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Impulsivity, Risk Taking, and Timing

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Abstract

This study examined the relations among measures of impulsivity and timing. Impulsivity was assessed using delay and probability discounting, and self-report impulsivity (as measured by the Barratt Impulsiveness Scale; BIS-11). Timing was assessed using temporal perception as measured on a temporal bisection task and time perspective (as measured by the Zimbardo Time Perspective Inventory). One hundred and forty three college students completed these measures in a computer laboratory. The degree of delay discounting was positively correlated with the mean and range of the temporal bisection procedure. The degree of delay and probability discounting were also positively correlated. Self-reported Motor impulsiveness on the BIS-11 was positively correlated with Present Hedonism and negatively correlated with Future orientation on the ZTPI. Self-reported Non-Planning on the BIS-11 was positively correlated with Fatalism on the ZTPI. These results show that people who overestimate the passage of time (perceive time as passing more quickly) hold less value in delayed rewards. They also confirm previous results regarding the relation between delay and probability discounting, as well as highlight similarities in self-report measures of impulsivity and time perspective.

Keywords

delay discounting; probability discounting; time perception; time perspective; impulsivity; timing

1. Introduction

Impulsivity is a construct with multiple meanings, measured in multiple ways (see e.g., de Wit, 2008; Evenden, 1999). Delay discounting refers to the decrease in the value of a reward as the delay until its receipt increases (e.g., Mazur, 1987; Rachlin, Raineri, & Cross, 1991). Steep delay discounting is also known as impulsive decision making (e.g., de Wit, 2008). Delay discounting is a robust empirical phenomenon with strong cross-species generality (see Odum, 2011a, for discussion). The degree of delay discounting that an individual shows is related to maladaptive behavioral outcomes in clinical and pre-clinical studies (see Madden & Bickel, 2010). Thus, determining the processes that undergird delay discounting is important.

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Time perception is one process that may be related to impulsivity in general, and delay discounting in particular (Berlin, Rolls, & Kischka, 2004; Glicksohn, Leshem, & Aharoni, 2006; Rubia, Halari, Christakou, & Taylor, 2009; Takahashi, 2005). When making choices between smaller immediate versus larger delayed outcomes, impulsive individuals tend to choose the smaller immediate outcome more often (i.e., show steep discounting) compared to self-controlled participants, who tend to choose the larger delayed outcomes. Delay discounting may be affected by how one perceives time: impulsive individuals may perceive the duration of the delay to the larger outcome as longer than a less impulsive individual, thereby increasing the likelihood the impulsive person would choose the smaller immediate outcome (Rubia et al., 2009; Takahashi, 2005; Wittmann & Paulus, 2008).

One of the overarching goals of the present study was to evaluate how different aspects of impulsivity and time perception are related. The data of the existent studies are not clear. For example, Barkley and colleagues (Barkley, Edwards, Laneri, Fletcher, & Metevia, 2001) showed that teenagers with attention deficit hyperactivity disorder discounted delayed money more steeply and manifested more impaired time reproduction, but not time estimation, than control participants. Similarly, Reynolds and Schiffbauer (2004) showed that sleep deprived undergraduate students underestimated temporal intervals and showed steeper delay discounting compared to when they were not sleep deprived. When McDonald and colleagues (McDonald, Schleifer, Richards, & de Wit, 2003), however, exposed community volunteers to Δ^9 – tetrahydrocannabinol (THC) and assessed their performance on a delay discounting and a time reproduction task, THC had a different effect on the two measures. Participants tended to overestimate time when under the influence of THC, but THC did not affect the degree of discounting, showing that delay discounting and time perception are not necessarily related.

In these prior studies, time perception was measured using a time reproduction task, in which participants were asked to maintain a key press for a target duration (e.g., 4 s). The length of time the key is pressed, however, is made up of two intervals: the estimated target duration, and the participant’s reaction time to release the key once the perceived target duration has elapsed. Thus, the measure of time perception could be influenced by reaction time. In the McDonald et al. (2003) study above, for example, THC could have increased reaction time, but not influenced the estimated target duration.

In another timing task however, the measure of temporal perception is unaffected by the participant’s reaction time. In the temporal bisection procedure, participants categorize the duration of temporal stimuli as relatively long or short (Church & Deluty, 1977). The proportion of choices for the long and short categories (which is unaffected by reaction time) is used to assess temporal perception, rather than the temporal properties of the behavior itself. Thus, we used the temporal bisection procedure to assess timing in the current study to determine how this measure relates to delay discounting.

The studies described so far evaluated the relation between delay discounting and objective time, or how participants perceive the actual passage of time. Another interesting relation to investigate is between delay discounting and time perspective, or how people view their present, past or future (Block, Buggie & Matsui, 1996; Sobol-Kwapinska, 2007). In general, there appears to be a moderate relation between time perspective and delay discounting (see Teuscher & Mitcheel, 2011, for review). People who describe themselves as valuing the future, for example, tend to have a lower degree of discounting by delay (e.g., Daugherty and Brase, 2010). We were interested in this relation, as well as the potential relation between time perception (as measured by the temporal bisection task) and time perspective (as measured by the Zimbardo Time Perspetive Inventory; Zimbardo & Boyd, 1999).

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Because impulsivity is a multi-dimensional construct, in the present study we also examined self-reported impulsivity through questionnaire (i.e., the Barratt Impulsiveness Scale (BIS-11; Patton, Standford, & Barratt, 1995) in addition to examining impulsive decision making (delay discounting). In prior work, some studies have reported significant correlations between delay discounting and scores on the BIS (Bjork, Hommer, Grant, & Danube, 2004, Experiment I; de Wit et al., 2007; Kirby & Petry, 2004; Yeomans, Leitch & Mobini, 2008), while others report no significant correlation between these two measures (Coffey, Gudleski, Saladin, & Brady, 2003; Einsenberg, Campbell, MacKillop, Lum & Wilson, 2007; Krishnan-Sarin, Reynolds, Duhig, Smith, Liss, McFetridge, et al., 2007; Lane, Cherek, Rhoades, Pietras, & Tcheremissine, 2003). Among possible explanations for such inconsistency in the data is that some studies report the correlation between delay discounting and the total score of the BIS scale, whereas others conduct separate analyses with each subscale of the questionnaire (e.g., Coffey et al., 2003; Krishnan-Sarin et al., 2007; Lane et al., 2003) or an item analysis of the questionnaire (Kirby & Finch, 2010). The BIS has three subscales (attention, motor and non-planning), and analyzing the correlation between delay discounting and each subscale is important because the subscales access different aspects of impulsivity (Osburn, 2000). In this study, we assessed the correlation between delay discounting and the scores on each subscale of the BIS.

A final comparison of the present study was between risky behavior and time perspective. The literature shows that steep delay discounting is correlated with risky behaviors such as drug use and gambling (MacKillop, Amlung, Few, Ray, Sweet, & Munafò, 2011; Reynolds, 2006), and time perspective has also been correlated with risky behaviors. For example, pathological gambling substance abusers have higher hedonism and lower future orientation than their control counterparts (Petry, 2001), and present time perspective was found to be predictor of self-report of risky driving (Zimbardo, Keough, & Boyd, 1997). Strong future orientation has been consistently associated with academic achievement, high social class and less substance abuse (Boyd & Zimbardo, 2005).

In prior studies, risk taking has been assessed via delay discounting or self-report questionnaires. While delay discounting may involve risk because there is a likelihood that something will prevent the receipt of the outcome at greater delays (e.g., Green & Myerson, 1996; Myerson et al., 2003; Patak & Reynolds, 2007), some researchers have suggested that impulsivity and risk taking are different decision-making processes (e.g., Green & Myeron, 2010). Risk taking can be measured by the probability discounting task, a task that explicitly involves risk. Probability discounting refers to the decrease in the subjective value of an outcome as the odds against its receipt increase (Green & Myerson, 2010). In the single previous study assessing the correlation between the degree of probability discounting and the BIS (Mitchell, 1999), there was no significant relation between these measures in a relatively small sample of cigarette smokers and non-smokers. We determined whether there would be a relation between probability discounting and self-report impulsivity in a larger sample.

In summary, we conducted in one relatively large sample of participants a comprehensive evaluation of the relation between delay discounting and several possible related processes. Specifically, we examined the extent to which delay discounting is related to (a) a behavioral measure of time perception (as assessed by the temporal bisection procedure), (b) a self-report of time perspective (Zimbardo Time Perspective Inventory), (c) a self-report measure of impulsivity (the Barratt Impulsiveness Scale), and (d) a behavioral measure of risk taking (probability discounting).

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2. Methods

2.1. Participants

One hundred and forty three undergraduate students from Introductory Psychology classes participated in this study to receive course credit. The participants were contacted through class announcements about available research projects. This study was approved by the Utah State University Internal Review Board.

2.2. Apparatus/Instruments

The experiment was conducted in multiple sessions in a computer laboratory with a capacity of 25. Each participant worked at a separate computer. Participants could attend one of the different days and times scheduled for the data collection sessions. Stimuli were presented and responses were recorded on the computers using a program developed by the first author in Visual Basic.Net 2005 software.

2.3. Procedure

After reading and signing the informed consent, participants completed the behavioral tasks (delay discounting, probability discounting, temporal bisection procedure) and then answered the BIS-11 and ZTPI questionnaires. In the delay and probability tasks, participants made choices about $10 and $100 (see below for more details). Block randomization was used to determine the order of administration of (a) the behavioral tasks; and (b) the amounts of money used in the delay and probability tasks; and (c) the questionnaires. At the end of the experiment, participants completed a brief demographic questionnaire. We will first describe the behavioral tasks (delay discounting, probability discounting, and the time perception task), and then the questionnaires.

2.3.1. Delay discounting—For the delay and probability discounting tasks, participants first completed a practice procedure, which consisted of five trials similar to the testing trials. After the practice trials, the participants could choose to practice more, to ask questions about the experiment, or to start the experiment itself. No participant repeated the practice trials or asked questions about the procedure.

For each trial, the participants made choices between immediate and delayed outcomes. To make choices, participants used the mouse to click on squares on the computer screen with the amount of money they selected. The delays were 1 day, 2 days, 1 week, 2 weeks, 1 month, 2 months, and 6 years. The order of the delays was chosen randomly for each participant. For each delay, participants were exposed to 10 trials. The first trial was always $100 delayed versus $50 now in the large condition, or $10 delayed versus $5 now in the small condition. For the subsequent choices, the immediate amount was adjusted based on the participant’s response. If the participant had chosen the immediate outcome, the next immediate outcome decreased. If the participant had chosen the delayed outcome, the amount of the immediate outcome increased.

The quantity added to or subtracted from the immediate outcome was adjusted across the trials (Du, Green, & Myerson, 2002). The first adjustment was half of the difference between the immediate and the delayed amount [($100 - $50)/2 = $25 in this example for the large condition]. For the next trials, the size of the adjustment was half of the size of the previous adjustment. Therefore, in the third trial, if the participant had chosen the immediate outcome on the first and second trials, the amounts on the third trial was $100 delayed versus $12.50 now ($25 from the previous trial minus the adjustment, which was $12.50 on this trial), whereas if he had chosen the delayed option, the amounts were $100 delayed

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versus $87.50 now ($25 plus the adjustment). This process continued for 10 trials. The indifference point was taken as the last immediate amount for each delay.

2.3.2. Probability Discounting—In the probability discounting task, participants were asked to choose between a sure and a risky outcome. The probabilities were .95, .90, .70, .50, .30, .10, and .05 and were shown on the screen as a percentage chance of receiving the probabilistic outcome (e.g., 50% chance). Analogous to the delay discounting procedure, the first choice was always $100 with a probability of less than 1 versus $50 with certainty. If, on one hand, the participant chose the certain amount, the certain amount decreased on the next trial. If, on the other hand, the participant chose the probabilistic amount, the value of the certain amount increased on the next trial. Similarly to the delay discounting procedure, the size of the first adjustment was half of the certain amount, and the size of the next adjustment was half of the previous adjustment. Participants were exposed to 10 trials per probability. The indifference point was taken as the last certain amount for each probability.

The Area Under the Curve (AUC; Myerson, Green, & Warusiwatharana, 2001) was calculated for the delay and probability discounting procedures. To calculate the AUC, the delays (or probabilities) and indifference points are normalized, and the actual area underneath the curve is calculated by summing the results of the following equation applied to each delay (or probability) and indifference point pair: $x_2\ x_1[(y_1+y_2)/2]$, where x_1 and x_2 are successive delays (or probabilities) and y_1 and y_2 are the indifference points associated with those delays (or probabilities). The AUC can range from 1 to 0. For delay discounting, an AUC of 0 means a steep discounting (high impulsivity), whereas for probability discounting, an AUC of 0 means shallow discounting (low risk taking; Myerson, Green, Holt, & Estle, 2003).

2.3.3. Bisection Procedure—In this task, participants were asked to categorize the duration of the presence of a circle as either short or long. At the beginning of the task, participants were exposed to four “short” trials (S) and four “long” trials (L) in the following order: *SLSLSLSL*. On the short trials, the circle was presented for 2 s with the label SHORT at the bottom of the screen. On the long trials, the circle was presented for 4 s with the label LONG at the bottom of the screen. After the duration elapsed, the circle disappeared from the screen. Following these trials, participants categorized the samples as either short or long by clicking on the “Short” or “Long” labels, which were both now present on the screen. During this training phase, participants received feedback for their responses. There was no time limit to complete the training, which had a minimum of 6 trials total showing the “Short and “Long” samples in random order. To go to the next phase, a participant had to reach a performance criterion of at least 90% accuracy in responding short following the 2 s sample and in responding long following the 4 s sample. All participants achieved 100% accuracy on the first 6 trials.

After training, participants were exposed to the testing trials. In this phase, samples across a range of durations (2.0 s, 2.2 s, 2.8 s, 3.1 s, 3.5 s and 4.0.s) were presented in random order in five blocks and participants classified the samples as ‘long’or ‘short’ as before. Before each block, two forced-choice trials were conducted, in which only the short (2 s) and the long (4 s) duration was presented. All trials were separated by a random inter-trial interval (ITI) chosen from a distribution between 5 and 7 s in the testing phase. The number of trials used in training and testing, the ITI duration, type of feedback, and sample durations of the present procedure are consistent with those used in previous studies (e.g., Lieving, Lane, Cherek, & Tcheremissine, 2006a, 2006b; Wearden, Wearden, & Rabbitt, 1997).

To analyze the data from the bisection procedure, time perception was assessed by recording the proportion of ‘long’ responses after presentation of each sample duration. The proportion

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of long responses was plotted as a function of sample duration and then analyzed to obtain the range, mean, and SD of the function (Blough, 1996). The range of the function indicates the degree of overall stimulus control and is measured by subtracting the value of the lower asymptote from the upper asymptote. A larger range indicates greater stimulus control, whereas a smaller range indicates less stimulus control. According to Blough, the range indicates how much attention is paid to the samples, because at the endpoints, the difference between the stimuli is maximal, and any errors likely reflect inattention rather than failure to discriminate. The mean reflects the time at which the proportion of responses to the long option is 0.5. This measure is the point of subjective equality and quantifies lateral shifts in the function. Smaller means are associated with overestimation of the passage of time, whereas larger means are associated with underestimation of the passage of time (e.g., Meck, 1996). The SD is a measure of sensitivity to time, with smaller SD values indicating greater sensitivity to the differences between the short and long sample durations.

To obtain estimates of the mean and SD, we first normalized the functions to correct for differences in range, which can alter the estimate of the other parameters (Odum & Ward, 2007). We subtracted the proportion of long responses at the 2 s sample duration from the obtained proportion of long response for each ‘short’ sample duration with the constraint that the result could not be less than zero. For the long sample durations, we added the difference between the proportion of long response at the 4 s sample duration and 1.0 to the obtained proportion of long response with the constraint that the result could not be more than 1.0.

Finally, the normalized data were fit using the equation proposed by Blough (1996):

$$f(t)=a+\frac{b}{\sqrt{2\pi\sigma}}\left[\exp-\left(\frac{(t-\mu)^2}{2\sigma^2}\right)\right] \quad (1)$$

where $f(t)$ is the proportion of long responses at a given stimulus duration (t), a is the lower asymptote of the function, b is the range of the function (upper - lower asymptote), μ the mean, and σ the standard deviation. Fits were done with the solver tool of the Microsoft Excel.

2.3.4. Questionnaires—After participants completed the behavioral tasks, they answered computerized versions of three questionnaires. The *Barratt Impulsiveness Scale* (BIS-11; Patton et al., 1995) has 30 items divided in three subscales: attention/cognitive (e.g., “I do things without thinking”), motor (e.g., “I am restless at the theater or lectures”), and non-planning (e.g., “I can only think about one problem at a time”). The *Zimbardo Time Perspective Inventory* (ZTPI; Zimbardo & Boyd, 1999) is a multidimensional scale of perspective of time containing 56 items divided into five different subscales: (1) Past Negative (e.g., “I think about the bad things that have happened to me in the past”, (2) Present Hedonistic (e.g., “I often follow my heart more than my head”), (3) Future (e.g., “I complete projects on time by making steady progress”), (4) Past Positive (e.g., “I enjoy stories about how things used to be in the ‘good old times’”), and (5) Present Fatalistic (e.g., “My life path is controlled by forces I cannot influence”). The order of the BIS-11 and ZTPI was randomized across participants. All participants answered a brief demographic questionnaire at the end of the experiment.

3. Results

Forty-one percent of the participants were males. The participants were on average 19.88 years old (SD = 2.4) and unmarried (88.11%). They had on average 13.89 years of education (SD = 0.09) and earned US $590 per month (SD = 74.64).

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The Results section is organized as follows: first we present data from the delay and probability discounting tasks (assessing impulsive and risky choice), then we describe the relation between impulsive choice, risky choice, and self-reported impulsivity. Next, we describe the relation between time perception and time perspective. Finally, we show the correlations between all measures. For correlations, to control Type I error due to the number of tests performed, we adopted $\alpha = .01$ as a conservative significance level rather than the more customary $\alpha = .05$ (Keppel, 1991).

3.1. Delay and Probability Discounting

Figure 1 shows the AUCs for the delay and probability discounting tasks for the $10 and $100 amounts averaged across participants. The AUC for $10 was smaller than the AUC for $100 in the delay discounting task (paired $t_{142} = 10.29$, $p < 0.001$). The AUC for $10 was larger than the AUC for $100 in the probability discounting task (paired $t_{142} = 6.14$, $p < 0.001$). This finding replicates the results of previous studies in the literature and establishes that we had a valid measure of delay and probability discounting.

3.2. Time Perception

Figure 2 shows the obtained proportion of long responses, prior to normalization, as a function of sample duration averaged across all participants. The range of the function was 0.86, indicating robust stimulus control. After normalization, Equation 1 did not converge for data from 19 participants, so data from these participants are not included in analyses. The mean of the normalized function was 2.91 s showing relatively accurate perception of the mean (3 s) overall. The standard deviation of the function was 1.13, indicating sensitivity to the differences in sample stimuli. The correlational analyses were conducted with the individual means and standard deviations from the normalized data.

3.3. Barratt Impulsiveness Scale and Zimbardo Time Perspective Inventory

To establish the suitability of the scales for further analyses, alpha reliabilities were calculated for the full scale and for each subscale of the BIS-11 and the ZTPI. Table 1 shows the Cronbach's alpha, range, mean, and standard deviation for each subscale. Regarding the BIS-11, Cronbach's alpha was acceptable only for the motor subscale (i.e., in the range of 0.8 and 0.7; Cronbach, 1951). A review of scale properties revealed that minor changes resulted in adequate alphas for the non-planning subscale. By removing the item 3 ("I am happy-go-lucky."), the alpha for this scale increased to 0.72. After removing item 3, the minimum score was 1, the maximum 3, the mean 2.01, and the SD .42. A review of scale properties for the attention subscale showed that major changes would be needed to make the scale useful; thus, this scale was dropped from further analyses.

The ZTPI does not have an overall score. Cronbach's alpha was acceptable for all subscales with the exception of the present fatalistic subscale. An item analysis showed that item 47 had a low corrected item-total correlation with the scale. Removing this item ("Life today is too complicated; I would prefer the simpler life of the past.") resulted in an adequate alpha (0.70; min = 1.13, max. = 3.88, M = 2.17, SD = .55). All correlations were conducted with the scales with acceptable alphas.

3.4. Correlations

To assess the relation between the different decision making processes, we first evaluated the correlation between impulsive choice, risky choice, and self-reported impulsivity and the correlation between the time perspective and time perception measures separately. We averaged the AUC for $10 and $100 for the delay discounting tasks, and the AUC for $10 and $100 for the probability discounting tasks, to obtain a single AUC for each task to

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minimize the number of tests performed. Table 2 shows the correlation matrix for the delay discounting, BIS-11 subscales, and probability discounting measures. Pearson correlation coefficients showed a significant weak positive correlation between the AUC for delay discounting task and the AUC for the probability discounting task, indicating that participants that showed steep delay discounting also showed steep probability discounting. Steep discounting by delay indicates someone would more likely take a smaller sooner reward over a larger later reward, whereas steep discounting by probability shows someone would more likely take a smaller certain reward over a larger less likely reward. There was a significant weak negative correlation between the AUC for delay discounting with score on the Non-Planning subscale, suggesting that participants that showed steep delay discounting were less likely to plan ahead carefully. Other correlations were not significant.

Table 3 shows the correlations within and between time perception (the mean, standard deviation and range from the temporal bisection procedure) and time perspective (scores on the ZTPI subscales). The range of the temporal bisection procedure was significantly weakly negatively correlated with the mean and significantly strongly correlated with the SD of the temporal bisection procedure. The scores on the Future subscale were significantly weakly negatively correlated with the scores on the Present Hedonistic subscale, and the scores on the Past Positive subscale were significantly weakly negatively correlated with the scores on Past Negative subscale. None of the measures of time perception were significantly correlated with the measures of time perspective.

The correlations between the impulsivity measures (delay discounting, probability discounting, and self-reported impulsivity) with the time measures (time perception and time perspective) are shown in Table 4. The AUC for delay discounting was significantly weakly positively related to the mean and range of the temporal bisection procedure, showing that steep discounting is associated with overestimation of time and less stimulus control by time. That is, people that were more impulsive on the delay discounting task judged time to pass more quickly, and did not attend as well to the samples in the temporal bisection procedure. The AUCs for delay discounting and probability discounting were not significantly related to the scores on the ZTPI subscales.

The scores on the BIS-11 subscales had no significant correlation with the outcomes of the temporal bisection procedure, but did have some significant correlations with the time perspective subscales. The Motor subscale score was significantly moderately positively correlated with the Present Hedonistic score and significantly weakly negatively correlated with the Future subscale score. These data indicate that people that are restless also tend to be hedonistic and have a lower tendency to plan for the future. The Non-Planning subscale score was significantly weakly positively correlated with the Fatalistic subscale scores, showing that people who tend not to plan things carefully have more hopeless attitudes towards life.

4. Discussion

The goal of this study was to assess the relation between measures of impulsivity (impulsive and risky choice and self-reported impulsivity) and measures of time (time perception and time perspective). This is the first study to evaluate the relation between the degree of delay discounting with temporal perception as measured by the temporal bisection procedure. Our measure of time perception was not influenced by the reaction time to make a choice, and thus may provide a good estimate of the relation between delay discounting and temporal perception. We found a weak positive correlation between the degree of delay discounting and the mean of the temporal bisection procedure. This finding shows that people that were more impulsive (showed steep discounting of value when rewards were delayed) also tended

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to overestimate how much time had passed. Thus, one reason that a person may not value delayed rewards very much is that the delay seems longer than it does to another person. There was also a weak positive correlation between the steepness of delay discounting and the range of the temporal bisection function. This finding shows that people who are more impulsive on the delay discounting task tend not to pay as much attention to the temporal bisection procedure.

The correlations between the degree of delay discounting and the measures of temporal perception, while significant and intriguing, were also somewhat weak. There are a number of possible contributions to the weakness of the correlations. One reason could be that the time spans of the two tasks are quite different (i.e., years for delay discounting and seconds for the temporal bisection procedure). Future research could evaluate this possibility by increasing the similarity of the temporal ranges used in the two tasks.

We also evaluated the relation between impulsive choice as assessed by the delay discounting task and self-reported impulsivity as measured by the Barratt Impulsiveness Scale. The degree of delay discounting was weakly negatively correlated with the score on the Non-Planning subscale of the BIS, indicating that individuals for whom delay degrades reward value more steeply tend not to plan ahead. This finding could be important because it suggests that, while the construct of impulsivity is complex and multi-faceted, elements of sensitivity to delayed reward and self report measures of impulsivity can reflect similar personal aspects (see Odum, 2011a, 2011b, for discussion of delay discounting and personality).

Several prior studies have also reported a positive correlation between the discounting of delayed outcomes and scores on the Non-Planning subscale (e.g., de Wit et al., 2007; Kirby & Petry, 2004; Mitchell, 1999; Swann et al., 2002; Yeomans et al., 2008). Other studies have also shown a positive correlation between the degree of delay discounting and scores on the Motor subscale (Einsenberg et al., 2007; Kirby & Petry, 2004; McLeish & Oxoby, 2007, Petry, 2001), while one study found a negative correlation between the degree of delay discounting and scores on the Attention subscale (Mitchell, 1999). The variability in the literature is likely due to the use of different sample sizes and populations as well as the relatively weak degree of correlation between the measures. We also found that the attention subscale had low internal consistency in our sample. Future studies directed at the correlation between self-report measures of impulsivity and delay discounting would ideally evaluate the internal consistency of the subscales as well as ensure to plan for sufficient statistical power.

The present data showed that the mean in the temporal bisection procedure was correlated with the degree of delay, but not probability, discounting, a finding that appears to contradict a single timing account of the two processes (Gallistel & Gibbon, 2002). These data are particularly interesting in light of previous results indicating that delay and probability discounting are different processes (see Green & Myerson, 2010 for a review of this topic). That is, previous data show that experimental manipulations have different effects on discounting of delayed and probabilistic outcomes. For example, as shown in the present study, while people discount smaller amounts of money more steeply than larger amounts of money in delay discounting, the reverse happens in probability discounting (e.g., Green, Myerson, & Ostaszewski, 1999).

Furthermore, if delay and probability discounting were the same process, the correlation between the AUCs should be negative: a smaller AUC in delay discounting represents more impulsive behavior, whereas a larger AUC in probability discounting represents more risk taking behavior. People that discount delayed outcomes steeply, however, do not necessarily

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discount probabilistic outcomes in the same fashion; in other words people that are impulsive in delay discounting are not necessarily risk takers when making decisions about probabilistic outcomes (Green & Myerson, 2010). The positive correlation in the AUCs found in the present study confirms previous data in which the correlation between delay and probability discounting was also positive (Estle et al., 2006; Myerson et al., 2003), supporting suggestions that delay and probability discounting may be different processes (Green & Myerson, 2010).

In the present study, we did not find a significant relation between the perception of time, as measured by the temporal bisection task, and the perspective on time, as measured by the ZTPI. Due to the number of correlations we computer, we adjusted the level of significance from $p<.05$ to $p<.01$ to control Type I error. Even if one were to adopt a less stringent standard for considering a result statistically significant (e.g., $p < .05$), the correlations between delay discounting and the subscales of the ZTPI were very weak (between .2 and −.2). Therefore, these relations are unlikely to prove particularly meaningful. It is interesting, therefore, that how people perceive the passage of objective time may have little relation to the subjective understanding of time (how people view their person past, present, and future).

The present study has some drawbacks. First, while significant, the correlations amongst the measures tended to be weak. Second, it is unclear why the Attention subscale, which measures the ability to focus attention or concentrate, had such internal consistency for the present sample. Further replications of the questionnaire in college samples with factor analysis of the questionnaire are necessary. Third, this study was conducted with college students, while other studies that have examined the relation between impulsivity and time perception, and time perspective were done with other populations. It would be interesting to evaluate whether the same findings would be found in different population (e.g., substance abusers).

As a final caveat, this study did not manipulate delay discounting or time perception to experimentally alter these measures. Instead, we examined whether they were related in their state of natural variation within individuals as tested in our laboratory procedures. We found the extent to which a person perceives time as passing more quickly is predictive of how delay affects reward value. Future studies should focus on the degree to which this effect is replicable in different populations and also with different techniques of varying temporal perception. For example, a person who overestimates the passage of time could receive training on veridical time. If improving the accuracy of temporal perception could help rewards maintain value when delayed, this finding would have broad and important implications in the understanding and treatment of impulsivity.

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Highlights

- We investigated the relation between delay discounting and temporal bisection task, self-report scales of impulsivity and time perspective (ZTPI and BIS-11); and probability discounting.
- Temporal bisection procedure was correlated with delay discounting; ZTPI subscales were correlated with the impulsivity measures and with probability discounting; delay discounting was related to the BIS-11 scale; and delay and probability discounting were positively correlated.

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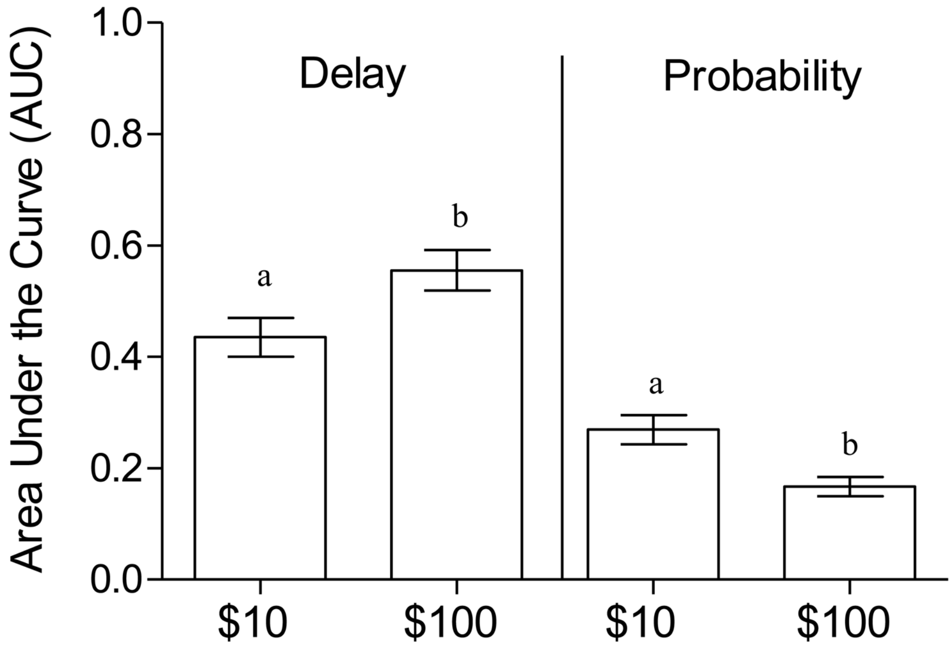

Figure 1.
Mean AUC for delay and probability discounting for two amounts, $10 and $100. Vertical lines show one standard error above and below the means.

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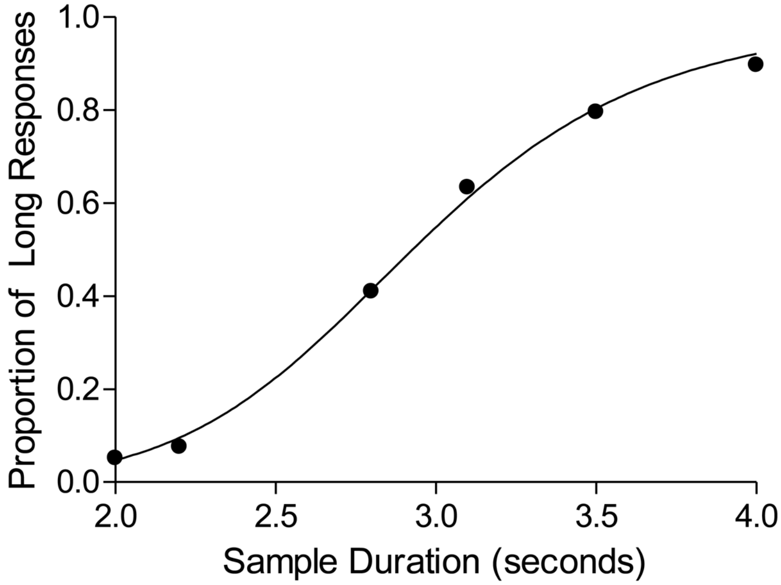

Figure 2.
Mean proportion of responses to the long sample as a function of sample duration.

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Table 1

Obtained Minimum, Maximum, Mean and Standard Deviation Scores for Each of the Barratt Impulsiveness Scale and Zimbardo Time Perspective Inventory subscales.

Scale	Subscale	alpha	Min.	Max.	Mean	SD
Barratt Impulsiveness Scale	*Total scores for BIS (30 items; 30–120)*	*.80*	*1.50*	*2.97*	*2.20*	*.30*
	Motor (10 items; 10–40)	.75	1.20	3.30	2.24	.42
	Non planning (12 items; 12–48)	.68	1.08	3.00	2.06	.42
	Attention (8 items; 8–36)	.58	1.50	3.25	2.37	.38
Zimbardo Time Perspective Inventory	Past negative (10 items; 10–50)	.82	1.20	4.50	2.94	.67
	Present hedonistic (15 items; 15–75)	.80	2.33	4.53	3.40	.48
	Future (13 items; 13–65)	.73	2.08	4.46	3.47	.48
	Present fatalistic (9 items; 9–45)	.68	1.22	3.56	2.23	.52
	Past positive (9 items; 9–45)	.73	1.78	4.89	3.74	.53

Note. Number of items and the range of scores for each subscale are shown in parentheses.

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Table 2

Correlation of the AUCs for Delay and Probability Discounting, and the scores on the Motor and Non Planning subscales from the Barratt Impulsiveness Questionnaire.

Tasks		1	2	3	4
1. Delay Discounting	r =	1.0			
2. Probability Discounting	r =	.279**	1.0		
3. Motor	r =	−.139	.090	1.0	
4. Non Planning	r =	−.169^	−.119	.280**	1.0

Note:

* *p*< .01 (two-tailed test);

** *p*< .001 (two-tailed test);

^ *p* < .05 (two-tailed test).

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Table 3

Correlations of the Normalized Data from the Temporal Bisection Procedure and the Scores on the Zimbardo Time Perspective Inventory Subscales.

Tasks		**6**	**7**	**8**	**9**	**10**	**11**	**12**
6. Mean	r =	1.0						
7. SD	r =	.135	1.0					
8. Range	r =	−.289***	−.883**	1.0				
9. Past negative	r =	−.109	−.011	.020	1.0			
10. Present hedonistic	r =	−.130	.062	−.136	−.071	1.0		
11. Future	r =	.145	−.081	.050	.039	−.376**	1.0	
12. Fatalistic	r =	.033	.008	−.043	.133	−.041	−.107	1.0
13. Past positive	r =	.006	−.206^	.129	−.365**	.026	.197^	−.022

Note:

* $p < .01$ (two-tailed test);

** $p < .001$ (two-tailed test);

^ $p < .05$ (two-tailed test).

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Table 4

Correlations Between the Delay Discounting, Probability Discounting, Temporal Bisection Task, and the subscales from the Barratt Impulsiveness Questionnaire and the Zimbardo Time Perspective Inventory.

Tasks		Mean[a]	SD[a]	Range[a]	Past Negative	Present Hedonistic	Future	Fatalistic	Past Positive
AUC DD	r =	.249**	−.142	.228**	−.166^	−.193^	.078	−.171^	.172^
AUC PD	r =	.068	−.050	−.191^	−.042	.181^	−.149	.055	.048
Motor	r =	−.148	.145	−.121	.110	.535**	−.284*	−.017	−.094
Non-Planning	r =	.033	−.018	.050	.014	−.190^	−.052	.427**	−.079

Note.

[a] = from the normalized temporal bisection task,

* $p < .01$ (two-tailed test);

** $p < .001$ (two-tailed test);

^ $p < .05$ (two-tailed test).