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WORKING MEMORY CAPACITY, TEMPORAL  
DISCOUNTING, AND EXERCISE RATES

by

Kathleen Lambourne

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

of

MASTER OF SCIENCE

in

Psychology

Approved:

UTAH STATE UNIVERSITY  
Logan, Utah

2005

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## ABSTRACT

Working Memory Capacity, Temporal  
Discounting, and Exercise Rates

by

Kathleen Lambourne, Master of Science

Utah State University, 2005

Major Professor: Steve Lehman, Ph.D  
Department: Psychology

During decision-making, an individual must weigh the value of the outcomes involved while also considering the amount of time until the outcomes will occur. Discounting occurs when a smaller, immediately available reward is chosen over a larger, more delayed reward. Discounting rates are likely related to working memory capacity, because working memory stores and processes the value of the outcomes. The purpose of this study was to examine the relationship between working memory, temporal discounting, and the decision to engage in physical activity.

The results showed that working memory capacity was related to the physical activity rates. Discounting rates from a money task and a health task were not related to activity rates. However, in the subsample of individuals who reported that their primary motive to exercise was health, working memory and discounting rates from the money task were both statistically significant predictors of physical activity.

(83 pages)

## DEDICATION

For my parents, Wayne and Claudia, whom I have always been able to count on for  
guidance and support. I love you both.

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I would especially like to thank my chairperson, Dr. Steve Lehman, for the great deal of time and energy he spent helping me with this project. I also appreciate the wisdom and expertise he provided while helping me with the process of getting my master's degree. I would also like to thank my committee members, Dr. Odum and Dr. Heath, for their generous contributions. I greatly appreciated Dr. Heath's sense of humor and Dr. Odum's kindness during the development of this project.

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Kathleen Lambourne

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# CHAPTER I

## INTRODUCTION

The evidence that regular leisure-time physical activity is beneficial to one's health is extensive and continually expanding. Awareness of these benefits appears to be fairly ubiquitous among adults. Nevertheless, 73.8% of American adults report that they do not participate in the amount of physical activity necessary to benefit their health (Center for Disease Control & Prevention [CDC], 1996). Many adults have the desire to exercise, yet there is a large discrepancy between this desire and the ability to maintain an exercise regimen (Willis & Campbell, 1992).

Several theoretical models have been created in an attempt to explain exercise behaviors. Theories can be useful because they help identify the reasons that people initiate and maintain exercise behaviors. Also, many exercise behavior theorists believe that information about what predicts adherence to exercise programs can be useful in creating successful exercise interventions.

Many factors have been identified and shown to have varying degrees of predictive capability. These have included individual factors such as exercise history, current level of fitness, age, gender, marital status, education, and income. Others have included psychological factors, such as personality, attitude, health knowledge, and beliefs. Still others have investigated environmental factors, such as facility convenience, social support, and incentives (Willis & Campbell, 1992).

Researchers have enjoyed some success with predicting exercise adherence from these factors, but the models with the most predictive power are those that are related to beliefs and self-control. Such models include the health belief model, the

theory of reasoned action, the theory of planned behavior, the theory self-efficacy, and the theory of fear appeals (Willis & Campbell, 1992). These models are similar in that they are concerned with how extraneous external and internal factors interfere with people's choices. Also, the constructs involved in these models are guided by motivational theory.

People who exercise must weigh the physical and time-related costs of exercise against their knowledge of the long-term benefits. Cognitive theory might help explain the mental processes that occur within these motivational frameworks. Viewing the choice to exercise in terms of the cognitive processes that take place during this decision is a unique approach to this issue, and would provide additional insight into the decision-making processes that lead to regular physical activity.

Within the domain of psychology, cognitive psychologists and applied behavior analysts have taken different approaches to the investigation of decision-making processes. For instance, behavior analysts have typically used operant procedures to reveal which behaviors will be produced given certain reinforcements or punishments with varying amounts of delay. According to this paradigm, behavior is determined by past consequences. In contrast, cognitive psychologists have assumed that behavior is determined by the anticipation of future outcomes, and have studied decision-making by asking subjects to indicate what their response would be given a description of future consequences (Critchfield & Kollins, 2001).

Therefore, the behavioral and cognitive traditions have different assumptions about whether past or future consequences govern behavior. Regardless of this, Critchfield and Kollins (2001) asserted that researchers in both of these traditions

have reached the same conclusion with regard to the impact of delay on the value of a consequence. The power of a consequence to influence behavior tends to decrease with delay. This phenomenon is known as temporal or delay discounting, a theory that has been enhanced by the empirical work in both the behavioral and cognitive traditions. Cognitive theory could also be used to explain a discounting task by adding insight into the underlying cognitive and neural processes behind the decision-making behavior observed in these studies.

To be more specific, decision-making involves the activation of memory traces of potential outcomes within the memory systems. The consequences associated with a particular decision tend to be activated together, due to repeated association in the past (Anderson, 2000). Then, working memory is employed to maintain this information in the focus of attention, so that the different outcomes of a decision may be compared. Thus, a discounting task might be seen as a working memory problem, where a person must actively maintain the value of different outcomes while also evaluating how the value of an outcome will change across time (Hinson, Jameson, & Whitney, 2003).

In summary, the desire to participate in leisure-time physical activity and knowledge of its benefits might not be enough to increase the activity levels of American adults. Several different theories have been formed to explain participation in physical activity. However, the study of the decision to exercise using temporal discounting procedures and the exploration of working memory's contribution to this decision-making may give additional insight into exercise behavior. As previously

mentioned, this type of insight is important because it could be used to create interventions that will help individuals maintain an exercise regimen.

It was hypothesized that because working memory plays such a large role in the ability to process and weigh future consequences (Hinson et al., 2003), working memory capacity would be predictive of discounting rates. In the present study, the discounting of delayed rewards was also expected to be related to physical activity levels, because the decision to exercise involves weighing the value of future health.

If discounting rates are related to exercise habits, then different steps might be taken to create interventions for people who discount the value of delayed rewards. The goal of these interventions would be to help these individuals exhibit more control over their behavior. Rachlin and Green (1972) asserted that commitment strategies can be a useful way to do this, because they can keep an individual from shifting his or her preference to the smaller reward as it approaches. In the choice to exercise, the smaller reward would consist of the sedentary alternative.

In addition, because working memory capacity is likely to be related to discounting of exercise-related health benefits, an intervention might also focus on working memory limitations. Working memory is already confined by a limited capacity, so the goal of this intervention would be to free up additional working memory resources when the decision to exercise is being processed. One way that this can be done is by associating exercise with positive thoughts until the association becomes automatic.

Therefore, the purpose of this study was to examine exercise habits as a function of working memory capacity and of discounting rates. It addressed the following questions:

1. Were individual differences in working memory capacity related to the rate of impulsive choices made on discounting tasks?
2. Was the rate at which individuals discount the value of future rewards related to their exercise level?
3. Were individual differences in working memory span and rate of discounting predictive of how much physical activity one engages in?

## CHAPTER II

### REVIEW OF LITERATURE

There is a large amount of scientific evidence for the positive health benefits of regular physical activity. Physical activity has been found to decrease the risk of heart disease, the leading cause of death in this country. It also reduces the risk of stroke, certain types of cancer, diabetes, and high blood pressure. Other benefits include weight management, a reduced risk of injury, and healthier bones, muscles, and joints. There is also evidence for the psychological benefits of exercise, such as a reduction of the symptoms of anxiety and depression (CDC, 1996).

According to the CDC (2000b), poor diet and physical inactivity are responsible for about 16% of all deaths in the United States. Despite the strong case for the benefits of exercise, many people do not participate in enough physical activity to benefit their health. The CDC recommends that adults participate in leisure-time physical activity at least 5 times per week for the duration of 30 min at a moderate intensity, or physical activity at least 3 times per week for the duration of 20 min at a vigorous intensity. In a survey conducted by the CDC in 2000(a), only 26.2% of adults reported that they met this requirement. In fact, 27.6% of adults reported that they had engaged in no physical activity in the past month.

Numerous researchers and theorists have studied the determinants of physical activity habits. According to some theorists, identifying the factors that lead people to participate in regular physical activity will facilitate the creation of interventions for those who do not (Buckworth, Granello, & Belmore, 2002; Marcus et al., 2000).

Many researchers have investigated individual characteristics such as demographics, personality traits, health behaviors, and attitudes. Others have investigated environmental and social influences (Sallis et al., 1990; Willis & Campbell, 1992).

Several different factors have been identified as predictive of exercise adherence. For instance, physical activity has been found to decrease as people age. Smokers are much more likely to drop out of an exercise program than non-smokers. Spousal support is also a large predictor of exercise adherence, as is social support within an exercise program. Environmental factors such as convenience of the program, the exercise facility itself, and program intensity are also key variables (Willis & Campbell, 1992).

Another factor that may be related to exercise adherence is the discounting of future health benefits (Critchfield & Kollins, 2001). This relationship has been suggested in the discounting literature (Critchfield & Kollins), but has not been tested empirically. Examining exercise rates in the framework of temporal discounting theory might add additional insight into the processes that occur in an individual's decision to exercise. According to this framework, this decision involves a choice between the larger, long-term outcome of health and the smaller, short-term sedentary alternative. When an individual decides to exercise, he is making the self-controlled choice as opposed to the impulsive choice (Ainslie, 1974) because he is selecting the larger, more delayed reward.

The cognitive component that is likely to be responsible for the processing involved in this decision is the working memory. Working memory load has been linked to impulsive decision-making on discounting tasks (Hinson et al., 2003). Also,



self-report measures of working memory capacity and impulsivity have been connected to impulsive delay discounting decisions (Hinson et al., 2003). Therefore, this literature review will cover past findings relating to delay discounting as well as working memory, the cognitive component that is likely to be involved in delay discounting.

First, however, the concept of self-control in exercise will be discussed. Discounting could be considered one way to examine self-control in choices. Studies that have used other measures of self control to predict exercise adherence have shown support for the hypothesis that exercise habits are related to self-control. One such study was conducted by Yates, Edman, Crago, Crowell, and Zimmerman (1999). These authors constructed and administered an Exercise Orientation Questionnaire in order to measure exercise attitudes and behaviors. The questionnaire produced 6 separate factors: Self-control, Orientation to Exercise, Self-Loathing, Weight Reduction, Competition, and Identity. The combination of factors accounted for 44.6% of the total variance in attitudes and behaviors. By itself, the self-control factor correlated highly with exercise regularity ( $r = 0.491, p < .0001$ ), exercise intensity ( $r = 0.400, p < .0001$ ), and exercise investment ( $r = 0.604, p < .001$ ).

Ketzenberger (1996) also conducted a study that provides support for the idea that self-control and perceived self-control are predictive of exercise adherence. The author measured the participants' lack of intention and deliberateness with the Barratt Impulsiveness Scale-10th Revision (BIS-10). She then categorized the participants into four groups based upon the amount of exercise they reported: super-exercisers (who exercised 5 or more times per week for the past 6 months), general exercisers

(who exercised 2-4 times per week for the past 6 months), intermittent exercisers (who exercised 2-4 times weekly for 3 months or more and then stopped or cut back in frequency), and non-exercisers (who reported that they have never initiated a workout plan or had not exercised in the past 3 years).

After controlling for age, gender, perceived enjoyment of exercise, spousal support of physical activity participation, and exercise format, type, and intensity, Ketzenberger found that super-exercisers were less impulsive than the other groups ( $F = 3.94, p < 0.009$ ). In fact, the BIS-10 carried a significant amount of discriminatory power between the exercise groups ( $\chi^2 = 12.31, p = .006$ ).

These studies suggest that an individual's level of self-control might be an important predictor of exercise adherence. This makes intuitive sense, because as mentioned earlier, engaging in regular physical activity involves an individual continually making a choice between sedentary and active alternatives (Epstein, Kilanowski, Consalvi, & Paluch, 1999). As previously discussed, one way to examine levels of self-control in decision-making is the temporal or delay discounting procedure. This procedure and its potential relationship to the decision to exercise have not been explored.

Following is a brief review of the literature on temporal discounting. Though discounting studies have typically focused on the decision to use drugs, researchers (Critchfield & Kollins, 2001) have suggested that discounting applies to other types of decisions such as the decision to exercise. Discounting will then be discussed in the context of exercise behavior. Next, two concepts from cognitive theory will be explored in order to explain the processes involved in the discounting of delayed

rewards. More specifically, the process by which memory traces relevant to a decision become activated will be described. Also to be described is the role of working memory in processing these activated traces. Finally, the potential exercise-related interventions that are implied by these concepts will be explored.

### Temporal Discounting

The processes involved in decision-making are important to many different fields ranging from the social sciences to economics. As previously mentioned, the behavioral and cognitive traditions have different assumptions about whether past or future consequences govern behavior. However, the literature from these two traditions supports the same conclusion with regard to the impact of delay on the value of a consequence. The power of a consequence to influence behavior tends to decrease with delay, a phenomenon known as temporal or delay discounting.

There are many procedures that can be used to study temporal discounting, most of which involve asking a participant for a verbal response to a hypothetical choice situation. The hypothetical rewards described in these situations have varied, including rewards such as money, good health, or the drug of choice for drug-addicted populations. Most commonly, the method used to study temporal discounting involves giving the participant a series of choices between hypothetical sums of money because it can be easily quantified (Critchfield & Kollins, 2001). The smaller amount is available immediately, and the larger amount is available after a varying amount of delay (Mazur, 1987). For example, the participant might be asked

to choose between \$50 that would be available immediately and \$500 that would be available after a 10-year delay.

By varying the amount of one of the rewards, it then becomes possible to determine the point at which the participant switches his or her preference between the alternatives. In a sequence where the delay ascends, the participants are likely to initially prefer the larger, long-term reinforcer but switch to the smaller, short-term reinforcer as the short-term reinforcer increases in size. In a descending sequence, the participant is likely to prefer the short-term reinforcer but switch preference to the long-term reinforcer as the short-term reinforcer shrinks (Critchfield & Kollins, 2001). The point at which preference reverses is known as the indifference point, a series of which are used to estimate the relative value of the larger, delayed reward. Because discounting is not constant across delays, it is best described by the hyperbolic function (Mazur, 1987)

$$V = \frac{A}{1 + kD} \quad (1)$$

In Equation 1, V is equal to the discounted value of a delayed reward, A is equal to the amount of the reward, and D is equal to the delay until the reward. The k-value determines how fast the function decreases, where larger k-values indicate that the delayed reward is valued less. It is steep at shorter delays, and flat at longer delays. This allows the hyperbolic curves to cross, which is indicative of the point at which preference reverses (Kirby & Maraković, 1996).

Temporal discounting could be useful in accounting for impulsive behavior.

An impulsive choice can be described as forgoing a larger, long-term gain in favor of a smaller, more immediate gain (Ainslie, 1974). Because impulsiveness depends on the potential for reversal in preference, discounting functions have been implicated in models of self-control versus impulsiveness.

As mentioned in the introduction, applied behavior analysts and cognitive psychologists study decision-making in different ways. The temporal discounting procedures deviate from the procedures used in traditional behavioral analyses. In fact, the discounting procedures are more similar to the procedures typically used by cognitive psychologists, where participants are asked to indicate what their response would be given a description of future consequences. This discrepancy has promoted some skepticism in behavioral analysts with regard to this procedure (Critchfield & Kollins, 2001).

One such skepticism is that the participants do not receive the rewards they choose, so the verbal responses that they make might not correspond to the choice that would be made if the rewards were real. Researchers have addressed this concern by randomly selecting one of the choices made on the task and awarding it to the participant. The discounting rates from these procedures do not differ significantly from the rates from hypothetical procedures in the same participants (Madden, Begotka, Raiff, & Kastern, 2003) or between groups of participants (Madden et al., 2004).

As with any measure, the reliability of discounting procedures is a concern that has been raised. Reliability was the focus of a study conducted by Simpson and

Vuchinich (2000). In this within-group study, participants completed a discounting procedure followed by another discounting procedure one week later. According to the authors, the indifference points and discounting rates were consistent and reliable across the sessions ( $r = .906$ ). They concluded that discounting might be similar to a personality trait, in that it is a steady individual difference variable.

However, between-group comparisons have shown that discounting rates change across the lifespan. Green, Fry, and Myerson (1994) compared the discounting rates of children, young adults, and older adults. They discovered a developmental trend toward self-control. Children discounted the value of delayed rewards more rapidly than young adults, who discounted the value of delayed rewards more rapidly than older adults. The authors conclude that while there may be an increase in the ability to delay gratification as a function of development. However, with an age-specific parameter, the discounting function fit the data that were obtained in all three age groups. This suggests that the choices made on discounting tasks are qualitatively similar across a person's life-span.

In a follow-up study, the role of age in temporal discounting was examined as well as the role of income (Green, Myerson, Lichtman, Rosen, & Fry, 1996). Three groups were used, consisting of upper-income younger adults, upper income older adults, and lower income older adults. Within the upper-income groups, there were no age-related differences in discounting. However, the lower-income older adults discounted the value of delayed rewards more rapidly than either of the upper-income groups. In addition, with income held constant, there was a consistent decrease in

temporal discounting rates between the ages of 20 and 30 years. After the age of 30 years, the rates stabilize as an individual moves into old age.

The utility of the temporal discounting procedures has caused them to become popular in the operant theory literature. In particular, they have been used to study decision-making in substance-abusing versus non-abusing populations (Petry, 2003). This makes sense when one considers the impulsive behavior that is demonstrated in drug dependence. For instance, individuals who are dependent on drugs often choose immediate but brief drug intoxication over deferred but greater benefits, such as good health or family relationships.

The studies that have compared the discounting rates of substance-abusing and control populations have consistently demonstrated that the drug-abusing populations discount at higher rates. Therefore, these individuals have a tendency to prefer the smaller, immediate reward as opposed to a larger, more delayed reward. In other words, these individuals demonstrate more impulsive choices on these tasks. The studies have examined populations using nicotine (Bickel, Odum, & Madden, 1999), alcohol (Petry, 2001a), heroin (Kirby & Petry, 1999; Madden, Petry, Badger, & Bickel, 1997; Odum, Madden, Badger, & Bickel, 2000), cocaine (Kirby & Petry, 2004), and amphetamines (Bretteville-Jensen, 1999). In addition, individuals who are addicted to gambling discount the value of delayed rewards at higher rates (Dixon, Marley, & Jacobs, 2003; Petry, 2001b), whether or not they also have a substance abuse problem (Petry, 2001b).

Several studies have indicated that the poor decisions made by these individuals are not the result of a lack of knowledge about future losses. For instance,

the knowledge that smoking leads to several different physical ailments such as lung cancer is pervasive, as is the fact that needle-sharing for intravenous drug use can lead to AIDS (Kelley & Petry, 2000). Despite this, many people continue to smoke cigarettes or share needles when clean ones are not available. Temporal discounting procedures have shown that current smokers discounted the delayed health gains and losses more steeply than non-smokers (Odum, Madden, & Bickel, 2002). Similarly, heroin addicts who agreed to share a needle in a hypothetical situation discounted the value of delayed money and heroin more steeply than non-drug users (Odum et al., 2000). Knowledge is not always equivalent to behavior, and it appears that certain choices may be more affected by the relative value of consequences at a particular point in time.

#### *Temporal Discounting of Health Benefits*

Critchfield and Kollins (2001) suggested that temporal discounting can be extended to other types of behavior besides drug abuse. For instance, most people are aware of the health-related benefits associated with regular physical exercise, yet many people forego these benefits in favor of short-term sedentary alternatives. Examples of short-term sedentary alternatives might be activities such as watching television or reading. Therefore, it is possible that people who engage in regular exercise instead of these sedentary alternatives do not discount the value of the delayed reward of health as much as people who do not exercise.

These people might be described as being less impulsive with regard to this choice, because they are able to forego the smaller, immediate gain in favor of the



larger one (Ainslie, 1974). In contrast, people who do not exercise might be displaying more impulsivity, because they consistently choose the short-term reward over the long term one. Thus, regular exercisers might be more able to exhibit self-control over this choice, because self-control means choosing the alternative that leads to the larger delayed outcome instead of the smaller, immediate one.

Viewing physical activity as a choice among outcomes allows for the temporal discounting theory to be used as a framework for examining physical activity adherence. Under this assumption, it follows that the choice between sedentary and physically active alternatives will depend on the delay to access of the relevant outcomes. Evidence for this comes from a study in which the choice of sedentary and physically active behavior was contingent on the proximity to exercise facilities (Sallis et al., 1990). One reason for this might be the response cost associated with driving to distant exercise facilities in the form of lost time. Another reason is that the delay imposed by the distance to a facility also delays the activity-related reinforcers (Critchfield & Kollins, 2001). This finding is well documented within the exercise literature (Willis & Campbell, 1992).

If non-exercisers tend to discount delayed consequences more than exercisers, certain steps can be taken in order to create more effective interventions for these individuals. The goal of these interventions would be to help these individuals exhibit more control over their behavior. Research has shown that commitment strategies can be a useful way to do this, by keeping an individual from shifting their preference to the smaller reward as it approaches in time. For example, an individual who knows he or she will be tempted to remain sedentary instead of participating in physical activity

might make a regular appointment to meet a friend at the gym. Another strategy might be to conceal the temptations that lead to sedentary choices such as keeping the television in a cabinet with doors that close or lock (Rachlin & Green, 1972).

### *Temporal Discounting and Cognitive Theory*

Cognitive theory might also provide some insight into effective interventions for individuals who discount the value of future benefits. In particular, information regarding the activation of memory traces and how they are processed in working memory has potential applications to this problem. It also gives insight into the cognitive processes that might be occurring in a discounting task.

*Activation.* There are several different models that attempt to describe how memory is organized and retrieved in generic memory; however, the spreading activation model is the most dominant theory. Specifically, the tenets of the model proposed by Collins and Loftus (1975) can explain much of the empirical data relating to semantic processing. According to this model, the activation of a concept spreads to all related concepts.

This theory makes several assumptions about the nature of this activation. First, as the number of paths increases between related concepts, the strength of activation decreases, like a signal that attenuates as it travels from its source. Second, activation is spread from a concept as long as it is being processed. Only one concept may be actively processed at a time, but activation can spread in parallel from the other nodes that are subsequently activated. Third, activation decreases over time and it is vulnerable to interference. And finally, the more features that two concepts share,

the more links there will be between them. This means that semantic relatedness depends on the collective connections between two concepts.

Similar to Collins and Loftus, Anderson (2000) described spreading activation as the process by which information is retrieved from memory. His research suggests that memory traces become active when associated concepts are presented. This activation determines the probability that a concept will be accessed, as well as how fast it is accessed. The level to which a concept is activated is dependent on how recently it has been accessed, and how much the retrieval of this concept has been practiced.

The best empirical support for the spreading activation model comes from the associative priming data. Many studies have shown that the response to a word is faster when it has been primed by a related word. For example, if a participant is presented with the word, “dog,” he or she will respond faster to the word “bone” because these two concepts are closely connected in the memory. Activation of the word “dog” spreads to the concept of “bone,” causing it to become activated as well. This phenomenon can be applied to more than word recognition. For instance, text that is coherent can be read more quickly than text that does not have a strong associative relatedness (Anderson, 2000).

Spreading activation may also be applied to the concept of temporal discounting. When a person is faced with a choice between two alternatives, one choice (such as smoking a cigarette) and the consequences that have come to be implicitly associated with it (such as relief from nicotine withdrawal) will also become activated. The choice that becomes activated and the consequences

associated with it are likely to be the ones that have been recently activated, or the ones that are more frequently activated. Therefore, people who make self-defeating choices that have negative long-term consequences may be responding to the strength of activation of the choice that is immediately available.

In the case of discounting exercise-related health benefits, the choice to exercise may be associated with many different things. For instance, someone may have associated exercise with negative ideas such as muscle soreness, fatigue, or inconvenience. The more often this person has activated these concepts together, the more likely it seems that he or she would discount the value of the future benefits of exercise. Similarly, someone who has associated exercise with positive ideas such as enjoyment or health and fitness might have a less difficult time making the choice to exercise.

If this is the case, then an intervention might be designed for people who have learned to associate exercise with negative thoughts who activate these concepts together. According to Jiménez (2003), associations like this occur implicitly because the cognitive systems are able to extract structure in the environment without conscious awareness of it. The information learned in this manner can then have an impact on behavior, cognitive processes, perceptions of the world, and conscious experience. This suggests that changing the structure of one's environment could change these associations.

One way to do this is to build strong self-efficacy beliefs through a series of enactive mastery experiences. Self-efficacy is the confidence that one has to perform a certain activity successfully (Bandura, 1997). After experiencing a series of

successes, a person becomes more likely to associate that activity with more positive ideas or feelings. In the case of physical activity, a person could set small and attainable goals related to exercise. When the person succeeds at achieving these goals, the nature of his or her environment would change. This would enable the person to increase the number of times that the activity is associated with positive thoughts, which would increase the strength of these connections and the likelihood they will be activated together in the future.

One theory that is in support of this intervention is the somatic marker hypothesis. According to Damasio (1996), the main idea of this hypothesis is that “marker” signals have an influence on an individual’s response to a stimulus. The markers are described as somatic because they are related to the bioregulatory state that has been associated with the stimulus in an individual’s past. This occurs in structures located in the ventromedial prefrontal cortex of the brain. Thus, the ventromedial sector of the brain holds information about the connections between facts about a certain situation or outcome and the emotions that have previously been associated with it. In terms of activation, exposure to a stimulus will result in the activation of associated concepts, and the result of combined activation results in a factual-emotional set.

The somatic marker hypothesis is appealing for several reasons. First, the development of somatic markers would seem to be adaptive, because the somatic state that arises as a result of exposure to a situation can alert an individual to the benefits or costs of option-outcome pairs. This frees up cognitive resources for other uses, and increases efficiency by allowing the individual to make decisions in a

shorter amount of time. Second, the theory combines the behavioral and cognitive traditions in an attempt to explain human decision-making. This is because the theory does not rely on conditioning or cognition alone to account for the choices in decision-making tasks.

The somatic marker hypothesis has been empirically tested using a gambling task that is similar to the task used in temporal discounting procedures. The participant is faced with four different card decks, two of which result in higher immediate payoffs, and two of which result in lower payments. However, in the decks with higher immediate payoffs, penalties are incurred which result in an overall net loss. Therefore, because the participants are told to maximize their profit, the appropriate strategy is to draw cards from the lower-paying decks that have fewer or smaller penalties.

Normal control participants tend to sample from all of the decks, but eventually begin selecting cards from the decks which pay lower but maximize net profit. In contrast, participants with damage to the ventromedial prefrontal cortex continue to play from the higher-paying but more penalizing decks, ultimately losing all of their money. This is significant because it implicates this area of the brain as a source of poor decision-making. Normal subjects are able to implicitly sense which decks are good and which are bad, but the ventromedial participants do not seem able to do this. Apparently, these participants do not establish proper markers for the circumstances of future outcomes.

According to Damasio (1996), the failure to create proper somatic markers may be due to deficits in attention and working memory, both areas that rely heavily

on the prefrontal cortex. Representations of future outcomes may not be held in the working memory long enough for logical reasoning strategies to manage them. Others have implicated the role of working memory in deficiencies in rational decision-making (Hinson et al., 2003), which will be discussed further in the next section.

*Working memory.* Working memory is the component of cognitive processing that is responsible for temporarily storing and manipulating information for tasks such as comprehension or reasoning (Baddeley, 1992). The term working memory is typically associated with Baddeley, although alternative models have been proposed (Cowan, 1988).

According to Baddeley (1992), the working memory is divided into subcomponents that include the central executive, the visuospatial sketch-pad, and the phonological loop. These components are responsible for the control of attention, the manipulation of visual information, and the storage and rehearsal of speech-based information, respectively. A further subcomponent, the episodic buffer, has recently been added to the memory system to account for empirical data suggesting that information from long-term memory might be held separately from other types of information (Neath & Surprenant, 2003).

Cowan's account of working memory is similar to Baddeley's, although it does not divide the working memory into separate components (Neath & Surprenant, 2003). Instead, working memory works within long-term memory to bring information to a heightened state of activation (Cowan, 1988). Thus, working memory is related to activation in that working memory is essentially information that is in a heightened state of activation.

Working memory capacity varies among individuals, and has been found to have an influence on several different cognitive tasks. These vary from language and reading comprehension to reasoning, which indicate that working memory has a role that is central to cognitive processes (Neath & Surprenant, 2003).

Also as previously mentioned, working memory functions seem to be related to impairments in rational decision-making. For instance, when under the influence of alcohol, individuals with a low working memory capacity exhibit more impulsive behavior than participants with normal working memory capacities. In addition, the executive control system within the working memory is likely to be responsible for managing the information that is used for decision-making (Hinson et al., 2003).

Temporal discounting may, therefore, be discussed in terms of activation and working memory. First, the information and associations that are relevant to the decision being made are activated. Next, these newly-activated concepts are maintained within working memory so that they might be compared. Items that are activated simultaneously are more likely to be activated together because they become associated. When this occurs frequently, the strength of the connection between the associated concepts becomes stronger (Anderson, 2000).

Thus, the individual must be able to evaluate the different outcomes that will result as consequences of his or her choices, and the value of these potential outcomes. This information, which includes the choice plus the emotional consequences that have been associated with it, must be held within the working memory. It follows, then, that deficits in working memory should lead to poorer decision-making. An individual who activates the concept of a smaller but immediate



reward and compares this to a delayed reward must be able to evaluate how the value of the delayed reward would change over time. If working memory is unable to process all the information, the individual might select the immediate outcome for the sake of simplicity. The immediate outcome may also have an advantage because it is easier to process, and the individual may select it because it is easier to understand.

Hinson et al. (2003) directly tested this hypothesis with a sample of college students. In the first two experiments, participants made temporal discounting decisions while the load on their working memory was manipulated. In Experiment 1, participants were given the task of maintaining a digit or letter string in the memory. In Experiment 2, participants were given more than the usual two alternatives per choice in the discounting task. As predicted, both conditions increased the number of impulsive choices in the tasks. In other words, the  $k$ -values of these participants increased when working memory had a larger load.

In Experiment 3, the participants completed two self-report measures, and participants with extreme scores on these measures were selected to complete a discounting task. The first measure, the Barratt Impulsiveness Scale, 11<sup>th</sup> revision (BIS-11), was derived from the personality literature. The second measure, the Dysexecutive Questionnaire (DEX), was derived from the neuropsychological literature. The DEX is designed to assess changes in the processes that reveal problems with executive control, which is one task that is controlled by working memory. When a person develops a problem with executive control, symptoms might include cognitive, motivational, or emotional changes. The scores on the BIS-11 and

the DEX were positively correlated ( $r = .76, p < .01$ ), lending further support to the hypothesis that impulsivity is related to executive control of working memory.

The next part of the experiment involved the participants who scored the highest and the lowest on the BIS-11, who then completed a discounting task. Those who had high scores on the standardized self-report measure (BIS-11) were also more likely to discount the value of delayed rewards in the discounting task. Furthermore, the DEX was able to predict individual differences in performance on the discounting task. These findings show further support for the relationship between impulsivity and discounting, as well as impulsivity and working memory load.

The final experiment conducted by these researchers, Experiment 4, involved the discounting task and the same working load manipulations as in Experiment 1 and Experiment 2, but investigated the effects of real versus hypothetical rewards. In most discounting tasks, the participant must imagine receiving the immediate or delayed reward. It would be impractical to award the amounts of money that the participants choose. As previously discussed, studies have shown that the same hyperbolic discounting functions fit the data when the participants are given one of the rewards chosen (Madden et al., 2003, 2004). It seems that the choices made by participants who are carefully monitoring their choices because they expect one of the rewards are similar to the choices made by participants who must imagine receiving the rewards.

This finding was replicated in Experiment 4. When participants were told that they could expect to receive one of the rewards that were chosen in the discounting task, delayed rewards were still discounted at a higher rate. Even when the working

memory of these participants was loaded, the results were consistent with the results from Experiments 1 through 3, which were conducted with hypothetical outcomes.

The results of these experiments point to the idea that working memory is related to the impulsive personality trait. It is also related to the performance on temporal discounting tasks, because it is related to how individuals might be processing the value of the different alternatives of an option. When working memory is resource-limited, it is more difficult to assess the value of the consequences and thus people become more likely to resort to simplified methods, leading to poorer decisions.

In summary, there is evidence that points to the idea that working memory has an influence on decision-making processes. This can be explained partially by the fact that a decision involves the activation and maintenance of many different concepts and affective information within working memory. Individuals with resource-limited or deficient working memories have been shown to make more impulsive choices. The relationship between impulsivity and working memory capacity suggests that working memory should be investigated as a possible influence on discounting. In addition, the influence of discounting on the decision to exercise was also of interest.

*Interventions.* If working memory capacity is related to discounting, and discounting rates are predictive of exercise rates, an intervention to increase adherence to an exercise program might focus on working memory limitations. According to Damasio, deficient or loaded working memory prevents the formation of the somatic markers that direct and simplify decision making. Fortunately, somatic

markers can be formed through one of the concepts from Bandura's theory of social learning theory; namely the enactive mastery experiences that enhance self-efficacy beliefs. According to this theory, the most certain path to increase self-efficacy for a certain task is repeated successful performance of the task. Increases in self-efficacy are predictive of exercise behavior (Bandura, 1997; Miller, Coombs, & Fuqua, 2002; Miller, Ogletree, & Welshimer, 2002).

One possible reason that this would be an effective intervention is that repeated activation of the concept of exercise and the positive thoughts and feelings of success will strengthen the connection between them (Anderson, 2000). If a person has experienced a series of successes at a particular activity, the positive thoughts and feelings associated with this success are also more likely to become activated in working memory. As these connections become stronger with repeated activation, they become more automatic, which imposes a smaller load on the working memory. The working memory will then have more resources to dedicate to the higher cognitive processes involved in decision making, such as weighing the value of future rewards.

The somatic marker hypothesis is also in support of this intervention. According to this hypothesis, the "markers" on a stimulus are related to the bioregulatory state that has been associated with the stimulus in an individual's past. The marker signals come to have an influence on an individual's response to a stimulus. If positive bioregulatory state become activated concurrently with the idea to exercise, then the individual should be more likely to respond by making the choice to exercise.

To summarize, temporal discounting can be explained in terms of cognitive theory, particularly the concepts of spreading activation and working memory. Spreading activation elucidates the process by which a decision and its potential consequences become activated. The somatic marker hypothesis describes the affective response that becomes associated with a particular decision, which aids in the decision-making process. Then, these activated concepts are processed in the working memory.

Furthermore, it seems that the cognitive and behavioral paradigms are in agreement that the value of a reward decreases with delay. This decision seems to rely on working memory function and the activation level of associated concepts. This suggests that interventions targeting these processes may benefit exercise adherence.

Cognitive theory also serves to identify potential interventions for people who discount exercise-related health benefits. Helping individuals associate exercise with positive thoughts and feelings through enactive mastery experiences might be beneficial in gaining positive somatic markers. It may also reduce the load on working memory and allow individuals to use higher cognitive processes when making a decision. This is especially important for individuals with a limited working memory capacity, who might have a difficult time forming somatic markers on their own and also might struggle with the processing involved in rational-decision making.

## Research Hypotheses

The question remains, however, whether working memory predicts discounting rates in individuals seeking to adhere to exercise regimens. One purpose of this study is to compare the discounting rates of individuals with different working memory capacities. Also, this study will investigate the relationship between discounting rates and physical activity levels. It is predicted that individuals with a smaller working memory capacity will discount the value of future rewards at a higher level, reflecting greater levels of impulsivity. These individuals should also score higher on a standardized self-report measure of impulsivity.

In addition, it is predicted that individuals who discount at higher rate will have lower levels of physical activity. Therefore, working memory should be related to discounting rates. The combination of working memory and discounting rates should be predictive of exercise rates.

One potential exception is individuals who are addicted to exercise. Because individuals who are addicted to substances such as nicotine or heroin discount at higher rates, the same might also be true for individuals with an addiction to exercise. However, Ketzenberger (1996) found that individuals with a potential exercise addiction, super-exercisers, displayed less impulsivity than individuals with lower levels of exercise adherence. Due to this finding and the preliminary nature of this investigation, this dynamic was not explored.

## CHAPTER III

### METHODS

#### Sample and Procedures

Forty-seven students attending Utah State University were recruited from the psychology and exercise science departments. The sample consisted of undergraduate and graduate students. The undergraduate students received extra credit in one of their courses for participation. The data collected were coded so that the participant's name did not appear on any of the records. To ensure that the students received extra credit, each individual's name was written on a participant list with the instructor's name. This information was not connected to the data collected in any way.

A pilot study was conducted to make certain that instructions were clear to the participants, as well as to refine the discounting procedures. Once these refinements had been made, a power analysis was conducted on the initial data. Results of the power analysis indicated that a sample size of 45 was needed to achieve 80% power to detect an  $R^2$  of 0.15. This  $R^2$  was attributed to three independent variables (working memory and area under the curve [AUC] values from the two discounting tasks) using an alpha level of 0.05.

Because the sample was self-selected, it is likely that these individuals had different characteristics than the individuals who chose not to participate. The results of the study may have been influenced by these characteristics, and might not generalize to the entire population of college-aged students. Also, there are differences between individuals who seek out higher education and those who do not.

The findings of this study are based on individuals who attend college, so it is possible that they do not generalize to those who do not.

Each participant completed a demographic questionnaire, a physical activity scale, the Barratt Impulsivness Scale (BIS-11), two discounting tasks, and a working memory task. The order in which the participants received the discounting and working memory tasks was randomized to counterbalance order effects. Participants were tested individually in a quiet office space.

### *Demographic Questionnaire*

The demographic questionnaire was aimed at assessing each participant's age, height, weight, sex, marital status, socioeconomic status, number of children, cigarette use, and alcohol use. The participants were also asked to rate their perceived level of physical fitness and enjoyment of physical activity, and to rank the motives and barriers that are involved in their decision to engage in physical activity.

The information that was obtained from this questionnaire was important because it provided data that, if not controlled for, might have biased the outcome. For instance, parts of this survey assessed levels of exercise enjoyment, exercise addiction, and support factors; all potential influences that may have confound the results (Willis & Campbell, 1992). In addition, the information from this questionnaire allowed for the exploration of correlational relationships between demographic information and the outcome variables. This questionnaire can be found in Appendix A.



### *Physical Activity Scale*

Next, the participants completed a physical activity scale. This scale was a paper-and-pencil instrument developed by the Cooper Institute for Aerobics Research (Kohl, Blair, Paffenbarger, Macera, & Kronenfeld, 1988) to assess physical activity habits in the general population. Participants were asked to report moderate or vigorous activities that had been performed regularly in the previous 3 months, and to estimate the amount of that activity. The activities ranged from walking to weight training. Scoring involved assigning metabolic equivalent task (MET) values to each activity, which was placed in a formula that resulted in a MET-h/wk value. Because the purpose of this study was to investigate deliberate physical activity performed to increase fitness and health, the MET values for household activities was not included in the total MET-h/wk. This instrument can be found in Appendix B.

Validation studies conducted on this questionnaire have shown significant correlations with treadmill time and portions of the questionnaire (Kohl et al., 1988). Despite some evidence for the validity of this instrument, there is an inherent source of bias in the form of social desirability response set. The possibility that participants responded in order to appear as though they exercise more than they actually do must be taken into account when interpreting the results of this investigation.

### *The Barratt Impulsiveness Scale-11<sup>th</sup> Revision (BIS-11)*

An existing measure of impulsivity was administered to the participants in order to explore its relationship with the discounting task outcomes. The BIS-11 has been used widely among adults. This instrument uses a 4-point Likert-type scale in

order to measure six different independent components of impulsiveness. These include motor impulsiveness, non-planning impulsiveness, cognitive complexity, self-control, attention, and perseverance. The scale has been shown to have an internal consistency of  $\alpha = .82$  (Fossati, Ceglie, Acquarini, & Barratt, 2001). Versions of the BIS have been shown to be predictive of performance in motor tasks, anger, and appear to be valid and reliable. The BIS-11 can be found in Appendix C.

### *Discounting Tasks*

*Health rewards.* Two of the tasks involved in this study were delay discounting procedures. Discounting rates have been shown to be domain-specific, and because future health gains are what can be expected from regular exercise, hypothetical outcomes in this task were health gains. Therefore, the participants were asked to imagine that they had a permanent, chronic illness with a multitude of symptoms. The scenario (adapted from Chapman, 1996) used was as follows:

*‘For the past 2 years, imagine that your state of health has fit the following description. Your state of health will not change for the rest of your life.*

Because of your doctor’s instructions, you need to take medication (pills) once a day. You must also be very careful about your nutrition, and spend a lot of time keeping track of what you eat. Your mouth feels dry, and foods do not seem to have as much taste as they used to. You find it necessary to visit the bathroom quite often.

You often feel tired and sometimes light-headed. Every night, you have trouble falling asleep and have nightmares when you do sleep. You feel angry or irritated, and it is difficult to concentrate. You also have less feeling and movement in your arms and legs, and will eventually have to use a wheelchair.’

Participants were then told to imagine that there were two treatments available for the disease. The first treatment (Treatment A) was available immediately, and

would return them to full health for a specified amount of time. The second treatment (Treatment B) was available after a delay, but would return the participant to full health for 15 years. The amount of time that Treatment A would return the participant to full health was at one of five magnitudes, including 1 year, 4 years, 8 years, 12 years, and 15 years. The delay until Treatment B was available also varied, being postponed 1 year, 5 years, 10 years, 25 years, and 50 years. The outcomes and delays were printed on 3 X 5 index cards. Therefore, a sample question that each participant was asked is as follows:

‘Treatment A will return you to full health for 4 years, starting today. Treatment B will return you to full health for 15 years; however, it would not take effect until 10 years from today.’

A listing of each alternative given to the participants can be found in Appendix D. The indifference points, where the participant’s preference shifted to the immediate outcome, were then plotted at each delay, and the slope of this function ( $k$ ) was used to indicate the amount that each participant discounted the value of future health gains. In addition, the area under the curve (AUC) that connects the indifference points was also calculated. This has been done in the literature because the hyperbolic model does not always fit the data from each participant. AUC can be calculated regardless of the shape of the curve because the data are normalized (Myerson et al., 2001).

*Money rewards.* The second discounting task consisted of hypothetical monetary outcomes. This task was included in keeping with the temporal discounting literature, where monetary outcomes are included in studies that also explore the

discounting rates of other rewards. The instructions to the participants were adapted from Petry (2003):

‘I am going to ask you to make some decisions about which of two rewards you would prefer. You will not receive the rewards that you choose, but I want you to make your decisions as though you were really going to get the rewards you choose. The possible rewards are written on these sets of cards. The cards on your right show a reward that you can get after you have waited for some period of time. The choices you make are completely up to you. Please select the option that you prefer, not what you think I want you to prefer. I do not expect you to choose one particular reward over another. Just choose the reward that you would really want.’

The value of the delayed reward was held constant at \$100. The immediate reward ranged from \$0.10 to \$100. The first question was always between \$100 available immediately and \$100 available after the specified delay interval. Then, the value of the immediate reward was decreased, so the participant had to choose between \$99.90 available immediately or \$100 available after the delay. The value of the immediate reward continued to decrease until the participant shifted his or her preference to the delayed reward. Once this had occurred, the amount of the delay was increased and the process started again. The delay intervals were 6 hours, 1 day, 1 week, 2 months, 6 months, 1 year, 5 years, and 25 years. The indifference points were recorded as the last immediate reward chosen by the participant before his or her preference switched to the delayed reward. A listing of the values of the immediate and delayed reward at each delay interval can be found in Appendix E.

Similar to the health-outcome discounting task, the participants’ k-values and AUCs were computed for this task. As previously mentioned, one of the purposes of this investigation was to examine if the same processes involved in temporal discounted could also be occurring when a person is making a decision to exercise. Therefore, discounting rates were predictor variables in this study.

### *Working Memory Task*

Participants also completed a task that was adapted from Daneman and Carpenter's (1980) reading span task. In this task, the participants were asked to read a series of sentences out loud as they were presented individually on 5 X 8 index cards. The sentences were grouped, and the end of a group was signaled by a blank index card. The number of sentences in each group increased as the task progressed, with five sets each of two, three, four, five, and six sentence groups for a total of 100 sentences. Each sentence was between 13 and 16 words, and each ended in a different word.

After a set had been read, the participant was asked to write down the last word from each sentence. Participants were instructed to recall the last words from the sentences in the order that they were presented. If the participants were unable to do this, they were instructed to recall whatever they could. Reading span was calculated as the last set at which the participant could correctly recall 80% of the words.

While this task is designed to assess reading span, it has also been widely used as a measure of working memory capacity (Daneman & Merikle, 1996) because the central executive in working memory is assumed to have both a storage capability and a processing capability. This task reflects both of these components, and is able to identify differences in people's ability to coordinate them. For example, individuals with a small storage capacity who are unable to temporarily store information in their

working memory are also unable to integrate new information with previously processed information, and will score lower on the task.

The literature on the Daneman and Carpenter task supports this theory. In a meta-analysis of 77 studies that have used this task (Daneman & Merikle, 1996), it was found that individual differences on this measure of working memory correlated with global and specific tests of reading comprehension ( $r = 0.41$  &  $r = 0.52$ , respectively). It seems that because poor comprehenders dedicate more working memory resources to processing, they can only store a few of the final words.

It was predicted that the proper coordination of working memory resources applies to more than comprehension. When making a decision, the costs and benefits of the alternatives must be maintained in the storage component of working memory while the processing component compares them. Therefore, working memory capacity was also a predictor variable in this study. It was expected to be predictive of discounting rates, as well as exercise rates.

### Analysis

Inferential statistical tests using the parametric data obtained in this study were done using SPSS. This included the correlational and multiple regression analyses. An alpha level of .05 was used for all statistical tests. Because the function for k-values is hyperbolic, each participant's k-value was calculated using nonlinear regression and the hyperbolic equation previously discussed (Equation 1). This was done using GraphPad Prism® statistical software.

Discounting outcomes were described in two ways. First, each participant's k-values for the money outcome discounting task and the health outcome discounting task were determined. Participants who did not show any discounting were assigned a k-value of 0. Second, the AUC of the indifference points were calculated for the two tasks. As previously mentioned, calculating the AUC avoids some of the problems that are associated with estimates from discounting functions (Myerson, Green, & Warusawitharana, 2001).

Next, the relationships between participants' k-values, demographic information, and the exercise-related questions were explored through correlational analysis. The demographics used in this analysis included age, gender, body mass index (BMI), marital status, and socioeconomic status. The exercise-related questions included the rating of exercise importance, which was measured on a Likert scale ranging from very important to very unimportant. Other questions involved in this analysis were the reported level of exercise enjoyment, level of physical fitness, and satisfaction with current level of physical fitness. Also included were the rankings for the factors that motivate and prevent the participants from participating in physical activity.

The participants also responded to an exercise-related question regarding whether or not they feel guilty when they do not exercise. This question, in combination with a high level of exercise, was included because these two factors are major indicators of exercise addiction. It is possible that people who were addicted to exercise performed like drug-addicted individuals on the discounting tasks and displayed higher discounting rates. This would confound the hypothesis that people

who exercise discount less than people who do not exercise. It was determined a priori that participants with extremely high MET-h/wk values who reported guilt associated with not exercising would not be included in the analysis.

A correlational analysis was also conducted to explore the relationship between working memory capacity and discounting rates. A Pearson product-moment correlation coefficient was computed for the results of the Daneman and Carpenter reading span task and the AUC values from the money and health outcome discounting tasks. The AUC values were used in this analysis because they are normalized and parametric. The final correlational analysis was used to investigate the relationship between a paper-and-pencil measure of impulsivity (BIS-11) and discounting rates. Pearson product-moment correlation coefficients were computed with BIS-11 scores and the AUC values obtained on the discounting tasks.

To further examine the relationship between BIS-11 scores and discounting rates, the sample was divided into two groups. The groups consisted of participants who scored in the lowest and highest quartiles of the distribution. A Mann-Whitney *U*-test was performed to examine if there were statistically significant differences in discounting rates between the groups.

The last analyses that were performed on the data were hierarchical multiple linear regressions. The regressions were used to examine the degree to which exercise levels were related to the predictor variables (working memory task and discounting tasks). The outcome variable in these analyses was the amount of exercise reported by the participants in the form of MET-h/wk. Covariates were entered in the first step of the regression. In order to determine which variables were used as covariates, simple



regressions were computed without the predictor variables (working memory and discounting rates). This was done to examine the independent impact of potential covariates on the dependent variable. All potential covariates were entered at one time, and sequentially, the covariate with the lowest predictive power was removed. The remaining covariates were left in the model if they were statistically significant predictors of MET-h/wk. The covariates tested were age, marital status, socioeconomic status, positive or negative association with exercise, importance of exercise, enjoyment of exercise, department, and perceived level of fitness.

Working memory capacity, which has been predictive of performance on discounting tasks (Hinson et al., 2003), was entered in the second step. This analysis was performed twice, once with the AUC values obtained from the money task entered in the third step, and once with the health outcome discounting tasks entered in the third step. Then, these analyses were repeated for the participants who selected overall health as their primary motive to exercise. The AUC values were used in this analysis because the distribution of k-values is skewed and therefore non-parametric.

## CHAPTER VI

### RESULTS

#### Descriptive Statistics

The initial sample consisted of 21 males and 26 females, for a total of 47 participants. No significant differences were found between males and females on any of the predictor or outcome variables (MET-hr/week, discounting rates, working memory capacity, etc.).

Three male participants were excluded from analyses as a result of extreme values on one or more of the variables. Two of these participants displayed extreme discounting rates which may have reflected a lack of understanding of the task. The other participant reported an extreme amount of activity that resulted in a MET-hr/week value over 4 standard deviations from the mean of the rest of the group. This participant also indicated feelings of guilt associated with not exercising, and therefore fit the profile of an exercise addict as defined at the outset of this study.

The following demographic information describes the remainder of the participants. The participants had a mean age of 24.0 ( $SD = 5.29$ , range 19 to 49 years). The mean body mass index (BMI) was 24.7 ( $SD = 5.79$ ). Forty-three percent of the sample reported using vitamins, 2.3% reported using cigarettes, and 22.7% reported using alcohol. Using the CDC's (2000a) criteria for the amount of exercise necessary to benefit health, 59.1% reported the recommended amount, 31.9% reported an insufficient amount, and 9.0% reported no activity at all in the past 3

months. The percentage of participants that reported the recommended amount of activity is much higher than the percentage reported in the general population, suggesting that there was restriction of range present in the sample. This may have been related to the characteristics of a university-student sample, or the availability of recreational activities in the geographical area.

Each participant ranked his or her motives and barriers for participating in physical activity, and the results of these rankings can be found in Table 1.

More than half the sample (54.5%) reported that exercise was very important to them, 31.8% reported that it was somewhat important, 9.1% reported being neutral, and 4.5% reported that it was not important. Also, more than half the sample reported a high level of exercise enjoyment (52.3%).

Table 2 contains the means and standard deviations for the discounting and working memory tasks, as well as the BIS-11 and the outcome variable for the regression analyses, MET-h/wk.

Table 1

*Motives and Barriers in Exercise Participation*

Motives			Barriers		
	<i>N</i> <sup>a</sup>	Percentage		<i>N</i>	Percentage
Overall Health	18	38.6%	Lack of Time	35	77.3%
Weight Control	13	29.5%	Lack of Willpower	6	13.6%
Enjoyment	6	13.6%	No Exercise Partner	2	4.5%
Competition	4	9.1%	Lack of Knowledge	1	2.3%
Stress Relief	3	6.8%	Lack of Facilities	1	2.3%
Social Benefits	1	2.3%	Fatigue	0	0.0%

<sup>a</sup>Number of participants ranking item as primary motive/barrier

Table 2  
*Mean Scores on Tasks and Tests*

Variable	Mean	SD
MET-hr/wk	32.64	23.65
Working Memory Capacity	3.91	1.44
BIS-11	64.32	9.95
Discounting of Health Reward	0.0115	(0.006-0.163)
Discounting of Money Reward	0.0266	(0.003-0.105)
AUC of Health Reward	0.4011	0.2222
AUC of Money Reward	0.4531	0.2978

*Note.* Values are means and standard deviations, unless otherwise indicated.

<sup>a</sup> Median, interquartile ranges in parentheses.

As previously mentioned, the majority of the individuals who participated in this study were recruited from two undergraduate courses, one offered by the psychology department and one offered by the physical education department. The rest of the participants were graduate students from one of these departments. Twenty-one of the participants were in the psychology course or the psychology department, and 23 participants were from the physical education course or the physical education department. Upon exploration of the data, it was discovered that the individuals in these groups differed on several of the variables in this study. Independent sample t-tests were used in this analysis, and family-wise error inflation

was controlled for using the Bonferroni post hoc procedure. A summary of the variables with statistically significant differences can be found in Table 3.

Table 3  
*Variable Differences as a Function of Department*

	Psychology students	Physical education students	<i>p</i> -value
Importance of Exercise	1.95	1.32	0.012
Perceived Level of Fitness	3.76	4.45	0.045
Enjoyment of Exercise	4.43	5.59	0.003
k-value from Health Reward Discounting Task	.1664 <sup>a</sup>	.0072 <sup>a</sup>	0.000 <sup>b</sup>
k-value from Money Reward Discounting Task	.0078 <sup>a</sup>	.0736 <sup>a</sup>	0.041 <sup>b</sup>
AUC for Money Rewards	0.54	0.35	0.044
Body Mass Index	26.55	22.79	0.033
MET-h/wk	24.421	40.428	0.025

*Note.* Mean reported unless otherwise indicated.

<sup>a</sup>Median.

<sup>b</sup>Computed from Mean Rank Scores, Mann-Whitney *U*-Test.

In order to explore the differences between different exercise groups, the CDC's recommendations for a recommended amount of physical activity were used to divide the sample into those who were getting the required amount of activity and those who were not. The CDC recommends moderate physical activity at least 5 times per week for the duration of 30 min, or vigorous physical activity at least 3 times per week for the duration of 20 min. The physical activity scale used in this study took into account the intensity of exercise performed, as well as the frequency and duration. Using independent sample t-tests, it was discovered that the groups were different on certain variables. The means from the groups and significance levels of the difference between these variables can be found in Table 4.

Table 4

*Differences in Variables as a Function of Participant's Exercise Group*

	Meeting requirements	Not meeting requirements	p-value
Importance of Exercise	2.11	1.31	0.001
Perceived Level of Fitness	4.58	3.33	0
Enjoyment of Exercise	2.56	3.89	0
Satisfaction with Level of Fitness	3.92	2.67	0.006
Working Memory	4.269	3.39	0.001

*Note.* Exercise group based on CDC's recommendations for recommended amount of physical activity (2000).

The sample was divided once again to determine if there were differences in discounting rates between the highest and lowest scoring individuals on the BIS-11. The Mann-Whitney  $U$ -tests were used for this purpose, one test for health discounting rates and one for money discounting rates. Neither test yielded statistically significant results ( $U = 46.5, p = .358$ ;  $U = 50.0, p = .491$ , respectively).

### Correlational Analyses

The correlational analysis performed with the demographic variables and exercise-related questions revealed that several of the variables were related. For instance, BMI was positively correlated with exercise importance ( $r = .437, p = .003$ ), and negatively correlated with perceived level of fitness ( $r = -.480, p = .001$ ), satisfaction with current level of fitness ( $r = -.392, p = .009$ ), and enjoyment of exercise ( $r = -.359, p = .017$ ). BMI also had an association with a lack of an exercise partner being reported as a barrier to exercise ( $r = -.356, p = .019$ ), and exercising with a partner or group as opposed to exercising alone ( $r = .481, p = .001$ ).

The participants' age was also related to several other variables. Age was positively correlated with BMI ( $r = .420, p = .003$ ), and negatively correlated with perceived level of fitness ( $r = -.399, p = .007$ ), exercise importance ( $r = .299, p = .048$ ), and satisfaction with current level of fitness ( $r = -.359, p = .005$ ). Gender was associated with the several of the motives to participate in physical activity. Reporting the motive of overall health was associated with being female ( $r = -.447, p = .003$ ), as was reporting the motive of stress reduction ( $r = -.376, p = .013$ ). Reporting enjoyment ( $r = .316, p = .039$ ) and competition as a motive to exercise ( $r =$

.414,  $p = .006$ ) was associated with being male. Females were more likely to report one of the barriers to physical activity, having no exercise partner ( $r = -.372$ ,  $p = .014$ ).

Finally, being married was associated with levels of physical activity ( $r = -.316$ ,  $p = .036$ ). Being married was also associated with a lower socioeconomic status ( $r = -.422$ ,  $p = .004$ ), and higher alcohol use ( $r = .363$ ,  $p = .015$ ).

Correlational analyses for the questionnaire data revealed that several of the exercise-related questions were correlated. In addition, several of these questions were correlated with the outcome variable, MET-h/wk. The size and level of statistical significance of the correlations between these variables can be found in Table 5.

Correlational analyses also yielded a few unexpected results. For example, the AUC value from the health reward discounting task was not related to working memory capacity ( $r = .243$ ,  $p = .111$ ). Furthermore, the AUC values from the money reward discounting task and the health reward discounting task were not related to MET-h/wk ( $r = -0.030$ ,  $p = .848$ ,  $r = .072$ ,  $p = .135$ ; respectively).

In contrast, working memory capacity was correlated with the AUC values from the money reward discounting task ( $r = .349$ ,  $p = .020$ ). Working memory capacity was correlated with MET-h/wk ( $r = .369$ ,  $p = .014$ ).



Table 5

*Intercorrelations Between Exercise-Related Questions*

	Exercise enjoyment	Perceived level of fitness	Exercise importance	Satisfaction with fitness level	MET-hr/wk
Exercise Enjoyment		.653**	.699**	.263	.428**
Perceived Level of Fitness			.639**	.641**	.495*
Exercise Importance				.260	.520**
Satisfaction with Fitness Level					.202
MET-hr/week					

\*\* $p < .01$ .

## Regression Analyses

Four hierarchical multiple regression analyses were performed on the data. Importance of exercise was the only covariate used in these analyses for two reasons. First, perceived importance of exercise has been shown to be predictive of exercise habits (Willis & Campbell, 1992). Second, it was the only variable that was a statistically significant predictor in the simple regressions performed using the covariates. Beta values for exercise importance varied from  $\beta = -.455, p = .025$  to  $\beta = -.482, p = .001$  as these regressions were performed. This finding may be a function of the homogeneity in the sample.

The first analyses conducted on the data were conducted using this covariate in the first step of the regression model. Working memory capacity was placed in the

second step of the model. In the third step, the first analysis used the health reward discounting rate in the form of AUC values, and the second analysis used the AUC values from the money reward task. In both analyses, working memory was a statistically significant predictor of MET-h/week. The health reward discounting rate was not a statistically significant predictor, and the money reward discounting rate approached significance but did not reach it. Table 6 shows the raw and standardized coefficients, as well as the  $R^2$  change and significant  $F$ -change for these analyses. Overall, the model using the health reward AUC accounted for 36.0% of the variance in MET-h/week, and the model using the money reward AUC accounted for 41.3% of the variance in MET-h/week.

Table 6

*Summary of Hierarchical Regression Analysis for Variables Predicting MET-h/wk*

Variable	$R^2$	$R^2$ change	$B$	$SE B$	$\beta$	Sig. $F$ change
Health Rewards						
Step 1						
Importance	0.271	0.271	13.507	3.61	0.478	0.000
Step 2						
Working Memory	0.359	0.088	5.055	2.154	0.309	0.022
Step 3						
AUC Health	0.360	0.001	-3.750	13.882	-0.035	0.788
Money Rewards						
Step 1						
Importance	0.271	0.271	14.340	3.485	-0.508	0.000
Step 2						
Working Memory	0.359	0.088	6.271	2.126	0.383	0.022
Step 3						
AUC Money	0.413	0.054	-19.838	10.354	-0.250	0.063

The next set of regressions conducted involved only the participants who rated overall health as their primary motivation to exercise. This subsample consisted of 17 individuals, 38.6% of the total sample. Again, importance of exercise was entered in the first step and working memory in the second step. The third step consisted of the AUC values representing the health reward discounting rates in the first analysis, and the money reward discounting rates in the second analysis.

Table 7 shows the raw and standardized coefficients, as well as the  $R^2$  change and significant  $F$ -change for these analyses.

Table 7  
*Summary of Hierarchical Regression Analysis for Variables Predicting  
 MET-hr/week for Participants Who Exercise for Health*

Variable	$R^2$	$R^2$ change	$B$	$SE B$	$\beta$	Sig. $F$ change
Health Rewards						
Step 1						
Importance	0.234	0.049	13.351	3.188	-0.557	0.001
Step 2						
Working Memory	0.732	0.000	12.505	2.201	0.779	0.000
Step 3						
AUC Health	0.780	0.115	-22.108	13.107	-0.235	0.115
Money Rewards						
Step 1						
Importance	0.234	0.049	14.895	2.599	0.621	0.000
Step 2						
Working Memory	0.732	0.000	12.105	1.679	0.754	0.000
Step 3						
AUC Money	0.861	0.004	-32.794	9.463	-0.378	0.004

Working memory was a statistically significant predictor variable in both of these analyses. Similar to the regressions performed on the entire sample, health reward discounting rates did not add a significant amount of predictive power to the model. However, the money reward AUC was a statistically significant predictor in this analysis. The model using the health reward AUC values accounted for 78.0% of the variance in MET-h/wk, and the model using the money reward AUC accounted for 86.1% of the variance in MET-h/wk.

## CHAPTER V

### DISCUSSION

The factors that lead to exercise are important to consider when designing interventions to increase physical activity. The purpose of this investigation was to examine whether working memory, a concept from cognitive theory, is one of the processes involved in the decision to exercise. The role of working memory is to activate the consequences of a decision and maintain these consequences in the focus of attention while processing how their value changes across time. In the case of exercise, the long-term health rewards might be weighed against more immediate, sedentary alternatives.

Thus, individuals who make the choice to exercise are constantly choosing the larger, long-term reward as opposed to the smaller, more immediate reward. This means that these individuals are making what is considered to be self-controlled choices (Ainslie, 1974) instead of impulsive choices. It follows that these individuals would be more likely to make self-controlled choices on discounting tasks.

The data collected for this study were aimed at addressing these premises. More specifically, this study was directed toward answering the questions posed at the outset of this study. The first of these questions was whether or not differences in working memory capacity were related to the discounting rates from money or health reward tasks. It was anticipated that working memory capacity would be related to both, however, in this study it was only related to the discounting rates from the money reward task.

Before explaining this finding, a limitation of the present study deserves mention. With regard to the money reward discounting task, the present study inadvertently included a departure from typical discounting procedures. When a participant shifted his or her preference to the delayed reward at a particular delay, the last immediate value chosen was recorded as the indifference point. Then, instead of flipping through the remainder of the cards, the participants were moved to the next delay magnitude. This introduced the possibility that the participants switched their preference to the delayed reward earlier than they would otherwise in order to finish the task sooner. The discrepancy between the procedure used and the typical procedure used in the literature must be taken into account when interpreting the results.

One possible explanation for the finding that only the discounting rates from the money reward task were related to working memory could be that the individuals in this study processed the rewards from the health and money tasks in different ways. Chapman (1996) found that discounting rates are domain independent for money and health rewards. According to her, making decisions about future health may draw on different decision-making processes than those used in decisions about money. More specifically, she suggests that different analogies and schemas may be used on these tasks. Working memory may contribute more to intertemporal monetary decisions, when individuals take into account previous investment decisions, interest that could be made with the money, or the items the money could be exchanged for. However, emotions such as dread or anticipation may play more of a role when one considers intertemporal health decisions (Chapman, 1996).

As discussed in the literature review, the somatic marker hypothesis states that somatic “marker” signals are present during the encoding of information, in order to create additional information from which to draw when making a decision. If the participants were using emotional information to guide their decision-making on health outcome task, it would have been possible to rely less on the working memory in these decisions.

Comparing the discounting rates between the monetary and health domains is also difficult because the money and health rewards were expressed in different units (years of health vs. dollar amount). It is possible that the health and monetary rewards would be processed in the same manner if they were expressed using the same metric. For instance, the rewards in the money task could represent the years earning a certain salary to be consistent with the years spent in a certain health state (Chapman, 1996).

Furthermore, the tasks may be difficult to compare due to differences in the participant’s familiarity with the task. It is likely that the participants had many experiences with money in the past, but not with the health scenario. However, in patients with headaches and Crohn’s disease, Chapman, Nelson, and Hier (1999) found that time preferences for money were not correlated with time preferences for health, even when the participants were familiar with the health scenario. Therefore, the expression of rewards in a different metric and familiarity with the task might not be the best explanations for these findings.

A better explanation for the present results might be related to the finding that discounting rates tend to be higher for rewards of greater magnitude (Petry, 2003).

Previous studies have shown that health rewards are not discounted as highly as monetary rewards, suggesting that more value may be placed on health (Chapman, 1996; Petry, 2003). These findings were replicated in this study. Furthermore, it was discovered that there was not as much variance in the health discounting rates across participants, which may also possibly reflect the greater subjective value placed on health.

The second question posed at the beginning of this study was whether the participant's discounting rates were related to their activity levels. Again, it was hypothesized that the discounting rates from both the money reward and health reward tasks would be related to activity levels. It was also hypothesized that health rewards would have a stronger relationship, because health rewards are what can be expected from exercise adherence. The data from this investigation did not support these hypotheses, as the AUC values from both tasks were unrelated to activity levels.

This might be explained by the idea that future rewards may not be what individuals consider when they make the decision to exercise. Therefore, the way that individuals weigh future rewards in the discounting tasks might not transfer to the decision to exercise if individuals are motivated by other reasons, such as enjoyment. The majority of the participants in this study reported being motivated by factors other than health.

Despite the lack of support for these hypotheses, there was support for the hypothesis generated by the third research question. This question was whether working memory and discounting rates were predictive of physical activity levels. In each regression analysis that was performed to address this question, working



memory was a significant predictor of activity level in the form of MET-h/wk. In the models testing the entire sample, however, neither of the AUC values from the discounting tasks was statistically significant. The AUC from the money discounting task did approach statistical significance.

In contrast, there was significance in the models testing the participants who reported that their primary motivation to exercise was health. It would seem that the hypotheses proposed would be the most applicable to these individuals, because it is they who are considering the value of future health against the short-term, sedentary alternatives. This stands in contrast to the individuals who are weighing other factors (such as enjoyment, social benefits, weight control, stress relief, or competition) more heavily in their decision to exercise.

Despite the small size of the sample remaining after these participants were selected, the regression analyses performed on this sample detected statistical significance among predictors and displayed an extremely good fit to the data. Not only was working memory a statistically significant predictor of exercise rates, but so was the AUC value from the money reward discounting task. However, the discounting rates from the health reward discounting task was not a statistically significant predictor in the model. This is most likely due to the factors discussed above, such as the different type of cognitive processing that may be involved in this task.

Therefore, the hypotheses generated by the third research question were supported in the subsample of individuals who choose to exercise in order to affect

their future health. Working memory was a significant predictor of activity levels, as were the discounting rates from the money reward task.

The lack of support for the research hypotheses in the rest of the sample is most likely related to the complex nature of the decision to exercise. In contrast to the money reward discounting task, the decision to engage in physical activity may involve several different factors being taken into consideration such as enjoyment, amount of time available, current weather conditions, etc. However, it may be the complexity of this decision that is the factor leading to lower levels of exercise adherence. In particular, the complexity of this decision might have an influence on individuals with a lower working memory capacity, who choose the short-term sedentary alternatives because they cannot process all of the factors involved in the decision. This might explain why working memory was a consistent predictor of exercise rates, while the discounting rates were not.

The majority of the data collected for this study was designed to test the research hypotheses. However, there were some interesting relationships discovered in the rest of the data. For example, higher BMI were associated with reporting “lack of exercise partner(s)” as a barrier to exercise. It seems that not having someone to exercise with might be more detrimental to overweight individuals. In addition, the participants with high BMI’s were more likely to report that they exercise with a partner or group. This may suggest that overweight individuals are more comfortable exercising when they are not alone, and more likely to exercise when they have someone else to exercise with. Alternatively, it may suggest that the participants with high BMI’s are overweight because they lack the motivation necessary to engage in

regular physical activity without having another person with whom to feel accountable.

Another interesting relationship discovered in the correlational analysis was the correlation between marital status and exercise rates. In this sample, the married participants had lower exercise levels than the single participants. One possible explanation for this finding is that married people work more to support their children and/or their spouses, resulting in less time or energy to dedicate to physical activity.

Also of interest were the significant differences between the participants from different departments. The participants recruited from the physical education department had higher activity levels, lower BMI's, and more positive attitudes towards exercise than the participants recruited from the psychology department. This finding illustrates a methodological issue that may arise in any study of exercise habits. When using a convenience sample of college students, it would be wise to gather participants from a variety of different courses and departments. Many studies use only students from one department, but as can be seen in this study, the results from one group of students might not generalize well to the population of university students.

One last finding of interest was the lack of relationship between the BIS-11 and the discounting rates. The BIS-11 was included in order to contribute additional information about the participants with regard to impulsivity, and to replicate the findings of Hinson et al. (2003) where the BIS-11 was related to performance on a discounting task. The mean and standard deviation for the sample in this study were

64.2 and 9.95 for the BIS-11, which was fairly similar to the results obtained by Hinson et al. ( $M = 63.6$ ,  $SD = 10.63$ ).

Also similar to Hinson et al., the sample was divided into two groups based on extreme scores on the BIS-11. However, in contrast to previous findings, the groups did not differ with regard to discounting rates. This could be due to the differences in discounting procedures used. In Hinson et al., the magnitude of the immediate and delayed rewards were much higher than in the present study. The magnitude of the outcomes in a discounting procedure has been shown to have an impact on discounting rate (Petry, 2003). In addition, the experimenters in the Hinson et al. study included more than two alternatives in the discounting task, in order to increase the load on the participant's working memory. In contrast, participants were only given two alternatives in this study.

Despite finding some support for the hypotheses proposed in this study, the results should be interpreted with caution. The study had limitations such as a small sample size, as well as the generalizability issues that arise whenever volunteer or college student samples are used. Future research would be needed to examine if these results generalize to other populations, such as older adults or populations that use commercial gym facilities.

In addition, the design of interventions based on these results is premature based on the preliminary nature of this study. However, it seems that interventions targeting working memory limitations and focusing on commitment strategies to reduce discounting might be used with individuals that exercise for the long-term

outcome of health. Future research might focus on the design and implementation of such interventions in this population.

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APPENDICES

## APPENDIX A

## DEMOGRAPHIC QUESTIONNAIRE

Do not write your name on this form, as this questionnaire is anonymous. NO IDENTIFYING INFORMATION IS COLLECTED ON THIS FORM. Please be completely honest in your responses.

1. \_\_\_\_\_ Age

2. \_\_\_\_\_ Height (in ft and inches)

3. \_\_\_\_\_ Weight Estimate

4. Male   
Female

5. Are you in school?

Yes  
 No

If yes, what year are you?

\_\_\_\_\_

6. Marital Status

Single  
 Engaged  
 Married  
 Separated  
 Divorced  
 Widowed

7. Do you take vitamins?

Yes  
 No

8. How important is physical exercise to you?

Very important  
 Somewhat important  
 Neutral  
 Somewhat unimportant  
 Very unimportant

9. Number of children in your care:

\_\_\_\_\_

10. How often do you smoke cigarettes?

More than 20 times per day  
 Between 10 and 20 per day  
 Between 1 and 9 per day  
 A few times a week  
 A few times a month  
 A few times per year  
 Never

11. How often do you drink alcoholic beverages?

Every day  
 A few times per week  
 A few times per month  
 Once every six months  
 Once a year  
 Never

12. On the following scale, rate your perceived level of physical fitness.

Poor 1 2 3 4 5 6 Excellent

13. On the following scale, rate your satisfaction with your current level of physical fitness.

Unsatisfied 1 2 3 4 5 6 Completely satisfied

14. On the following scale, rate your level of agreement with the statement, "I find physical exercise to be enjoyable."

Disagree 1 2 3 4 5 6 Agree

15. Which of the following is (or would be) the biggest motivating factor in your decision to exercise? Rank the items, with 1 being the biggest motivating factor and 6 being the least.

- \_\_\_\_\_ weight control or appearance
- \_\_\_\_\_ overall health
- \_\_\_\_\_ stress relief
- \_\_\_\_\_ enjoyment
- \_\_\_\_\_ social benefits
- \_\_\_\_\_ competition

16. Which of the following is (or would be) the biggest factor in preventing you from exercising? Please rank the items, with 1 being the biggest barrier and 6 being the smallest.

- \_\_\_\_\_ lack of time
- \_\_\_\_\_ fatigue
- \_\_\_\_\_ lack of facilities
- \_\_\_\_\_ lack of knowledge about fitness
- \_\_\_\_\_ lack of willpower
- \_\_\_\_\_ no one to exercise with

17. How much do you exercise in comparison to your family's exercise history?

- much less
- a little less
- about the same
- a little more
- a lot more

18. Most often:

- I exercise alone
- I exercise with an exercise partner
- I exercise with a group of people
- Not Applicable → **I would prefer to:**

- Exercise alone
- Exercise with an exercise partner
- Exercise with a group of people

19. When I think about physical exercise (going to the gym, running, playing a sport to stay in shape, etc.) the FIRST thing(s) to come to mind:

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20. Do you ever have feelings of guilt if/when you do not exercise?

- Yes
- No

Please check to make sure you responded to every item. Thank you.

## APPENDIX B

## PHYSICAL ACTIVITY SCALE

In this section we would like to ask you about your current physical activity and exercise habits that you perform regularly, at least once a week. Please answer as accurately as possible. Circle your answer or supply a specific number when asked.

## EXERCISE/PHYSICAL ACTIVITY

1. For the last three months, which of the following moderate or vigorous activities have you performed regularly? (*Please circle YES for all that apply and NOT if you do not perform the activity; provide an estimate of the amount of activity for all marked YES. Be as complete as possible.*)

## Walking

NO YES → How many sessions per week? \_\_\_\_\_  
 How many miles (or fractions) per session? \_\_\_\_\_  
 Average duration per session? \_\_\_\_\_ (minutes)

What is your usual pace walking? (*Please circle one*)

Casual or strolling ( $< 2$ mph)	Average or normal (2 to 3 mph)	Fairly brisk (3 to 4 mph)	Brisk striding (4 mph or faster)
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## Stair Climbing

NO YES → How many flights of stairs do you climb UP each day? \_\_\_\_\_  
 (1 flight = 10 steps)

## Jogging or Running

NO YES → How many sessions per week? \_\_\_\_\_  
 How many miles (or fractions) per session? \_\_\_\_\_  
 Average duration per session? \_\_\_\_\_ (minutes)

## Treadmill

NO YES → How many sessions per week? \_\_\_\_\_  
 Average duration per session? \_\_\_\_\_ (minutes)  
 Speed? \_\_\_\_\_ (mph) Grade? \_\_\_\_\_ (%)

## Bicycling

NO YES → How many sessions per week? \_\_\_\_\_  
 How many miles per session? \_\_\_\_\_  
 Average duration per session? \_\_\_\_\_ (minutes)

## Swimming Laps

NO YES → How many sessions per week? \_\_\_\_\_  
 How many miles per session? \_\_\_\_\_

(880 yds = 0.5 miles)

Average duration per session? \_\_\_\_\_ (minutes)

## Aerobic Dance/Calisthenics/Floor Exercise

NO YES → How many sessions per week? \_\_\_\_\_

Average duration per session? \_\_\_\_\_ (minutes)

## Moderate Sports

(e.g. Leisure volleyball, golf (not riding),  
social dancing, doubles tennis)

NO YES → How many sessions per week? \_\_\_\_\_

Average duration per session? \_\_\_\_\_ (minutes)

## Vigorous Racquet Sports

(e.g. Racquetball, singles tennis)

NO YES → How many sessions per week? \_\_\_\_\_

Average duration per session? \_\_\_\_\_ (minutes)

## Vigorous Racquet Sports

or Exercise Involving

Running (e.g. Basketball, soccer)

NO YES → Please specify \_\_\_\_\_

How many sessions per week? \_\_\_\_\_

Average duration per session? \_\_\_\_\_ (minutes)

## Other Activities

NO YES → Please specify \_\_\_\_\_

How many sessions per week? \_\_\_\_\_

Average duration per session? \_\_\_\_\_ (minutes)

## Weight Training

(Machines, free weights)

NO YES → How many sessions per week? \_\_\_\_\_

Average duration per session? \_\_\_\_\_ (minutes)

## Household Activities (Sweeping, vacuuming,

washing clothes, scrubbing floors)

NO YES → How many hours per week? \_\_\_\_\_

## Lawn Work and Gardening

NO YES → How many hours per week? \_\_\_\_\_

2. How many times a week do you engage in vigorous physical activity long enough to work up a sweat? \_\_\_\_\_ times per week



## APPENDIX C

## BIS-11

Directions: People differ in the ways they act and think in different situations. This is a test to measure some of the ways in which you act and think. Read each statement and place a check in the appropriate box on the right side of the page. Do not spend too much time on any statement. Answer quickly and honestly.

Rarely/Never

Occasionally

Often

Almost always/  
Always

1.	I plan tasks carefully				
2.	I do things without thinking				
3.	I am happy-go-lucky				
4.	I have "racing" thoughts				
5.	I plan trips well ahead of time				
6.	I am self-controlled				
7.	I concentrate easily				
8.	I save regularly				
9.	I find it hard to sit still for long periods of time				
10.	I am a careful thinker				
11.	I plan for job security				
12.	I say things without thinking				
13.	I like to think about complex problems				
14.	I change jobs				
15.	I act "on impulse"				
16.	I get easily bored when solving thought problems				
17.	I have regular medical/dental checkups				
18.	I act on the spur of the moment				
19.	I am a steady thinker				
20.	I change where I live				
21.	I buy things on impulse				
22.	I finish what I start				
23.	I walk and move fast				
24.	I solve problems by trial-and-error				

25.	I spend or charge more than I earn				
26.	I talk fast				
27.	I have outside thoughts when thinking				
28.	I am more interested in the present than the future				
29.	I am restless at lectures or talks				
30.	I plan for the future				

## APPENDIX D

## Health Reward Discounting Task

Now	1 Year	Now	5 Years	Now	10 Years
Treatment A	Treatment B	Treatment A	Treatment B	Treatment A	Treatment B
1 Year	15 Years	1 Year	15 Years	1 Year	15 Years
4 Years	15 Years	4 Years	15 Years	4 Years	15 Years
8 Years	15 Years	8 Years	15 Years	8 Years	15 Years
12 Years	15 Years	12 Years	15 Years	12 Years	15 Years
15 Years	15 Years	15 Years	15 Years	15 Years	15 Years

Now	25 Years	Now	50 Years
Treatment A	Treatment B	Treatment A	Treatment B
1 Year	15 Years	1 Year	15 Years
4 Years	15 Years	4 Years	15 Years
8 Years	15 Years	8 Years	15 Years
12 Years	15 Years	12 Years	15 Years
15 Years	15 Years	15 Years	15 Years

