanding/acceptance paradigms, we have demonstrated that for certain temporal discounting choices it is better to wait for the larger delayed reward and that choosing to wait is more effortful for participants. These results are also consistent with prior research that demonstrated associations between a preference for larger delayed rewards and higher intellectual ability (Shamosh & Gray, 2008), stronger orientation to the future (Steinberg et al., 2009), and more effortful cognition in neural studies (McClure et al., 2004). These results are also consistent with prior research in the rational thinking literature that demonstrated significant correlations between good decision-making and higher intellectual ability, stronger critical thinking dispositions, and more effortful cognition (Evans, 2003; Stanovich, 2008; 2009; Kahneman, 2011). That waiting for a larger delayed reward can be considered the better, more effortful choice under certain task conditions lends scientific support to conceptualizing and using temporal discounting as an indicator of instrumental rationality.

Temporal Discounting as an Indicator of Instrumental Rationality

In difficult, complex, or unfamiliar situations, an overreliance on emotions, instinct, and intuition can lead humans to make bad decisions (Evans, 2003; Stanovich, Toplak, & West, 2008; Stanovich, 2009; 2011; Kahneman, 2011; Stanovich, West, & Toplak, 2012). In such situations, it would be more effective to engage in more effortful cognitive processing and evaluation. Instrumental rationality, or one's ability to get what one wants, may often consist of deliberate and effortful cognitive processing for effective goal setting and planning (Stanovich, 2011; Stanovich, West, & Toplak, 2012). Our results in combination with prior research (Ostaszewski, 1996; Coffey, Gudleski, Saladin, & Brady, 2003; Zhong & DeVoe, 2010; McClure et al., 2004) suggest that a preference for smaller immediate rewards may be conceptualized as a measure of impulsive, emotional, or instinctual decision-making. In contrast, a preference for larger delayed rewards may be conceptualized as a measure of one's ability to engage in instrumental rationality and in deeper, more effortful reasoning that targets maximization of outcomes.

Participants that are high in instrumental rationality should seek choices that offer the greatest gain. In Study One, our results indicated that participants who displayed higher intellectual ability and stronger critical thinking dispositions were more likely to recognize that waiting for larger delayed rewards in our temporal discounting tasks was more beneficial than accepting the smaller sooner rewards, especially when the long term gains were relatively high (i.e., temporal discounting choices with high annual return). An over-reliance on intuition or emotion can interfere with rational decision-making, sometimes even despite high intellectual ability (Stanovich, 2009; Kahneman, 2011). We assessed thinking dispositions that are thought to impact whether a person with sufficient intellectual ability will actually use those abilities when making decisions (Perkins, Jay & Tishman, 1992; Stanovich, 2008; Stanovich & West, 2011). A person with more actively open-minded thinking may be more willing to wait for larger delayed rewards because he/she generally tends to question his/her options and generate multiple scenarios for each option. A person with stronger need for cognition and stronger motive to act according to reason may be more likely to recognize that larger delayed rewards are the optimal choice because he/she's intellectual curiosity and desire to behave rationally urges he/she to be analytic, thorough, and precise when making decisions. A person with stronger tendency to consider the future consequences of his/her decisions may be more likely to determine that larger delayed rewards yield greater outcomes. Finally, a person who is high in superstitious thinking, may show stronger preferences for smaller sooner rewards because he/she does not have the general tendency to base his/her decisions on reason or computational formulas. These thinking dispositions may contribute to whether a person will pause when faced with temporal discounting choices, in favor of engaging in more effortful reasoning in order to maximize potential outcomes. Those who are not motivated to behave rationally or not disposed to persistent and flexible thinking are likely prone to preferring immediate rewards despite long-term loss, in part because they lack the general tendencies to pause and consciously consider the long-term implications to *all* of their potential choices. A failure to consider the long-term implications of one's choices would likely interfere with instrumental rationality. A person cannot effectively set and reach optimum goals if they fail to pause and consider their options. Results in Study One have indicated that thinking dispositions might impact temporal discounting preferences even despite high intellectual ability. We showed that thinking dispositions accounted for significant unique variance in preferences for larger delayed rewards. In Study Two, we showed that even if participants do not initially recognize that the long term gains in waiting for the larger delayed rewards outweigh the short term gains in accepting the smaller rewards, we can provoke a significant proportion of participants to make better choices by explaining to them what they stand to *gain* by waiting. Participants that were higher in instrumental rationality would be more likely to accept and use our axiom for waiting for the larger delayed rewards.

That preferences for larger delayed rewards may be conceptualized as instrumentally rational is further supported by a series of experiments conducted by Kim, Schnall, and White (2013). Participants were more likely to choose larger delayed rewards when the rewards were offered to them as travel vouchers *with* specific details about quality and location of hotels, rather than as 1) travel vouchers *without* the specific details about quality and location of hotels or 2) as basic monetary rewards. These findings coincide with our results, which demonstrated that thinking dispositions related to being open-minded, flexible, and considerate of future consequences were significantly predictive of more willingness to wait for larger delayed rewards. These findings suggest that participants were not considering the future utility of larger delayed rewards.

Measuring Rationality. Many recognize that traditional tests of intelligence miss important skills related to emotion, empathy, and interpersonal abilities, but assume that these tests encompass most of cognition (Stanovich, 2009). Intelligence tests (e.g., tests of IQ) do not encompass all aspects of cognition (Stanovich, 2009; Kahneman, 2011). They miss important traits related to rational-thinking, including judgment and decision-making. It is crucial that researchers develop a rational-thinking test (i.e., a measure of RQ), comprised of tasks that assess the cognitive skills and dispositions that intelligence tests miss and that are required to make good decisions in the real world. Our results indicate that temporal discounting preferences may be used as one index of rationality.

We showed that although these thinking dispositions are related to intellectual ability, they account for significant unique variance in preferences for larger delayed rewards suggesting that dispositional thinking styles can interfere with willingness to wait for larger delayed rewards *despite* one's intellectual ability. Our findings thus provide further evidence to support that rational-thinking and intelligence are two separable constructs and that intelligence and rational-thinking are *both* related to preferences for larger delayed rewards. Intelligence and rationality involve different processes. Performances on rational-thinking tasks are more strongly related to one another than to performance on measures of intelligence/executive functions (Stanovich, 2009; West, Toplak, & Stanovich, 2008; Toplak, West, & Stanovich, 2011). We can see instances in our typical everyday environments of intelligent people making bad decisions (Stanovich, 2009; Kahneman, 2011). For example, we may witness a university student choosing to socialize over study, know of a friend who spends a little too much money, or hear of a lawyer who is addicted to alcohol. Intelligence tests measure one's abilities, or for an analogy, the size of one's car engine; they fail to predict how good one will be at using those abilities in real situations, or to continue the analogy, at driving one's car. Our results indicated that rational-thinking tests (i.e., measures of RQ) might be able to incorporate temporal discounting tasks as indicators of impulsive decision-making, which intelligence tests fail to assess (Stanovich, 2009; Toplak, West, Stanovich, 2011). Study One and Study Two provided converging evidence to support that under certain task manipulations, strong preferences for larger delayed rewards can be linked to more instrumental rationality. Our modified versions of the temporal discounting paradigm in Study One and Study Two allowed us to study temporal discounting as a construct of rationality.

Practical Implications

Humans can be taught to think more critically (Burbules & Rupert, 1999; Ozturk, Muslu, & Dicle, 2007; Abrami, Bernard, Borokhovski, Wade et al., 2008). In contrast, intellectual ability, as measured by traditional tests of intelligence, is a relatively stable construct (e.g., Hertzog & Schaie, 1986; Canivas, 1999). In Study One, we showed that more willingness to wait for larger delayed rewards was significantly and uniquely predicted by critical thinking dispositions. In Study Two, we showed that explaining to participants their temporal discounting options could provoke participants to make better temporal discounting choices. Our results suggest that people may be influenced to think more critically about choosing immediate benefits at the expense of more beneficial delayed gains.

Thaler and Sunstein (2008) have argued that we can "nudge" people towards making certain decisions. A nudge is defined as, "any aspect of choice architecture that alters people's behaviour in a predictable way without bidding forbidding any options or significantly changing their economic incentives". Our results indicated that we similarly may be able to contribute to that line of research by showing that people can be "nudged" towards making more optimal temporal discounting choices. Thaler and Sunstein (2008) have discussed multiple ways that choices can be presented in our environment that will make a person more likely to choose the more optimal choice. For example, arranging food on a shelf in a school cafeteria in a certain way can influence children to make more healthy choices when buying their lunch. Arranging fruit so that it is at eye-level will provoke more children to purchase fruit over junk food.

In Study One, we showed that the way a series of temporal discounting choices are framed could make people more or less likely to make better choices. The number of participants who chose the larger delayed reward for a specific level of annual return tended to be larger in the Staircase task (e.g., when the annual return was 33%, 99 participants chose the larger delayed reward) than in the Mixed task (e.g., when the annual return was 36%, 38 participants chose the larger delayed reward). Items in the Staircase task were presented in descending order while items in the Mixed task were presented in random order. Providing a participant with back to back choices that yield drastically different outcomes and gains in the Mixed task (i.e., presenting a participant with an item that yields relatively low annual return directly before presenting a participant with an item that yields relatively high return) may have an impact on how a participant will make a series of choices. A participant may be more likely to overvalue items with relatively high annual return or undervalue items with relatively low return. While presenting participants with temporal discounting choices in the Staircase that yield increasingly higher annual returns with each item, may invoke less bias in how each item is judged. These findings may be applied within banks and financial institutions in order to promote better decision-making when presenting people with mortgage, insurance, or investment options.

We have also shown that providing a good reason to prefer larger delayed rewards can "nudge" people towards changing their initial preferences for smaller sooner rewards. It is possible that this concept may be applied to other choices in our environment to alter choice architecture so that people are pushed towards making more optimal financial choices. For example, strong preferences for smaller sooner rewards have previously been shown to associate with poor financial management (Meier & Sprenger, 2011). Credit card companies may be governed by laws that insist on explaining to credit card users the financial consequence to accumulating large interest on their purchases. These explanations may be included on credit card bills and used to nudge people towards waiting to spend more and paying off their debts.

Generalizability of Temporal Discounting as an Index of Rational Thinking

Some research has shown significant differences in temporal discounting across various personal, social, and environmental factors. Temporal discounting varies across age (Green, Myerson, Lichtman, Rosen & Fry, 1996; Steinberg et al., 2009). Adults were significantly more likely to wait for larger delayed rewards than children and adolescents (Green et al., 1996; Steinberg et al., 2009), and emerging adults showed significantly greater preferences for smaller sooner rewards than both adolescents and adults (Steinberg et al., 2009). Temporal discounting may also vary across socio-economical status. For example, adults with high income were significantly more likely than adults with low income to wait for larger delayed rewards (Green et al., 1996). Additionally, individuals who grew up in a resource rich environment were significantly more likely than individuals who grew up in a resource poor environment to wait for larger delayed rewards (Griskevicius, Tybur, Delton, & Robertson). Temporal discounting may also vary across different social contexts. For example, individuals who felt they were receiving a just and fair income in life were more likely than individuals who felt they were receiving an unjust and unfair income to wait for larger delayed rewards (Callan, Shead, & Olson; 2011). Callan, Harvey, and Sutton (2014) also showed that individuals who believed in a fair and just world were more likely than individuals who believed in an unfair and unjust world to wait for larger delayed rewards. Finally, people showed a significant increase in their preferences for smaller sooner rewards after surviving a major natural catastrophe (an earthquake). One's age, income, and environmental context may all contribute to whether or not delaying gratification in favor of waiting for larger delayed rewards is necessarily more beneficial than choosing smaller immediate rewards. For example, an individual whose social context does not provide fair treatment or security may be better off taking a smaller reward that offers immediate and certain gain than to risk waiting for a larger reward.

Future Considerations

There are several suggestions for future directions. In Study One, the temporal discounting items in the Staircase task and the Mixed task were not identical. In order to enable direct comparison of choices across these two methods and strength of correlations with individual differences measures, future studies should incorporate a Staircase task and a Mixed task that consist of identical items. In Study One, we did not compare performance on our temporal discounting tasks to performance on other established measures of rational decision-making. Future studies should compare temporal discounting performance to an established measure of rational decision-making. Results in Study Two suggested that a significant proportion of participants would make more consistent choices if the axiom of consistency were explained to them. Future temporal discounting studies should examine whether incorporating this axiom into the instructions given to a participant prior to administering a temporal discounting task will impact response patterns. Finally, we were not able to conclude that every switch towards preferring larger delayed rewards and responding more consistently in Study Two was definitely attributable to participants having accepted our axioms. Similarly, we were not able to conclude that participants who did not switch responses after being given our axioms to prefer larger delayed rewards and to respond consistently did not accept our axioms. In future studies, participants should be asked to explain why he/she decided to switch or to not switch his/her preferences in the Understanding/Acceptance tasks.

Conclusion

Specifically, we have provided new evidence to support that under certain task conditions, waiting for the larger delayed reward is a better decision that is associated with more effortful thinking. Our results indicated that certain temporal discounting preferences may be conceptualized as an index of instrumental rationality. We have also demonstrated novel methods to operationalize temporal discounting preferences as an index of rational decision-making. More generally, our results provided evidence to support existing research on the measureable differences between human rationality and human intelligence, and the utility of developing tests to measure impulsive decision-making as a component of instrumental rationality.

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Appendices

Appendix A: Measures

Demographic Information

1. Sex: Male ___ Female ___
2. Age: ____

3. Date of Birth (Month/Day/Year):

4. Year in University:
___ 1st year undergrad
___ 2nd year undergrad
___ 3rd year undergrad
___ 4th year undergrad
___ Graduated
___ Post-BA Continuing

5. Is English your first language?
___ Yes ___ No
If no, how long have you been speaking English? ___________ Years

6. What is your ethnic background?

7. What was your final average at the end of high school? (percentage) ____%

8. Estimate your current university average (estimate percentage): ____ %

9. Mother's highest level of education:
____ less than high school
____ high school
____ some college
____ BA degree
____ MA degree
____ PhD
____ professional degree
____ not applicable

10. Father's highest level of education:
____ less than high school
____ high school
____ some college
____ BA degree
____ MA degree
____ PhD

____ professional degree
____ not applicable

11. Did you ever receive special assistance in school to assist with learning?
____ yes
____ no
If you indicated "yes" for the previous question, indicate what you received assistance for: (e.g., reading problems, math problems, attentional problems)

12. Please indicate what your current (or intended) university major is:

Temporal Discounting Tasks

Instructions: For the next set of items, imagine that you are offered a choice between receiving a specific amount of money sooner or a larger amount later. Your choice would probably depend on how much greater the later amount is, and how long you would have to wait to get the larger amount. For example, you probably would prefer receiving $500 right now rather than receiving $501 in 12 months. You also would prefer receiving $500 in 1 week rather than receiving $25 right now.

Staircase Task

Do you prefer…

$1, 990 now	or	$2000 in 1 year
$1, 980 now	or	$2000 in 1 year
$1, 950 now	or	$2000 in 1 year
$1, 900 now	or	$2000 in 1 year
$1, 850 now	or	$2000 in 1 year
$1, 800 now	or	$2000 in 1 year
$1,700 now	or	$2000 in 1 year
$1, 600 now	or	$2000 in 1 year

…	or	$2000 in 1 year
$1, 000 now	or	$2000 in 1 year
$900 now	or	$2000 in 1 year
$800 now	or	$2000 in 1 year
…	or	$2000 in 1 year
$50 now	or	$2000 in 1 year
$20 now	or	$2000 in 1 year

Mixed Task

(Note: These items were presented to participants in random order but they are rearranged below to reflect three separate levels of annual return)

TD Mixed: Low Return Rate

1. Do you prefer $34 now or $35 in 186 days?
2. Do you prefer $54 now or $55 in 117 days?
3. Do you prefer $75 now or $80 in 162 days?
4. Do you prefer $80 now or $85 in 157 days?
5. Do you prefer $47 now or $50 in 160 days?
6. Do you prefer $28 now or $30 in 179 days?
7. Do you prefer $67 now or $75 in 119 days?

8. Do you prefer $54 now or $60 in 111 days?

9. Do you prefer $22 now or $25 in 136 days?

TD Mixed: Med Interest Rate

1. Do you prefer $69 now or $85 in 91 days?

2. Do you prefer $49 now or $60 in 89 days?

3. Do you prefer $25 now or $30 in 80 days?

4. Do you prefer $55 now or $75 in 61 days?

5. Do you prefer $19 now or $25 in 53 days?

6. Do you prefer $40 now or $55 in 62 days?

7. Do you prefer $24 now or $35 in 29 days?

8. Do you prefer $34 now or $50 in 30 days?

9. Do you prefer $54 now or $80 in 30 days?

TD Mixed: High Interest Rate

1. Do you prefer $14 now or $25 in 19 days?

2. Do you prefer $27 now or $50 in 21 days?

3. Do you prefer $41 now or $75 in 20 days?

4. Do you prefer $25 now or $60 in 14

days?

5. Do you prefer $15 now or $35 in 13 days?

6. Do you prefer $33 now or $88 in 14 days?

7. Do you prefer $31 now or $85 in 7 days?

8. Do you prefer $11 now or $30 in 7 days?

9. Do you prefer $20 now or $55 in 7 days?

Invariance Task

(*Note:* These items were presented to participants in random order but they are rearranged below so that items that correspond to one another are grouped into pairs)

Group One	Group Two
1. If you had a choice, would you prefer $340 now or $400 in 4 months? Very strongly prefer $340 now Strongly prefer $340 now Prefer $340 now Prefer $400 in 4 months Strongly prefer $400 in 4 months Very strongly prefer $400 in 4 months	1. If you had a choice, would you prefer $340 in 10 months or $400 in 14 months? Very strongly prefer $340 in 10 months Strongly prefer $340 in 10 months Prefer $340 in 10 months Prefer $400 in 14 months Strongly prefer $400 in 14 months Very strongly prefer $400 in 14 months
2. If you had a choice, would you prefer $110 now or $120 in 4 weeks?	2. If you had a choice, would you prefer $110 in 8 weeks or $120 in 12 weeks?
3. If you had a choice, would you prefer $65 now or $70 in 3 weeks?	3. If you had a choice, would you prefer $65 in 20 weeks or $70 in 23 weeks?
4. If you had a choice, would you prefer $60 now or $90 in 3 months?	4. If you had a choice, would you prefer $60 in 10 months or $90 in 13 months?

5. If you had a choice, would you prefer $300 now or $315 in 1 week?	5. If you had a choice, would you prefer $300 in 20 weeks or $315 in 21 week?
6. If you had a choice, would you prefer $150 now or $160 in 4 weeks?	6. If you had a choice, would you prefer $150 in 20 weeks or $160 in 24 weeks?
7. If you had a choice, would you prefer $180 now or $200 in 2 weeks?	7. If you had a choice, would you prefer $150 in 20 weeks or $160 in 24 weeks?
8. If you had a choice, would you prefer $95 now or $105 in 2 weeks?	8. If you had a choice, would you prefer $95 in 10 weeks or $105 in 12 weeks
9. If you had a choice, would you prefer $75 now or $80 in 1 week?	9. If you had a choice, would you prefer $75 in 10 weeks or $80 in 11 weeks?
10. If you had a choice, would you prefer $70 now or $110 in 6 months?	10. If you had a choice, would you prefer $70 in 12 months or $110 in 16 months?
11. If you had a choice, would you prefer $235 now or $270 in 4 months?	11. If you had a choice, would you prefer $235 in 12 months or $270 in 16 months?
12. If you had a choice, would you prefer $45 now or $50 in 4 weeks?	12. If you had a choice, would you prefer $45 in 10 weeks or $50 in 14 weeks?
13. If you had a choice, would you prefer $210 now or $220 in 3 weeks?	13. If you had a choice, would you prefer $210 in 20 weeks or $220 in 23 weeks?

<u>Understanding/Acceptance Task- Reason To Wait</u>

1. Let's consider the choice between **$60 now** VERSUS **$90 in 3 months**.

There would be a good reason to wait 3 months for $90 instead of taking $60 right now. Waiting for an extra $30 is getting a 50% return for just waiting 3 months. This would amount to a 200% return based on an annual interest rate. This is an extraordinarily higher return than most banks or investment firms would give you. They would give you less than a 5% annual interest rate.

Based on this information, what would you prefer?

Very strongly prefer $60 now
Strongly prefer $60 now
Prefer $60 now
Prefer $90 in 3 months
Strongly prefer $90 in 3 months
Very strongly prefer $90 in 3 months

2. Let's consider the choice between **$75 now** VERSUS **$80 in 1 week**.

There would be a good reason to wait 1 week for $80 instead of taking $75 right now. Waiting for an extra $5 is getting a 7% return for just waiting 1 week. This would amount to a 347% return based on an annual interest rate. This is an extraordinarily higher return than most banks or investment firms would give you. They would give you less than a 5% annual interest rate.

Based on this information, what would you prefer?

Very strongly prefer $75 now
Strongly prefer $75 now
Prefer $75 now
Prefer $80 in 1 week
Strongly prefer $80 in 1 week
Very strongly prefer $80 in 1 week

<u>Understanding/Acceptance Task- Invariance</u>

1. Consider the following two situations:

Situation 1 offers a choice between $70 now <u>or</u> $110 in 6 months.

Situation 2 offers a choice between $70 in 12 months <u>or</u> $110 in 18 months.

In 12 months, you will be in exactly the same situation as in the first choice – you could be receiving $70 now or $110 in 6 months.

Based on this information, please make your choices below.

Situation #1

Very strongly prefer $70 now
Strongly prefer $70 now
Prefer $70 now
Prefer $110 in 6 months
Strongly prefer $110 in 6 months
Very strongly prefer $110 in 6 months

Situation #2

Very strongly prefer $70 in 12 months
Strongly prefer $70 in 12 months
Prefer $70 in 12 months
Prefer $110 in 18 months
Strongly prefer $110 in 18 months
Very strongly prefer $110 in 18 months

<u>Vocabulary Checklist</u>

Instructions: Below you will see a list of 60 letter strings. ***Some of the strings are actual words and some are not****. You are to read through the list of items and indicate whether or not you think the letter string is a word by clicking the box next to those that you know to be words.* ***Do not guess****, but only check those who you know to be words.*

1. absolution _____
2. arrate _____
3. asinine _____
4. audible _____
5. ceiloplaty _____
6. clandestine _____
7. comectial _____
8. concurrent _____
9. confluence _____
10. connote _____
11. denotation _____
12. denouement _____
13. disconcert _____
14. disler _____
15. dropant _____
31. neotatin _____
32. niche _____
33. nonquasity _____
34. nuance _____
35. nitrous _____
36. optimize _____
37. plabage _____
38. polarity _____
39. potomite _____
40. purview _____
41. recidivism _____
42. reportage _____
43. reverent _____
44. rochead _____
45. seblement _____

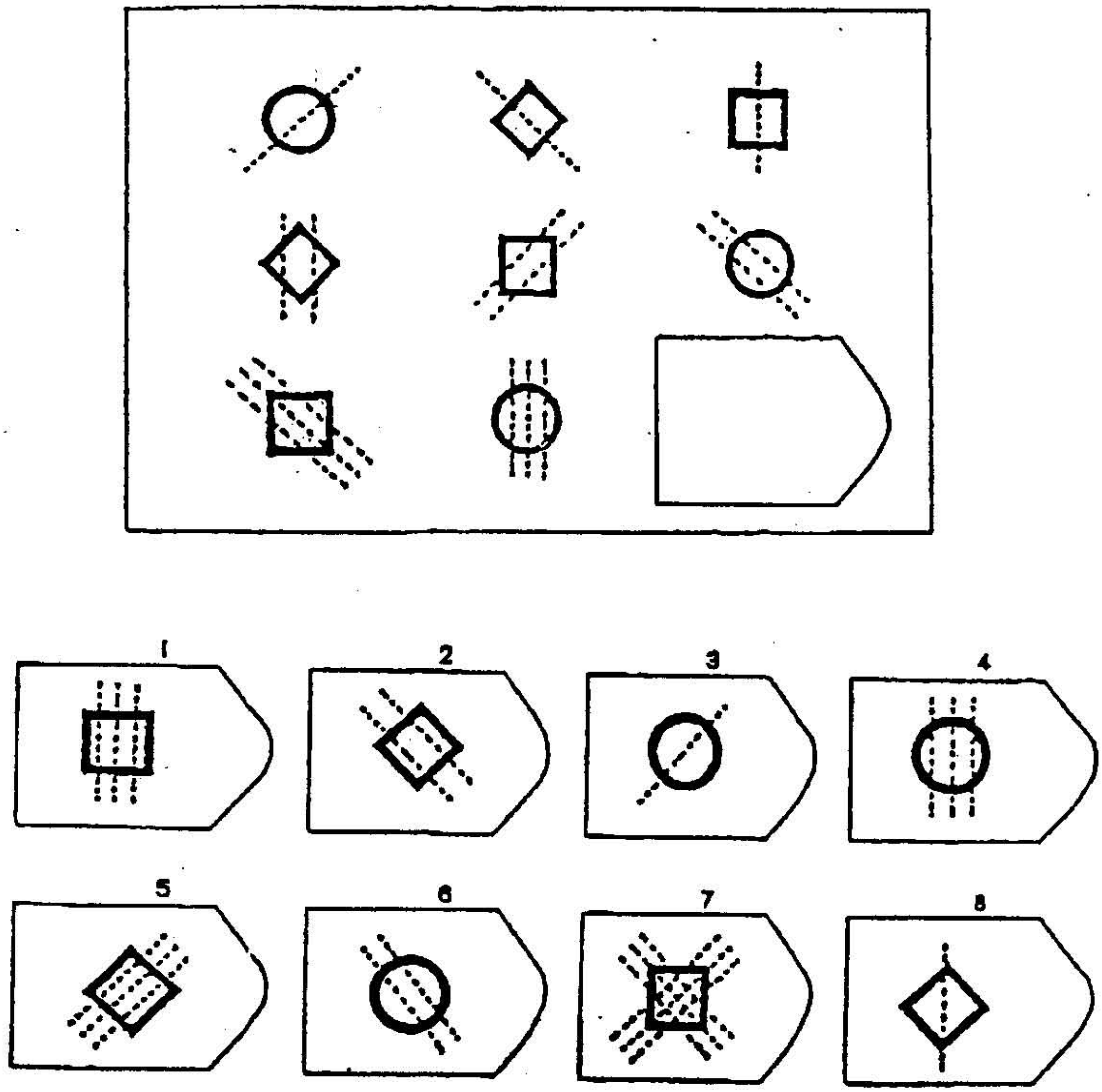
16. epicurean _____
17. eventuate _____
18. fusigenic _____
19. gustation _____
20. heuristic _____
21. hyplexion _____
22. ineffity _____
23. inflect _____
24. inundate _____
25. irksome _____
26. lacuna _____
27. languor _____
28. laudatory _____
29. litany _____
30. metenetion _____
46. sheal _____
47. sparkhouse _____
48. stratagem _____
49. subjugate _____
50. substratum _____
51. suffuse _____
52. tenacious _____
53. tradured _____
54. tumcier _____
55. ubiquitous _____
56. unction _____
57. unmanal _____
58. wanderlust _____
59. waterfowl _____
60. xenophobia _____

<u>Raven's Progressive Matrices</u>

Instructions: Below is an example of a spatial matrix problem. In the top box is a pattern with a piece missing. Your task is to choose from the eight alternative pieces below the box and identify the correct one that completes the pattern at the top.

Take a look at this example and see how it can be solved. First, you can see that each of the top two rows contains one circle, one square, and one diamond shape. Since the last row already contains a square and a circle, the missing piece must have a diamond shape. Thus, the answer must be either #2, #5, or #8. Looking further, you can see that the pieces in the top row have one line going through them, the pieces in the middle row have two lines going through them, and the pieces in the bottom row have three lines gong through them. Therefore, since you have eliminated all alternatives except #2, #5, and #8, the answer must be #5. You can check this by noting that in each row the lines are vertical in one piece, slanted to the left in one piece, and slanted to the right in another. You can confirm that #5 is the correct example by noting that its lines are slanted in the correct direction.

Study the example below.



The computer will give you the rest of the matrix problems. There are 18 problems in all. The problems will get harder and harder as you go along, but the task is always the same, to pick the piece that you think best fits the pattern. No one should expect to solve all the problems, because some of them are very difficult and you will be working under a time limit. Just try to do as well as you can. You will have fifteen minutes to complete the 18 problems, so do not spend all of your time on one that you cannot answer. If you run out of time, please do NOT simply guess at problems you have not yet looked at.

Note: This task included 18 items. Only the sample item is shown above.

Dispositions Questionnaire

Instructions:

This questionnaire lists a series of statements about various topics. Read each statement and decide whether you agree or disagree with each statement as follows:

1 - Disagree Strongly
2 - Disagree Moderately
3 - Disagree Slightly
4 - Agree Slightly
5 - Agree Moderately
6 - Agree Strongly

Mark the alternative that best describes your opinion. There are no right or wrong answers so do not spend too much time deciding on an answer. The first thing that comes to mind is probably the best response. There is no time limit, but work as quickly as possible.

Actively Open-Minded Thinking Scale

1. Even though freedom of speech for all groups is a worthwhile goal, it is unfortunately necessary to restrict the freedom of certain political groups.
2. What beliefs you hold have more to do with your own personal character than the experiences that may have given rise to them.
3. I tend to classify people as either for me or against me.
4. A person should always consider new possibilities.
5. There are two kinds of people in this world: those who are for the truth and those who are against the truth.
6. Changing your mind is a sign of weakness.
7. I believe we should look to our religious authorities for decisions on moral issues.
8. I think there are many wrong ways, but only one right way, to almost anything.
9. It makes me happy and proud when someone famous holds the same beliefs that I do.
10. Difficulties can usually be overcome by thinking about the problem, rather than through waiting for good fortune.
11. There are a number of people I have come to hate because of the things they stand for.
12. Abandoning a previous belief is a sign of strong character.
13. No one can talk me out of something I know is right.

14. Basically, I know everything I need to know about the important things in life.
15. It is important to persevere in your beliefs even when evidence is brought to bear against them.
16. Considering too many different opinions often leads to bad decisions.
17. There are basically two kinds of people in this world, good and bad.
18. I consider myself broad-minded and tolerant of other people's lifestyles.
19. Certain beliefs are just too important to abandon no matter how good a case can be made against them.
20. Most people just don't know what's good for them.
21. It is a noble thing when someone holds the same beliefs as their parents.
22. Coming to decisions quickly is a sign of wisdom.
23. I believe that loyalty to one's ideals and principles is more important than "open-mindedness."
24. Of all the different philosophies which exist in the world there is probably only one which is correct.
25. My beliefs would not have been very different if I had been raised by a different set of parents.
26. If I think longer about a problem I will be more likely to solve it.
27. I believe that the different ideas of right and wrong that people in other societies have may be valid for them.
28. Even if my environment (family, neighborhood, schools) had been different, I probably would have the same religious views.
29. There is nothing wrong with being undecided about many issues.
30. I believe that laws and social policies should change to reflect the needs of a changing world.
31. My blood boils over whenever a person stubbornly refuses to admit he's wrong.
32. I believe that the "new morality" of permissiveness is no morality at all.
33. One should disregard evidence that conflicts with your established beliefs.
34. Someone who attacks my beliefs is not insulting me personally.
35. A group which tolerates too much difference of opinion among its members cannot exist for long.
36. Often, when people criticize me, they don't have their facts straight.
37. Beliefs should always be revised in response to new information or evidence.
38. I think that if people don't know what they believe in by the time they're 25, there's something wrong with them.
39. I believe letting students hear controversial speakers can only confuse and mislead them.
40. Intuition is the best guide in making decisions.
41. People should always take into consideration evidence that goes against their beliefs.

Master Rationality Motive Scale

1. I believe in following my heart more than my head.
2. I like to gather many different types of evidence before I decide what to do.
3. After I make a decision, it is often difficult for me to give logical reasons for it.
4. I think things through before coming to a decision.
5. I don't feel I have to have reasons for what I do.
6. I always consider the consequences before I take action.
7. I like to think that my actions are motivated by sound reasons.
8. It is more important to me than to most people to behave in a logical way.

9. I like to have reasons for what I do.
10. I do not like to be too objective in the way I look at things.
11. I am only confident of decisions that are made after careful analysis of all available information.
12. I don't like to have to justify my actions.
13. If a belief suits me then I am comfortable, it really doesn’t matter if the belief is true.

Need for Cognition Scale

1. I would prefer complex to simple problems.
2. I like to have the responsibility of handling a situation that requires a lot of thinking.
3. Thinking is not my idea of fun.
4. I would rather do something that requires little thought than something that is sure to challenge my thinking abilities.
5. I try to anticipate and avoid situations where there is likely a chance I will have to think in depth about something.
6. I find satisfaction in deliberating hard and for long hours.
7. I only think as hard as I have to.
8. I prefer to think about small, daily projects to long-term ones.
9. I like tasks that require little thought once I’ve learned them.
10. The idea of relying on thought to make my way to the top appeals to me.
11. I really enjoy a task that involves coming up with new solutions to problems.
12. Learning new ways to think doesn’t excite me very much.
13. I prefer my life to be filled with puzzles that I must solve.
14. The notion of thinking abstractly is appealing to me.
15. I would prefer a task that is intellectual, difficult, and important to one that is somewhat important but does not require much thought.
16. I feel relief rather than satisfaction after completing a task that required a lot of mental effort.
17. It’s enough for me that something gets the job done; I don’t care how or why it works.
18. I usually end up deliberating about issues even when they do not affect me personally.

Consideration of Future Consequences Scale

1. I consider how things might be in the future, and try to influence those things with my day to day behavior.
2. Often I engage in a particular behavior in order to achieve outcomes that may not result for many years.
3. I only act to satisfy immediate concerns, figuring the future will take care for itself.
4. My behavior is only influenced by the immediate (i.e., a matter of days or weeks) outcomes of my actions.
5. My convenience is a big factor in the decisions I make or the actions I take.
6. I am willing to sacrifice my immediate happiness or well-being in order to achieve future outcomes.
7. I think it is important to take warnings about negative outcomes seriously even if the negative outcome will not occur for many years.

8. I think it is more important to perform a behavior with important distant consequences than a behavior with less-important immediate consequences.
9. I generally ignore warnings about possible future problems because I think the problems will be resolved before they reach crisis level.
10. I think that sacrificing now is usually unnecessary since future outcomes can be dealt with at a later time.
11. I only act to satisfy immediate concerns, figuring that I will take care of future problems that may occur at a later date.
12. Since my day to day work has specific outcomes, it is more important to me than behavior that has distant outcomes.

Superstitious Thinking Scale

Superstitious Thinking:
1. I have found that talking about successes that I am looking forward to can keep them from happening.
2. I do not believe in any superstitions.
3. When something good happens to me, I believe it is likely to be balanced by something bad.

Concept of Luck:
1. I have personal possessions that bring me luck at times.
2. The number 13 is unlucky.
3. It is bad luck to have a black cat cross your path.
4. Opening an umbrella indoors will increase one's chances of misfortune in the near future.

Paranormal:
1. It is advisable to consult your horoscope daily.
2. Astrology can be useful in making personality judgments.

ESP:
1. Some people have the ability to predict the future.
2. Mind reading is not possible.
3. Dreams can provide information about the future.
4. A person's thoughts can influence the movement of a physical object.

Appendix B Supplemental Results

Table 1.
The Number of Times and Proportion of Participants Who Preferred the Larger, Delayed Reward in the Staircase Task, which Included 25 items that Offered Participants the Choice Between $2000 in 1 year or a Smaller Reward Now.

Score	n	Percentage of N (%)
0	1	.6
4	1	.6
5	1	.6
6	2	1.2
7	1	.6
8	2	1.2
9	1	.6
10	2	1.2
11	20	11.9
12	10	6.0
13	5	3.0
14	6	3.6
15	16	9.5
16	12	7.1
17	15	8.9
18	22	13.1
19	7	4.2
20	9	5.4
21	23	13.7
22	2	1.2
23	10	6.0

Note: Lower Scores Represent Less Waiting and A Greater Frequency of Choosing A Smaller, Immediate Reward over $2000.

Table 2.
The Number of Times and Proportion of Participants Who Preferred the Larger, Delayed Reward in the Mixed task.

TD MIXED: LOW RETURN		
Score	n	Percentage of N (%)
0	119	70.8
1	8	4.8
2	7	4.2
3	5	3.0
4	5	3.6
5	6	2.4
6	4	1.2
7	2	1.8
8	3	5.4
9	9	100.0

TD MIXED: MEDIUM RETURN		
Score	n	Percentage of N (%)
0	36	21.4
1	20	11.9
2	24	14.3
3	17	10.1
4	15	8.9
5	13	7.7
6	8	4.8
7	7	4.2
8	7	4.2
9	21	12.5

TD MIXED: HIGH RETURN		
Score	n	Percentage of N (%)
0	3	1.8
1	4	2.4
2	1	.6
3	6	3.6
4	5	3.0
5	8	4.8
6	17	10.1
7	15	8.9
8	31	18.5
9	78	46.4

Note: Lower Scores Represent Less Waiting and a Greater Frequency of Choosing the Smaller, Immediate Reward.

Table 3.
Correlations between Thinking Disposition Measures and Intellectual Ability

	NFC	AOT	CFC	MRM	ST	Verbal Ability	Non-Verbal Ability	Intellectual Ability
Need for Cognition (NFC)	1.00							
Actively Open-Minded Thinking (AOT)	.39**	1.00						
Consideration of Future Consequences (CFC)	.52**	.44**	1.00					
Master Rationality Motive (MRM)	.41**	.41**	.59**	1.00				
Superstitious Thinking (ST)	-.27**	-.49**	-.31**	-.34**	1.00			
Verbal Ability	.18*	.33**	.20**	.24**	-.34**	1.00		
Non Verbal Ability	.14	.40**	.23**	.24**	-.44**	.33**	1.00	
Cognitive Ability Composite	.20*	.45**	.27**	.30**	-.48**	.82**	.82**	1.00