TIME PERCEPTION'S EFFECT ON INDIVIDUAL DIFFERENCES AND BEHAVIOR: THE MEDIATING ROLE OF IMPULSIVITY ON THE RELATIONSHIP BETWEEN TIME PERCEPTION AND INTERTEMPORAL HEALTH BEHAVIORS

by

JAMES R. DAUGHERTY

B.S., High Point University, 2005
M.S., Villanova University, 2007

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Psychology
College of Arts and Sciences

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2011

Abstract

This research tested a general mediation model which proposes that individual differences (e.g., impulsivity, delay discounting, and time orientation) mediate the relationship between time perception (one's subjective experience of the passage of time relative to actual time) and intertemporal behavior (decision-making involving tradeoffs between costs and rewards in both the present and the future). Study I did not find evidence to support the general mediation model and found that time perception was only weakly correlated with individual differences and intertemporal behavior ($\bar{r} = .06$). Study II found tentative support for the proposed mediation model: individual differences in impulsivity fully mediated the relationship between time perception and intertemporal behavior in 4 separate mediation models. Three additional mediation models met the assumptions of mediation, demonstrating indirect effects significantly different from zero, but did not fully mediate the relationship between time perception and intertemporal behavior. In general, the mediation models explored in Study II (both fully and partially mediated) suggest that self-report impulsivity mediates the relationship between time perception and intertemporal health behaviors, like hours of sleep slept per night, sociosexual orientation, and frequency of eating breakfast. The findings from Study II suggest that how time is perceived influences intertemporal behavior indirectly by influencing impulsivity. Guidelines to aid future research linking time perception to individual differences and intertemporal behavior are provided.

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Table of Contents

List of Figures

List of Tables

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Dedication

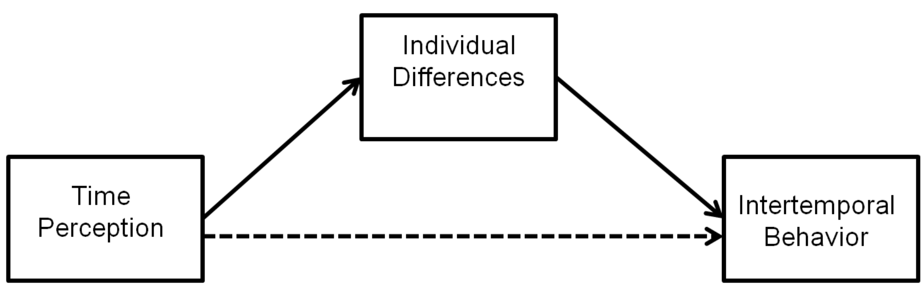
This work and the accompanying degree were only possible through the love and support of my wife, Kimberly. Thank you for keeping me focused on the important things in life. To Gwynevere, Noah, and any future additions to our family, may life bring you all the hyperopic time perception you need to reach your goals and dreams.

Preface

Behaviors performed now can influence events in the future. Diet and exercise, when implemented in the present, can ward off future difficulties with heart disease, diabetes, and obesity. Not spending money that can be saved or invested for a later day can help secure future financial freedom. Efforts to reduce, re-use, and recycle today, can prevent the necessity for new landfills and decrease demands for new natural resources. Unfortunately, people do not always act in ways that will benefit them later on. People smoke, drink excessively, have unprotected sex, overeat, use tanning beds, drive recklessly, gamble, overspend the money they have, spend money they don't have, underestimate future expenses, waste water, energy, and resources, buy new rather than used, and throw away recyclable materials. Although research has documented these myopic and present-oriented intertemporal behaviors, scarce research has tried to provide a theoretical framework to explain the origins of individual differences in these types of decisions.

The examples of present-minded intertemporal behavior listed above suggest a general predicament: many people struggle to act now, in the present, in ways which will benefit them in the future. The explanation for these and other myopic behavior is undoubtedly multifaceted – including social and cultural influences and other psychological mechanisms not discussed here. The research examined in this document focus on a potentially significant biological factor, within the brain, that gives rise to individual differences in how information is processed, when making decisions. Specifically, this research will explore whether or not an internal timing mechanism influences behavior by systematically biasing judgments of the passage of time. To illustrate, consider common adages which suggest that *a watched pot never boils* and *time flies when you are having fun*. Although these sayings suggest attention and arousal influence time perception, what if people are generally *pot watchers* and perceive time as moving slowly or *time fliers* and perceive time as moving fast? Might these differences in time perception predict other individual differences like delay discounting, impulsivity, and time orientation? Is it also possible that differences in time perception might correspond to differences in intertemporal behavior –decision-making regarding tradeoffs between the present and future? This research proposes that the functioning of interval timing does predict individual differences like those listed above and intertemporal behavior. Furthermore, as predicted, and demonstrated in a limited set of mediation models, the relationship between time perception and intertemporal behavior is mediated by individual differences (specifically impulsivity) as depicted in Figure 0.1.

Figure 0.1. General proposed mediation model.



Chapter 1 - Introduction

Time Perception

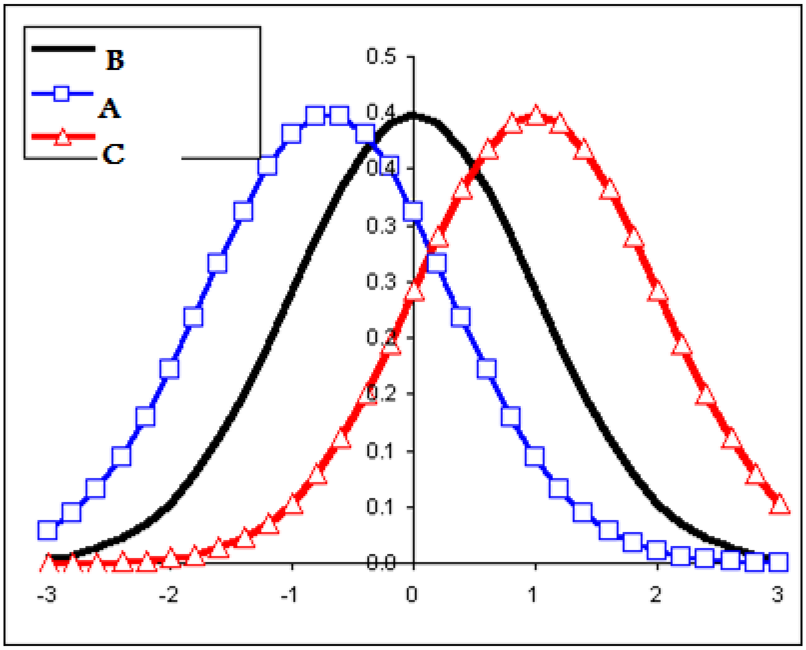
The passage of time is automatically encoded (Hasher & Zacks, 1979), and specialized mechanisms are used to process different intervals of time. Intervals of time spanning hours and days are controlled by circadian rhythms (Wittmann & Paulus, 2009). A second mechanism has been proposed to track shorter intervals of time from partial seconds to minutes (Gibbon & Allan, 1984), and a third class of timing mechanism is used to coordinate split-second intervals of time used for movement and balance (Shadmehr & Holcomb, 1997). Split-second timing used to coordinate movement occurs in lower brain regions and is unlikely to influence processes control by cortical areas like the frontal lobe. Circadian rhythms influence behavior (e.g., eating and sleeping) across large scales of time and perception of these long time intervals are proposed to influence decision-making (Wittmann & Paulus, 2009). Less research and attention, however, has been paid to how interval timing influences behavior. Unlike circadian rhythms, which measures passing time from external cues like the Sun and changing seasons, interval timing is controlled by internal mechanisms within the brain (Buhusi & Meck, 2005) and demonstrates important individual differences (Meck & Church an unpublished manuscript, cited by Church, 1984). It is proposed that individual differences in interval timing systematically vary with intertemporal behaviors (Wittmann & Paulus, 2008).

Scalar Expectancy Theory

A predominant theory within the interval timing literature is the *scalar expectancy theory* (Gibbon, Church, & Meck, 1984). Scalar expectancy theory proposes, like several models before it (Creelman, 1962; Treisman, 1963), that intervals of time from partial seconds to minutes are processed by an internal clock with several distinct components. The first component is a pacemaker that emits pulses, which are counted by a second component that is an accumulator. Quantities of pulses collected in the accumulator are stored in reference memory. Decisions regarding the passage of time are made by comparing the quantity of gathered pulses in the accumulator to reference memory for similar quantities of pulses.

Scalar expectancy theory is supported by animal performance on time perception tasks, and evidence suggests parallels between animal and human timing mechanisms (e.g., Penney, Gibbon, & Meck, 2008; Rakitin, Gibbon, Penney, Malapani, Hinton, & Meck, 1998). A task relevant to interval timing and scalar expectancy theory is the peak interval procedure (Roberts, 1981). In this procedure, animals (commonly rats or pigeons) are reinforced (with food or water) for the first response (lever press or peck) after a set interval of exposure to a conditioned stimulus (continuous light or tone). On test trials, the conditioned stimulus remains on and responses are not reinforced. On test trials, animals respond in anticipation of the reinforcement around the expected time of reinforcement (Gibbon et al., 1984). The rate of response gradually increases as the reinforcement interval approaches. Responses *peak* (are at the highest rate) at the expected time of reinforcement and steadily decrease as time past the point of reinforcement elapses. The observation that peak response rates correspond closely to the interval of time at which reinforcement occurs suggests that animals are able to make fairly accurate judgments of the passage of time.

Figure 1.1. Theoretical response distributions for accurate time perception (center, B), myopic time perception (left, A), and hyperopic time perception (right, C).



Despite general accuracy in timing, individual differences in peak timing have been observed (Meck & Church an unpublished manuscript, cited by Church, 1984). These individual differences in peak timing demonstrate that some animals behave as if expecting reinforcement either slightly earlier or later than scheduled. These shifts in peak response are diagrammed in Figure 1.1. This observation suggests that, despite reinforcement at a specific time, perception of the passage of time is variable and subjective. It is predicted that individual differences in the perception of time –like those observed in the peak interval procedure— influence individual differences and intertemporal behavior. Rats responding earlier than the period of reinforcement perceive that more time has passed than has actually passed (i.e., distribution A in Figure 1.1). This suggests impatient perception of time (*pot watchers*). Events in the future, like reinforcement, arrive later than expected. This tendency to perceive actual time as moving slowly is proposed to result in more myopic, or shortsighted, intertemporal choice. In other words, the future is perceived to be further away than reality/actuality; thus smaller, immediate rewards are expected to be more desirable than larger, delayed rewards.

Rats responding later than the period of reinforcement perceive that less time has passed than has actually passed (i.e., distribution C in Figure 1.1). Events in the future arrive earlier than expected (*time fliers*). This tendency to perceive actual time as moving fast is proposed to result in more hyperopic, or farsighted, intertemporal choice. In other words, the future is perceived to be closer than reality/actuality; thus waiting for larger, future rewards is easier for these individual than for myopic time perceivers.

To clarify discussions of time perception in this document, a common vernacular will be adopted. When referring to perceptions of time flowing more slowly than actual time (e.g., distribution A in Figure 1.1, *pot watchers*), the terms shortsighted or myopic time perception or interval timing will be used. When referring to perceptions of time flowing faster than actual time (e.g., distribution C in Figure 1.1, *time fliers*), the terms farsighted or hyperopic time perception or interval timing will be used.

Sources of Variance in Scalar Expectancy Theory

Gibbon et al.'s (1984) scalar expectancy theory accounts for myopic and hyperopic time perception by acknowledging several sources of variance within the internal timing mechanism. For instance, data suggest that variance exists in the pacemaker. Specifically, research has found that arousal influences pacemaker rate (for a review see, Block & Zakay, 2008). Further, Gibbon et al. propose that while the speed of emitted pulses may change from pulse to pulse, across time a reliable rate and standard deviation of pulses emerges. Theoretically, using a timing model without feedback, variations in pacemaker rate could account for myopic and hyperopic time perception; however, this is not a tenable explanation as feedback is generally accessible and stored in reference memory. For animals, feedback is provided in the form of reinforcement. For humans, feedback is acquired through met or unmet expectations (e.g., the bus should be here already) and through clocks and other timing devices.

Another source of variance within the internal timing mechanism is the switch that opens and closes (or starts and stops) pulses from gathering in the accumulator. The switch is believed to be influenced by attention (Block & Zakay, 2008). Because the same switch mechanism is proposed to be responsible for both opening and closing the accumulator, variation in operating speed for these two mechanisms cancel each other out. In other words, across trials any error in the switch opening and closing should result in no systematic bias on the number of pulses accumulated (Gibbon et al., 1984).

A third identified source of variance within the internal timing mechanism is reference memory. Accumulated amounts of pulses are compared to reference memory for past instances where similar amounts of pulses were experienced. Meck (1983) demonstrates that the process of storing reference memories, and not retrieval of reference memories, can lead to systematic errors in the judgment of time. Scalar expectancy theory accounts for systematic errors in reference memory by incorporating a memory constant (K^*) which shifts peak response distributions either right or left (as depicted in Figure 1.1). These shifts correspond to later (hyperopic) and earlier (myopic) responding, respectively. Shifts in peak response are made by multiplying all responses in a distribution by K^*. A K^* value equaling one suggests that a response distribution is centered over the correct reinforcement value (hence, no adjustment is necessary, e.g., distribution B in Figure 1.1). Values of $K^* < 1$ (myopic perception) shift the response distributions left (i.e., from distribution B to distribution A in Figure 1.1). Values of K^*

> 1 (hyperopic perception) shift response distributions right (i.e., from distribution B to distribution C in **Error! Reference source not found.**).

External Sources of Variance in Time Perception

Past research demonstrates that time perception is influenced by arousal (Burle & Casini, 2001; Loehlin, 1959; Zakay & Block, 1997), attention (Brown & Boltz, 2002; Macar, Grondin, & Casini, 1994; Pouthas & Perbal, 2004), diet (Roberts, 1981), body temperature (Campbell & Birnbaum, 1994; Wearden & Penton-Voak, 1995), stimulant-use (Wittmann, Leland, Churan, & Paulus, 2007), and external flashing or pulsing stimuli (Treisman & Brodan, 1992, Treisman, Faulkner, Naish, Brogan, 1990, Wearden, Philpott, & Win, 1999). The myriad ways time perception has been shown to be variable has likely limited research seeking to examine timing as an individual difference. This current research is an initial step to fill this void.

A relatively smaller body of research suggests that time perception is consistent across trials (Bakan & Kleba, 1957; Danziger & DuPreez, 1963; McConchie & Rutschmann, 1970; Siegman, 1962) and across periods of time ranging from days to weeks (McCauley, Kennedy, & Bittner, 1980; Kruup, 1961). Practicing time perception tasks over several days also appears to improve test-retest reliability estimates (McCauley et al., 1980). Counting also improves the reliability of time perception (Kruup, 1961) and decreases variability (Hinton & Rao, 2004); however, researchers argue that counting should be minimized to isolate the natural functioning of the internal clock (Buhusi & Meck, 2005; Wittmann & Paulus, 2008). This research suggests that individual differences in time perception can be measured reliably.

Time Perception and Behavior

Past Literature

Interest in time perception as a predictor of behavior has a long history in psychology (for a review see Wallace & Rabin, 1960). Differences in time perception have been demonstrated across several mental disorders. Depressed individuals experience hyperopic time perception, while manic individuals experience myopic time perception (Bschor, Ising, Bauer, Lewitzkal, Skerstupeit, Müller-Oerlinghausen et al., 2004; Mahlberg, Kienast, Bschor, & Adli, 2008). Schizophrenics (Densen, 1977; Orme, 1962; Rabin, 1957) and individuals with attention deficit hyperactivity disorder (ADHD; Barkley, Murphy, & Bush, 2001; Smith, Taylor, Warner Rogers, Newman, & Rubia, 2002) both experience myopic time perception. Individuals with behavioral problems also demonstrate altered perceptions of time. For instance, pathological gamblers (Goudriaan, Oosterlaan, de Beurs, & van den Brink, 2006), drug and alcohol abusers (Goudriaan et al., 2006; Solowij, Stephens, Roffman, Babor, Kadden, Miller et al., 2002; Wittmann et al., 2007), and individuals who have been convicted of crimes (Carroll, Hemingway, Bower, Ashman, Houghton, & Durkin, 2006; Partridge & Fox, 2000; Siegman, 1961) are more likely to be myopic time perceivers than hyperopic time perceivers.

Combined, this past research suggests a bidirectional causal relationship between behavior and time perception. Altered perception of time accompanying mental disorders suggests that altered neurological functioning disrupts the perceived passage of time. Likewise, behavioral disorders, like substance abuse, gambling, and antisocial behavior, are also associated with disrupted perception of time. Although the majority of the aforementioned research focuses on the impact of mental illness and behavior on time perception, this current proposal is interested in determining how time perception manifests itself in normal everyday behavior, especially with intertemporal decision-making, or choices involving tradeoffs between the present and future.

At this point, only indirect evidence suggests that time perception predicts intertemporal behavior. Future intervals of time are not perceived linearly, but rather logarithmically (Zauberman, Kim, Malkoc, & Bettman, 2009), and as delays become larger, intertemporal behavior becomes more myopic (Killeen, 2009). Kim and Zauberman (2009) report that individual differences in the perception of future time intervals influence intertemporal behavior. Specifically, the perceived length of a delay and sensitivity to different delay lengths are both important determinants of intertemporal behavior. This research suggests that perceiving future time intervals as longer results in more myopic or present-minded decision-making (i.e., rewards now, not later). Conversely, perceiving future time intervals as shorter results in more hyperopic or future-minded decision-making (i.e., a willingness to wait for later rewards). This research concluded that time perception, specifically prospective time perception, influences intertemporal behavior. It is currently unknown whether or not prospective time perception is related to, or influenced by, interval timing. This current research proposes that interval timing does influence perceptions of delays.

Current Predictions

A current gap in the interval timing literature is whether interval timing tasks predict behaviors. As mentioned before, the myriad ways time perception performance has been shown to be malleable has likely limited the perceived stability of time perception as an individual difference and mitigated the amount of research dedicated to understanding the impact of this variable on behavior. Of specific interest in this current research is intertemporal behavior, or decision-making that involves tradeoffs between the present and future. Several domains of intertemporal choice exist, but this study focused on only three: health behaviors, environmentalism, and financial planning. These intertemporal domains were selected because each deals with future costs/benefits that are generally realized in the distant future (i.e., several or many years later). For example, environmentalism –like recycling-- involves immediate costs of time and effort for future benefits that may not be fully realized within one's lifespan (see Sumaila & Walters, 2005 for a discussion of intergenerational discounting).

This study proposes that individual differences in interval timing affect the perceived value of delayed costs and rewards and thus influence intertemporal behavior. More specifically, because myopic time perceivers experience time as moving slowly, future rewards are perceived to be temporally far away. Hyperopic time perceivers experience time as moving quickly, thus future rewards are perceived to be temporally close at hand. In essence, interval timing creates expectations for when rewards will be received. Myopic time perception involves misremembering past events (and responding early) which creates expectations that future rewards will occur later than (after) they are expected to occur. Hyperopic time perception involves misremembering past events (and responding late) which creates expectations that future rewards will occur sooner than (before) they are expected to occur.

As a general principle, humans (and animals) are not willing to wait for what they can enjoy in the moment. For instance, given the choice between $25 today or $25 tomorrow, most people choose the immediate payout. In this example, there is no additional incentive for waiting until tomorrow to receive what can be had today. With intertemporal behaviors, future incentives are able to outweigh immediate incentives. Eating a salad instead of a hamburger for lunch contributes to a slimmer waistline in the future. Taking time to recycle aluminum cans today contributes to a cleaner environment in the future. Putting aside money for future expenses today makes those funds available in the future – for retirement or to purchase a home, vehicle, or vacation.

So how might time perception influence intertemporal behavior? Research suggests that despite relative accuracy in time perception when aggregating across individuals, individual accuracy varies (Meck, 1983). This paper proposes that intertemporal behaviors systematically vary with individual differences in interval timing. Specifically, myopic interval timers are predicted to engage in less future-minded intertemporal behaviors. In essence, for myopic interval timers, waiting for future rewards/benefits is harder because the future arrives later than expected. In contrast, hyperopic interval timers are predicted to engage in more future-benefiting intertemporal behaviors. For hyperopic interval timers, waiting for future benefits is easier because future rewards/benefits arrive earlier than expected.

Time Perception and Individual Differences

Another area of research that has received limited attention is the relationship between time perception and other individual difference measures. Currently, little is known on whether time perception influences consistent patterns of behaving and thinking (i.e., personality). Research does suggest, however, that brain areas associated with interval timing are dispersed throughout the brain, and interval timing is a result of coordinated neural activity across these areas (Buhusi & Meck, 2005). A brain area active during interval timing is the prefrontal cortex (Lewis & Miall, 2003). The prefrontal cortex is also vital to other cognitive systems, such as, performance-based and self-report impulsivity (Horn, Dolan, Elliot, Deakin, & Woodruff, 2003) and decision-making (Shamosh, DeYoung, Green, Reis, Johnson, Conway et al., 2008). This indirect evidence may suggest that brain areas responsible for interval timing also influence, or are related to, other individual differences besides impulsivity, like delay discounting and time orientation. Next, each of these individual difference variables will be discussed in turn and an argument for why these variables should be related to time perception will be provided.

Delay Discounting

Delay discounting is the expectation that waiting to receive a reward will be offset by additional rewards. For example, when deciding whether or not to forgo dessert, one weighs immediate benefits of eating the dessert against the future benefits of not eating the dessert. Choosing to eat the dessert implies that the immediate benefits outweigh the delayed or future benefits. Likewise, choosing to forgo the dessert suggests that the future benefits outweigh the immediate benefits.

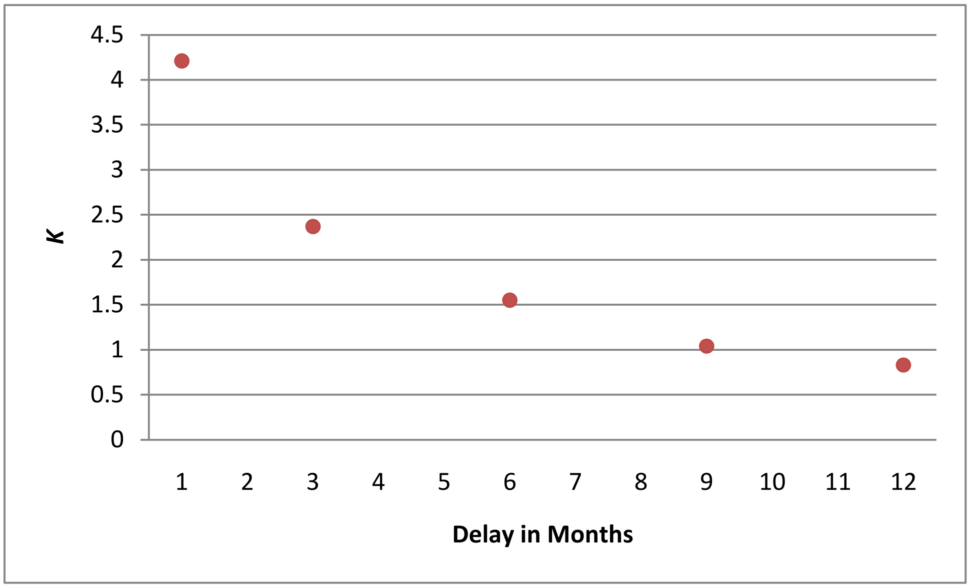
One common delay discounting paradigm asks people to make decisions between different pay-offs experienced at different delays. One example is: which would you rather have, $50 today or $55 tomorrow. In this decision situation, the individual can either choose the smaller, immediate reward ($50) or the delayed, larger reward ($55). Individual differences in response to this and similar questions are commonly observed, showing that individuals vary in their thresholds for future rewards. Individuals requiring more future incentive to offset immediate gratification are known as steep discounters, because the value of future incentives is discounted or depreciates quickly. For example, a steep discounter would prefer $50 today over $55 tomorrow. Individuals requiring less future incentive to offset immediate gratification are known as shallow discounters, because the value of future incentives is discounted or depreciates slowly. For example, shallow discounters prefer $55 tomorrow over $50 today.

Using responses across a series of delay discounting choices, a discounting parameter can be estimated by examining when preferences switch between immediate and delayed choices. This essentially establishes a discounting threshold estimate. Using an open ended approach (e.g., I would have to receive an extra $_______ to wait a year to receive a $100), a discounting parameter can be calculated for different intervals of time. Derived from Mazur (1987), the discounting parameter, *k*, equals:

$$k = \frac{|V_i - V_d|}{DV_d}$$

where V_i equals the immediate reward value, V_d equals the delayed reward value, and *D* equals the delay in years. As shown in Figure 1.2, and consistent with other research (Killeen, 2009), this discount function is hyperbolic and suggests that increasing the delay until a future incentive is received results in a disproportionately large increase in the value expected for the future incentive (Killeen, 2009). This means that people expect proportionally less compensation for waiting brief periods than for long periods of time. Or, put another way, the proportion of future incentive needed to wait one week is smaller than the proportion of future incentive needed to wait one year (see Figure 1.2).

Figure 1.2. Logarithmic discounting function (*k*) for $100 using within subjects data from Kansas State University undergraduates (*N* = 131).



Delay discounting paradigms ask people to weight choices by perception of time. Generally, perceiving a greater amount of time until a future reward is received leads to steeper discounting of the future (i.e., myopic decision-making; Kim & Zauberman, 2009). This process parallels the predictions made regarding time perception: As interval timing becomes more myopic, people will behave in ways which demonstrate less farsightedness. Given this connection between time perception and delay discounting, it is predicted that steeper discounting rates will be positively associated with greater myopic interval timing. Individuals who view passing time as moving slowly may also view prospective intervals of time as long, and thus report steeper discounting. Although research has not previously tested the relationship between delay discounting and time perception for actually experienced intervals of time, past research does suggest parallels between delay discounting and prospective time perception (Kim & Zauberman, 2009).

Research has established links between delay discounting and intertemporal behavior. For instance, Daugherty and Brase (2010) found that steeper discounters were more likely to engage in myopic health behaviors like tobacco use, alcohol use, and sexual risk-taking. Shallow discounting also positively predicted hyperopic intertemporal behavior like breakfast eating, wearing a safety belt, and sunscreen use. Unpublished, preliminary data also suggests that delay discounting is positively correlated with environmentalism behaviors like recycling and pro-environmental advocacy. The exact relationship between delay discounting and financial planning is currently unknown, but given that both of these variables relate to the functional use of money, it is likely that they will also show significant correlations with each other. Research suggests that smokers, alcoholics, and drug addicts, all of which demonstrate general tendencies for myopic time perception, also demonstrate steeper discounting rates (Baker, Johnson, &

Bickel, 2003; Kirby & Petry, 2004; Kirby, Petry, & Bickel, 1999; Petry, 2001; Petry, 2003; Vuchinich & Simpson, 1998). Schizophrenics (Heerey, Robinson, McMahon, & Gold, 2007), individuals with ADHD (Barkley, Edwards, Laneri, Fletcher, & Metevia, 2001), and pathological gamblers (Petry, 2001) also demonstrate similar patterns of myopic time perception and steep discounting. Despite conceptual overlap between time perception and delay discounting, research has not explored the relationship these two variables share with intertemporal behavior.

Impulsivity

Impulsivity is a multifaceted construct that encompasses urgency, lack of perseverance and premeditation, and sensation seeking (Whiteside & Lynam, 2001) and involves thinking and acting with little consideration for future outcomes (Reynolds, Ortengren, Richards, & de Wit, 2006). Impulsivity is conceptually related to extraversion (Costa & McCrae, 1995), and although considerable research has attempted to determine the relationship between time perception and extraversion (for a review, see Rammsayer, 1997, 2002), relatively little research has explored time perception and impulsivity.

Self-reported impulsivity is related to time perception (Barratt & Patton, 1983; Berlin, Rolls, & Kischka, 2004; Glicksohn, Leshem, & Aharoni, 2006; Keilp, Sackeim, & Mann, 2005; for an exception see Lenning & Burns, 1998). Using short time intervals to assess time perception, however, appears to mitigate the relationship between time perception and impulsivity (Barratt, 1981; Gerbing, Ahadi, & Patton, 1987; van den Broek, Bradshaw, & Szabadi, 1992), thus suggesting for intervals less than 10 to 15 seconds, individual differences in impulsivity are not differentiated in time perception. This past research suggests that myopic time perception is positively correlated with impulsivity. These results suggest that a general tendency or inability to wait may underlie both of these concepts.

An additional consideration is that because impulsivity is multifaceted, only certain facets of impulsivity may be related to time perception. For instance, Keilp et al. (2005) found that only self-reported cognitive impulsivity, and neither self-reported motor impulsiveness nor non-planning impulsiveness, was significantly correlated with time production. Bachorowski and Newman (1985) found that time estimation was significantly correlated with a performance-based measure of impulsivity (a line tracing task), but not self-report measure of impulsivity. Glicksohn et al. (2006) found opposite results: time reproduction was significantly correlated with two self-report measures of impulsivity and venturesomeness (*BIS*; Patton, Stanford, & Barratt, 1995; I_7; Eysenck, Pearson, Easting, & Allsopp, 1985), but not three performance-based measures of impulsivity. Although this research will focus on self-report measures of impulsivity, time perception does not appear to show a consistent pattern of relationships across impulsivity measures. Despite this, for this study, it is predicted that myopic interval timing will be positively related to impulsivity.

Time Orientation

Time orientation is the tendency to focus on temporal information related to the past, present, and/or future (Lasane & O'Donnell, 2005). Past time orientation is not expected to predict time perception and will not be discussed further. Given that time perception deals with the passage of time, present and future time orientation should predict time perception. Being present-minded (i.e., present time orientation) suggests a focus on the immediate events and actions occurring with an individual. Present-mindedness has been conceptualized as hedonism (pleasure seeking) and fatalism (belief that events are out of one's control) (Boyd & Zimbardo, 2005). These conceptualizations of present time orientation distinguish between different motivations for why people “live in the moment.” Future-mindedness has been conceptualized as the opposite of present-mindedness by some researchers (Strathman, Gleicher, Boninger, & Edwards, 1994), while others maintain that present-mindedness and future-mindedness are independent constructs and people can be low or high in either or both dimensions (Zimbardo & Boyd, 1999). Regardless of this distinction, both orientations should relate to time perception. Viewing the future as a far distance away (myopic interval timing) may lead individuals to focus on immediate situations and actions, with little regard for the future. Conversely, viewing the future as closely approaching (hyperopic interval timing) may allow individuals to focus more easily on time periods distant from the present.

Several authors argue that individual differences in interval timing might influence how time is processed and interpreted (Fraisse, 1984; Wallace & Rabin, 1960), however, few studies have been conducted to support the predicted relationship between time perception and time orientation. Siegman (1961) found that hyperopic interval timing was significantly related to greater future-mindedness, with both delinquent and control populations. This finding has been replicated with college students (Geiwitz, 1965; Zurcher, Willis, Ikard, & Dohme, 1967). In the last 40 years, not much additional research has been performed. Indirect evidence for the relationship between interval timing and time orientation is suggested by populations which demonstrate –across studies– myopic views of time, steep delay discounting, and also more present-mindedness. For instance, schizophrenics (Dilling & Rabin, 1967; Wallace, 1956), psychiatric outpatients (Braley & Freed, 1971), depression patients (Dilling & Rabin, 1967; Breier-Williford & Bramlett, 1995), individuals with ADHD (Myers, 2004), delinquents (Barndt & Johnson, 1955; Davids & Falkof, 1975; Landau, 1976; Trommsdroff & Lamm, 1980), pathological gamblers (Petry, 2001; Hodgins & Engel, 2002), substance abusers (Hulbert & Lens, 1988; Keough, Zimbardo, & Boyd, 1999; MacKillop, Mattson, Anderson MacKillop, Castelda, & Donovick, 2007; Petry, 2001; Robbins & Bryan, 2004), and smokers (Adams, 2009a,b; Jones, Landes, Yi, & Bickel, 2009) all demonstrate limited future-mindedness.

Time orientation also predicts intertemporal behavior. Daugherty and Brase (2010) found that time orientation predicted a host of health behaviors, such as, tobacco and alcohol use, exercise, eating breakfast, wearing a safety belt or helmet, sexual risk taking, and sunscreen use. For each of these variables, future time orientation was positively associated with positive health behaviors (e.g., wearing sunscreen, exercise) and negatively associated with health risks (e.g., tobacco and alcohol use, sexual risk taking). Present time orientation demonstrated the reverse pattern –negative associations with positive health behaviors and positive associations with negative health behaviors. Unpublished data suggests that future time orientation is positively associated with engaging in environmental behaviors. The relationship between time orientation and financial planning has not been previously explored, but will be examined in the following studies.

Summary and Review

Time perception is proposed to systematically influence individual differences and intertemporal behavior. Specifically, this study proposes that reference memory, for intervals of time actually experienced, distorts the interpretation of prospective time intervals. This leads people to misremember future intervals of time as being longer or shorter than reality, further leading to behaviors which are present or future focused. More severe myopic interval timers are predicted to engage in less future-minded intertemporal behavior, discount the future more steeply, report higher impulsivity, more present-mindedness, and less future-mindedness.

Conversely, more severe hyperopic interval timers are predicted to engage in more future-minded intertemporal behavior, discount the future less steeply, report lower impulsivity and present-mindedness, and more future-mindedness.

A general mediation model is proposed to explain the relationships between time perception, individual differences, and intertemporal behavior. Specifically, it is proposed that individual differences mediate the relationship between time perception and intertemporal behavior (see Figure 1.1). Indirect support for this mediation model originates from brain imaging studies which suggest that a similar brain structure, the prefrontal cortex, is activated for each variable in the model, and more generally for decision-making regarding behavioral control (e.g., Horn et al., 2003; Lewis & Miall, 2003; Shamosh et al., 2008). Indirect support for this mediation model also arises from research showing that populations with mental illness, addiction(s), and past criminal behavior demonstrate altered time perception, present-minded intertemporal behavior, impulsivity, and present-minded time orientation. More direct support for this mediation model originates from past research linking individual differences with intertemporal behavior (e.g., Adams & Nettle, 2009; Daugherty & Brase, 2010) and research linking time perception and other individual differences (e.g., Barrett & Patton, 1983; Siegman, 1961). Research has not clearly documented relationships between time perception and delay discounting, nor between time perception and intertemporal behaviors. This current study will fill gaps in the existing literature on time perception and test the general mediation model depicted in Figure 1.1.

Predictions

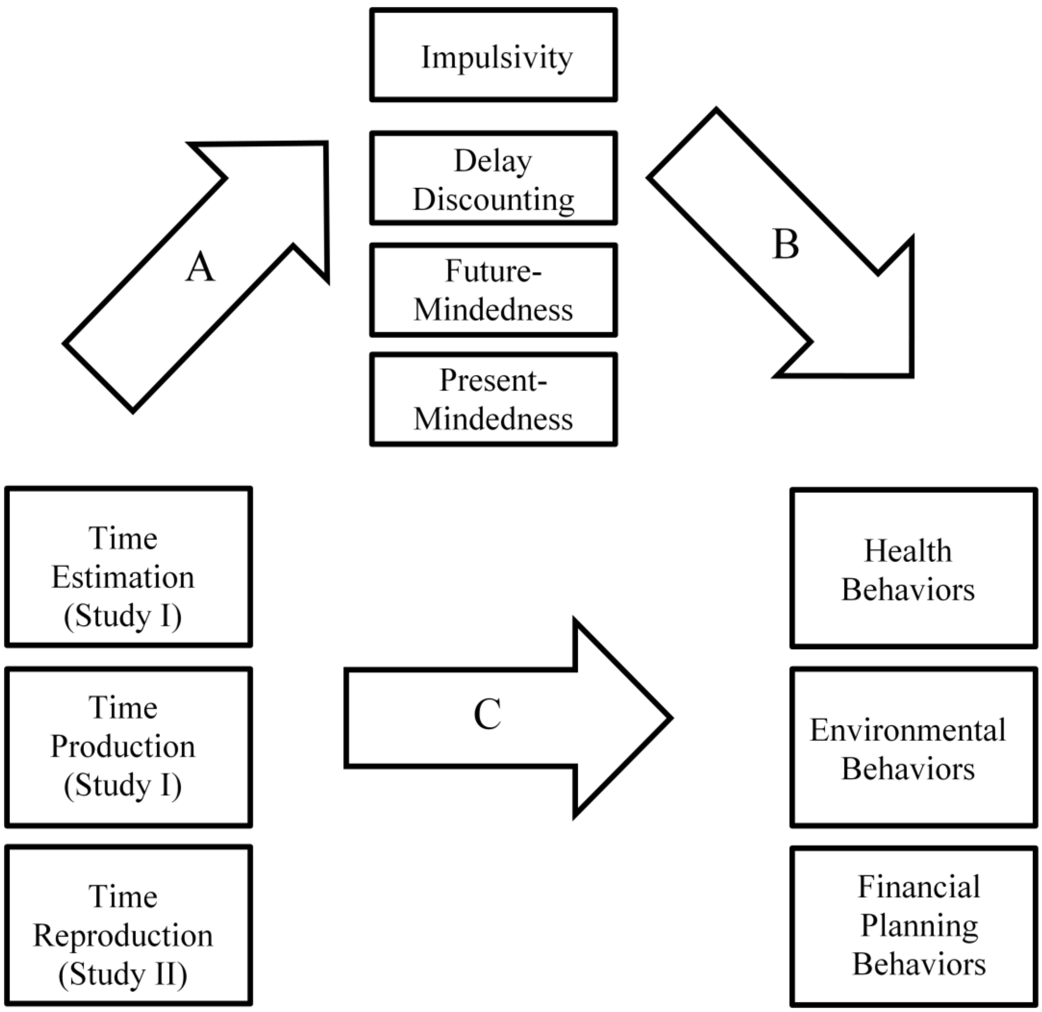
The mediation model depicted in Figure 1.1 makes general predictions regarding the expected relationships between time perception, individual differences, and intertemporal behavior (see Figure 1.3 for an expanded depiction of the general mediation model). These predictions are labeled hypotheses 1-4 and correspond to Baron and Kenny's (1986) requirements for mediation.

Hypothesis 1: Time perception will significantly predict intertemporal behavior. The direction of the relationship between these two variables is such that more myopic time perception will be positively correlated with greater engagement in present-minded intertemporal behavior (i.e., path *C* in Figure 1.3).

Hypothesis 2: Individual differences, including delay discounting, impulsivity, and time orientation will each significantly predict intertemporal behavior. Discounting the future will be negatively associated with future-minded intertemporal behavior. Impulsivity will be negatively correlated with intertemporal behavior, such that, individuals with higher levels of impulsivity will demonstrate less future-minded intertemporal behavior. Future time orientation will demonstrate a positive association with future-minded intertemporal behavior and present time orientation will demonstrate a negative association with future-minded intertemporal behavior (i.e., path *B* in Figure 1.3).

Hypothesis 3: Time perception will significantly predict individual differences. Increases in myopic time perception will be positively correlated with impulsivity and present time orientation. Increases in myopic time perception will be negatively associated with delay discounting and future time orientation (i.e., path *A* in Figure 1.3).

Figure 1.3. Expanded diagram of proposed mediation model with components comprising the independent variable (time perception, column of boxes on left), mediator (individual differences, column on boxes in center), and dependent variable (intertemporal behaviors, column of boxes on right) identified.



Chapter 2 - Study 1

Method

Participants

This study utilized 226 undergraduate research participants recruited from General Psychology classes at Kansas State University. Research participants were compensated for their time and effort with partial credit toward a research course requirement. A majority of the sample were college freshman (72%), on average 18.85 (*SD* = 1.65) years old, and comprised of 55.8% women (*n* = 126). Eighty-one percent (*n* = 183) self identified as Caucasian, 8% (*n* = 17) as African American, 5% (*n* = 11) Asian/Pacific Islander, 5% Hispanic, 2% (*n* = 4) other or mixed ethnic origin.

Measures

Time Perception

Two different tasks, time estimation and time production, were employed to measure time perception, or the perceived experience of time relative to actual passing time. These two tasks were selected to maximize variance (Block, 1989; Fraisse, 1963; Zakay, 1990) which is desirable when examining individual differences. These two tasks negatively correlate with each other (Davidson & House, 1982; Fraisse, 1978) and the primary difference between the two tasks is that the former relies more on motor functioning when responding whereas the later relies more on verbal functioning to respond (Bindra & Waksberg, 1956; Wallace & Rabin, 1960). Participants were given one practice trial with each type of task. The interval for both practice trials was ten seconds. No feedback was given on either practice trial nor any time perception trial in the study.

To minimize the impact of counting on time perception, as suggested by Buhusi and Meck (2005) and Wittmann and Paulus (2008), participants were shown a three-digit number for 8 seconds (Berlin & Rolls, 2004; Rakitin et al., 1998) prior to the beginning of each time perception trial. The three-digit numbers were generated randomly and only numbers without repeating digits were used in the study (e.g., 817). Participants were instructed to *hold this number in your memory* while performing the time perception tasks. After each time perception trial, participants were asked to type out the to-be-remembered number. The decision to use three-digit numbers, and not longer or shorter digit numbers, was based on pilot testing of a convenience sample. Three-digit numbers were selected for this study for several reasons: (a) The number of to-be-remembered digits was deliberately set low to make the task accessible to all ability levels. (b) At the same time, adding a concurrent memory task makes the time perception tasks sufficiently difficult (i.e., possible, yet challenging) for college-aged participants. This addition to the concurrent task requires more engagement in the task, hopefully reducing boredom and fatigue. (c) A three-digit number should not completely fill working memory (Miller, 1956), thus allowing spare cognitive energy to be devoted to the time perception task. Increasing the number of to-be-remembered digits hindered task performance during the pilot testing.

Before the beginning of each time perception trial, participants were instructed to take a break if needed. Participants were also told which type of time perception task they would be performing next. Once participants signaled they were ready (with a mouse click), a three-digit number appeared for 8 seconds. After a one second delay, the participant started either a time production or time estimation trial.

On time production trials, an interval of time was given and the participant produced the given duration. For instance, in the practice trial, participants were asked to produce an interval of time lasting 10 seconds. In this type of time production trial, the person pushed a start button, waited until he or she believed 10 seconds has elapsed, and then pushed the same button again to stop the trial. Immediately after clicking the stop button, the participant was prompted to type in the three-digit number shown to them before the start of the trial. The intervals that were produced are: 7, 11, 14, 19, 21, 22, 25, 29, 30, 32, 40, and 60 seconds.

On time estimation trials, an interval of time was experienced by the participant and then an estimation of the interval was generated. For instance, in the practice trial, participants viewed a three-digit number for eight seconds, followed by the presentation of a 5 by 5 cm black square that remained visible for 10 seconds. After a one second pause, the participant was prompted to estimate how long the black square was visible, by typing out a response. After typing the estimated duration, the participant was prompted to type in the three-digit number shown at the beginning of the trial. The intervals that were estimated are: 6, 9, 15, 18, 20, 23, 24, 27, 28, 31, 44, and 60 seconds.

The type of trial (production or estimation) and the interval within each trial was individually randomized for each participant. Time perception was measured in two blocks. In each block, each time production and time estimation interval was completed once. Each participant thus experienced each interval twice, once in the first block at the beginning of the research session and again during the second block at the end of the session. The repetition used in this study was deliberate. By measuring timing perception in two blocks, the general reliability of time perception can be assessed (i.e., within blocks, within time perception tasks, across blocks, and across time perception tasks).

Impulsivity

Impulsivity was measured using the *UPPS Impulsive Behavior Scale* (Whiteside & Lynam, 2001). This 45-item scale was generated from factor analysis of nine pre-existing impulsivity scales. Whiteside and Lynam (2001) determined a four-factor structure for impulsivity, which includes the following facets: Factor 1: *(lack of) Premeditation*. This factor measures the degree to which forethought, careful thinking, and planning are used in place of immediate action. A sample item from this factor is: "I like to stop and think things over before I do them." Lower scores on this factor reflect higher impulsivity. Factor 2: *Urgency*. This factor represents a lack of foresight and planning that stems from negative emotional states. A sample item from this factor is: "When I am upset I often act without thinking." Factor 3: *Sensation Seeking*. This factor represents the tendency to seek out novel, adventurous, and stimulating situations or experiences. A sample item from this factor is: "I generally seek new and exciting experiences and sensations." Factor 4: *(lack of) Perseverance*. The factor measures the degree to which an individual is capable of sticking with a task until it is completed. A sample item is: "I generally like to see things through to the end." Like Factor 1, lower scores on this scale reflect higher impulsivity. The UPPS Impulsive Behavior Scale is internally consistent, and research has confirmed the four-factor structure and demonstrated construct validity (Miller, Flory, Lynam, & Leukefeld, 2003). Descriptive statistics for these scales and all the other individual differences are provided in Table 2.1.

Table 2.1 Descriptive Statistics and Cronbach's Alphas for Individual Difference Scales Used in Study I.

Scale	Number of Scale Items	M	SD	Cronbach's α
UPPS Impulsivity Scale				
Premeditation	10	39.90	7.53	.86
Urgency	10	36.10	9.31	.86
Sensation Seeking	10	45.23	8.88	.85
Perseverance	10	38.12	6.129	.83
Money Choice Questionnaire (MCQr)	38	16.51	10.95	n/a
Zimbardo Time Perspective Inventory				
Future-Mindedness	13	47.49	6.88	.73
Hedonism	15	54.10	8.45	.82
Fatalism	9	23.02	5.96	.72
Consideration of Future Consequences (CFC)	12	41.30	6.81	.78

Note. *N* = 206 for all measures.

Delay Discounting

Delay discounting measures how much a person discounts the future, in other words, how quickly future rewards depreciate in value as a function of time. This study used an extended version of the *Money Choice Question* (MCQ; Kirby & Maraković, 1996). People were given a series of 38 hypothetical choices between a smaller monetary value received immediately and a larger monetary value received after a given delay. For instance, one item asked people whether they would prefer: $30 today, or $35 in 50 days. Commonly, a delay discounting score is calculated by determining a point at which a participant's choices between immediate and delayed rewards are equalized (i.e., *k;* Mazur, 1987). The extended MCQ uses prescribed choices, rather than single, open-ended responses, so a proxy for *k* was calculated. Because all individuals answered the same 38 questions, with a binary choice between a smaller, immediate reward or a larger, delayed reward, scores were calculated based on the number of delayed choices selected. As examples: A person who always chooses the smaller, immediate reward over the larger, delayed reward would receive a score of 0, suggesting extremely steep discounting. A person who always chooses the larger, delayed reward over the smaller, immediate reward would receive a score of 38, suggesting extremely shallow discounting.

Traditional indices of internal reliability, like Cronbach's Alpha, do not apply to the MCQ because each item measures a different tradeoff (i.e., *k*-value) between the present and future. Past research suggests less than one-percent of response choices deviate from the calculated *k*-values (Kirby, 2009) and that discount rates are stable over a one-year period (Kirby, 2009). Unlike Kirby and Maraković's (1996) scoring procedure, the proxy *k* score used in this study treats all responses as valid choices (rather than ignoring values that do not fit consistent patterns of results). This also means that no procedures were used to alter the data from its original form, unlike methods prescribed elsewhere (Kirby, 2009). The proxy *k*-score method has also been used in previous research. For instance, Daugherty and Brase (2010) reported that proxy *k*-scores derived from the MCQ were significantly correlated with personality, time orientation, and intertemporal health behaviors.

Time Orientation

Time orientation is the tendency to focus on temporal information related to the past, present, and/or future (Lasane & O'Donnell, 2005). Two measures were used in this study to capture this construct. The *Zimbardo Time Perspective Inventory* (ZTPI; Zimbardo & Boyd, 1999) uses five different scales to measure time orientation and conceptualizes present and future time orientation as separate dimensions. For this study, only the *present-fatalistic*, *present-hedonistic*, and *future* scales were used. Zimbardo and Boyd's *past-positive* and *past-negative* scales were not used because explaining why the emotional interpretation of past events influences intertemporal behavior is not of primary interest in this research.

The 9-item present-fatalistic scale measures a general focus on the present that is driven from a lost sense of control over the future. A sample item for this scale is "Since whatever will be will be, it doesn't really matter what I do." The 14-item present-hedonistic scale measure a general focus on the present that is motivated by a desire to seek out immediate pleasures and enjoy life in the moment. A sample item for this scale is "I take each day as it is rather than try to plan it out." The 12-item future scale measures a general focus on the future characterized by advance planning and task persistence. A sample item for this scale is "I believe that a person's day should be planned ahead each morning."

The *Consideration of Future Consequences Scale* (CFCS; Strathman, Gleicher, Boninger, & Edwards, 1994) is a second measure assessing time orientation. Unlike the ZTPI, the CFCS conceptualizes time orientation as a single, continuous dimension between present- and future-mindedness. This 12-item scale emphasizes the element of planning as a central part of future time orientation. Sample items from this scale are "I consider how things might be in the future, and try to influence those things with my day to day behavior" and "I am willing to sacrifice my immediate happiness or well-being in order to achieve future outcomes."

The ZTPI and CFCS demonstrated adequate internal consistency in Study I (see Table 2.1). Previous research has found moderate correlations between the ZTPI and CFCS (Adams & Nettle, 2009; Daugherty & Brase, 2010; Zimbardo & Boyd, 1999), suggesting conceptual overlap between the scales. Despite similarities between the scales, Daugherty and Brase (2010) found that while the ZTPI generally outperformed the CFCS in predicting intertemporal health behaviors (tested with hierarchical regressions), scales from both the ZTPI and the CFC demonstrated divergent validity and uniquely predicted different time intertemporal health behaviors. This past research justifies inclusion of these two similar, but not redundant measures. Construct validity regarding intertemporal behavior exists for both the ZTPI (Boyd & Zimbardo, 2005; Drake, Duncan, Sutherland, Abernethy, & Henry, 2008) and the CFCS (Dorr, Krueckeberg, Strathman, & Wood, 1999; Lindsay & Strathman, 1997; Strathman, Boninger, Gleicher, & Baker, 1994).

Intertemporal Behaviors

An intertemporal behavior is a decision involving tradeoffs between the present and future. More specifically, tradeoffs are made between immediate costs/benefits and future costs/benefits. This study is interested in intertemporal behaviors which require immediate sacrifice (more costs and fewer benefits in the present) to obtain future outcomes. This conceptualization of intertemporal behavior parallels definitions of delay discounting, however, the perceived costs and benefits are not manipulated, but rather decided by the individual. Implied, but not explicit, is the idea that acting in future-minded ways results in greater benefits than acting in present-mindedly. Three broad domains of intertemporal behavior were explored in this study. Each domain is discussed next and descriptive statistics for these domains can be found in Table 2.2.

Table 2.2. Descriptive Statistics and Cronbach's Alphas for Intertemporal Behaviors Used in Study I.

Scale	*N*	*M*	*SD*	Cronbach's α
Health Behaviors				
Tobacco Use	226	1.60	1.27	-
Alcohol Use	226	2.02	.83	-
Drug Use	226	1.32	.72	-
Exercise	226	3.59	1.28	-
Eating Breakfast	226	3.08	1.34	-
Hours of Sleep per Night	226	2.88	.66	-
Wearing Safety Belt	226	4.93	1.31	-
Helmet Use	226	3.57	1.95	-
Frequency of Stair Use	226	3.76	1.13	-
Doctor and Dentist Visits	226	3.12	1.33	-
Expected Longevity	223	83.55	13.09	-
BMI	218	23.67	4.92	-
Health Concern	226	10.70	4.73	.84
Sociosexual Orientation	226	53.39	40.73	-
Environmental Behaviors				
Recycle	226	23.44	9.67	.87
Conservation	226	44.62	11.41	.80
Advocacy	226	12.23	5.41	.78
Transportation	226	13.75	3.89	.48
Re-Use	226	27.69	7.23	.78
Pro-Environmental Behaviors	226	39.80	11.53	.83
Financial Planning				
Future Financial Planning	226	38.41	16.29	.91
Present Financial Behavior	226	51.64	11.78	.81
Financial Impulsivity	226	19.42	5.78	.65

Intertemporal Health Behaviors.

Future-minded intertemporal health behaviors involve postponing immediate gratification in favor of greater health in the future. The questions used in this study were taken from previous research (Daugherty & Brase, 2010). The questions address a variety of behaviors which are correlated either positively or negatively with physical health (e.g., exercise frequency, alcohol use) and behaviors which require small, immediate actions to offset potentially hazardous future health issues (e.g., applying sunscreen, wearing a helmet). Optimism is also related to future health (Smith & MacKenzie, 2006), so participants were asked to estimate/predict their longevity. A series of questions also measured perceived health risk or concerns about: high cholesterol, high blood pressure, cancer, HIV/AIDS, and diabetes. Responses were aggregated across these 5 questions to provide a general index of *health concerns*. The *Sociosexual Orientation Inventory* (SOI; Jackson & Kirkpatrick, 2007; Simpson & Gangestad, 1991) was employed as an indicator of sexual health risk. The SOI measures the degree to which individuals are restricted versus unrestricted in their sexual behavior. Unrestricted individuals are more comfortable engaging in sexual behaviors without mental or emotional commitment, compared to restricted individuals. Unrestricted individuals also report having more sexual partners and are more likely to engage in unprotected sexual intercourse (Seal & Agostinelli, 1994). Current physical health was assessed by calculating a Body Mass Index from self-reported weight and height values.

A complete list of intertemporal health behaviors is provided in Appendix A. Past research suggests that these health behaviors demonstrate small to moderate correlations with delay discounting and time orientation (Daugherty & Brase, 2010). Unpublished data by the author also suggests that these health behaviors are related to impulsivity, with correlations comparable to those found with delay discounting and time orientation. No previous research was located which has correlated health behaviors with time perception.

Intertemporal Environmentalism Behaviors.

Intertemporal environmental behaviors were assessed with a series of 58 questions designed to measure several components of environmental behavior. These questions were generated from previous measures (Kaiser, Doka, Hofstetter, & Ranney, 2003; Kaiser & Wilson,

2000) and a thorough Internet search for additional behaviors related to environmentalism. The six components of environmental behavior measures are *recycling*, *energy/water conversation*, *advocacy*, *transportation*, *re-use*, and *pro-environmental behaviors*. Using a large sample of college undergraduates (N = 525), all but one scale, transportation, demonstrated adequate internal consistency. The low reliability coefficient for transportation behaviors is likely due to a lack of automobile ownership by freshman/sophomore students and/or by the potential lack of personal choice in automobile ownership. This scale needs to be validated with a non-college aged sample.

A complete list of the intertemporal environmental behaviors used in this study is provided in Appendix B. Currently, no research has been published using this measure of environmental behaviors. Preliminary data collected by the author suggests that impulsivity, delay discounting, and time orientation demonstrate small, yet significant effects with environmental behaviors. The factor demonstrating the highest correlation with these individual difference measures is advocacy, or a willingness to take action or speak out for environmental causes.

Intertemporal Financial Planning Behaviors.

Intertemporal financial-planning behaviors involve short-term sacrifices of time and resources to promote long-term financial gains. A set of questions related to financial planning was generated by combining items from several sources (Fünfgeld & Wang, 2009; Loix, Pepermans, Mentens, Goedee, & Jegers, 2005; Perry & Morris, 2005; Yamauchi & Templer, 1982). Using a large sample of 705 undergraduates, a Principal Components Analysis with varimax rotation was used to assess the factorial structure of 34 items.

Three components were extracted and accounted for a total of 42.3% of the variance in responses. Items with factor loadings greater than .40 and no cross-loadings greater than .40 with the other two factors were maintained. The first factor had an Eigenvalue of 8.73, accounted for 25.7% of the variance in responses, and is comprised of 12 items. Based on the content of these items, this first factor is labeled *future financial planning*. The items composing this factor center on behaviors related to planning and preparing for future financial decisions. Sample items include, *I have a financial plan set up for my retirement* and *I have met with a financial planner or counselor*. The second factor had an Eigenvalue of 3.79, accounted for 11.13% of the variance in responses, and is comprised of 10 items. Based on the contents of these items, the second factor was labeled *present financial behavior*. The items composing this factor center on financial behaviors occurring on a daily or regular basis. Sample items include, *I maintain a financial budget to keep track of my spending* and *I check my bank account balances regularly*. The third factor had an Eigenvalue of 1.87, accounted for 5.49% of the variance in responses, and is comprised of 5 items. Based on the contents of these items, the third factor was labeled *financial impulsivity*. The items composing this factor center on an inability to save money and tendency to spend money impulsively. Sample items include, *I am not very good at saving money* and *It's hard for me to pass up a bargain*. Using the current sample, a confirmatory factor analysis was conducted using varimax rotation with three fixed factors for 27 items. The three extracted components accounted for a total of 47.35% of the variance in responses. Factor loadings are provided in Table 2.3.

Table 2.3. Factor Loadings for Financial Planning Items in Study 1.

Financial Planning Items	Factor 1	Factor 2	Factor 3
1. I have made voluntary contributions to a retirement savings plan during the past 12 months.	**.81**	.15	-.02
2. I visit investing or financial planning sites on the World Wide Web.	**.79**	.01	.07
3. I read brochures/articles on investing or financial planning.	**.76**	.04	.07
4. I have already started building my retirement nest egg.	**.75**	.16	-.07
5. I read one or more books on investing or financial planning.	**.73**	-.09	.11
6. I have a financial plan set up for my retirement.	**.72**	.13	.16
7. I seek out financial information from books, radio/television shows, and/or websites.	**.70**	.02	.20
8. I have set specific goals for how much will need to be saved for my retirement.	**.70**	.16	.11
9. I have attended a seminar or workshop to improve my finances.	**.67**	-.02	-.14
10. I have met with a financial planner or counselor.	**.62**	.07	-.07
11. I try to keep track of general economic trends.	**.55**	.16	.28
12. I am not very good at saving money.	.04	**-.79**	-.04
13. I am very prudent with money.	.04	**.71**	.04
14. I enjoy spending money more than saving.	-.01	**-.68**	-.01
15. I put aside a little bit of money from each paycheck.	.09	**.57**	.31
16. I accurately plan my expenses.	.16	**.57**	.26
17. I keep track of my money.	.04	**.56**	.50
18. I follow a careful financial budget.	.24	**.54**	.32
19. I hesitate to spend money, even on necessities.	.00	**.52**	.10
20. I have money put away for a rainy day.	.19	**.51**	.24
21. I save now to prepare for my old age.	.43	**.50**	-.09
22. I check my bank account balances regularly.	.13	.02	**.70**
23. I always pay my bills/debts on time.	.02	.17	**.59**
24. I keep track of my personal expenses in a systematic way.	.14	.31	**.57**
25. I maintain a financial budget to keep track of my spending.	.15	.46	**.52**
26. I rarely receive late fees.	-.12	.26	**.45**
27. It's hard for me to pass up a bargain.	-.02	-.30	**.35**
Eigenvalues	7.15	4.03	1.61
Percentage of Variance Explained	26.50	14.90	6.00

Note. Bold values represent highest factor loading. $N = 206$.

Procedure

This study was performed in a computer laboratory equipped with eight desktop computers. Each computer was separated by a divider to ensure privacy when responding and to discourage distraction from other participants. The time perception tasks and measures were presented with MediaLab (Jarvis, 2008) which is software platform capable of presenting surveys and multimedia stimuli while recording participants' responses and reaction times with partial second accuracy. After completing two practice trials (one for time estimation and one for time production), participants completed a block of 24 time perception trials. Next, participants completed the individual difference and intertemporal behavior measures. Finally, participants completed a second block of 24 time perception trials. After the data were collected, a programming error was found that prohibited the interpretation of results from the time estimation trials of the second block. These trials will not be discussed further. Time perception trials within each block were presented in a different, random order for each participant. Individual difference and intertemporal behavior measures were also presented in random order, with item order for each measure also randomized. The study took participants 60 to 90 minutes to complete.

Statistical Analysis

The mediation model proposed in Figure 0.1 shows the general expected pattern of results for this research. Given the only small or moderate relationship between several of the individual difference measures (Daugherty & Brase, 2010) it is not appropriate to combine these measures into a single variable. Instead, each individual difference scale was tested in separate mediation analyses. Likewise, low inter-scale and inter-item correlations for health, environmental, and financial planning behaviors suggest that separate analyses should be performed on each intertemporal behavior. Time perception was also conceptualized in several ways. By parceling out independent variables (time perception), mediators (individual differences), and dependent variables (intertemporal behavior) there is the potential for a very large number of separate mediation analyses (see Figure 1.4). This in turn leads to an increased risk of Type I errors. To control for Type I errors, a more conservative alpha level was employed. Specifically, a Bonferroni correction of $\alpha = .05/20$ was used to determine a cut-off for statistical significance.

To test the general model shown in Figure 0.1, as well as the more specific models discussed in the previous paragraph, mediation analyses was performed with linear regression following the procedure outlined by Baron and Kenny (1986) and confirmed with bootstrapped confidence intervals as suggested by Preacher and Hayes (2004, 2008). To meet Baron and Kenny's criteria for mediation, the following three steps were performed, each with a linear regression: (a) predict mediator (individual difference) with independent variable (time perception), (b) predict dependent variable (intertemporal behavior) with mediator (individual difference), (c) predict dependent variable (intertemporal behavior) with independent variable (time perception). To demonstrate mediation, both the independent variable (time perception) and mediator (individual difference) were simultaneously regressed to predict the dependent variable (intertemporal behavior). The proposed model(s) are supported if the relationship between the independent variable (time perception) and dependent variable (intertemporal behavior) is no longer statistically significant when controlling for the predictive influence of the mediator (individual difference) or if the bootstrapped confidence intervals for indirect effects do not contain zero.

Results

Data Cleaning

Of the 226 participants who completed the study, data from 6 participants were excluded from further analysis due to missing time perception responses. Time perception data from the remaining 220 participants were subjected to additional screening procedures.

For time estimation trials, participants were asked to provide the duration of the interval first (amount of time lapsed in seconds), and second, the 3-digit number shown before the onset of the interval to be timed. In less than 1% of trials, participants appeared to have reversed these two steps, thus providing a 3-digit number instead of an interval of time. For 37 individual trials with a 3-digit response, values were replaced with the mean response time for the appropriate time interval, rounded to the closest whole integer.

On approximately 4% of individual time production trials, responses were faster than 3 seconds. In many of these cases, responses were quicker than one second. These quick responses could represent double-click errors in which participants accidentally started and ended the time production interval without allowing an accurate amount of time to pass. Or, these quick responses could represent deliberate impatience with the task, thus allowing participants to move on to the next time perception trial without accurately producing an interval.

To remove the influence of these errors, a data screening process was enacted to identify and control for participants with severely inaccurate time perception. First, all time perception trials were subtracted from the actual duration of time for each interval. These individual deviation scores were summated across each time perception task:

$$\sum_{k=i}^{12} [T_{ij} - t_i]$$

where T_{ij} represents a single time perception trial for duration *i* within block *j*. The actual time of the interval being timed is denoted by t_i. Descriptive statistics for these summated deviation scores are presented in Table 2.4. Participants with severely inaccurate time perception were identified by *z*-transforming each summated deviation score, and screening out individual with at least one deviation score which was equal to or greater than 3 standard deviations from the group mean. Data from these severely inaccurate time perceivers (*n* = 14) were excluded from further analyses. After screening out severely inaccurate time perceivers, complete data from 206 participants remained for analysis.

Table 2.4. Descriptive Statistics for Sum Deviation Scores.

Sum Deviation for:	Min	Max	*M*	*SD*
Before excluding severely inaccurate time perceivers (*N* = 220)				
Time Estimation, Block 1	-156.00	317.00	-11.00	74.11
Time Production, Block 1	-306.03	225.00	-9.30	96.41
Time Production, Block 2	-306.33	272.94	-5.74	86.56
After excluding severely inaccurate Time perceivers (*N* = 206)				
Time Estimation, Block 1	-156.00	195.00	-18.24	58.00
Time Production, Block 1	-283.28	239.80	2.78	74.45
Time Production, Block 2	-244.47	189.59	4.09	63.78

Note. Unit for all numbers is seconds.

Time Perception Data

Conceptual Considerations

After cleaning the time perception data, it was important to establish the validity of the remaining data, both conceptually and theoretically. Conceptually, if the time estimation and time production tasks are tapping a similar underlying construct of time perception, they should be correlated with each other. Correlations between time perception tasks should be negative (Davidson & House, 1982; Fraisse, 1978). Additionally, individual trials within each type of time perception task should be highly correlated with each other. To provide evidence for these conceptual validity markers, individual trials within and between time perception blocks were correlated with each other, *z*-score transformed, averaged together, and converted back to correlation coefficients.

Average correlations within each time perception task provide an index of internal consistency. These average correlations are provided in the diagonal of Table 2.5. Average correlations between each time perception task provide an index of reliability across tasks. Time perception trials within each task were strongly correlated with each other, using Cohen's (1992) conventions. This finding is consistent with traditional indices of internal consistency; Cronbach's alphas were .91, .92, and .91 across twelve different intervals for time estimation block 1, time production block 1, and time production block 2, respectively. As would be expected, time estimation trials were, on average, negatively correlated with time production trials. Correlations between time perception tasks and blocks were moderately correlated with each other. These results are consistent with a conceptual understanding of time perception.

Table 2.5. Average correlation coefficients within and between time perception tasks and blocks.

	1	2	3
1. Time Estimation, Block 1	.63	-.45	-.44
2. Time Production, Block 1		.74	.56
3. Time Production, Block 2			.72

Note. *N* = 206.

Another conceptual check for time perception is whether estimated and produced intervals increase linearly relative to actual time. Put differently, as intervals of time increase, so should people's estimations and productions of time. Figure 2.1 depicts the average response time for the different blocks of time perception. Time perception increased linearly with actual time (see Tables 2.6 and 1.7 for the descriptive statistics displayed in Figure 2.1 and 2.2). Figure 2.2 depicts the median response time for the different blocks of time perception. This figure demonstrates the same pattern of results as Figure 2.1, while suggesting that outliers are not altering the pattern of results. Together, Tables 2.6 and 2.7 and Figures 2.1 and 2.2 suggest that the time perception data collected is valid.

Figure 2.1. Plotted average response times for time production (TP) and time estimation (TE) in blocks 1 and 2.

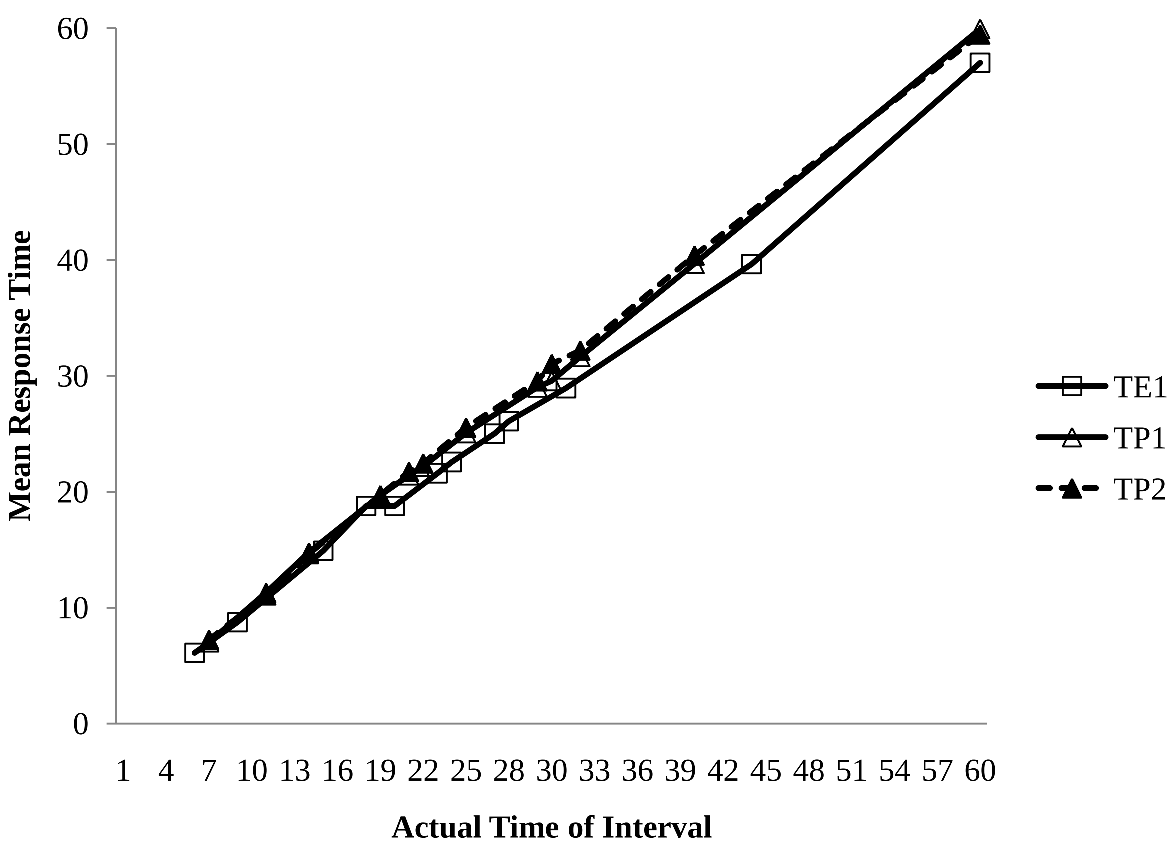


Figure 2.2. Plotted median response times for time production (TP) and time estimation (TE) in blocks 1 and 2.

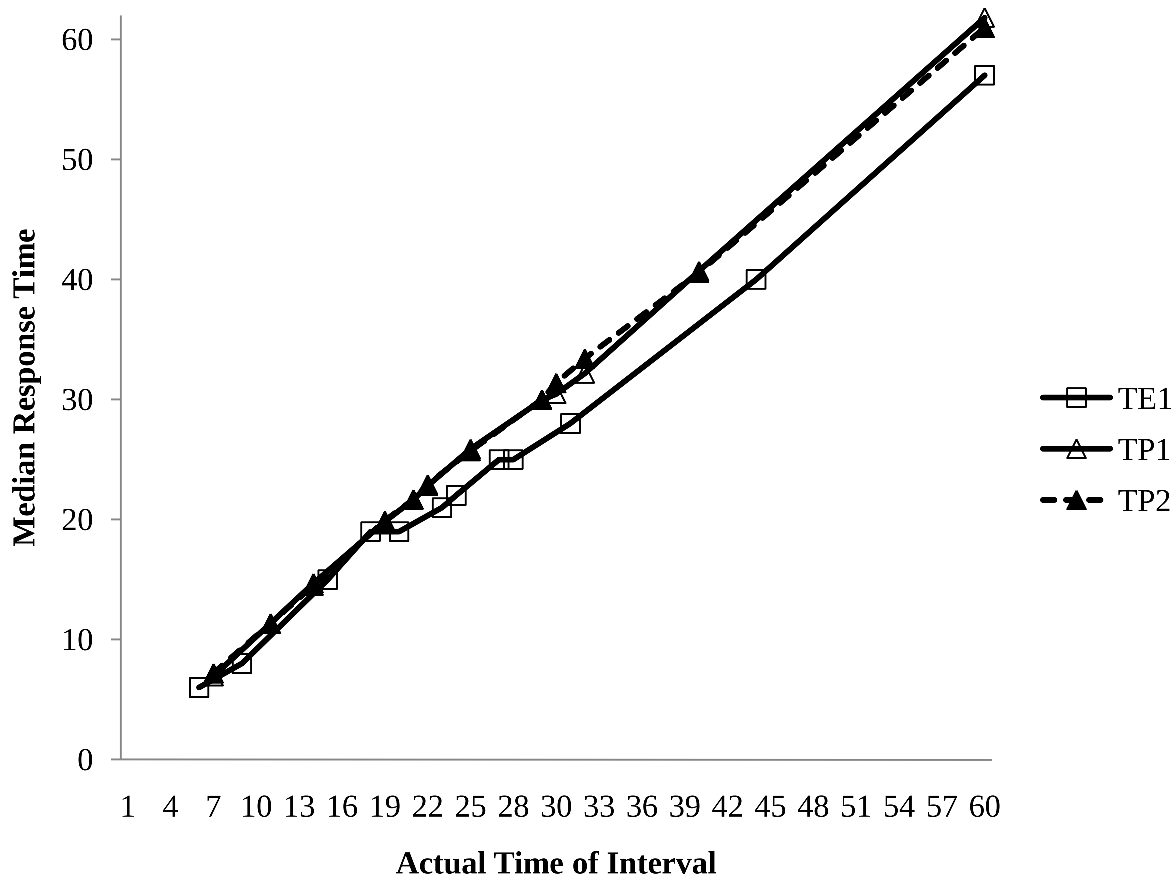


Table 2.6. Descriptive Statistics for Time Estimation Trials.

	Block 1		
	Median	*M*	*SD*
Actual Timed Interval (in seconds)			
6	6.0	6.11	1.91
9	8.0	8.80	2.47
15	14.5	14.73	3.76
18	16.5	17.55	5.20
20	18.0	18.75	4.92
23	21.0	21.61	5.74
24	22.0	22.65	5.95
27	25.0	25.01	6.09
28	25.5	26.15	7.28
31	28.0	28.93	7.43
44	40.0	39.74	9.33
60	55.0	55.54	14.52

Note. *N* = 206, Time Estimation for Block 2 was lost due to a programming error.

Table 2.7. Descriptive Statistics for Time Production Trials.

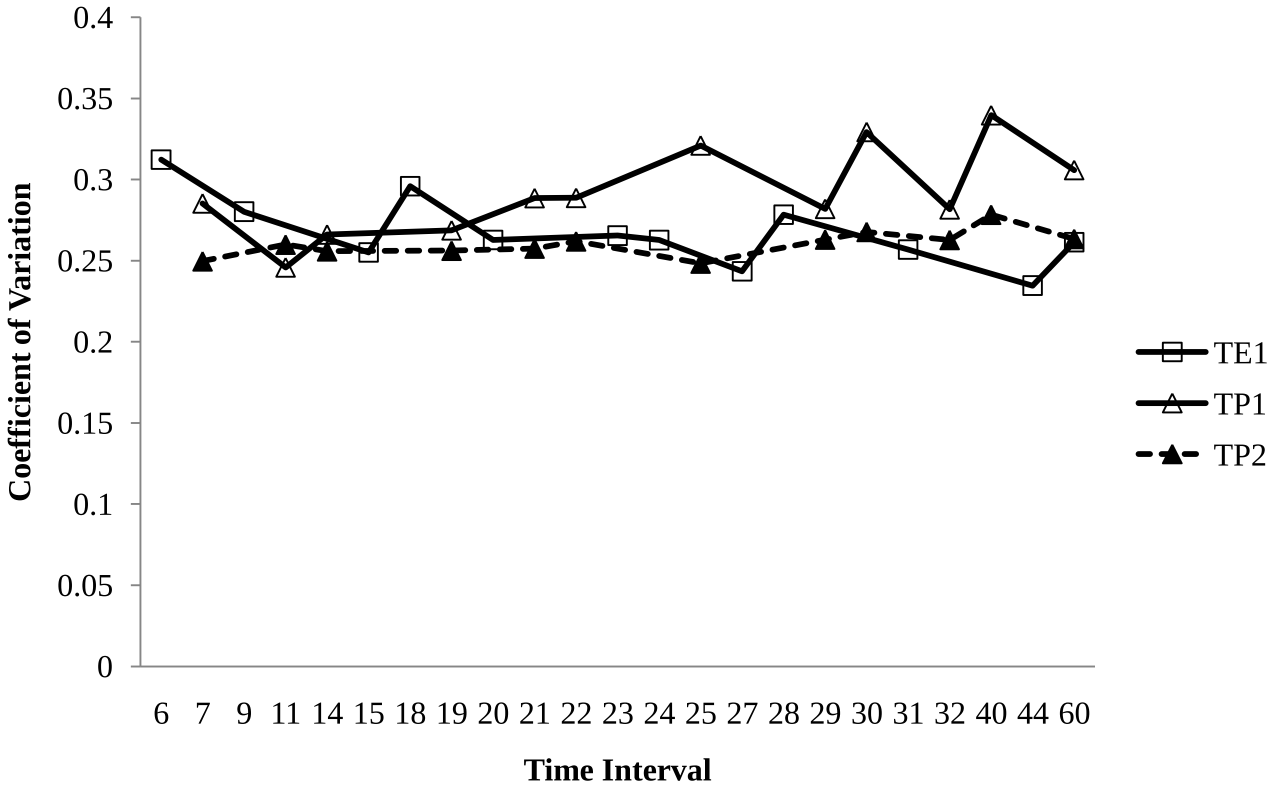
	Block 1			Block 2		
	Median	*M*	*SD*	Median	*M*	*SD*
Actual Timed Interval (in seconds)						
7.00	6.95	7.12	2.03	7.21	7.24	1.81
11.00	11.36	11.39	2.80	11.34	11.07	2.88
14.00	14.72	14.99	3.99	14.66	14.71	3.76
19.00	19.87	19.99	5.37	19.99	19.78	5.07
21.00	21.91	21.77	6.28	21.70	21.87	5.63
22.00	22.98	22.56	6.51	23.10	22.49	5.89
25.00	25.94	25.45	8.17	25.88	25.65	6.37
29.00	30.08	29.39	8.29	30.07	29.66	7.80
30.00	30.52	29.99	9.88	31.45	31.04	8.31
32.00	32.22	32.08	9.03	33.56	32.43	8.52
40.00	40.82	40.25	13.67	40.68	40.61	11.30
60.00	61.35	60.33	18.45	61.27	59.68	15.72

Note. *N* = 206

Theoretical Considerations

The time perception data collected should also conform to theoretical assumptions of human timing, namely scalar expectancy theory (SET; Gibbon et al., 1984). A foundational assumption of SET is that variance in time perception is proportional to the interval being timed. Thus, time perception for a longer interval will have more variability than time perception for a shorter interval of time; however, the variability across intervals will be the same relative to the duration of the interval timed. To examine this underlying assumption of SET, a coefficient of variance (standard deviation divided by mean) was calculated for each time perception interval within each time perception task and block (see Figure 2.3). Consistent with SET, the coefficients of variance remained constant across the timing intervals (regression slopes were not significantly different from zero for any of the time perception tasks or blocks, ps < .45).

Figure 2.3. Coefficients of variation for time production (TP) and time estimation (TE) in blocks 1 and 2.



Reverse Coding Time Estimation

For both time perception tasks, deviation scores of greater magnitude, whether negative or positive, represent less accurate perceptions of time. For time estimation, positive deviation scores represent a tendency to perceive time as moving slowly (myopic time perception). For instance, if a person views a 30-second interval and reports that 35 seconds passed, this would result in a positive deviation score. For time production, negative deviation scores represent a tendency to perceive time as moving slowly (myopic time perception). For instance, if a person is asked to produce a 30-second interval and stops the interval after 25 seconds; this would produce a negative deviation score. In order to allow direct comparisons of time estimation and time production scores and aid conceptual understanding of the following analyses, deviation scores for time estimation trials were reverse signed (negative values become positive and positive values become negative). From here on, lower time perception scores indicate stronger myopic time perception.

Groups of Indices

To determine the best way to operationalize time perception, several groups of time perception scores were created and used in this study. The first group of time perception indices is mean deviations (for examples of this time perception index used in past research see Berlin et al., 2004; Gerbing et al., 1987). First, as discussed above, deviation scores were calculated by difference scores for each time perception trial. Different mean deviation scores were calculated by splitting trials into different groups. For instant, mean deviation scores were calculated for each time perception task within each block. This resulted in three time perception scores for each participant. Additionally, mean deviation scores were calculated for: time perceptions trials in block 1, time production trials across blocks 1 and 2, and a grand mean deviation score which included all time perception trials from (labeled *Total* in the accompanying tables). Descriptive statistics for these mean deviation scores are provided in Table 2.8.

The second category of time perception indices explored was median deviation scores. Although efforts were made to remove severely inaccurate time perceivers from the sample, relying on mean deviation scores allows remaining extreme scores and outliers to over-influence individual scores. To create an index of time perception less influenced by these extreme scores, a median deviation score was calculated for each time perception task within each block. This resulted in three time perception scores for each participant. Additionally, median deviation scores were calculated for: time perception trials in block 1, time production trials across blocks

1 and 2, and a grand median deviation score which included all time perception trials (labeled *Total* in the accompanying tables). Descriptive statistics for these median deviation scores are provided in Table 2.8.

Table 2.8. Descriptive Statistics for Mean and Median Deviation Reaction Time Indices.

	Mean Deviation		Median Deviation	
	M	*SD*	*M*	*SD*
Time Estimation, Block 1	1.62	4.91	1.43	4.33
Time Production, Block 1	.44	6.54	.52	5.54
Time Production, Block 2	.52	5.61	.70	4.94
Block 1	1.03	5.29	1.09	4.31
Time Production	.48	5.55	.70	4.54
Total	1.00	4.84	0.97	3.99

Note. *N* = 206. Units for all values are in seconds. Block 1 - reaction times combined across time estimation and time production trials in block 1. Time Production - reaction times combined across time production trials in Block 1 and 2. Total - reaction time combined across all time perception trials.

The third and fourth categories of time perception were created by calculating three least squares regression lines for each participants, one for each time perception task within each block (for examples of this time perception index used in past research see Barratt, 1981; Glicksohn et al., 2006). As discussed above, across the whole sample of participants, time estimation and time production increase linearly with the interval of actual time being timed (see Figures 2.1 and 2.2). Individual regression lines may, however, vary systematically with individual differences and intertemporal behavior. A slope and intercept value for each regression line were calculated for each participant. The purpose of calculating time perception slopes and intercepts is to assess a multiplicative model of time perception error. As proposed by Scalar Expectancy Theory (Gibbon et al., 1984), several sources of variation in the internal timing mechanism exist. Wearden, Edwards, Fakhri, and Percival (1998) propose that regression slopes and intercepts provide a measurement of pacemaker rate (by assuming a non-zero difference between the opening and closing of the accumulator switch). Slopes approaching 1.00 and smaller intercepts represent faster pacemaker rates. Descriptive statistics for both slopes and intercepts are provided in Table 2.9.

Table 2.9. Descriptive Statistics for Time Perception Slopes & Intercepts.

	Block 1		Block 2	
	M	*SD*	*M*	*SD*
Time Estimation				
Slope	.90	.23	--	--
Intercept	.85	3.29	--	--
Time Production				
Slope	.99	.34	.96	.30
Intercept	.63	3.96	1.28	7.33

Note. Units are in seconds. Slopes and intercepts were calculated for each participant, values provided above describe the whole sample (*N* = 206).

Proposed Mediation Model

Hypothesis 1: Time Perception & Intertemporal Behaviors

To test Hypothesis 1 of the proposed model (see path C in Figure 1.4), indices of time perception were correlated with health behaviors, environmental behaviors, and financial planning behaviors. Zero-order correlations between time perception indices and health behaviors are provided in Tables 2.10, 2.11, and 2.12. Applying a traditional alpha cutoff of $p < .05$ produced patterns of significant correlation for safety belt use and health concerns. Employing an a priori Bonferroni corrected alpha level of $p < .05/20$ (.0025) resulted in two significant correlations. Both correlations are with the health concerns variable. The first significant correlation is with the median deviation score for time production trials across blocks 1 and 2, $r = -.22$, $p = .0019$. The second significant correlation is with the total median deviation score across all of the time perception trials, $r = -.21$, $p = .0024$. The negative direction of these correlations suggests that as time perception becomes more myopic concern about contrasting various diseases increases. These relationships are in the predicted direction.

Zero-order correlations between time perception indices and environmental behaviors are provided in Tables 2.13, 2.14, and 2.15. Zero-order correlations between time perception indices and financial planning behaviors are provided in Tables 2.16 and 2.17. Time perception was not significantly correlated with either environmental or financial planning intertemporal behaviors at the conservative alpha level of $p < .0025$ or at the traditional significant level of $p < .05$.

Table 2.10. Zero-Order Correlations between Mean Deviation Time Perception Indices and Intertemporal Health Behaviors.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Time Estimation, Block 1	.12*	.07	.14*	.07	.11	.05	.15*	.04	-.04	.12	.07	-.04	-.17*	.01
Time Production, Block 1	.03	.01	.12	.09	.11	.07	.16*	.12	.02	.10	.07	-.07	-.20*	-.01
Time Production, Block 2	.06	.00	.07	.06	.07	.05	.13	.01	-.01	.12	.09	-.07	-.15*	-.02
Block 1	.07	.04	.14	.09	.12	.07	.17*	.09	.00	.12	.08	-.06	-.20*	.00
Time Production	.05	.01	.10	.09	.10	.07	.16*	.08	.01	.12	.09	-.08	-.19*	-.02
Total	.08	.03	.12	.08	.11	.07	.17*	.07	-.01	.13	.09	-.07	-.20*	-.01

Notes. $N = 206$, * $p < .05$, 1 – tobacco, 2 – alcohol, 3 – drugs, 4 - exercise, 5 – breakfast, 6 – sleep, 7 - safety belt, 8 - helmet use, 9 - freq of stairs use, 10 - doctor or dentist visits in last 12 months, 11 - expected longevity, 12 – BMI, 13 – Health Concerns, 14 – Sociosexual Orientation.

Table 2.11. Zero-Order Correlations between Median Deviation Time Perception Indices and Intertemporal Health Behaviors.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Time Estimation, Block 1	.15*	.08	.16*	.05	.10	.09	.15*	.04	-.04	.11	.06	-.04	-.16*	.03
Time Production, Block 1	.03	.00	.10	.09	.13	.10	.16*	.14	-.01	.07	.05	-.06	-.19*	.00
Time Production, Block 2	.07	.03	.07	.05	.07	.05	.13	.02	-.03	.14	.08	-.07	-.18*	-.02
Block 1	.10	.07	.14*	.07	.13	.07	.15*	.08	-.02	.09	.05	-.07	-.21*	.00
Time Production	.08	.04	.12	.08	.11	.08	.15*	.06	-.01	.11	.08	-.07	-.22†	.02
Total	.11	.06	.14	.07	.12	.08	.16*	.07	-.02	.11	.07	-.06	-.21†	-.01

Notes. $N = 206$, * $p < .05$, † $p < .0025$, 1 – tobacco, 2 – alcohol, 3 – drugs, 4 - exercise, 5 – breakfast, 6 – sleep, 7 - safety belt, 8 - helmet use, 9 - freq of stairs use, 10 - doctor or dentist visits in last 12 months, 11 - expected longevity, 12 – BMI, 13 – Health Concerns, 14 – Sociosexual Orientation.

Table 2.12. Zero-Order Correlations between Slope and Intercept Indices and Intertemporal Health Behaviors.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Time Estimation, Block 1														
Slope	-.05	-.03	-.08	-.08	-.04	-.04	-.13	-.03	.06	-.11	.00	.02	.06	.01
Intercept	-.10	-.03	-.06	.04	-.07	.00	.02	.02	-.04	.03	-.10	.03	.11	-.04
Time Production, Block 1														
Slope	-.02	-.05	.08	.06	.03	.00	.11	.05	.01	.12	.04	-.07	-.16*	-.01
Intercept	.11	.12	.03	.02	.04	.10	.00	.04	-.04	-.09	.02	.08	.09	.03
Time Production, Block 2														
Slope	.11	-.04	.01	.03	.18*	-.01	-.06	.00	-.03	-.03	-.10	-.01	-.06	-.10
Intercept	-.04	.03	.04	.01	-.12	.03	.12	.01	.01	.10	.13	-.03	-.02	.08

Notes. *N* = 206, * $p < .05$, 1 – tobacco, 2 – alcohol, 3 – drugs, 4 - exercise, 5 – breakfast, 6 – sleep, 7 - safety belt, 8 - helmet use, 9 - freq of stairs use, 10 - doctor or dentist visits in last 12 months, 11 - expected longevity, 12 – BMI, 13 – Health Concerns, 14 – Sociosexual Orientation.

Table 2.13. Zero-Order Correlations between Mean Deviation Time Perception Indices and Intertemporal Environmental Behaviors.

	Recycling	Conservation	Advocacy	Transportation	Re-Use	Pro-Environment
Time Estimation, Block 1	.00	-.06	-.11	.00	-.04	.00
Time Production, Block1	.00	.01	-.07	.02	-.02	.02
Time Production, Block 2	.01	-.07	-.11	-.06	-.06	-.03
Block 1	.00	-.02	-.09	.01	-.03	.01
Time Production	.01	-.03	-.10	-.02	-.04	.00
Total	.01	-.04	-.11	-.02	-.04	.00

Notes. *N* = 206.

Table 2.14. Zero-Order Correlations between Median Deviation Time Perception Indices and Intertemporal Environmental Behaviors.

.

	Recycling	Conservation	Advocacy	Transportation	Re-Use	Pro-Environment
Time Estimation, Block 1	-.01	-.07	-.10	-.01	-.04	-.01
Time Production, Block1	-.01	.00	-.08	.00	-.05	-.01
Time Production, Block 2	.01	-.10	-.11	-.05	-.06	-.03
Block 1	-.02	-.06	-.10	.00	-.06	-.01
Time Production	.00	-.07	-.09	-.01	-.06	.00
Total	.01	-.08	-.10	-.01	-.06	-.01

Notes. *N* = 206.

Table 2.15. Zero-Order Correlations between Slope and Intercept Indices and Intertemporal Health Behaviors.

	Recycling	Conservation	Advocacy	Transportation	Re-Use	Pro-Environment
Time Estimation, Block 1						
Slope	-.06	.03	.07	-.03	.03	-.05
Intercept	.11	.03	.04	.04	.02	.08
Time Production, Block 1						
Slope	-.02	.00	-.05	-.03	-.07	-.02
Intercept	.01	.04	.02	.09	.11	.08
Time Production, Block 2						
Slope	.03	-.06	-.02	-.07	-.09	-.02
Intercept	-.03	.02	-.04	.03	.04	.00

Notes. *N* = 206.

Table 2.16. Zero-Order Correlations between Time Perception Mean and Median Deviation Indices and Financial Planning Behaviors.

	Mean Deviation			Median Deviation		
	Future Financial Planning	Present Financial Behavior	Financial Impulsivity	Future Financial Planning	Present Financial Behavior	Financial Impulsivity
Time Estimation, Block 1	.08	.07	-.01	.10	.08	.00
Time Production, Block1	.06	.06	-.05	.06	.07	-.04
Time Production, Block 2	-.01	.00	-.02	.04	.02	-.02
Block 1	.07	.07	-.03	.11	.09	-.03
Time Production	.04	.03	-.04	.11	.06	.00
Total	.05	.05	-.03	.10	.07	-.03

Notes. *N* = 206.

Table 2.17. Zero-Order Correlations between Time Perception Slopes and Intercepts and Financial Planning Behaviors.

	Future Financial Planning	Present Financial Behavior	Financial Impulsivity
Time Estimation, Block 1			
Slope	-.07	-.06	.05
Intercept	-.01	.01	-.10
Time Production, Block 1			
Slope	.05	.01	.01
Intercept	-.01	.06	-.03
Time Production, Block 2			
Slope	.03	.03	-.03
Intercept	-.02	-.04	.04

Notes. *N* = 206.

Hypothesis 2: Individual Differences & Intertemporal Behaviors

To test the second hypothesis of the proposed model (see path B in Figure 1.4), individual differences were correlated with intertemporal behaviors to determine patterns of results across these variables. Zero-order correlations between individual differences and health behaviors are provided in Table 2.18. Applying a conservative alpha of $p < .0025$, several correlations emerged as statistically significant. Alcohol consumption was correlated with UPPS premeditation, UPPS sensation seeking, and ZTPI hedonism. Exercise frequency was correlated with UPPS urgency and ZTPI fatalism. Sociosexual orientation was correlated with UPPS sensation seeking and ZTPI future-minded. These correlations suggest: As premeditation increases, alcohol consumption decreases. As sensation seeking and hedonism increases, alcohol consumption increases. As fatalism and urgency increase, exercise frequency decreases. People higher in sensation seeking and lower in future-mindedness are more comfortable engaging in sexual behavior without commitment. All of these correlations are in the predicted direction, such that, being less impulsive and more future-minded is related to more health-promoting behaviors.

Zero-order correlations between individual differences and environmental behaviors are provided in Table 2.19. Applying a conservative alpha of $p < .0025$, consideration of future consequences (CFC) was significantly correlated with environmental behaviors related to conservation, transportation, re-use, and pro-environmental behaviors. Because several environmental behavior scales were significantly correlated with CFC, a multiple regression was run with CFC entered as a dependent variable and all six environmental behavior scales were simultaneously entered as predictors into the first step of the regression. Only recycling ($\beta = .25$, $t = 2.30$, $p = .02$) and re-use ($\beta = -.37$, $t = -3.44$, $p = .001$) behaviors were significant predictors when all sub-scales were given equal chance to explain the variance in CFC scores. The model as a whole significantly predicted CFC, $R^2 = .09$, $F(6, 199) = 3.27$, $p = .004$.

Zero-order correlations between individual differences and financial planning are provided in Table 2.20. When applying a conservative alpha of $p < .0025$, several correlations reached statistical significance. Future financial planning was positively correlated with UPPS perseverance. Present financial behavior was positively correlated with UPPS perseverance, ZTPI future, and consideration of future consequences. Financial impulsivity was negatively correlated with UPPS premeditation, UPPS perseverance, ZPTI future, and consideration of future consequences. Financial impulsivity was positively correlated with UPPS urgency. All of these correlations were in the predicted direction, such that, low impulsiveness and future-mindedness were associated with greater financial planning.

Hypothesis 3: Time perception & individual differences

To test the third hypothesis of the proposed model (see path A in Figure 1.4), time perception indices were correlated with individual differences to determine patterns of results across these variables. Zero-order correlations between time perception and individual differences are provided in Tables 2.21, 2.22, and 2.23. Applying a conservative alpha of $p < .0025$ revealed no significant correlations between time perception and individual differences. Correlations between these constructs were also largely unsuccessful at reaching statistical significance at traditional levels ($p < .05$).

Table 2.18. Zero-Order Correlations between Individual Differences and Intertemporal Health Behaviors.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Impulsivity														
Premeditation	-.03	-.22†	-.04	-.02	.02	.16*	.14*	.14*	.15*	-.03	.01	-.04	.07	-.14*
Urgency	.08	.11	.11	-.23†	-.14*	-.05	-.06	-.09	-.10	.02	-.10	.11	.03	.09
Sensation Seeking	.16*	.25†	.14*	.14*	-.02	-.12	-.13	-.07	-.01	.10	-.02	-.13	.02	.24†
Perseverance	-.07	-.09	-.14*	.19*	.18*	.05	.16*	.17*	.17*	.05	.16*	-.13	.02	-.06
MCQr	.02	.03	-.05	.02	.13	.04	.06	.06	.13	-.01	.08	-.15*	-.03	-.03
Time Orientation														
Future	-.16*	-.20*	-.19*	.09	.20*	.13	.20*	.17*	.14*	-.01	.17*	-.12	.09	-.22†
Hedonism	.14*	.28†	.18*	-.02	-.03	-.18*	-.13	-.06	.01	.06	-.06	-.07	.08	.20*
Fatalism	.04	.05	.07	-.22†	-.16*	.03	-.07	-.05	-.12	.13	-.15*	.03	.09	.04
CFC	-.14*	-.14*	-.12	.16*	.16*	.08	.15*	.07	.12	-.04	.17*	-.12	.04	-.12

Notes. *N* = 206, * *p* < .05, † *p* < .0025, MCQr – expanded Money Choice Questionnaire, CFC – Consideration of Future Consequences, 1 – tobacco, 2 – alcohol, 3 – drugs, 4 - exercise, 5 – breakfast, 6 – sleep, 7 - safety belt, 8 - helmet use, 9 - freq of stairs use, 10 - doctor or dentist visits in last 12 months, 11 - expected longevity, 12 – BMI, 13 – Health Concerns, 14 – Sociosexual Orientation.

Table 2.19. Zero-Order Correlations between Individual Differences and Intertemporal Environmental Behaviors.

.

	Recycling	Conservation	Advocacy	Transportation	Re-Use	Pro-Environment
Impulsivity						
Premeditation	.02	.06	.09	.13	-.01	.04
Urgency	-.10	-.10	-.08	-.17*	-.17*	-.16*
Sensation Seeking	.12	.07	.11	.13	.12	.14*
Perseverance	.12	.15*	.08	.16*	.15*	.12
MCQr	.10	.08	.04	.15*	.11	.07
Time Orientation						
Future	.10	.15*	.04	.12	.15*	.15*
Hedonic	.07	.01	.04	.02	.03	.04
Fatalistic	.02	-.11	.01	-.04	-.19*	-.06
CFC	.17*	.27†	.13	.22†	.29†	.24†

Notes. N = 206. * $p < .05$, † $p < .0025$, MCQr – expanded Money Choice Questionnaire, CFC – Consideration of Future Consequences.

Table 2.20. Zero-Order Correlations between Individual Differences and Financial Planning Behaviors.

	Future Financial Planning	Present Financial Behavior	Financial Impulsivity
Impulsivity			
Premeditation	.16*	.19*	-.22†
Urgency	-.11	-.20*	.35†
Sensation Seeking	.19*	.20*	-.02
Perseverance	.25†	.32†	-.25†
MCQr	.12	.13	-.20*
Time Orientation			
Future	.17*	.35†	-.32†
Hedonism	.05	.04	.19*
Fatalism	.11	-.03	.12
CFC	.04	.27†	-.30†

Notes. *N* = 206. * $p < .05$, † $p < .0025$, MCQr – expanded Money Choice Questionnaire, CFC – Consideration of Future Consequences.

Table 2.21. Zero-Order Correlations between Mean Deviation Time Perception Indices and Individual Differences.

	Impulsivity					Time Orientation			
	Premed	Urgen	Sens Seek	Persev	MCQr	Future	Hedon	Fatal	CFC
Time Estimation, Block 1	-.08	.01	.07	-.06	.07	-.11	.07	.06	-.07
Time Production, Block1	-.09	.01	.02	-.04	.04	-.13	-.02	-.05	-.07
Time Production, Block 2	-.10	-.06	.00	-.11	.08	-.10	-.04	-.02	-.02
Block 1	-.09	.01	.04	-.06	.06	-.13	.02	.00	-.07
Time Production	-.10	-.02	.01	-.08	.07	-.13	-.03	-.04	-.05
Total	-.10	-.02	.03	-.08	.07	-.13	.00	.01	-.06

Notes. *N* = 206, Premed – premeditation, Urgen – urgency, Sens Seek – sensation seeking, Presev – perseverance, MCQr – extended Money Choice Questionnaire, Hedon – hedonism, Fatal – fatalism, CFC – Consideration of Future Consequences.

Table 2.22. Zero-Order Correlations between Median Deviation Time Perception Indices and Individual Differences.

	Impulsivity					Time Orientation			
	Premed	Urgen	Sens Seek	Persev	MCQr	Future	Hedon	Fatal	CFC
Time Estimation, Block 1	-.06	.02	.04	-.08	.08	-.10	.05	.05	-.06
Time Production, Block1	-.07	.00	.00	-.03	.05	-.10	-.04	-.06	-.07
Time Production, Block 2	-.09	-.06	.03	-.09	.09	-.08	-.03	-.03	-.02
Block 1	-.07	.02	.03	-.07	.06	-.12	.02	.02	-.09
Time Production	-.09	-.02	.03	-.08	.07	-.12	-.02	-.03	-.07
Total	-.08	-.01	.04	-.08	.07	-.11	.01	.00	-.08

Notes. *N* = 206, Premed – premeditation, Urgen – urgency, Sens Seek – sensation seeking, Presev – perseverance, MCQr – extended Money Choice Questionnaire, Hedon – hedonism, Fatal – fatalism, CFC – Consideration of Future Consequences.

Table 2.23. Zero-Order Correlations between Time Perception Slopes and Intercepts and Individual Differences.

	Impulsivity					Time Orientation			
	Premed	Urgen	Sens Seek	Persev	MCQr	Future	Hedon	Fatal	CFC
Time Estimation, Block 1									
Slope	.03	-.01	-.12	.07	-.07	.09	-.12	-.11	.07
Intercept	.06	.00	.09	-.01	-.01	-.01	.11	.14	-.05
Time Production, Block 1									
Slope	-.07	.03	.05	-.03	-.03	-.15*	-.01	-.02	-.05
Intercept	-.05	-.01	-.07	-.05	.12	.11	-.01	-.07	.00
Time Production, Block 2									
Slope	-.10	.01	.00	.11	-.01	.04	.05	-.03	.08
Intercept	.03	-.05	.02	-.16*	.05	-.08	-.07	-.01	-.07

Notes. N = 206, * $p < .05$, Premed – premeditation, Urgen – urgency, Sens Seek – sensation seeking, Presev – perseverance, MCQr – extended Money Choice Questionnaire, Hedon – hedonism, Fatal – fatalism, CFC – Consideration of Future Consequences.

Hypothesis 4: Mediation Models

Based on the data provided above, it is inappropriate to conduct mediation analyses because for every possible mediation model one or more assumptions of mediation were not met. This means for each possible mediation model, one or more of the following assumptions were not statistically significant: (a) The independent variable must significantly predict the dependent variable, (b) The mediator must significantly predict the dependent variable, and (c) The independent variable must significantly predict the mediator (Baron & Kenny, 1986). More specifically, only two significant relationships (at $p < .05$) were found between time perception and individual differences (hypothesis 3). Additionally, consistent results across the two remaining assumptions of mediation are tenuous (hypotheses 1 and 2). For example, although time perception was significantly correlated with health concerns, no individual differences demonstrated significant correlations with this intertemporal health behavior.

Additional Analyses

A conceptual issue requiring attention is whether or not aggregating more time perception trials together results in better indices of how people perceive time. This issue is specifically relevant to using mean and median deviation scores. If increasing the number of trials aggregated together improves the prediction of outcome variables, then the limited correlations found in this study between time perception and outcomes may be a result of not gathering enough trials to create a sufficiently robust index of time perception. On the other hand, if aggregating more trials together does not improve the prediction of outcomes, then finding different methods for measuring time perception may be warranted.

To test this, zero-order correlations were calculated between the different indices of time perception and the 32 individual difference and intertemporal behavior outcome measures used in this study. Because not every individual difference measure and intertemporal behavior was expected to correlate with time perception in the same direction, only the absolute value (or magnitude) of each correlation was used. As displayed in Table 2.24, the average magnitude of effect size between time perception and outcome variables for this study (i.e., individual differences and intertemporal behaviors) was .06. Average correlations between aggregated indices of time perception and outcome variables were higher than individual time perception trials. Unfortunately, the magnitude of this increase is small (four to five tenths of a correlation coefficient), suggesting that aggregating time perception trials did not meaningfully influence the magnitude of correlation coefficients in this study.

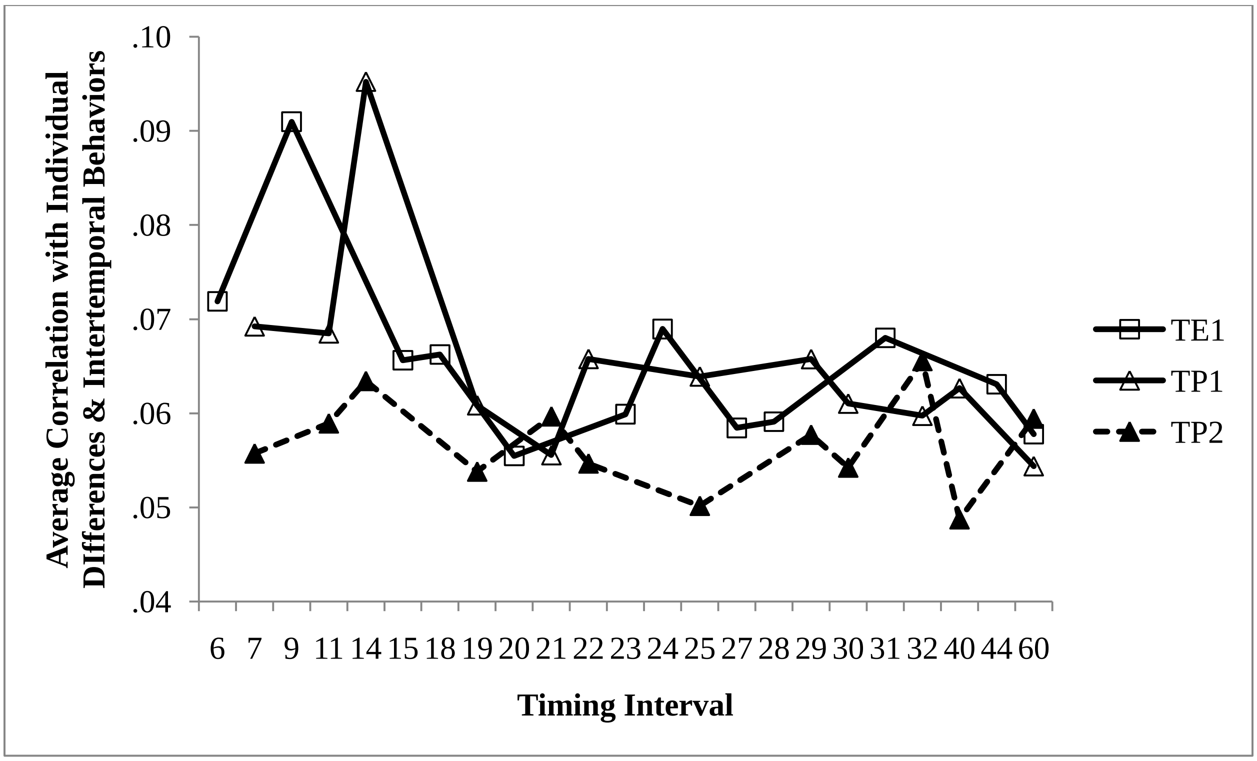
Another question of interest is whether the duration of the interval being perceived influences the magnitude of the correlation between time perception and outcomes (i.e., individual differences and intertemporal behaviors). To address this question, the absolute value of zero-order correlations were calculated between all time perception trials and the outcome variables used in this study. This resulted in 1,152 correlations. Next, these correlations were averaged across each time perception trial. This preliminary averaged correlation coefficient was then correlated with the timing interval used for that trial. For instance, the average correlation between outcomes variables and time production in block 1 for 32 seconds is $r = .0597$. This correlation coefficient was then paired with the numeric value 32, which represents the interval of time being perceived. The correlation between intervals of time being perceived and the magnitude of correlation between time perception and outcomes variables for those intervals of time is $r(36) = -.38$, $p = .023$. This significant correlation suggests that using longer time perception intervals is less successful at predicting outcome variables than shorter intervals of time (see Figure 2.4). The equation for this least squares regression line is $Y = -.0003X + .069$.

Table 2.24. Average magnitude of correlation with individual differences and intertemporal behaviors across different aggregations of the time perception.

	Average *r*	Number of Correlations Used to Calculate Average *r*
Individual Trials		
Time Estimation, Block 1	.069	384
Time Production, Block 1	.061	384
Time Production, Block 2	.065	384
All Individual Trials	.065	1,152
Aggregations		
Mean Deviation		
All Block 1 Trials	.065	32
All Time Production Trials	.070	32
All Trials	.069	32
Median Deviation		
All Block 1 Trials	.071	32
All Time Production Trials	.072	32
All Trials	.070	32

Note. All correlation used to derive average correlations used a sample size of $N = 206$.

Figure 2.4. Average magnitude of correlation between time estimation (TE) and time production (TP) blocks with outcome variables (individual differences and intertemporal behaviors) as a function of timing interval.



Discussion

Summary

The results from these analyses demonstrated the reliability of time perception trials ranging from a few seconds up to a minute, but failed to find support for the proposed mediation model. Time perception within time perception tasks and across blocks of trials was reliable. Time perception was largely uncorrelated with intertemporal behavior, although correlations with level of concern about contracting various diseases suggests that time perception may play a small predictive role in health behaviors. Although several significant correlations were found between individual differences and intertemporal behavior, no significant correlations were found between individual differences and time perception. Additionally, it was found that aggregating trials did not dramatically improve correlations between time perception and outcome variables (individual differences and intertemporal behaviors). Shorter time perception intervals, versus longer intervals, were found to be more strongly correlated with individual differences and intertemporal behaviors.

Time Perception

Time perception was assessed with two comparable tasks: time estimation and time production. From conceptual and theoretical standpoints both tasks are interchangeable, although time estimation relies more heavily on language processes to label the passage of time and time production requires more motor skills to start and stop intervals precisely. The data from this study conformed to assumptions of scalar expectancy theory (Gibbon et al., 1984): variance in time perception was proportional to the duration of the interval being timed.

Time perception within tasks and blocks were, on average, moderately to strongly correlated with each other (Table 2.5). Cronbach's alphas for the different blocks of time perception were strong, thus minimizing attenuation as an alternative explanation for the low correlations found in this study. Average correlations between time perception tasks and blocks were also generally strong to moderate in magnitude and consistent with past research using time production on consecutive days (McCauley et al., 1980). This further suggests that people perceive time in a reliable pattern – with some viewing time as moving faster than reality (hyperopic time perception) and others viewing time as moving slower than reality (myopic time perception).

Quantifying Time Perception

This study explored several operational definitions of time perception. Deviation scores were used to assess how inaccurate people were at judging time. The direction (i.e., sign) of the deviation scores was used to assess whether someone is a myopic or hyperopic timer perceiver. The magnitude of the deviation scores assessed the degree of accuracy in perceiving time, with more extreme deviation scores suggesting less accurate time perception. Deviation scores were aggregated two different ways by calculating mean deviation and median deviation scores. Median deviation scores should be less influenced by outliers in comparison to mean deviation scores; however, evidence derived from this study suggests that both categories of deviation scores were equivalent. Minute correlational advantages for median deviation scores (see Table 2.24) were not statistically significant (*t*s < .50). Both types of deviation scores were largely ineffective predictors of individual differences and intertemporal behaviors. On a brighter note, when significant correlations were found, the direction of the relationships were consistent with predictions -–myopic time perception led to less future-minded intertemporal behavior.

It was suggested by Barratt and Patton (1983) that longer timing intervals -–specifically those greater than 10-15 seconds-- would elicit stronger correlations with individual differences (e.g., impulsivity). This prediction was not supported by these data. It appears that shorter time intervals correlate more strongly with individual differences and intertemporal behaviors than longer time intervals. Overall, time perception poorly predicted both individual differences and intertemporal behavior. Conceptually, aggregating more time perception trials together should lead to more robust indices of time perception, thus aiding in the prediction of individual differences and intertemporal behavior. Results from this study suggest that aggregating more time perception trials does not dramatically improve the predictability of individual differences or intertemporal behaviors. This is a troubling conclusion, which suggests that at best, time perception is only weakly correlated with individual differences and intertemporal choice; and increasing the number of trials collected from the same setting to improve the prediction of outcomes may be unfruitful.

Individual Differences & Intertemporal Behaviors

Financial planning, followed by health and environmentalism, was the most productive class of intertemporal behaviors to correlate with the individual differences explored in this study. ZTPI Future and CFC scales were both significantly correlated with present financial behavior and financial impulsivity. Being more future-minded and considering the consequences of behavior were positively related to engaging in more responsible financial behaviors in the present and negatively related to impulsive financial behavior. Different dimensions of impulsivity were also significantly correlated with financial planning. Urgency was positively correlated with financial impulsivity, suggesting convergent validity for this measure of *impulsive* intertemporal behavior. Perseverance was significantly correlated with all three financial planning factors. Maintaining focus on a goal or outcome (i.e., perseverance) appears to be related to engaging in more financial planning both in the present and future and engaging in less impulsive financial behavior.

The three intertemporal health behaviors significantly correlated with individual differences (at $p < .0025$) were alcohol use, exercise frequency, and sociosexual orientation. When a traditional p-value is applied to the data (i.e., $p < .05$) additional significant correlations emerge; and results from this study parallel recently published studies (Adams & Nettle, 2009; Daugherty & Brase, 2010). Like Daugherty and Brase (2010), individual differences demonstrated differential patterns of correlations across the health behaviors measured. This suggests that although individual difference measures might be conceptually similar to each other (viz.: delay discounting, future-mindedness, and consideration of future consequences), each accounts for unique amounts of variance in health behaviors. Together, the significant correlations found in this study suggest that individual differences between people do predict at least some intertemporal health behaviors. Specifically, higher impulsivity and present-minded time orientation positively predict risk-invoking health behaviors (e.g., alcohol consumption) and negatively predict health-promoting behavior (e.g., exercise frequency). Future-minded time orientation predicts health behaviors in the opposite direction, by positively predicting health-promoting behaviors and negatively predicting risky health behaviors.

Consideration of future consequences was the only individual difference measure significantly correlated with environmental behaviors at $p < .0025$. CFC conceptualizes time orientation by combining future and present-mindedness on opposite ends of the same continuum (Strathman et al., 1994). This is different from the approach taken by Zimbardo and Boyd (1999) who created independent future and present-minded scales. When examining intertemporal environmental behaviors, a single-continuum approach yielded stronger correlations. The correlations found in this study suggest as people become more concerned about the consequences of their behavior, they engage in more pro-environmental behaviors, most notably recycling and re-using products.

When traditional significance levels were applied to the data from this study, three additional individual differences emerged as predictors of pro-environmental behaviors: urgency, perseverance, and future-mindedness. High urgency was associated with less pro-environmental behavior. This suggests that individuals feeling pressed for time may not consider helping the environment as an effective use of their time. High perseverance leads to more pro-environmental behavior. This suggests that individuals who stick with something to the end may be more likely to engage in pro-environmental behaviors, regardless of the short-term costs of time, effort, and energy. Future-mindedness also leads to more pro-environmental behavior. Having a future-oriented mindset might lead to greater focus on the future benefits of pro-environmental behavior with less focus on the present costs.

Time Perception & Individual Differences

Time perception by and large did not predict impulsivity, time orientation, or delay discounting. These results are inconsistent with several studies which have shown significant relationships between time perception and individual differences (Barratt & Patton, 1983; Berlin et al., 2004; Glicksohn et al., 2006; Keilp, Sackeim, & Mann, 2005; Siegman, 1961). On the other hand, this study is consistent with studies which have found non-significant relationships between time perception and individual differences (Bachorowski & Newman, 1985; Lenning & Burns, 1998). Inadvertently, the methodology used in this study may have been more consistent with studies that did not work (Bachorowski & Newman, 1985; Lenning & Burns, 1998) than studies that did work (Berlin et al., 2004; Glicksohn et al., 2006; Keilp et al., 2005).

This first study predicted that longer time perception intervals, versus short time perception intervals, should better differentiate impulsive individuals, based on Barratt and Patton (1983). So, a variety of intervals and two different time perception tasks were employed in this study to confirm this theory. The variety of intervals used, twelve for time estimation and another twelve for time production, made this study more comprehensive than any other published report. Including a more diverse range of time intervals (ranging from 6 to 60 seconds), however, limited the number of trials for each interval to two, one in the first block and one in the second block. In nearly all of the studies that found significant relationships between time perception and individual differences (Berlin et al., 2004; Glicksohn et al., 2006; Keilp et al., 2005), two or more trials with the same time perception interval were collected within the same block. Studies failing to find significant correlations between individual differences and time perception (Bachorowski & Newman, 1985; Lenning & Burns, 1998) often used a limited number of trials and did not repeat the same interval more than once. This current study falls somewhere between *what works* and *what does not work*. Although each interval was repeated once, there was at least a 25-40 minute gap between each. Past research indirectly suggests that stronger relationships between time perception and individual differences may emerge if identical intervals are assessed more than once (e.g., Berlin et al., 2004; Glicksohn et al., 2006; Keilp et al., 2005). Combining multiple trials for the same interval might create a better (i.e., more reliable) estimate of time perception, similar to personality research which uses multiple items to assess a trait. Additionally, aggregating trials of the same duration may increase the reliability and robustness of time perception indices, whereas, aggregating across different trials and tasks demonstrated limited success in the current study.

Summary

This study tested a proposed mediation model whereby the relationship between time perception and intertemporal behaviors is mediated by individual differences. The data collected from Study I did not permit testing the proposed model because the basic assumptions of mediation were not met (i.e., individual pathways in the mediation models were not statistically significant). Time perception demonstrated limited, or no, significant correlations with impulsivity, time orientation, delay discounting, health behaviors, pro-environmental behaviors, and financial planning behaviors. Individual differences and intertemporal behavior did shown small to moderate correlations, consistent with past research.

Chapter 3 - Study II

Introduction/Purpose

Study II was used to replication Study I. The central aim of Study II was the same as Study I: to test the general mediation model proposed in Figure 0.1. Study II used a similar methodological design as Study I, but with three modifications. First, based on the conclusions drawn from Study I, Study II used fewer time perception intervals and timed each interval twice. Additionally, only one block of time perception data was assessed. This change was designed to minimize participant fatigue by reducing the duration of the study from approximately 90 minutes down to approximately 60 minutes. Second, Study II used a time reproduction task instead of time estimation and time production. Time reproduction has been argued to be more reliable than time estimation and time production (Block, 1989; Fraisse, 1963; Zakay, 1990) and should result in fewer participant errors, like the ones seen for time estimation in Study I. Using time reproduction will also assess the generalizability of the results found in Study I to other time perception tasks. Third, Study II used a second measure of impulsivity, in addition to the UPPS.

Method

Participants

This study utilized 157 undergraduate research participants recruited from General Psychology classes at Kansas State University. Research participants were compensated for their time and effort with partial credit toward a research course requirement. Eleven participants were unable to complete the study in its entirety, thus demographic information for these participants is missing. Of the 146 participants with complete data, 77 (49%) were female. The average participant age was 19.01 (SD = 1.75) years. Over 75% (*N* = 112) of the sample were freshman.

Eighty-six percent (n = 125) self identified as Caucasian, 6% (n = 9) as African American, 4% (n = 6) Hispanic, 2% (n = 3) Native American, and 2% (n = 3) as other or mixed ethnic origin.

Measures

Time Perception

This study used a time reproduction task, which combines elements of both time estimation and time production (Block 1989; Fraisse, 1963; Zakay, 1990). In this task, participants were seated at a computer and first asked to keep a three-digit number in their working memory (to minimize the impact on counting on time perception, as suggested by Buhusi & Meck, 2005; Wittmann & Paulus, 2008). Next participants were asked to monitor how long a black box remained present on the screen. After the black box disappeared, participants were prompted to re-create (i.e., reproduce) the interval of time they just observed. This interval of time was re-created by clicking a button to start and end the interval of time. Finally, after the interval was reproduced, participants were asked type out the three-digit number provided at the beginning of the trial.

Before beginning the block of time perception trials, participants were given a practice trial. This practice trial used a ten-second interval. To ensure time perception was captured naturally, without outside influence, no feedback was given on any time perception trial, including the practice trial. Participants were also instructed not to use watches, cell phones, or other time-keep devices to monitor time while participating in the study. All participants reproduced six intervals (5, 10, 16, 29, 44, 60 seconds) twice, for a total of twelve time perception trials. The presentation order of the trials was randomized for each participant.

Table 3.1. Descriptive Statistics and Cronbach's Alphas for Individual Difference Scales Used in Study II.

Scale	Number of Scale Items	M	SD	Cronbach's α
Barratt Impulsivity Scale				
Total Score	30	67.69	10.51	.84
Second-Order, Attentional Impulsiveness	11	18.62	3.51	.63
Attention	5	11.58	2.76	.66
Cognitive Instability	3	7.04	1.63	.39
Second-Order, Motor Impulsiveness	8	23.00	4.40	.70
Motor Impulsiveness	7	15.50	3.43	.71
Perseverance	4	7.50	1.79	.34
Second-Order, Non-Planning Impulsiveness	11	26.07	4.98	.74
Self-Control	6	13.37	2.98	.67
Cognitive Complexity	5	12.70	2.73	.55
UPPS Impulsivity Scale				
Premeditation	10	39.35	7.28	.85
Urgency	10	36.73	8.99	.86
Sensation Seeking	10	45.43	8.69	.85
Perseverance	10	37.50	6.03	.79
MCQr	38	16.34	9.87	n/a
Zimbardo Time Perspective Inventory				
Future-Mindedness	13	45.82	6.86	.72
Hedonism	15	55.38	7.66	.78
Fatalism	9	24.01	6.10	.75
CFC	12	39.56	6.59	.77

Note. *N* = 157 for all measures.

Individual Differences

Study II used all the same measures as Study I, with the addition of a second impulsivity scale. Descriptive statistics and reliability coefficients for all individual difference measures are provided in Table 3.1. A second impulsivity scale was added to cross-validate the UPPS and determine whether the minimal correlations between time perception and impulsivity were an artifact of the impulsivity scale used in Study I.

The Barratt Impulsivity Scale (BIS, Patton et al., 1995) was adopted for this second study for two reasons. First, the program of research conducted by Barratt and colleagues was aimed at linking self-report measures of impulsivity with biological mechanisms (e.g., Barratt, 1983), much in the same way that Eysenck (1967) attempted to provide a biological foundation for extraversion. Barratt has also successfully correlated time perception with an earlier version of the BIS (Barratt & Patton, 1983), which suggests that the BIS may capture a component of impulsivity related to time perception which is not captured in the UPPS. A second reason for adding the BIS to this second study is the primary and secondary factor structures comprising the BIS. The BIS's primary factors break down impulsivity into six factors, unlike the UPPS which only has four factors. These extra factors allow a narrower look at what components of impulsivity are related to time perception. Additionally, all the BIS factors are all in the same direction, with higher scores representing more impulsivity; thus items can easily be summed into a global impulsivity factor. This is less easily accomplished with the UPPS.

The BIS is comprised of 30 items, with each individual primary factors comprised of 3 to 7 items. Responses were attained using a 4-point scale, with responses: *rarely/never*, *occasionally*, *often*, and *almost always/always*. The BIS's primary factors are, in order of extraction: attention – *focusing on the task at hand*, motor impulsiveness – *acting on the spur of the moment*, self-control – *planning and thinking carefully*, cognitive complexity – *enjoy challenging mental task*, perseverance – *a consistent life style*, and cognitive instability – *thought insertions and racing thoughts* (Patton et al., 1995, p. 770). The BIS's secondary factors group two primary factors into three second-order factors. The first second-order factor combines *attention* and *cognitive instability* to form *Attentional Impulsiveness*. The second second-order factor combines *motor impulsiveness* and *perseverance* to form *Motor Impulsiveness*. The third second-order factor combines *self-control* and *cognitive complexity* to form *Non-Planning Impulsiveness*. Total BIS scores were calculated by summing across all 30 items.

Intertemporal Behaviors

Study II uses the same health, environmental, and financial planning measures as Study I. Descriptive statistics, and Cronbach's alphas when appropriate, for these measures are provided in Table 3.2.

Procedure

This second study was performed in the same environment, with the same equipment and software as Study I. After signing informed consent, participants performed the twelve time perception trials, followed by the individual difference and intertemporal behavior measures. Individual difference and intertemporal behavior measures were presented in individualized random order, with the order of items within each measure also randomized. With the exception of 11 participants, this study took less than 60 minutes to complete.

Results

Of the 157 people who participated in this study, time reproduction data from 14 participants were excluded from further analysis due to severely inaccurate time perception performance. These fourteen people had at least one reproduction trial with a deviation score equal to or greater than 3 standard deviations away from the group mean. Sum deviation scores for these 14 people (M = -218.30, SD = 103.47) were significantly higher than the remaining sample (N = 143, M = -4.24, SD = 29.70), $t(13.21) = -7.71$, $p < .001$. Eleven participants had incomplete intertemporal behavior measures. Scales with incomplete data from these participants were excluded from further analyses on a pair-wise basis (as discussed later, mediation analyses were only conducted with complete data). Complete data were gathered from 134 people. Sample sizes for correlations and effects reported varied between 134 and 157, depending on the amount of missing data from participants.

Table 3.2. Descriptive Statistics and Cronbach's Alphas for Intertemporal Behaviors Used in Study II.

Scale	*N*	*M*	*SD*	Cronbach's α
Health Behaviors				
Tobacco Use	152	1.74	1.29	-
Alcohol Use	152	2.20	.94	-
Drug Use	152	1.50	.98	-
Eating Breakfast	152	2.95	1.41	-
Hours of Sleep per Night	152	2.93	.64	-
Exercise	152	3.58	1.40	-
Safety Belt Use	152	5.26	1.22	-
Helmet Use	152	3.57	2.04	-
Frequency of Stair Use	152	3.63	1.17	-
Doctor & Dentist Visits	152	3.22	1.47	-
Expected Longevity (in years)	152	84.53	13.01	-
Body Mass Index	151	23.44	4.06	-
Health Concerns	152	10.18	4.30	.82
Sociosexual Orientation	154	106.11	358.53	-
Environmental Behaviors				
Recycling	146	23.82	10.55	.89
Conservation	146	43.82	13.32	.85
Advocacy	146	12.73	6.16	.80
Transportation	146	13.28	4.37	.58
Re-Use	146	27.15	8.36	.82
Pro-Environmental Behaviors	146	39.90	13.32	.87
Financial Planning				
Future Financial Planning	149	38.97	17.30	.91
Present Financial Behavior	149	50.55	12.00	.81
Financial Impulsivity	149	19.61	6.12	.70

Time Perception Data

Conceptual Issues

Individual time reproduction trials should be highly correlated with each other. To test this, individual time reproduction trials were correlated with each other, *z*-score transformed, averaged together, and converted back to correlation coefficients. The average correlation between time reproduction trials, based on 66 correlations, was .13 (*SD* = .19), with individual correlations ranging from -.20 to .63. Cronbach's alpha, using all 12 trials, was .60. Visual inspection of the correlation matrix for the time reproduction trials revealed that smaller intervals (5, 10, and 16 second) and larger intervals (29, 44, and 60 second) are significantly correlated within each group, but non-significantly correlated across groups (see Table 3.3). When smaller and larger intervals are separated into two groups, Cronbach's alphas for both groups improved to .66. These segmented, internal consistency estimates are better than the estimate for all the intervals, but still indicate *poor* reliability and may lead to poor predictive validity (Nunnally & Bernstein, 1994).

Another conceptual validity check for time perception is whether reproduced intervals increase linearly relative to actual time. Figure 3.1 depicts the mean and median response times for each time reproduction interval and supports the conclusion that the reproduction trials are conceptually-valid measures of time perception.

Theoretical Considerations

According to scalar expectancy theory (SET, Gibbon et al., 1984), time perception for longer intervals will have more variability than time perception for shorter intervals of time; however, the variability across intervals will be the same relative to the duration of the interval timed. To examine this assumption, a coefficient of variance (standard deviation divided by mean) was calculated for each time perception interval (see Figure 3.2). Consistent with SET, the coefficients of variance remained constant across the timed intervals, the regression slope (*B* = -.0008) was not significantly greater than zero, *t*(141) = -.01, *p* > .99.

Table 3.3. Zero-Order Correlations between Time Reproduction Trials in Study II.

Time Reproduction Interval	5b	10a	10b	16a	16b	29a	29b	44a	44b	60a	60b
5a	.38**	.30**	.30**	.13	.36**	-.15	-.19*	-.10	-.03	-.19*	-.12
5b		.22**	.30**	.39**	.38**	.05	-.09	.06	-.05	-.16	-.01
10a			.20*	.18*	.35**	.03	.14	.16	-.05	-.18*	-.13
10b				.14	.31**	.09	.06	-.05	.18*	-.16	-.14
16a					.34**	.04	-.01	.32**	-.12	-.17*	.05
16b						.20*	.15	.16	.01	.05	.18*
29a							.28**	.28**	.11	.30**	.37**
29b								.21*	.33**	.30**	.23**
44a									-.08	.11	.24**
44b										.31**	.33**
60a											.56**

Note. N = 143. Differences between a and b intervals are arbitrary. * p < .05, ** p < .01.

Figure 3.1. Plotted Mean and Median Response Times for Time Reproduction in Study 2.

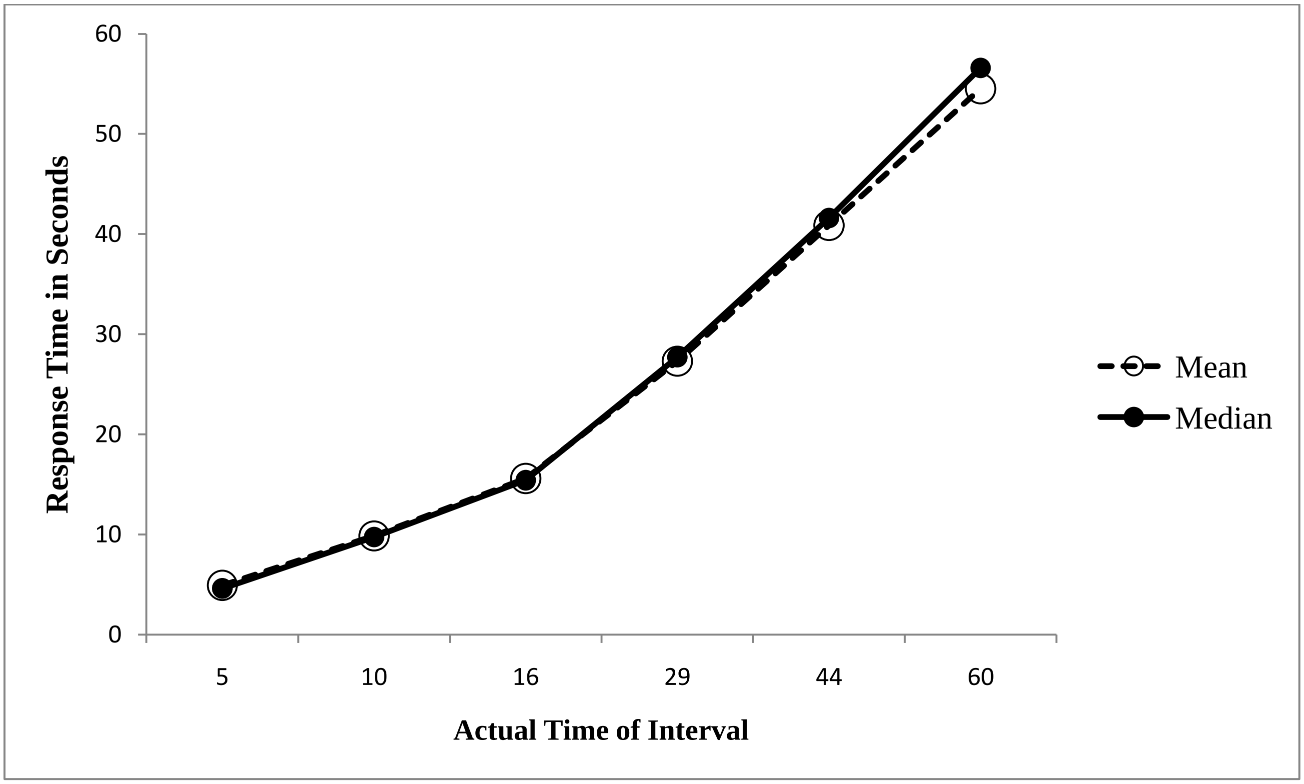
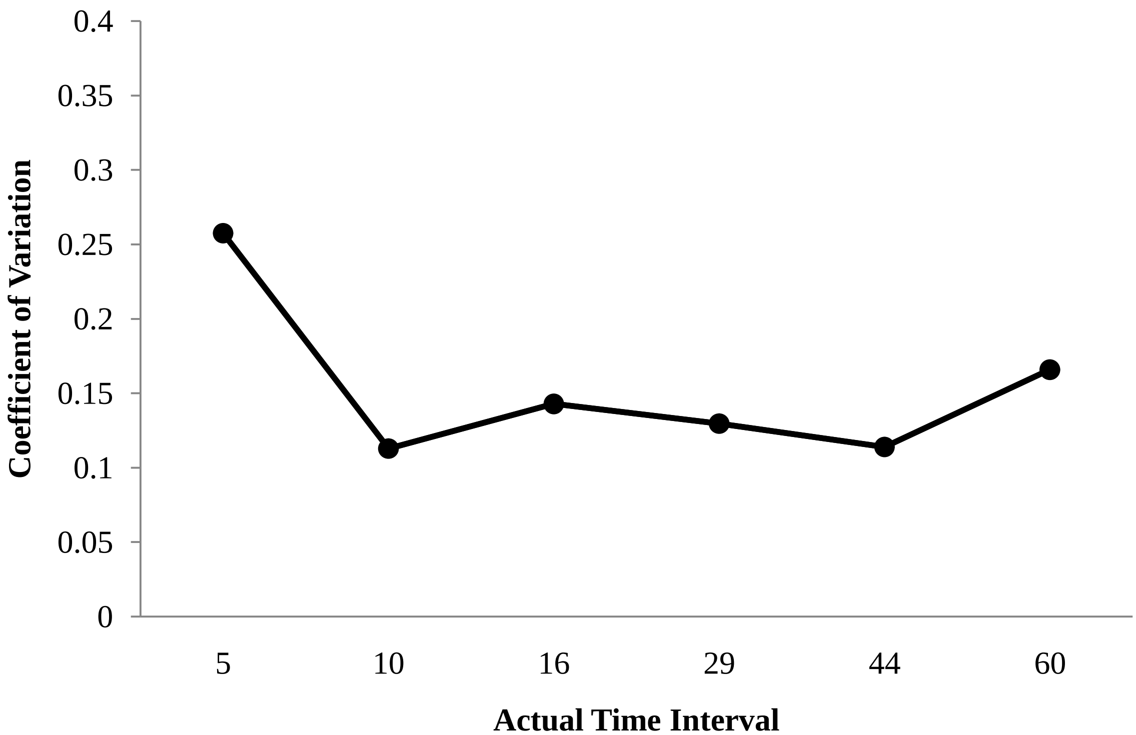


Figure 3.2. Coefficient of variation for each time reproduction interval.



Time Perception Indices

The same time perception indices used in Study 1 were calculated for the time reproduction trials in Study 2. This resulted in four indices of time perception for each person: mean deviation, median deviation, regression slope, and regression intercept. All four indices were based on the two trials for each of the 12 time reproduction intervals. Indirect evidence, based on past studies that found significant relationships with individual differences (Berlin et al., 2004; Glicksohn et al., 2006; Keilp et al., 2005), suggests that aggregating trials of the same duration may improve correlations between time perception and outcome variables, specifically individual differences. To examine this theory, average response times were calculated for each timing interval. Descriptive statistics for all time perception indices are provided in Table 3.4.

Proposed Mediation Model

Hypothesis 1: Time Perception & Intertemporal Behaviors

To test the first hypothesis of the proposed model (see path C in Figure 1.4), indices of time perception were correlated with health behaviors, environmental behaviors, and financial planning behaviors. Zero-order correlations between time perception indices and intertemporal behaviors are provided in Tables 3.5, 3.6, and 3.7.

Using a conservative *p*-value of .0025, only two correlations between time perception and intertemporal behaviors reached statistical significance. Drug use and sociosexual orientation were both positively correlated with the average response time for 10 second intervals. These correlations suggest that myopic time perceivers reproduced longer time interval than hyperopic timer perceivers, thus more myopic time perception leads to greater use of drugs and more willingness to engage in sexual activity with psychological commitment. Further discussion on the relationship between time perception and intertemporal behaviors, for short and long timing intervals, is provided in the discussion for Study II. Using a traditional *p*-value ($p < .05$), time perception was significantly correlated with tobacco and alcohol use, eating breakfast, hours of sleep per night, safety belt use, expected longevity, environmental behavior related to transportation, and financial impulsivity.

Table 3.4. Descriptive Statistics for Time Perception Indices in Study 2.

	M	*SD*	Min	Max
Mean Deviation	-1.82	2.37	-11.67	2.37
Median Deviation	-0.82	1.32	-7.51	3.47
Regression Slope	.90	.15	.23	1.23
Regression Intercept	.88	2.48	-4.27	9.37
Averaged Intervals				
5	4.91	1.26	2.89	13.42
10	9.86	1.11	7.43	16.25
16	15.59	2.23	9.45	29.82
29	27.30	3.54	15.02	36.02
44	40.88	4.66	22.20	53.21
60	54.52	9.04	14.18	74.95

Notes. Units are in seconds. Slopes and intercepts were calculated for each participant, values provided above describe the all participants with complete time perception data (N = 143).

Table 3.5. Zero-Order Correlations Between Time Reproduction Indices and Intertemporal Health Behaviors.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mean Deviation	-.12	-.01	-.03	.00	-.07	-.10	.06	.05	.07	-.09	.10	.08	.04	-.09
Median Deviation	-.01	.08	.14	.00	-.16	-.11	-.07	-.07	-.05	-.14	.13	.05	.08	.09
Regression Slope	-.19*	-.07	-.13	.00	.03	-.07	.07	.05	.11	-.02	.06	.06	.01	-.11
Regression Intercept	.21*	.11	.19*	.00	-.11	.02	-.06	-.03	-.11	-.06	.00	-.03	.02	.10
Average Intervals														
5	.17*	.14	.12	.00	-.18*	.00	-.17*	-.09	-.01	-.05	-.04	.13	.02	.12
10	.20*	.17*	.25†	.02	-.20*	-.03	-.05	.03	-.15	-.08	.09	.11	-.04	.26†
16	.15	.09	.10	.01	-.06	-.18*	-.13	.01	-.01	-.08	-.05	-.05	.13	.00
29	-.20*	-.01	.06	.00	-.06	.00	.22*	.05	.02	-.09	.18*	.01	-.01	-.11
44	-.05	-.10	-.08	.00	-.08	-.05	.11	.07	.04	-.16	.13	.04	.06	-.17*
60	-.17*	-.02	-.09	.00	.02	-.08	.02	.03	.10	.00	.03	.07	.01	-.06

Notes. $N = 139$, * $p < .05$, † $p < .0025$, 1 – tobacco, 2 – alcohol, 3 – drugs, 4 - exercise, 5 – breakfast, 6 – sleep, 7 - safety belt, 8 - helmet use, 9 - freq of stairs use, 10 - doctor or dentist visits in last 12 months, 11 - expected longevity, 12 – BMI, 13 – Health Concerns, 14 – Sociosexual Orientation.

Table 3.6. Zero-Order Correlations between Time Production Indices and Intertemporal Environmental Behaviors.

.

	Recycling	Conservation	Advocacy	Transportation	Re-Use	Pro-Environment
Mean Deviation	-.09	.03	-.02	.08	.06	.04
Median Deviation	-.15	-.02	-.04	-.02	-.01	-.03
Regression Slope	-.03	.08	.00	.14	.08	.09
Regression Intercept	-.04	-.11	-.02	-.17*	-.08	-.12
Average Intervals						
5	-.12	-.04	-.06	-.09	-.02	-.08
10	-.08	-.13	-.14	-.13	-.01	-.15
16	-.13	-.06	-.01	-.06	-.04	-.07
29	.03	.07	.07	.07	.09	.09
44	-.12	-.07	-.07	-.05	-.03	-.06
60	-.03	.09	.00	.16	.09	.10

Notes. N = 134, * $p < .05$.

Table 3.7. Zero-Order Correlations between Time Reproduction Indices and Financial Planning Behaviors.

	Future Financial Planning	Present Financial Behavior	Financial Impulsivity
Mean Deviation	.00	.04	-.12
Median Deviation	.06	.02	-.13
Regression Slope	-.01	.04	-.06
Regression Intercept	.03	-.03	.00
Average Intervals			
5	-.10	-.05	.05
10	.04	-.10	.04
16	-.01	-.02	-.04
29	.08	.06	-.23*
44	.05	.10	-.13
60	-.04	.01	-.04

Notes. N = 136. * $p < .05$.

Hypothesis 2: Individual Differences & Intertemporal Behaviors

To test the second hypothesis of the proposed model (see path B in Figure 1.4), individual differences were correlated with health, environmental, and financial planning behaviors (see Tables 3.8, 3.9, and 3.10). Using a conservative *p*-value of .0025, alcohol consumption, eating breakfast, number of hours of sleep per night, and safety belt use were each significantly correlated with at least one individual difference scale. Safety belt use was negatively correlated with fatalism and self-control, second-order motor impulsiveness, non-planning impulsiveness, and total BIS impulsivity. Consistent with predictions, these correlations suggest that present-mindedness and impulsivity increase as safety belt use decreases. Amount of sleep per night was negatively correlated with attention, suggesting that those who are unable to maintain focus on tasks get more sleep. Eating breakfast was negatively correlated with motor-impulsiveness at both the primary and secondary factor level, suggesting individuals who act on a whim are less likely to eat breakfast on a regular basis. Alcohol consumption was negatively correlated with premeditation and future-mindedness, and positively correlated with urgency, sensation seeking, hedonism, and fatalism. Alcohol consumption was also significantly correlated with five out of six primary BIS factors, the exception being perseverance. Alcohol consumption was also significantly correlated with the BIS's three second-order factors and total BIS scores. All of the correlations with alcohol consumption were in the predicted direction, such that higher impulsiveness, higher present-mindedness, and lower future-mindedness results in more risky health-related behavior.

Applying a conservative *p*-value of .0025 to the correlations between individual differences and environmental behaviors, suggests that delay discounting is positively correlated with environmentally-related transportation behavior. As predicted, willingness to postpone immediate rewards in favor of greater, future rewards is related to greater pro-environmental behavior related to transportation.

Applying a conservative *p*-value of .0025 to the correlations between individual differences and financial planning behaviors, suggests that future financial planning, present financial behavior, and financial impulsivity are all significantly related to at least six individual differences. In general terms, higher impulsivity, higher present-mindedness, and lower future-mindedness were negatively correlated with future financial planning and present financial behavior, but positively correlated with financial impulsivity. All of the correlations for this group of intertemporal behaviors were as predicted. Sensation seeking and cognitive instability were the only individual differences scales not significantly correlated to at least one financial planning variable.

Nearly all of the intertemporal behaviors examined in this second study were significantly correlated with at least one individual difference at $p < .05$. Only three health behaviors were not significantly correlated with any individual differences. These behaviors were: frequency of stair use, frequency of doctor or dentist visits in the last twelve months, and body mass index.

Table 3.8. Zero-Order Correlations between Individual Differences and Intertemporal Health Behaviors in Study II.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Barratt Impulsivity Scale														
Attention	.05	.32†	.01	-.12	-.01	-.24†	-.09	-.16*	-.09	.13	-.05	.03	.10	.15
Motor Imp	.20*	.42†	.22*	.06	-.30†	-.12	-.22*	-.09	-.02	.03	-.03	.12	-.15	.21*
Self-Control	.17*	.27†	.02	-.02	-.21*	-.13	-.26†	-.20*	-.08	-.12	-.21*	.08	-.04	.02
Cognitive Complexity	.12	.29†	.16	.04	-.13	-.15	-.18*	-.14	-.04	.09	-.01	.03	-.11	.01
Perseverance	.17*	.21*	.14	.11	-.05	-.20	-.18*	-.02	.00	-.06	-.21*	.01	.07	.03
Cognitive Stability	.17*	.26†	.12	.03	-.05	-.07	-.08	-.09	-.02	-.05	-.11	.12	.10	.03
Attentional Imp	.12	.37†	.06	-.08	-.03	-.23*	-.11	-.17*	-.08	.08	-.09	.08	.12	.13
2nd Order Motor Imp	.22*	.42†	.23*	.09	-.25†	-.17*	-.25†	-.08	-.02	.00	-.11	.10	-.09	.17*
Non-Planning Imp	.17*	.32†	.10	.01	-.19*	-.16*	-.25†	-.19*	-.07	-.02	-.13	.06	-.09	.02
Total Score	.21*	.45†	.16*	.01	-.21*	-.22*	-.26†	-.18*	-.07	.02	-.14	.10	-.04	.12
UPPS Impulsivity Scale														
Premeditation	-.05	-.28†	-.03	-.05	.18	.08	.18*	.05	-.02	.01	.03	-.15	.15	-.05
Urgency	.12	.31†	.05	-.10	-.04	-.19*	-.17*	-.03	-.10	.03	-.16	.09	.15	.07
Sensation Seeking	.20*	.24†	.18*	.13	-.12	.02	-.15	-.15	.08	.02	.03	-.01	-.18*	.01
Perseverance	-.10	-.15	-.09	.16*	.14	.17*	.00	.04	.09	-.02	.17*	-.02	.08	-.13
MCQr	.00	-.10	.05	.08	.13	.14	.08	-.01	.01	.02	.04	-.16	.03	-.11
Zimbardo Time Perspective Inventory														
Future-mindedness	-.20*	-.26†	-.16	.11	.20*	.10	.13	.14	-.05	.06	.20*	-.07	.22*	.00
Hedonism	.20*	.37†	.16*	.03	-.23*	-.05	-.09	.00	.06	.06	.01	-.02	-.04	.19*
Fatalism	.17*	.28†	.17*	.02	-.13	.00	-.24†	-.17*	.02	-.08	-.19*	.02	.03	.18*
CFC	-.18*	-.23*	-.18*	.08	.13	.04	.20*	.12	.05	-.02	.19*	-.03	.00	-.03

Notes. $N = 152$, * $p < .05$, † $p < .003125$, MCQr – expanded Money Choice Questionnaire, CFC – Consideration of Future Consequences, 1 – tobacco, 2 – alcohol, 3 – drugs, 4 - exercise, 5 – breakfast, 6 – sleep, 7 - safety belt, 8 - helmet use, 9 - freq of stairs use, 10 - doctor or dentist visits in last 12 months, 11 - expected longevity, 12 – BMI, 13 – Health Concerns, 14 – Sociosexual Orientation.

Table 3.9. Zero-Order Correlations between Individual Differences and Intertemporal Environmental Behaviors.

.

	Recycling	Conservation	Advocacy	Transportation	Re-Use	Pro-Environment
Barratt Impulsivity Scale						
Attention	-.02	-.10	-.08	-.13	-.14	-.10
Motor Imp	.00	-.03	-.03	-.03	.03	-.01
Self-Control	-.11	-.20*	-.15	-.14	-.14	-.18*
Cognitive Complexity	-.11	-.20*	-.12	-.23*	-.17*	-.16*
Perseverance	.04	-.06	-.08	-.03	-.04	-.02
Cognitive Stability	.11	.13	.05	.11	.08	.12
Attentional Imp	.03	-.02	-.04	-.05	-.07	-.02
2nd Order, Motor Imp	.02	-.05	-.06	-.03	.01	-.02
Non-Planning Imp	-.12	-.23*	-.15	-.21*	-.18*	-.20*
Total Score	-.04	-.13	-.11	-.13	-.10	-.11
UPPS Impulsivity Scale						
Premeditation	-.05	-.04	-.06	.01	-.04	-.04
Urgency	-.12	-.19*	-.09	-.14	-.16	-.11
Sensation Seeking	-.05	-.09	-.04	.02	-.08	-.06
Perseverance	.12	.17*	.15	.14	.09	.13
MCQr	.20*	.21*	.09	.25†	.23*	.19*
Zimbardo Time Perspective Inventory						
Future-mindedness	.16	.25†	.22*	.13	.19*	.21*
Hedonism	.11	.09	.07	.11	.17*	.16
Fatalism	.07	-.03	-.01	.09	.00	-.01
CFC	.14	.18*	.10	.09	.13	.13

Notes. *N* = 146. * $p < .05$, † $p < .003125$, Imp – impulsiveness, MCQr – expanded Money Choice Questionnaire, CFC – Consideration of Future Consequences.

Table 3.10. Zero-Order Correlations between Individual Differences and Financial Planning Behaviors in Study II.

	Future Financial Planning	Present Financial Behavior	Financial Impulsivity
Barratt Impulsivity Scale			
Attention	-.26†	-.32†	.31†
Motor Impulsiveness	-.15	-.28†	.37†
Self-Control	-.23*	-.43†	.44†
Cognitive Complexity	-.41†	-.44†	.43†
Perseverance	-.12	-.12	.27†
Cognitive Stability	-.03	-.16	.11
Second Order, Attentional Impulsiveness	-.21*	-.33†	.29†
Second Order, Motor Impulsiveness	-.17*	-.27†	.40†
Second Order, Non-Planning Impulsiveness	-.36†	-.50†	.50†
Total Score	-.31†	-.45†	.49†
UPPS Impulsivity Scale			
Premeditation	.18*	.30†	-.42†
Urgency	-.16*	-.27†	.35†
Sensation Seeking	.05	.07	-.01
Perseverance	.33†	.45†	-.44†
MCQr	.14	.30†	-.28†
Zimbardo Time Perspective Inventory			
Future-mindedness	.29†	.35†	-.43†
Hedonism	-.13	-.16*	.25†
Fatalism	.02	-.27†	.35†
CFC	.15	.22*	-.35†

Notes. N = 149. * $p < .05$, † $p < .003125$, MCQr – expanded Money Choice Questionnaire, CFC – Consideration of Future Consequences.

Table 3.11. Zero-Order Correlations Between Time Reproduction Indices and Individual Differences in Study II.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Mean Deviation	-.03	.02	-.13	-.14	.08	.14	.04	.05	-.16	-.04	.03	-.05	.08	.02	-.01	-.03	.06	-.06	.06
Median Deviation	-.09	.10	-.04	-.08	.11	.16*	.00	.12	-.07	.02	.06	.02	.11	.02	.06	.03	.09	.06	.00
Regression Slope	-.01	-.05	-.16	-.19*	-.05	.17*	.07	-.06	-.19*	-.09	.01	-.07	.07	-.01	.01	-.05	-.03	-.13	.11
Regression Intercept	-.02	.10	.13	.18*	.16	-.15	-.09	.14	.18*	.11	.01	.07	-.04	.04	-.03	.07	.11	.16	-.13
Average Interval																			
5	.07	.19*	.18*	.16	.16	.05	.08	.22*	.20*	.21*	-.17*	.12	.09	.04	-.01	-.09	.27†	.18*	-.17*
10	-.07	.30†	.13	.07	.19*	.08	-.02	.31†	.12	.17*	.01	.06	.12	.04	-.06	.00	.16	.20*	-.19*
16	.07	.09	.10	.14	.27†	.06	.09	.18*	.14	.17*	-.02	.09	.00	-.07	-.06	-.01	.13	.13	-.15
29	-.07	-.06	-.19*	-.14	-.02	-.01	-.06	-.05	-.19*	-.13	.14	-.09	.02	.08	.04	.05	.01	-.11	.15
44	-.17*	-.10	-.24*	-.19*	.09	-.09	-.17*	-.04	-.25*	-.19*	.12	-.15	-.03	.07	-.03	.11	-.05	-.09	.11
60	.05	.02	-.08	-.13	-.03	.23*	.14	.00	-.12	-.01	-.03	-.02	.10	-.03	.01	-.10	.02	-.09	.06

Notes. N = 143, * p < .05, † p < .003125, 1 – BIS Attention, 2 – BIS Motor Impulsiveness, 3 - BIS Self-Control, 4 – BIS Cognitive Complexity, 5 – BIS Perseverance, 6 – BIS Cognitive Stability, 7 – BIS, Second-Order, Attentional Impulsiveness, 8 – BIS, Second-Order, Motor Impulsiveness, 9 – BIS, Second-Order, Non-Planning Impulsiveness, 10 – Total BIS Score, 11 – UPPS Premeditation, 12 – UPSS Urgency, 13 – UPPS Sensation Seeking, 14 – UPPS Perseverance, 15 – Revised Money Choice Questionnaire, 16 – ZPTI – Future-mindedness, 17 – ZTPI Hedonism, 18 – ZTPI Fatalism, 19 – CFC.

Hypothesis 3: Time Perception & Individual Differences

To test the third hypothesis of the proposed model (see path A in Figure 1.4), time perception was correlated with individual differences (see Table 3.11). Four correlations between time perception and individual differences reached statistical significance at the $p < .0025$ level. Consistent with the predictions of this study, hedonism was positively correlated with the average response time for time reproduction at the 5 second interval. Both the primary and secondary motor-impulsivity factors were positively correlated with average response time for time reproduction at the 10 second interval. And perseverance was positively correlated with the average response time for time reproduction at the 16 second interval. Across the four statistically significant correlations found in Study II, myopic time perceivers reproduce longer intervals than hyperopic time perceivers, and greater myopic time perception leads to higher self-reported hedonism and impulsivity.

Hypothesis 4: Mediation Model

In the previous analyses, correlations were calculated on a pair-wise basis for all available data. In order to conduct the following mediation analyses only complete data was used. Complete data ensures that the different pathways in the mediation models are simultaneously tested. Using only complete data ($n = 134$), nine mediation models met the underlying assumptions of mediation (using $p < .05$, numerous individual pathways were significant beyond $p < .0025$, but no single mediation model met all three assumptions of mediation at $p < .0025$). All of the mediation models involved averaged response times for individual time reproduction trials, Barratt impulsivity scales, and intertemporal health behaviors as the independent variable, mediator, and dependent variable, respectively. See Table 3.12 for a listing of the nine mediation models.

Table 3.12. Mediation Models Meeting Underlying Assumption of Mediation as Set Forth by Baron and Kenny (1986).

See Figure ##	Independent Variable (Time Perception)	Mediator (Individual Difference)	Dependent Variable (Intertemporal Behavior)
10	Average Response 16 seconds	BIS Total	Hours of Sleep per Night
11	Average Response 16 seconds	Secondary Motor Impulsivity	Hours of Sleep per Night
12	Average Response 16 seconds	Perseverance	Hours of Sleep per Night
13	Average Response 10 seconds	Secondary Motor Impulsivity	Drug Use
14	Average Response 10 seconds	Secondary Motor Impulsivity	Eating Breakfast
15	Average Response 10 seconds	Secondary Motor Impulsivity	Sociosexual Orientation
16	Average Response 10 seconds	Primary Motor Impulsivity	Drug Use
17	Average Response 10 seconds	Primary Motor Impulsivity	Eating Breakfast
18	Average Response 10 seconds	Primary Motor Impulsivity	Sociosexual Orientation

Notes. Assumption of mediation met using complete data from 134 people, $p < .05$.

Each mediation model was analyzed following recommendations by Baron and Kenny (1986). First, the independent variable (time perception) was regressed on the dependent variable (intertemporal health behavior) and a standardized beta weight was attained. Next, the mediator (impulsivity measure) was regressed on the dependent variable (intertemporal health behavior) and a standardized beta weight was attained. Third, the independent variable (time perception) was regressed on the mediator (impulsivity measure) and a standardize beta weight was attained. Indirect effects (for this study, the effect of time perception on intertemporal behavior when controlling for an individual difference) were calculated by simultaneously regressing the independent variable and mediator on the dependent variable and standardized beta weights were again attained. Standardize beta weights for each mediation model are provided in Figures 3.3 through 3.11. Next, following recommendations by Preacher and Hayes (2004; 2008), each indirect effect was confirmed using a bootstrapping methodology with 5,000 iterations. Bootstrapping was used to create confidence intervals for the indirect effects because traditional Sobel tests (Sobel, 1982) of mediation are heavily dependent on assumptions of normal distributions. Meeting this assumption is problematic for data sets even larger than the current one (Micceri, 1989). Table 3.13 provides model summaries and 95% confidence intervals for the indirect effects of the mediation models. The confidence intervals used in Table 3.13 are bias corrected and accelerated, which removes bias and skew from the resulting bootstrapped distribution of indirect effects (Efron, 1987). Based on the 95% confidence intervals displayed in Table 3.13, all of the indirect effects are significantly different from zero (at $p < .05$).

Figure 3.3. Multiple Regression Mediation Analysis for the Indirect Effect of Total Barratt Impulsivity Score on the Relationship between Average Response Time for 16 Second Intervals and Average Hours of Sleep per Night, * denotes *p* < .05, † denoted *p* < .0025.

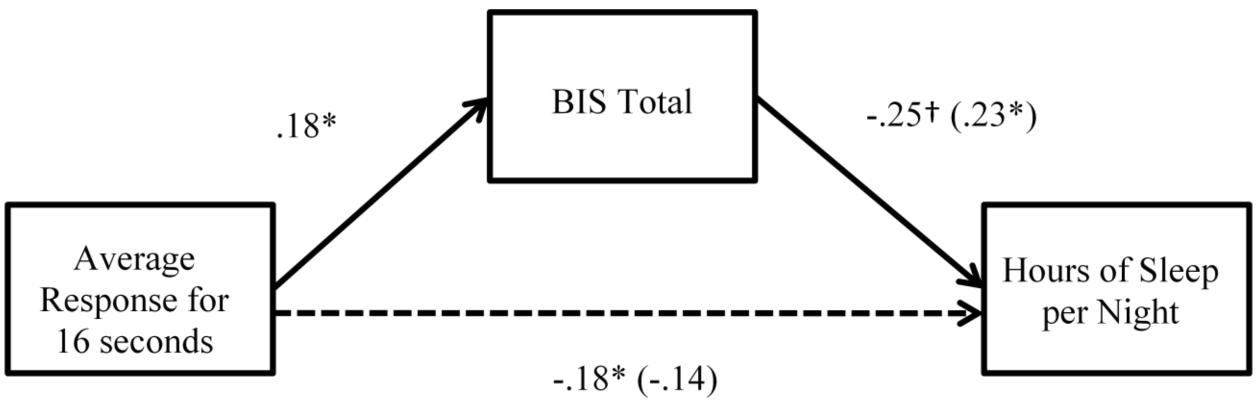


Figure 3.4. Multiple Regression Mediation Analysis for the Indirect Effect of Second-Order Motor Impulsivity on the Relationship between Average Response Time for 16 Second Intervals and Average Hours of Sleep per Night, * denotes *p* < .05, † denoted *p* < .0025.

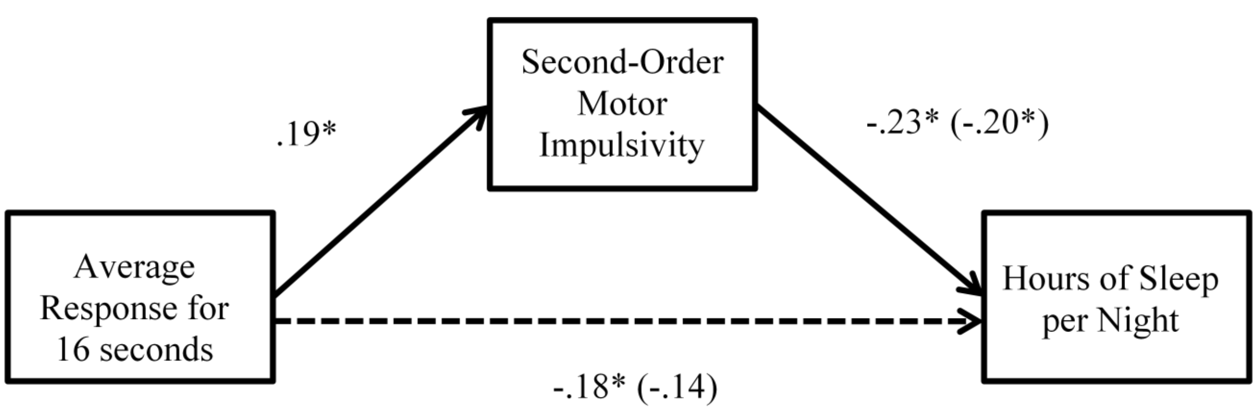


Figure 3.5. Multiple Regression Mediation Analysis for the Indirect Effect of Perseverance on the Relationship between Average Response Time for 16 Second Intervals and Average Hours of Sleep per Night, * denotes *p* < .05, † denoted *p* < .0025.

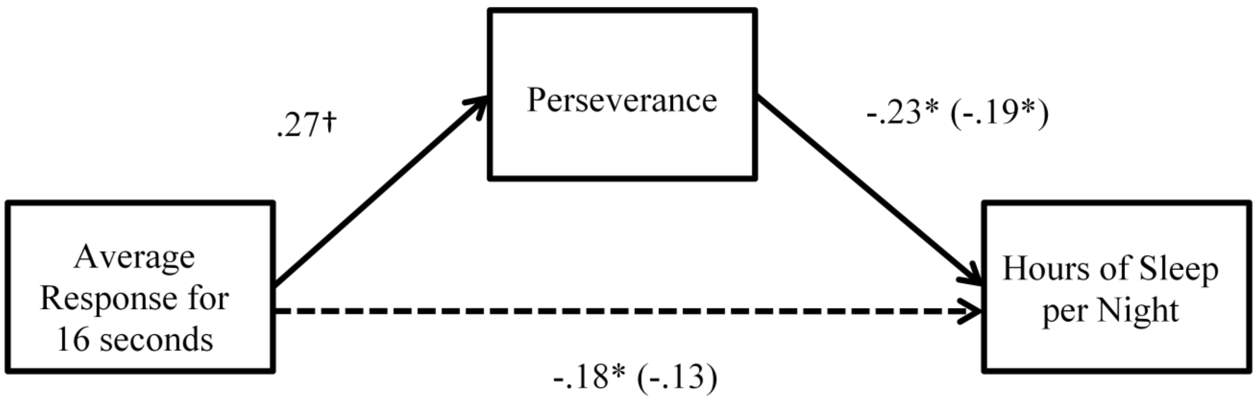


Figure 3.6. Multiple Regression Mediation Analysis for the Indirect Effect of Second-Order Motor Impulsivity on the Relationship between Average Response Time for 10 Second Intervals and Drug Use, * denotes *p* < .05, † denoted *p* < .0025.

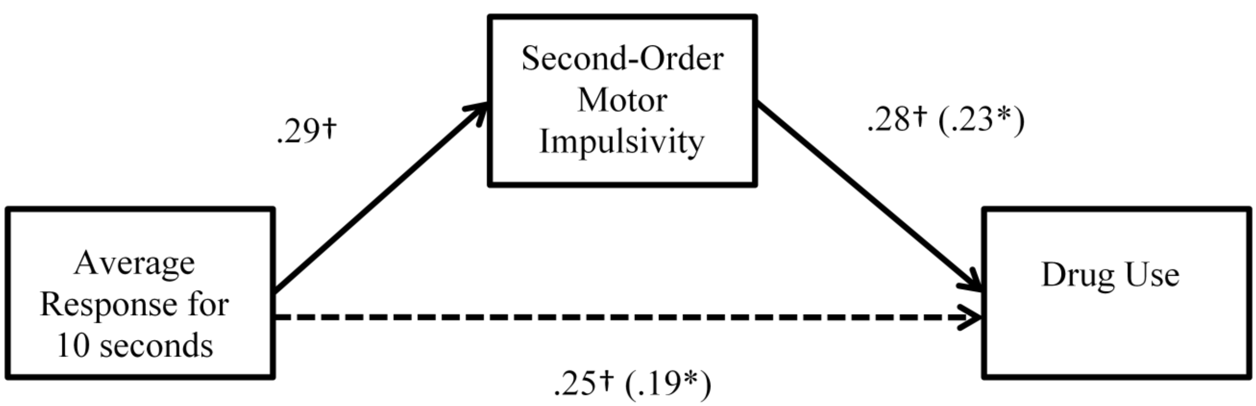


Figure 3.7. Multiple Regression Mediation Analysis for the Indirect Effect of Second-Order Motor Impulsivity on the Relationship between Average Response Time for 10 Second Intervals and Eating Breakfast, * denotes *p* < .05, † denoted *p* < .0025.

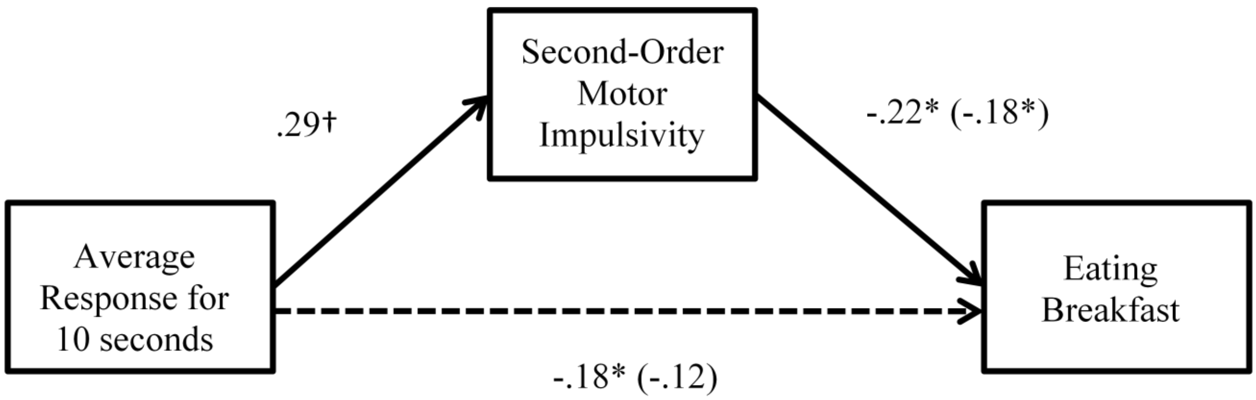


Figure 3.8. Multiple Regression Mediation Analysis for the Indirect Effect of Second-Order Motor Impulsivity on the Relationship between Average Response Time for 10 Second Intervals and Sociosexual Orientation, * denotes *p* < .05, † denoted *p* < .0025.

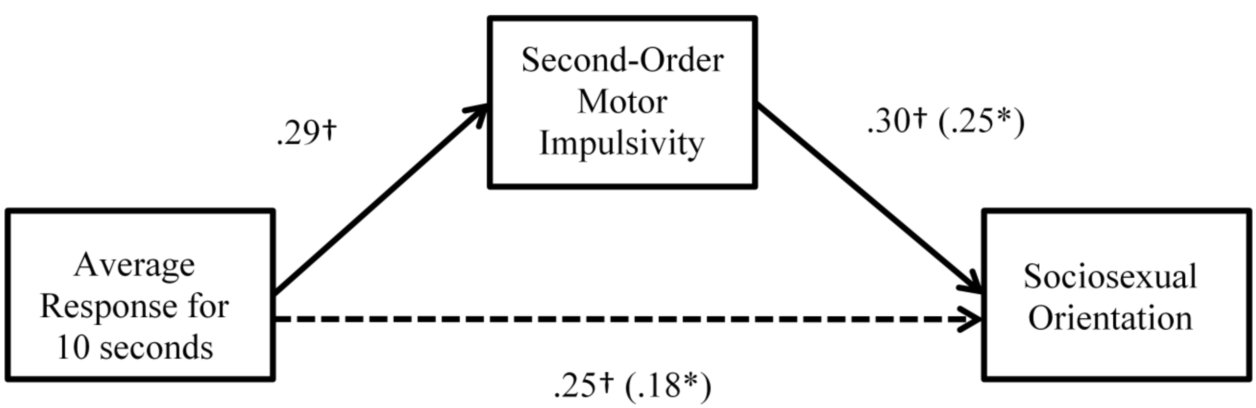


Figure 3.9. Multiple Regression Mediation Analysis for the Indirect Effect of Primary Motor Impulsivity on the Relationship between Average Response Time for 10 Second Intervals and Drug Use, * denotes *p* < .05, † denoted *p* < .0025.

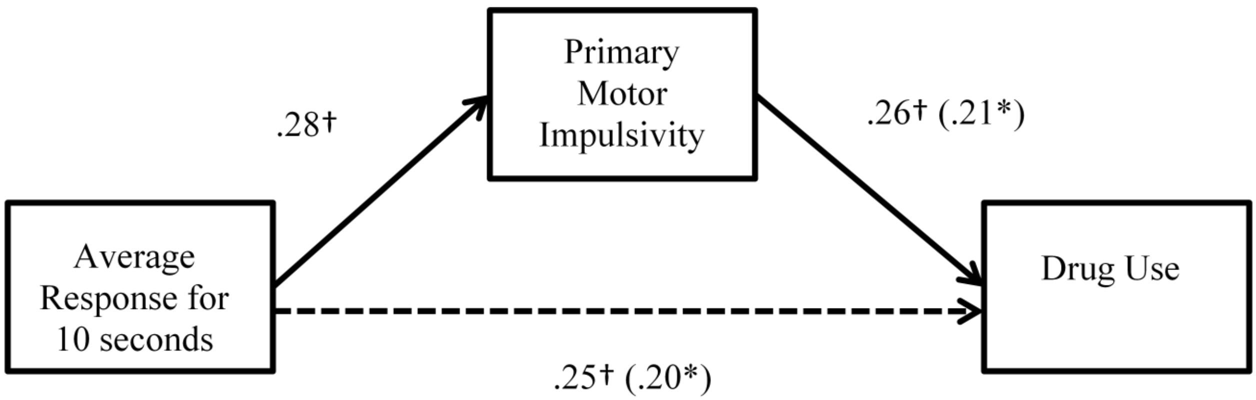


Figure 3.10. Multiple Regression Mediation Analysis for the Indirect Effect of Primary Motor Impulsivity on the Relationship between Average Response Time for 10 Second Intervals and Eating Breakfast, * denotes *p* < .05, † denoted *p* < .0025.

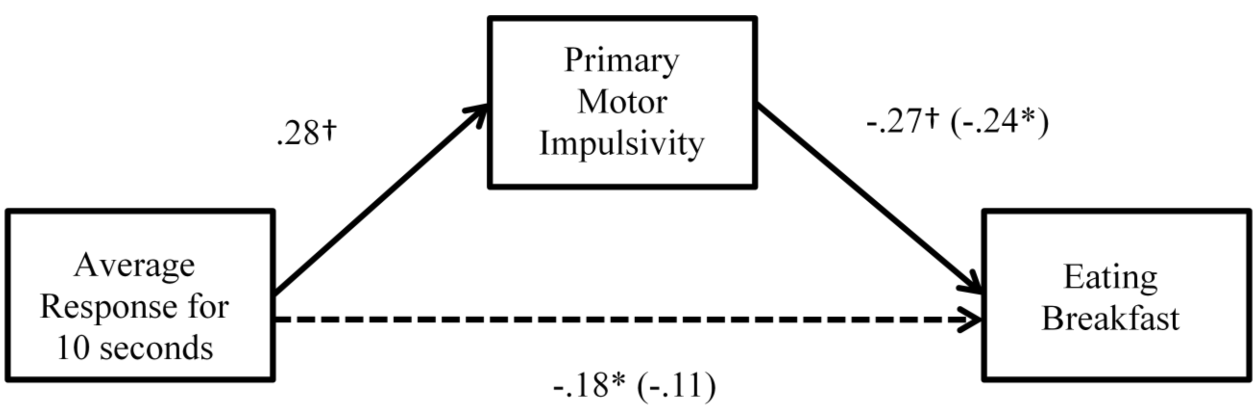


Figure 3.11. Multiple Regression Mediation Analysis for the Indirect Effect of Primary Motor Impulsivity on the Relationship between Average Response Time for 10 Second Intervals and Sociosexual Orientation, * denotes *p* < .05, † denoted *p* < .0025.

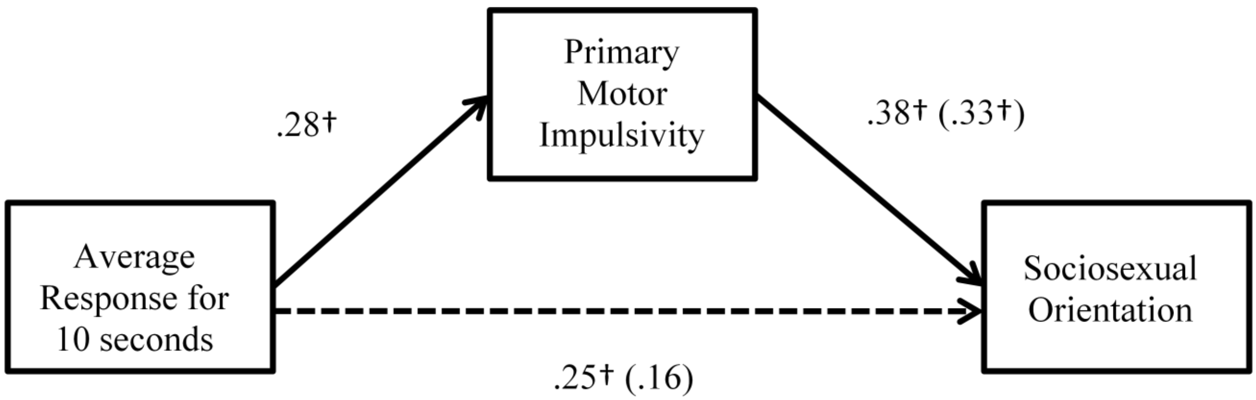


Table 3.13. Model Summaries and 95% Confidence Intervals for Indirect Effects between Time Perception and Intertemporal Health Behaviors.

Variables		Model Summary			Bootstrap (5,000 iterations)			
		R^2	Adj R^2	*F*(2, 131)	*M*	S.E.	Lower 95% CI	Upper 95% CI
I. V.	Average Response 16 seconds	.08	.07	5.85**	-.0108	.0056	-.0267	-.0028
M.	BIS Total							
D.V.	Hours of Sleep per Night							
I.V.	Average Response 16 seconds	.07	.06	5.15**	-.0103	.0058	-.0268	-.0022
M.	Secondary Motor Impulsivity							
D.V.	Hours Sleep per Night							
I.V.	Average Response 16 seconds	.07	.05	4.74*	-.0133	.0105	-.0553	-.0011
M.	Perseverance							
D.V.	Hours Sleep per Night							
I.V.	Average Response 10 seconds	.11	.10	8.26***	.0563	.0303	.0139	.1478
M.	Secondary Motor Impulsivity							
D.V.	Drug Use							
I.V.	Average Response 10 seconds	.06	.05	4.23*	-.0628	.0352	-.1547	-.0080
M.	Secondary Motor Impulsivity							
D.V.	Eating Breakfast							
I.V.	Average Response 10 seconds	.12	.11	9.04***	8.7363	4.7791	2.9878	26.7435
M.	Secondary Motor Impulsivity							
D.V.	Sociosexual Orientation							
I.V.	Average Response 10 seconds	.11	.09	7.70***	.0502	.0318	.0044	.1388
M.	Primary Motor Impulsivity							
D.V.	Drug Use							
I.V.	Average Response 10 seconds	.08	.07	5.81**	-.0800	.0387	-.1829	-.0223
M.	Primary Motor Impulsivity							
D.V.	Eating Breakfast							
I.V.	Average Response 10 seconds	.17	.15	12.94***	11.4253	6.5440	3.3944	34.6310
M.	Primary Motor Impulsivity							
D.V.	Sociosexual Orientation							

Notes. I.V. – Independent Variable, M. – Mediator, D. V. – Dependent Variable, CI – Confidence Interval. Model summaries are from multiple regressions in which the I.V. and M. were simultaneously regressed on the D.V. Mean bootstrap estimates are unstandardized Beta coefficients.

Many of the mediators within the nine mediation models are nested variables. For instance, the primary factors *perseverance* and *motor impulsivity* are both nested within *second-order motor impulsivity*. Primary factors, perseverance and motor impulsivity, and second-order motor impulsivity are all nested within total BIS scores. As such, the nine mediation models will be discussed in order of highest factor mediator (total BIS score) to lowest factor mediators (perseverance and motor impulsivity). Total BIS score, second-order motor impulsivity, and perseverance all fully mediated the relationship between time perception and average hours of sleep per night. Second-order motor impulsivity, which combines the primary factors of motor impulsivity and perseverance, fully mediated the relationship between time perception and eating breakfast. Motor impulsivity, at the primary level, fully mediated the relationship between time perception and eating breakfast, as well as, the relationship between time perception and sociosexual orientation. Neither primary nor secondary motor impulsivity fully mediate the relationship between time perception and drug use. Bootstrapped, 95% confidence intervals, displayed in Table 3.13 suggest that the indirect effect of impulsivity for each mediation model was significantly different than zero. This suggests that even in the models that were not fully mediated, the indirect effect was still significant.

Because many of the mediation models utilized nested variables, a series of post hoc analyses were conducted to better understand which component or components of the nested variables were responsible for mediating the relationship between time perception and intertemporal behaviors. For the following analyses, Preacher and Hayes' (2008) *Indirect* SPSS script was used. *Indirect* simultaneously tests several indirect mediation effects. In essence, *Indirect* tests mediation models in the same way a multiple regression simultaneously predicts a dependent variable with several independent variables.

Total BIS scores fully mediated the relationship between time perception and hours of sleep per night. A simple mediation model, as displayed in Figure 3.3, does not reveal which individual facets or factors are mediating the relationship between time perception and sleep. Using *Indirect*, each impulsivity facet contributing to the total BIS score were simultaneously analyzed as mediators of the relationship between time perception and sleep. A diagram of the multiple mediator mediation model is provided in Figure 3.12. Calculating 95% confidence intervals for each mediator, using bootstrapping methodology with 5,000 iterations, revealed that none of the indirect effects were significantly different from zero. A second multiple mediator mediation model was tested, using the BIS's three second-order impulsivity factors to mediate the relationship between time perception and sleep (see Figure 3.13). Calculating 95% confidence intervals for each mediator, using bootstrapping methodology with 5,000 iterations, revealed again that none of the indirect effects were significantly different from zero. These two mediation models suggest that no single facet or second-order impulsivity factor is responsible for total BIS score's mediating role on the relationship between time perception and sleep.

Figure 3.12. Exploratory Multiple Mediator Model for Total BIS Score's Mediating Role on the Relationship between Time Perception and Hours of Sleep per Night; values are standardized Beta coefficients, * *p* < .05.

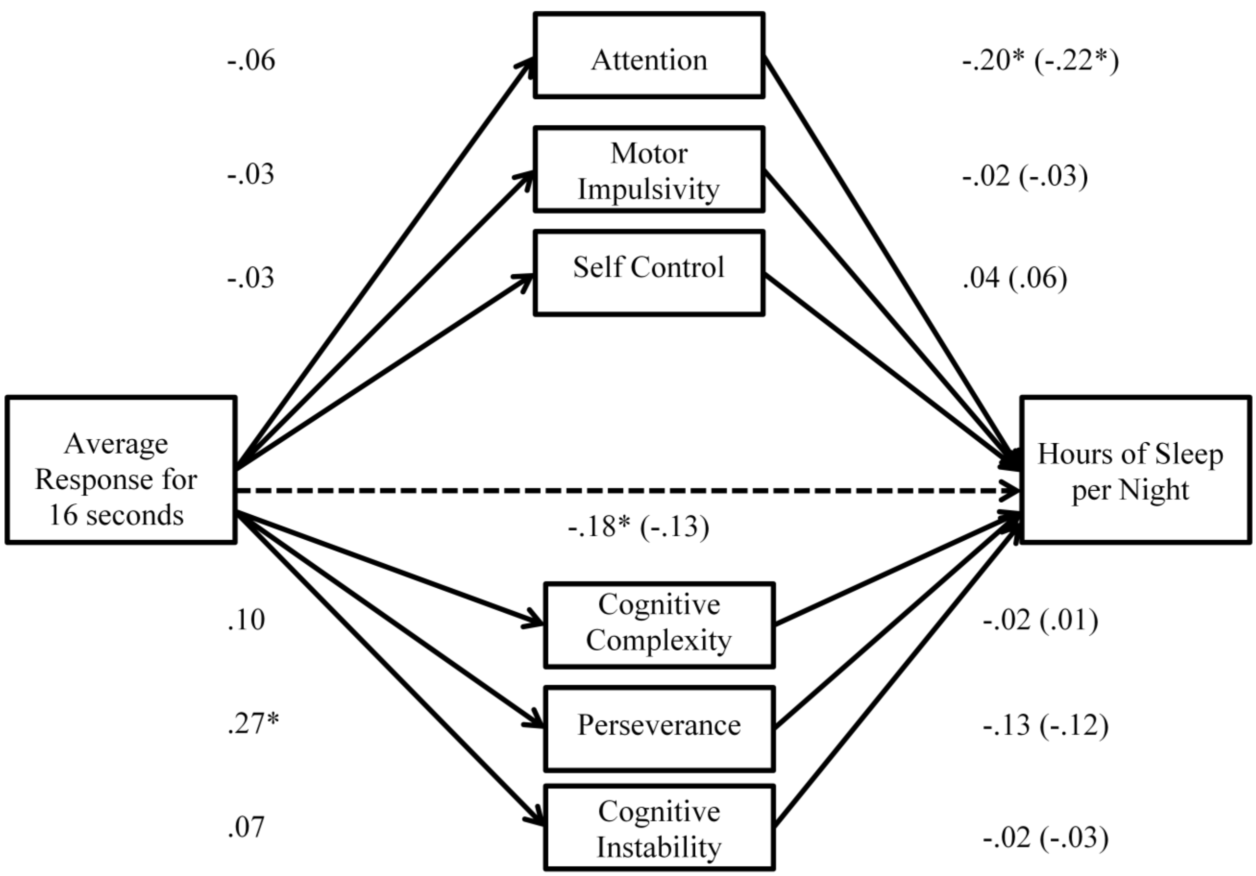
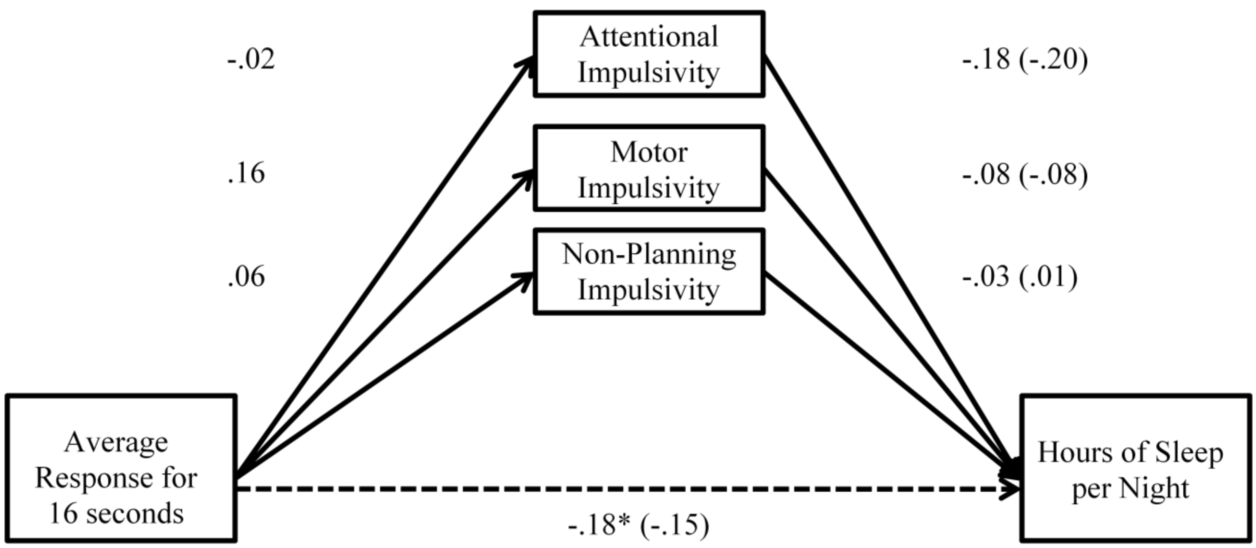
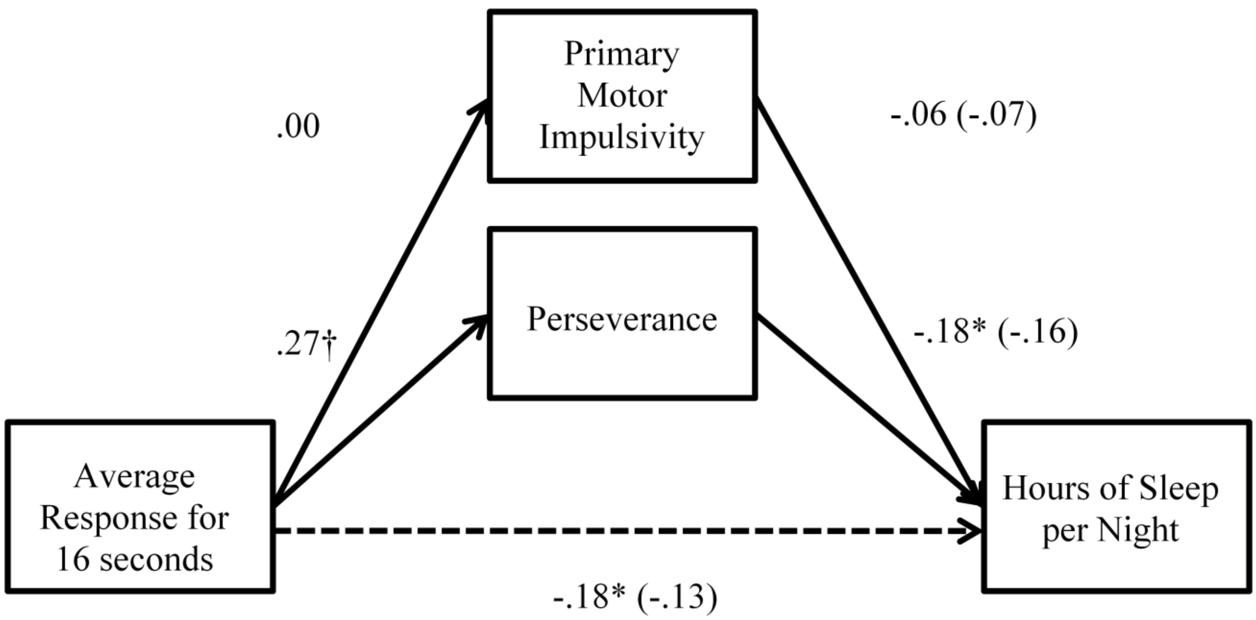


Figure 3.13. Exploratory Multiple Mediator Model for Total BIS Score's Mediating Role on the Relationship between Time Perception and Hours of Sleep per Night; values are standardized Beta coefficients, * *p* < .05.



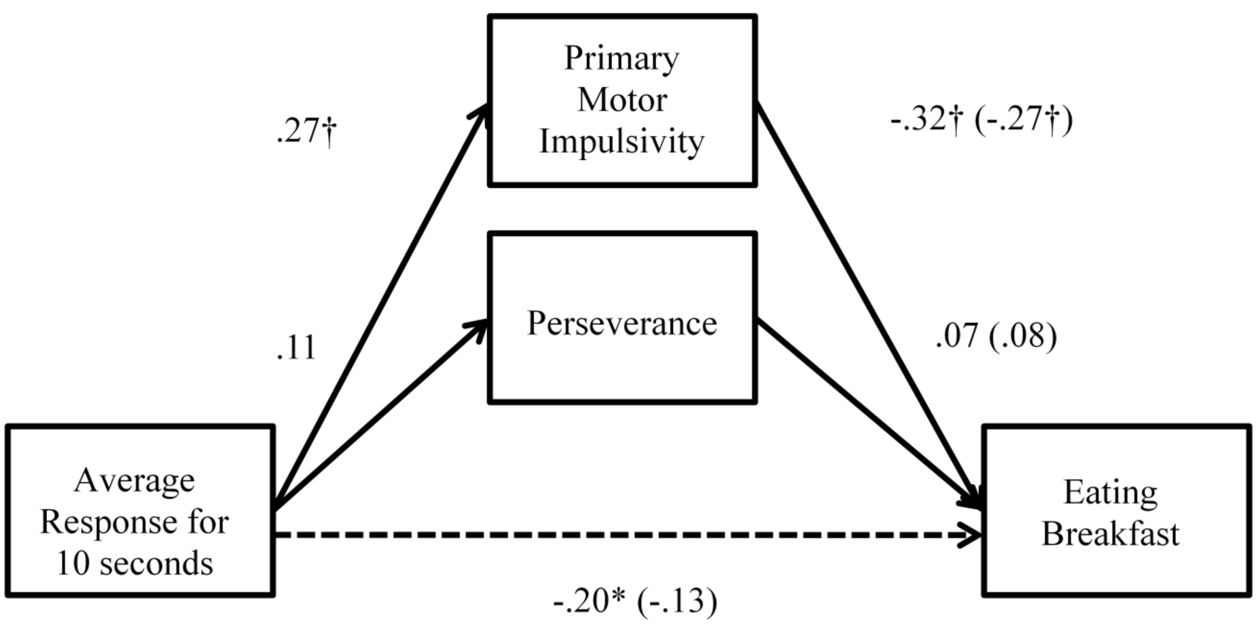
Second-order motor impulsivity fully mediated the relationship between time perception and hours of sleep per night. A simple mediation model, as displayed in Figure 3.4, does not reveal the relative contributions of the primary factors comprising the second-order factor. Using *Indirect*, primary motor impulsivity and perseverance were simultaneously analyzed as mediators of the relationship between time perception and sleep. A diagram of the mediation model is provided in Figure 3.14. Calculating 95% confidence intervals for each mediator, using the same bootstrapping methodology as above, revealed that only the indirect effect of perseverance was significantly different from zero (*M* = -.0108, *SE* = .0095, 95% CI = -.0470 to -.0003). This multiple mediator mediation model suggests that perseverance is the key mediating variable in the model. In other words, perseverance is a strong enough mediator to continue to carry the mediation effect even when a less successful element of impulsivity –namely, primary motor impulsivity-- is combined with the mediator.

Figure 3.14. Exploratory Multiple Mediator Model for Second-Order Motor Impulsivity's Mediating Role on the Relationship between Time Perception and Hours of Sleep per Night; values are standardized Beta coefficients, * *p* < .05.



Second-order motor impulsivity fully mediated the relationship between time perception and eating breakfast. A simple mediation model, as displayed in Figure 3.6, does not reveal the relative contributions of the primary factors comprising this second-order factor. Using *Indirect*, primary motor impulsivity and perseverance were simultaneous analyzed as mediators of the relationship between time perception and eating breakfast. A diagram of the mediation model is provided in Figure 3.15. Calculating 95% confidence intervals for each mediator, using the same bootstrapping methodology as above, revealed that only the indirect effect of primary motor impulsivity was significantly different from zero (*M* = -.1010, *SE* = .0431, 95% CI = -.2083 to -.0331). This multiple mediator model suggests that primary motor impulsivity is the key mediating variable in the model. In other words, primary motor impulsivity is a strong enough mediator to continue to carry the mediation effect even when a less successful element of impulsivity –namely, perseverance-- is combined with the mediator.

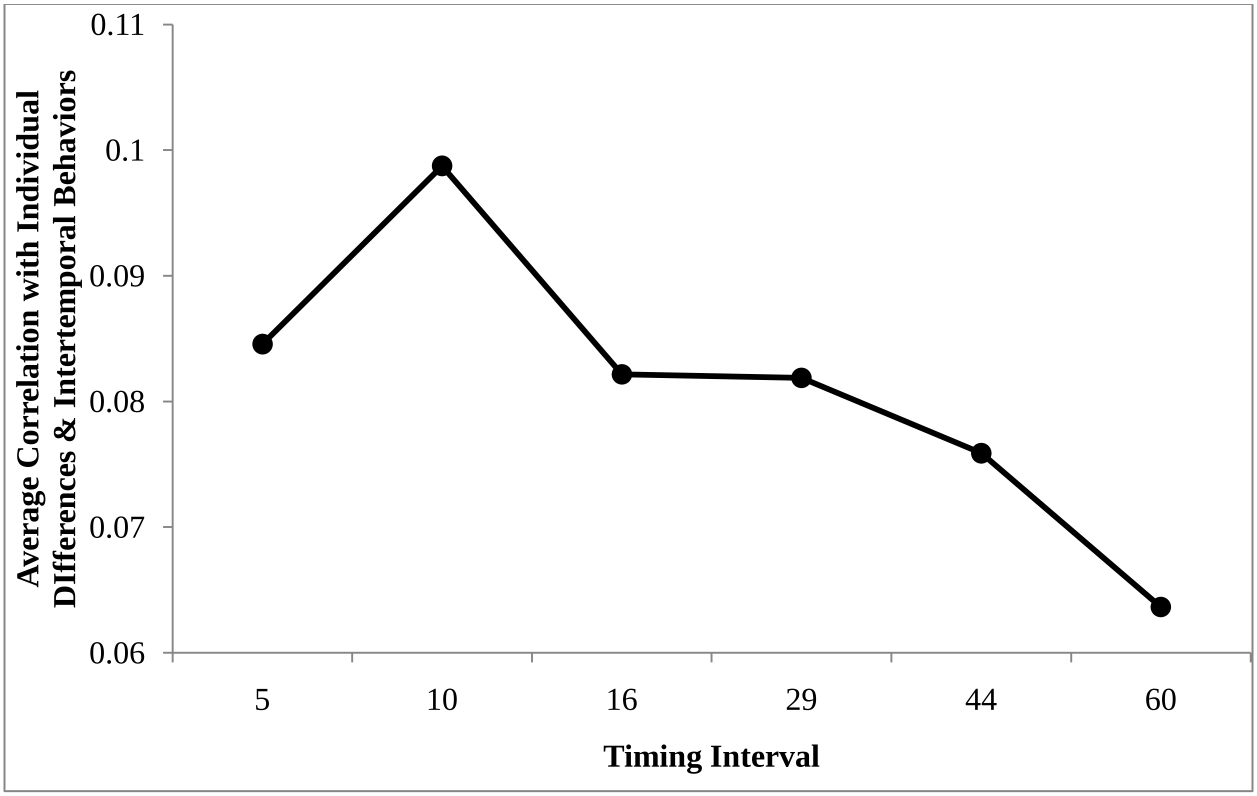
Figure 3.15. Exploratory Multiple Mediator Model for Second-Order Motor Impulsivity's Mediating Role on the Relationship between Time Perception and Eating Breakfast; values are standardized Beta coefficients, * *p* < .05.



Additional Analysis

Study I found that shorter time perception intervals produced larger correlations with outcomes variables (i.e., individual differences and intertemporal behaviors). This same question was addressed with the data from Study II. First, the absolute value of zero-order correlations was calculated between all time perception trials and the outcome variables used in this study. This resulted in 456 (12 time perception trials X 38 outcome variables) correlations. Next, these correlations were averaged across each time perception interval (5, 10, 16, 29, 44, 66 seconds). This preliminary averaged correlation coefficient was then correlated with the timing interval used for that trial. For instance, the average correlation between outcomes variables and time reproduction for 10 seconds is $r = .0987$. This correlation coefficient was then paired with the numeric value 10, which represents the interval of time being perceived. The correlation between intervals of time being perceived and the magnitude of correlation between time perception and outcomes variables for those intervals of time is $r(6) = -.86$, $p = .026$. This significant correlation suggests that using shorter time perception intervals is more successful at predicting outcome variables than longer intervals of time (see Figure 3.16). The equation for this least squares regression line is $Y = -.0005X + .094$.

Figure 3.16. Average correlations between time reproduction and outcome variables (individual differences and intertemporal behaviors) as a function of timing interval.



Discussion

Summary

Study II replicated and extended Study I. Like Study I, time perception was weakly correlated with intertemporal behaviors and individual differences. Small to moderate correlations, consistent with past research, were found between individual differences and intertemporal behaviors. Using the available significant correlations between time perception, intertemporal behaviors, and individual differences (with a traditional $p < .05$), nine models met the assumptions of mediation. After testing each mediation model with linear regressions, six models initially confirmed that time perception and intertemporal behavior were fully mediated by an individual difference. These indirect effects were confirmed with bootstrapped, 95% confidence intervals, as recommended by Preacher and Hayes (2004; 2008). Post hoc multiple mediator mediation models suggested that two of the six mediation models were redundant with other mediation models. In the end, four mediation models confirmed the theoretical position that individual differences are influenced by underlying time perception and influence intertemporal behavior.

Time Perception

Study II used time reproduction trials to assess time perception. This alternative measure of time perception combines elements of time estimation and time production into a single timing task. Instead of giving a person an interval of time to produce --like in time production-- the interval of time is experienced, like in time estimation. After experiencing the interval of time, the person reproduces the interval, in a manner similar to time production. Although time reproduction is viewed as a more reliable measurement of time perception (Block, 1989; Fraisse, 1963; Kruup, 1961; Zakay, 1990), this study found time reproduction to be less internally consistent -–as compared to time estimation and time production from Study I. Traditional assessments of internal consistency (i.e., Cronbach’s alpha), were lower than generally accepted for time reproduction across the twelve trials (Nunnally & Bernstein, 1994). The coefficient alphas attained in this study, however, do not negate the validity of time perception data. Schmitt (1996) argues that coefficient alphas even into the low .50s do not attenuate validity coefficients. McCrae, Kurtz, Yamagata, and Terracciano (2011) also report that internal consistency has no bearing on validity of a scale. Despite low internal consistency, the time reproduction trials displayed properties consistent with valid time perception. Reproduced intervals increased linearly with the interval of time actually displayed in the task (i.e., the presence of the black box). Variation in time perception was also proportional to the interval of timing being reproduced, consistent with Scalar Expectancy Theory (Gibbon et al., 1984).

Quantifying Time Perception

Study II employed the same indices of time perception as Study I, namely, mean deviation, median deviation, regression slope, and regression intercept. Like Study I, these indices were largely unsuccessful at predicting individual differences and intertemporal behaviors. None of the four indices produced a single statistically significant correlation with either construct, at the $p < .0025$ level. Aggregating trials for the same interval was a more successful approach to measuring time perception in Study II. This approach is consistent with past research which has successfully found relationships between time perception and impulsivity by using multiple trials of the interval (e.g., Barratt, 1981; Berlin et al., 2004; Glicksohn et al., 2006). In Study II, shorter intervals (e.g., 5, 10, and 16 seconds) more successfully predicted individual differences and intertemporal behavior than longer intervals (e.g., 29, 44, and 60 seconds). This finding is at odds with Barratt and Patton (1983) who concluded that longer intervals should better differentiate individual differences, specifically impulsivity.

Reproduction versus Estimation and Production

Study II demonstrated that time reproduction worked better at predicting individual differences and intertemporal behavior than time estimation or time production. Why might this be? First of all, it should be noted that the indices of time reproduction that were most successful at predicting individual differences and intertemporal behavior (i.e., average trials with identical intervals) were not calculated using time estimation and time production, because identical intervals of time were not measured within the same block. This could partially, or fully, explain the difference found between time reproduction and other two time perception tasks. Time reproduction is also different from the other two time perception tasks because there is no need to convert or link time perception experiences to formal measures of time, like seconds. In essence, for time reproduction, participants need to only experience the provided interval of time and recreate the duration, neither step requires language processing. For instance, time reproduction does not require converting the experience of time into seconds, like time estimation. Nor does time reproduction require an interval of time being processed from language into experience, like in time production. It is possible that language processing might actually interfere with interval timing. For instance, converting pulses into and out of language for time, like seconds, might cause distortions to interval timing. Before a firm conclusion can be drawn for this second explanation, future research should rule out the influence of the first proposed explanation.

Time Perception & Intertemporal Behaviors

Time perception was significantly correlated with two intertemporal health behaviors – drug use and sociosexual orientation. Both of these intertemporal health behaviors are health-risks. The direction of the correlations between these health risks and time perception suggest that myopic time perceivers reproduce longer intervals of times. Examining correlations in Table 3.11, suggests a similar pattern of results across short and long time reproduction trials. At lower time reproduction intervals, health risks (i.e., tobacco, alcohol, and drug use, and sociosexual orientation) were positively correlated with time perception and health-benefitting behaviors (e.g., eating breakfast, hours of sleep per night, and safety belt use) were negatively correlated with time perception. As the time reproduction interval increased (from 16 seconds to 60 seconds), this pattern reversed, such that, health risks were negatively correlated with time perception and health-benefitting behaviors were positively correlated with time perception. This suggests that time perception responses for time reproduction may change as a function of the interval being timed. For instance, the data suggest at shorter intervals myopic time perceivers reproduce longer intervals than hyperopic time perceivers. At longer intervals, however, myopic time perceivers reproduce shorter intervals than hyperopic time perceivers. Long reproduction intervals may create a conflict for myopic time perceivers. Observing a long interval of time may perceptually seem to take an extremely long time, however, when it comes time to reproduce the interval, myopic time perceivers may not possess the patience to endure waiting long enough to accurately reproduce the interval. This issue will be addressed again, when discussing time perception and individual differences.

Individual Differences & Intertemporal Behaviors

Financial planning was the most productive class of intertemporal behaviors to correlate with the individual differences explored in this study, followed by health and environmental behaviors. Most of the individual difference scales used in Study II were correlated with at least one financial planning factor. Financial impulsivity, which measures an inability to save and a tendency for impulsive shopping, was positively correlated with the other impulsivity scales used in this study, positively correlated with present-mindedness, and negatively correlated with future-mindedness and delay discounting. The same individual differences were correlated in the opposite direction with present financial behaviors (impulsivity and present-mindedness were negatively correlated, while future-mindedness and delay discounting were positively correlated). Future financial planning demonstrated fewer significant correlations with individual differences than the other two financial planning factors. The individual differences found to be significantly correlated with future financial planning paint a clear conceptual picture of the type of people who engage in long-term financial planning. People high in perseverance and future-mindedness engage in more future financial planning. These two traits are consistent with results found in Study 1. Study II also demonstrated, using BIS scores, that individuals who appreciate complex problems and are able to maintain focus on a task also engage in more future financial planning. Combined, these results suggest that people who appreciate and enjoy the complex nature of finance, maintain a future-oriented perspective, and persevere on tasks are the most likely to engage in intertemporal behaviors related to planning for the future.

Like Study I, individual differences were the most successful at predicting the health behavior of alcohol consumption. Similar to the pattern of results found for financial impulsivity, impulsivity scales and present-mindedness were positively correlated, and future-mindedness was negatively correlated with alcohol consumption. The direction of these correlations reversed for correlations with hours of sleep per night, eating breakfast, and safety belt use (impulsivity and present-mindedness were negatively correlated and future-mindedness positively correlated). These results suggest that being less impulsive, less present-minded, and more future-minded predicts greater health-benefiting behaviors and fewer health-risking behaviors. These results parallel recent published reports (Adams & Nettle, 2009; Daugherty & Brase, 2010).

There were only two statistically significant correlations (using $p < .0025$) between individual difference variables and environmental behaviors, however three individual differences demonstrate predictive ability across several environmental scales: delay discounting, future-mindedness, and non-planning impulsivity. People who were willing to postpone immediate gratification are more likely to engage in environmental behaviors. Future-minded people were also more likely to engage in environmental behaviors. People who had difficulties with self-control and avoid complex cognitive tasks (e.g., puzzles) --both facets of non-planning impulsivity-- engaged in fewer environmental behaviors.

Across the domains of intertemporal behaviors, patterns emerge: Higher impulsivity is related to engaging in fewer future-oriented behaviors. Present-mindedness is also related to engaging in fewer future-oriented behaviors. Shallower delay discounting and higher future-mindedness are related to engaging in more future-oriented behaviors. Together these patterns of results suggest that individual differences do predict intertemporal behaviors in a conceptually intuitive manner.

Time Perception & Individual Differences

Study II found correlations between time perception and individual differences that were consistent with those found in Study I. Mean deviation, mediation deviation, regression slope, and regression intercept were not significantly related to impulsivity, time orientation, or delay discounting. Significant correlations between time perception and individual differences were found when trials of the same duration were aggregated and when the Barratt Impulsivity Scale (BIS) was used. Three BIS factors were significantly correlated with time perception, at $p <$ .0025: primary motor impulsivity, perseverance, and secondary motor impulsivity. Every BIS factor (primary, secondary, and total score) was significantly correlated (at $p < .05$) with at least one time perception index. The impulsivity factors most strongly related to time perception were related to second-order motor impulsivity. This result is consistent with Keilp et al., in that time perception was significantly correlated with a second-order factor of the BIS, but inconsistent with Keilp et al. (2005) because they found that time production was significantly correlated with cognitive impulsivity and not motor impulsivity. The current study and Keilp et al. used different time perception tasks which may account for the differences in results. Ultimately, at this time, not enough research has been published to establish clear conceptual prediction on which facets or aspects of impulsivity relate to time perception.

Whereas the BIS was significantly correlated with time perception, the UPPS was not. What is it that makes the BIS correlate more strongly with time perception than the UPPS? In terms of item content, the BIS and UPPS scales only use one identical item, “I concentrate easily”. This item contributes to the perseverance factor of the UPPS and the attention facet of the BIS. The two impulsivity measures also share similar item content, even if different wording is used. For instance, “I act *on impulse”* appears in the BIS and “I have trouble controlling my impulses” appears in the UPPS. The UPPS was constructed from factor analyses of existing impulsivity scales (including the BIS) and scales between the two measures are moderately to strongly correlated, so it is difficult to pinpoint differences between the two measures. One difference between the two measures that could contribute to the difference in predictive validity with time perception is level of scale specificity. The BIS is comprised of 6 primary or basic facets and has a secondary or higher-order structure too. The UPPS has only four broad factors. This suggests that the scales of BIS are narrower than the scales of the UPPS. A limitation of this explanation is that second-order factors, and not just primary facets of the BIS, significantly correlated with time perception. In other words, regardless of the specificity of the BIS scale, it still out performed the UPPS. Another explanation for the difference between the two impulsivity measures is that the BIS items in this study utilized a four-point scale, while UPPS items used a five-point scale. Although only 15% (1,094/7,065) of UPPS responses used the middle or neural response, these responses do not differentiate impulsive from non-impulsive people.

Looking across the correlations in Table 3.11, average response times for shorter intervals (5, 10, and 16 seconds) are positively correlated with impulsivity scores, but average responses time for longer intervals (29, 44, and 60 seconds) are negatively correlated with impulsivity scores. Positive correlations suggest that more impulsive people reproduced longer intervals. This makes sense if impulsive people are myopic time perceivers and exposure to a brief interval of time seems longer than it does to hyperopic time perceivers. With longer exposure to intervals of time, myopic time perceivers, as indicated by their impulsivity scores, appear to reproduce shorter intervals of time than hyperopic time perceivers. These results, and similar patterns of results between time perception and intertemporal behaviors discussed above, could be explained by viewing time perception and impulsivity as two sides of the same coin, as is argued by Barratt and Patton (1983). Although Study I and Study II suggest that time perception and impulsivity are weakly related, changes in the direction of relationship between the two variables may foster, rather than distract from, the validity of this data. Barratt and Patton (1983) report that impulsive people under-produce intervals in time production (demonstrate myopic time perception). The time reproduction data in Study II, for longer intervals, are consistent with Barratt and Patton’s results. Accurate performance on any time perception task requires patience and self-control, personal attributes possibly lacking in impulsive individuals. The logic linking these two measures is circular, and unfortunately, the data collected in this study are not appropriate to unravel the interplay between them. An explanation for the data found in Study II is that hyperopic time perceivers perform the time reproduction task consistently across all of the intervals. Myopic time perceivers, on the other hand, may be more impatient with longer trials versus short trials, thus causing systematic under reproduction relative to hyperopic time perceivers. More research is needed to better understand this reversal in the direction of relationship between time reproduction and impulsivity.

Mediation Models

Study II found support for the proposed general mediation model, however, none of the mediation models were fully significant at $p < .0025$. The following results should be interpreted with caution, as there is an increased risk of Type I errors due to the large number of variables considered in this study. Nine mediation models met the assumptions of mediation outlined by Baron and Kenny (1986), again using the traditional $p < .05$. In six mediation models, impulsivity fully mediated the relationship between time perception and intertemporal health behaviors (two of these models were found to be redundant, due to nested variables within the mediator). Bootstrapped estimates for the indirect effect between time perception and intertemporal health behaviors for all nine mediation models were all significantly different from zero. This suggests that the indirect effect between time perception and intertemporal behavior was consistently present in the mediation models, whether or not the direct pathway between time perception and intertemporal behavior was reduced by the mediator.

As MacKinnon, Krull, and Lockwood (2000) warn, mediation is theory dependent. This means that the relevance of a significant mediator is only as good as its theoretical justification. This study proposes that biological timing mechanisms influence personality, or more specifically, individual differences related to impulsivity, delay discounting, and time orientation. Further, the influence of biological timing mechanisms is filtered through individual differences that affect intertemporal behavior. The proposed mediated or indirect effect between time perception and intertemporal behavior is also supported by fMRI studies showing that similar neural structures underlay interval timing, personality, and intertemporal behavior (Horn et al., 2003; Lewis & Miall, 2003; Shamosh et al., 2008). Additionally, research consistency demonstrates that some mental disorders (e.g., depression, mania) and behavioral patterns (e.g., smoking, addiction) are associated with distorted timing processes and personality. The general mediation model proposed in this study argues for a biological driven process. In other words, how an individual is wired for interval timing influences personality, and personality then influences behavior. The data presented in both studies clearly suggest that large portions of variance in individual differences and intertemporal behavior remain unexplained by time perception. This suggests that biological timing is only a partial, at best, explanation for individual differences and intertemporal behavior.

A future direction for research connecting time perception to individual differences and intertemporal behavior is to explore how uncertainty, whether from future mortality or past environmental instability, influences time perception, individual differences, and intertemporal behavior. Life history theory posits that past experiences and future expectations influence risk-taking and decision-making (e.g., Griskevicius, Tybur, Delton, & Robertson, in press). Additionally, it is important for future research to confirm the causal direction of the mediation model proposed in this research. It is possible that the relationship between time perception and individual differences may create a feedback loop, whereby time perception's influence on impulsivity may then cause impulsivity to further impair memory for time perception. This type of interaction between time perception and impulsivity could also suggest that impulsivity causes intertemporal behavior and the relationship between these two variables is mediated by time perception.

Summary of Study II

Study II replicated Study I on a global level. Similar patterns of results were found between the two samples of people: Time perception was weakly associated with individual differences and intertemporal behaviors. Individual differences were moderate predictors of intertemporal behavior. Unlike Study I, Study II found tentative support for the proposed general mediation model illustrated in Figure 0.1. Impulsivity mediated the relationship between time perception and intertemporal health behaviors.

Chapter 4 - General Discussion

This research sought to determine whether individual differences in time perception are related to personality and intertemporal behavior. Additionally, it was proposed that individual differences would mediate the relationship between time perception and intertemporal behavior. Studies I and II measured and explored the relationships between time perception, individual differences (impulsivity, delay discounting, and time orientation), and intertemporal behaviors related to the domains of health, environmentalism, and financial planning. Extremely small to sometimes moderate relationships were found between time perception and individual differences, and between time perception and intertemporal behaviors. Moderate relationships were found between individual differences and intertemporal behaviors. Study II, but not Study I, provided limited confirmation of the proposed mediation model and found that impulsivity mediated the relationship between time perception and intertemporal health behaviors. Together the results found in these studies suggest that one's underlying biological clock, or timing mechanism, may partially influence one's personality and behavior. Additionally, based on the findings in Study II, it appears that one's biological clock may not influence intertemporal behavior directly, but rather indirectly through individual differences.

The time perception data gathered in Studies I and II conformed to both conceptual and theoretical perspectives on human interval timing. Most importantly, time perception across all three tasks (time estimation, production, and reproduction) demonstrated accuracy (in aggregate) and scalar variance –variance in time perception, across people and timing intervals, was relatively consistent. These findings are consistent with scalar expectancy theory, a predominant theory of interval timing (Gibbon et al., 1984). This current research supports the idea that individual differences in time perception can influence individual differences and intertemporal behavior. It appears that reference memory for experienced durations of time influences interval timing, leading individuals to perceive intervals of time as long (myopic time perception) or short (hyperopic time perception). It is proposed, but not directly tested, that reference memory makes perceptions of prospective delays appear longer (for myopic interval timers) or shorter (for hyperopic interval timers) thus influencing intertemporal behavior. In terms of the Scalar Expectancy Theory (Gibbon et al., 1984), this current research suggests that time perception's influence on personality and intertemporal behavior is most likely attributable to the process of comparing an experienced sum of pulses held in working memory to pass experiences of similar quantities of pulses held in reference memory.

Numerous indices of time perception were utilized in Studies I and II. Mean deviation, mediation deviation, regression slope, and regression intercept were largely unsuccessful at predicting individual differences and intertemporal behavior, although these approaches have been used previously (for deviation scores, see Berlin et al., 2004; Gerbing et al., 1987; for regression slopes and intercepts, see Barratt, 1981; Glicksohn et al., 2006). A more successful index of time perception was found in Study II. Instead of combining time perception across different intervals, Study II averaged two time reproduction trials of the same duration. This approach was based on the observation that studies which measured intervals two or more times, found stronger correlations between time perception and impulsivity (Berlin et al., 2004; Glicksohn et al., 2006; Keilp, et al, 2005).

The idea that one's perception of time is related to personality and behavior is not new. The existing literature is replete with studies showing altered time perception in populations with altered mental states (e.g., Mahlberg et al., 2008; Goudriann et al., 2006). These same populations also demonstrate personality and behavioral differences (e.g., Carroll et al., 2006; Myer, 2004; MacKillop et al., 2007). Emerging brain imaging studies also show that similar areas of the brain, notably the prefrontal cortex, play a role in time perception, personality, and decision-making (Horn et al., 2003; Lewis & Miall, 2003; Shamosh et al., 2008). Barratt and Patton (1983) argued that time perception is one of several behavioral manifestations of impulsivity, however recent research contests this theory (Glicksohn et al., 2006; Reynolds et al., 2006; also see Gerbing et al., 1987 for an older example). This research also argues against Barratt and Patton's bidirectional view of time perception and impulsivity, proposing instead that time perception influences or leads to impulsivity. Put differently, being a myopic interval timer alters the expectation of when future rewards will be received, thus diminishing the perceived value of future rewards and leading to more myopic intertemporal behavior. Additionally, personality characteristics are influenced by time perception. It was proposed that myopic time perception leads to greater impulsivity and present-mindedness, steeper discounting, and lower future-mindedness. These individual differences, and not time perception directly, then direct behavior. For myopic time perceivers this results in fewer health-benefiting behaviors, more health risks, less environmental behavior, and less financial planning.

Results from Study II, but not Study I, demonstrate evidence consistent with the general mediation model proposed in this research. Both Study I and II used a *shotgun approach* to test the proposed mediation model. In other words, both studies used a wide variety of time perception indices, individual differences, and intertemporal behaviors, correlated all of them together, and interpreted the scattered significant results produced. A Bonferroni correlated *p*-value of .0025 was used to avoid Type I errors. Given that none of the mediation models were fully significant at this adjusted *p*-value, mediation models meeting the assumptions of mediation at the traditional *p*-value of .05 were still explored and interpreted. The results from these mediation models should be interpreted with caution, because ignoring the corrected significance level leaves open the possibility of committing Type I errors. The number of successful mediation models (i.e., those demonstrating full mediation) was further reduced by post hoc analyses which revealed that in two cases, models were redundant due to nested mediator variables. Multiplying the number of independent variables (time perception, $N = 10$) by the number of mediators (individual differences, $N = 13$) and by the number of dependent variables (intertemporal behaviors, $N = 23$) reveals that Study II had 2,990 potential mediation models. Study I had 1,656 potential mediation models. Out of over 4,500 possible mediation models, only nine models met all three assumptions of mediation (Baron & Kenny, 1986) and only four models found statistically significant mediation. The small number of successful mediation models, relative to the total possible mediation models, also suggests caution when generalizing the findings of this research.

The shotgun approach used in both studies was based on necessity. This research had to, in essence, build its own foundation because of the limited and inconsistent methodology used in previous research. First, as already mentioned, time perception can be measured with several different tasks (time estimation, production, or reproduction) and scores from time perception trials can be aggregated in numerous ways. In the timing literature there is no proposed *gold standard* for which type of time perception task should be used, nor a gold standard for how time perception scores should be aggregated to most effectively capture correlations between time perception and individual differences. The current research attempted to fill this gap by using three of the most common time perception tasks and by calculating and reporting several of the time perception indices used in previous research. Recommendations are provided below for future research predicting individual differences and intertemporal behavior with time perception. Second, no published work could be found relating time perception to intertemporal behavior. This gap in the existing literature makes this research the first of its kind. Although intertemporal behavior related to health, environmentalism, and financial planning were tested, intertemporal health behaviors demonstrated the most statistically significant correlations with time perception. The selection of appropriate intertemporal behaviors should be based on their relevance to the population being studied. A discussion of this issue is provided below. Third, although research has linked time perception to impulsivity (Barratt & Patton, 1983; Berlin et al., 2004; Glicksohn et al., 2006; Keilp et al., 2005), practically no research has attempted to link time perception with other individual differences like delay discounting and time orientation. All of the significant mediation models found in Study II had impulsivity as a mediator, adding credence to the existing literature. According to the model proposed in this research, time perception's inability to predict delay discounting and time orientation suggests that these individual differences are less influenced by time perception. The inclusion of time orientation and delay discounting was not without value to this study. Time orientation, and to a lesser extent, delay discounting were significant predictors of intertemporal behavior, findings consistent with recent published works (Adams & Nettle, 2009; Daugherty & Brase, 2010). Fourth, the research presented here is the first to test a theoretical, directional model whereby time perception is expected to predict personality and behavior. The results found in Study I and II allow future research to reduce the number of variables explored and focus in on the effects found, specifically the mediating role of impulsivity on the relationship between time perception and intertemporal health behaviors.

Tips for Future Research

Several findings from Study I and II bear repeating and enumerating to help future research explore the relationships between time perception, individual differences, and intertemporal behavior. (1) The average magnitude of effect when using time perception indices to predict individual differences and intertemporal behavior is small (Cohen, 1992). In Study I, the average effect was $\bar{r} = .06$. In Study II, the average effect was $\bar{r} = .08$. These effect estimates can be used to determine power and sample sizes for future studies. (2) Although less internally consistent than time estimation and time production, time reproduction performed better at predicting individual differences and intertemporal behavior. Caution should be observed when using time reproduction with larger intervals of time (i.e., above 25 seconds), as a reversal in performance may occur. (3) Time perception intervals around 5-15 seconds best predicted individual differences and intertemporal behavior. (4) Aggregating time perception performance within the same interval of time produced stronger correlations with individual differences and intertemporal behavior than aggregating across different timing intervals. Study II used only two trials for each interval. Increasing the number of trials for each interval may further improve the interval consistency of time perception and produce stronger correlations with individual differences and intertemporal behavior. (5) Of all the individual differences measures, time perception predicted impulsivity better than delay discounting and time orientation. (6) The BIS was more successfully predicted by time perception than the UPPS. This could be due to qualitative differences between the two measures, or because the UPPS in Study I and II was measured on a 5-point scale while the BIS was measured on a 4-point scale. Having a neutral midpoint response may lead to less differentiation between impulsive and non-impulsive individuals. (7) Time perception predicted intertemporal health behaviors better than intertemporal environmental or financial planning behaviors. This finding could be a product of the sample used (i.e., college freshmen). Further discussion of this issue is provided below. (8) As recommended by other researchers (Buhusi & Meck, 2005; Wittmann & Paulus, 2008), Study I and II had participants perform a concurrent memory task during time perception trials. Because this variable was not manipulated in either study, it is unknown how this concurrent task influenced performance in Study I and II.

Limitations and Directions for Future Research

Sample Restrictions

Study I and II used college undergraduates as participants. This population is likely to be more homogeneous than the general population in several ways. First, severe myopic time perception and the resulting impulsivity might select out individuals from college samples. In other words, the full spectrum of time perceivers may not be present in a college sample or quickly weeded out of a college sample. The use of a primarily freshman sample (collected during the first semester of the academic year), should mitigate this issue. Second, students entering college, versus individuals of the same age entering the work force, may differ in the individual differences explored in this study. Many students choose to invest time, money, and energy into a college education with the expectation that future earning potential will be higher than if they immediately entered into employment after high school. This choice to enter the work force versus attend college first resembles delay discounting, where smaller immediate rewards (e.g., entering the work force and receiving a paycheck) are balanced against larger future rewards (e.g., earning a degree first, than receiving a larger paycheck). Similarly, college students might be higher in future time-orientation than the general population too. Age is also a restricted variable in Study I and II. Research suggests that time perception changes of the life course (Block, Zakay, & Hancock, 1998; 1999); the data gathered in this research is not suited to address this issue.

Time perception predicted intertemporal health behaviors better than intertemporal environmental or financial planning behaviors. These results could be specific to the college sample used in Study I and II. Time perception's failure to predict environmental and financial planning behaviors could be due to a restriction of range in these classes of intertemporal behavior. College freshmen, living in college dormitories at Kansas State University, have easy access to some recycling options. Other environmental behaviors, like using low-flow shower heads or weather stripping windows or doors, are largely out of students' control. Environmental behaviors related to transportation provide another example of how college students may not have the financial resources to make pro-environmental decisions. For instance, one item asks if they drive a fuel efficient vehicle that gets 30 mpg or higher. Budgetary constraints may prohibit students from purchasing fuel efficient vehicles, even if they desire to own one. Similar restrictions may occur with financial planning items. Students can monitor their banking accounts, but few may have given consideration to retirement when they have not yet started earning a regular income. Health behaviors, on the other hand, are likely more applicable to college students. Behaviors like whether or not to consume alcohol, smoke, eat breakfast, or exercise are made daily by college students. Greater variability in these health behaviors may have contributed to stronger correlations with time perception. Based on the homogeneity of the sample used and the possible restriction in response range for intertemporal behaviors, the results provided in Study I and II may provide only a lower bound for the potential influence of time perception on individual differences and intertemporal behaviors. Future research using a more diverse sample may find stronger patterns of results with intertemporal behaviors that were less successful with a young, college sample.

Time Perception: State versus Trait

An assessment issue ignored completely by past research, and unfortunately not addressed in this current research, is what exactly is being assessed when participants complete time perception trials in a laboratory? Personality, from a theoretical perspective, is assumed to be stable across time (Srivastava, John, Gosling, & Potter, 2003) and across varying situations (Furr & Funder, 2004). Past research, extending back to Barratt's research in the 1970s (for a review see Barratt & Patton, 1983), views time perception as a component of personality. Viewing time perception this way invokes assumptions of stability about time perception. The logic goes like this: If time perception is a component of personality and personality is stable, then time perception should also demonstrate stability. A personality trait measured today is theoretically going to be the same when it is measured tomorrow, next week, or year from today. Evidence for test-retest reliability of time perception is limited and future research needs to explore whether or not time perception is a stable personality construct. McCauley et al. (1980) demonstrated time production performance was strongly correlated from day to day, but that performance further apart in time (across days) was more weakly correlated. This suggests that stability over time can be demonstrated for time perception, however, stability fades quickly across time. Measuring time perception in a single setting may be effective at capturing time perception as a *state*, but ineffective at capturing time perception as a *trait*. This research and past research has measured time perception in a laboratory on only one occasion and found only limited associations between time perception and individual differences, like impulsivity. It is proposed that the true relationship between time perception and individual differences (and intertemporal behavior) is attenuated by the methodology employed. Time perception measured as a state is only weakly related to individual differences and intertemporal behavior. Time perception measured as a trait *may* prove to be more effective at predicting individual differences and intertemporal behaviors, because outcome variables, like personality and behavior, are assessed as traits, not states.

Measuring time perception as a trait requires a different methodology than has been used in previous research. Instead of measuring time perception only once, future research needs to repeatedly measure time perception in a variety of situations and contexts. This methodological approach is called *intensive repeated measures in naturalistic settings* (IRM-NS, Moskowitz, Russell, Sadikaj, & Sutton, 2009) and has two major advantages. First, using IRM-NS should neutralize extraneous influences on time perception, like attention and arousal (for a review, see Zakay & Block, 1997). Second, aggregating time perception performance across days and contexts should produce a more robust index of time perception, one that more closely represents an individual's time perception as a trait.

IRM-NS is more feasible today than in the past, due largely to the prevalence of wireless Internet access and technologies to assess reaction time. There are several ways an IRM-NS methodology could be implemented to assess time perception as a trait. One possibility would be to design a mobile phone application that would randomly page a person to complete a time perception trial several times a day, for several days. Because a mobile device can be carried in most places, this approach would assess time perception across a wide range of situations and contexts (e.g., watching television, walking between places, working, etc.). A less technology-sophisticated approach could have people access a computer several times a day, log-on to a website that can compute and record reaction times, and complete time perception trials.

Requiring computer access dramatically limits the variety of contexts in which time perception is measures, but it still can gather time perception data over more than one session.

Causal Direction of Mediation Model

Study II provides tentative support suggesting that time perception indirectly influences intertemporal health behaviors through impulsivity. Solid empirical evidence does not yet exist to confirm the proposed direction of relationship between time perception and impulsivity. Studies employing a cross-sectional design with different ages of children would help elucidate the relationship between time perception and impulsivity. A cross-lag longitudinal design could also provide evidence supporting time perception's influence on impulsivity. The R^2 values for the fully mediated models found in Study II suggest that a sufficient amount of unexplained variance in intertemporal health behaviors remains to justify the possibility of other predictors. The nature of these other predictors and their influence on health behaviors relative to individual differences and time perception are also directions for future research to explore.

Conclusion

Many people struggle to act now in ways that will benefit them in the future. People put their health at risk, harm the environment, and leave themselves financially ill prepared for the future. The growing obesity problem in the United States and global warming are just two current contexts relevant to the present research. Fully explaining people's myopic tendencies is beyond the scope of this project. Nevertheless, this research proposed that individual differences in time perception would predict both individual differences and intertemporal behavior. Additionally, it was proposed that individual differences would mediate the relationship between time perception and intertemporal behavior. Time perception was found to be a meager predictor of individual differences and intertemporal behavior, however, individual differences and intertemporal behaviors were moderately related. Tentative empirical evidence supports the notion that time perception indirectly affects intertemporal health behaviors through impulsivity. Future research needs to confirm the directionality of the model proposed here and explore new methodologies to better correlate time perception with individual differences and intertemporal behaviors.

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Appendix A - Intertemporal Health Behaviors

Intertemporal health behaviors from Daugherty and Brase (2010), items used in Study I and Study II.

(1) How often do you use tobacco products (cigarettes, cigars, chewing tobacco, etc.)?
(2) How often do you drink alcohol (beer, wine, or liquor)?
(3) How often do you use drugs other than alcohol and tobacco?
(4) How often do you exercise?
(5) How often during an average week do you eat breakfast?
(6) On a typical weeknight, how many hours of sleep do you get?
(7) When occupying a moving vehicle, how often do you wear a safety belt?
(8) When you ride a motorcycle, moped, or bicycle (or if you were to do so), how often do you wear a helmet?
(9) How many visits have you had in the last year to a doctor or dentist for regular checkups?
(10) If outside for an extended period of time, how often do you apply sunscreen?
(11) Estimate, to the best of your ability, the age you are likely to live to _____

For the next set of items, please rate on the scales provided how concerned you are about the following issues, *as they relate to your life:*

(1) Having high cholesterol
(2) Developing heart disease/having a heart attack
(3) Developing diabetes
(4) Developing cancer
(5) Contracting HIV/AIDS

Appendix B - Intertemporal Environmental Behaviors

Intertemporal environmental items used in Study I and Study II.

How often do you:

1. Recycle aluminum
2. Use recycled paper
3. Support electoral candidates with pro-environmental platforms
4. Air-dry clothing
5. Re-use plastic or paper grocery bags
6. Request e-statements from your bank
7. Use re-usable flatware or silverware
8. Turn off lights when not in a room
9. Participate in an environmental advocacy organization
10. Keep current on vehicle maintenance
11. Eat vegetarian foods
12. Participate in an adopt-a-highway program
13. Recycle plastics
14. Support Earth-friendly companies
15. Maintain a compost pile
16. Turn down the heat when not at home in the winter
17. Eat organic food products
18. Raise the air conditioning temperature when not at home in the summer
19. Use energy-efficient light bulbs
20. Weatherstrip and caulk doors and windows
21. Turn off the water while washing during a shower
22. Plant a tree
23. Drive under the speed limit
24. Maintain a garden
25. Use public transportation
26. Unplug cell phone chargers when not in use
27. Use rechargeable batteries
28. Drink tap water
29. Use biodegradable soaps
30. Use fans
31. Use energy-efficient household devices (washers dryers etc.)
32. Carpool
33. Donate money to environmental organizations or causes
34. "Wear natural fiber clothing (i.e. cotton)"
35. Recycle paper
36. Use hand dryer in public bathrooms
37. Teach others to be environmentally responsible
38. Re-use hotel/motel towels
39. Recycle batteries
40. Install storm windows
41. Recycle ink and toner cartridges
42. Buy milk in returnable glass containers
43. Print on both sides of documents
44. Recycle tin and other non-aluminum metals
45. Pick up litter
46. Recycle chemicals
47. Use re-useable containers for food storage
48. Use bicycle for transportation
49. Buy products with minimal packaging
50. Recycle glass
51. Recycle used cell phones and/or electronics
52. Drive a fuel efficient vehicle (mgp > 30 highway)
53. Use low-flow shower heads
54. Use low-flow toilets
55. Shut down a computer when not in use
56. Unplug appliances when not in use
57. Purchase products in biodegradable packaging
58. Use re-useable cloth grocery bags