TWO STEPS FORWARD ONE STEP BACK? DELAY DISOUNTING OF MONEY AND RUNNING IN MARATHON RUNNERS

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Abstract

Delay discounting and physical exercise tend to be independently explored, despite the increasing role of both areas within substance abuse research. Delay discounting is primarily used to uncover addiction related phenomena, whereas physical exercise is studied as a treatment for substance abuse. Few studies, however, have evaluated delay discounting and physical exercise within the context of substance use. Further, samples with a narrow range of fitness are often used, a problem that is compounded by not measuring discounting for exercise related rewards. In the current study, 40 ultra, full, or half-marathon runners completed a Monetary Choice Questionnaire (MCQ) and a modified version of the MCQ using minutes of running as the reward (RCQ). Participants were asked how many minutes of running were worth $100 to them (Running valuation) and to report their weekly number of alcoholic drinks consumed. Minutes of running was discounted at significantly higher rates than money. Interestingly, higher relative rates of discounting on the RCQ and higher running valuation were significantly associated with fewer alcoholic drinks consumed per week. Individuals who exhibited this pattern were also more likely to display lower rates of discounting for money in contrast to those with lower rates of discounting on the RCQ and lower running valuation. Although promising, future research with clinical populations is needed in order to make more firm conclusions regarding discounting and physical exercise.

Keywords: delay discounting, delay discounting of PA, health rewards, marathon runners

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Two Steps Forward One Step Back? Delay Discounting of Money and Running in Marathon Runners

At one point or another, most have heard the expression, “good things come to he who waits.” A call to self-control, patience, and modesty, the expression has been intertwined in the religious and cultural foundations of both Eastern and Western civilization since the start of the AD era. A passage from Lamentations 3:25 (King James Version), for example, holds, “The LORD is good to those who wait for him, to anyone who seeks help from him.” From a slightly different perspective, eastern civilization has emphasized patience as exemplified by the philosopher Lao Tzu in 6 BC, "Nature does not hurry, yet everything is accomplished." More recently, researchers have studied individuals’ ability to delay gratification. As the authors of the Bible and Lao Tzu may have predicted, those who struggle to delay gratification are more likely to suffer from one or more clinical problems (Mischel, Shoda, & Rodriguez, 1989) which has helped to spur continued research on the topic.

In an effort to better understand self-control in children, Mischel, Ebbesen, and Zeiss (1972) studied children’s ability to delay gratification using a conceptually similar procedure to what is known today as delay discounting. Specifically, researchers either provided a smaller or larger amount of a preferred edible to a child. The larger amount was provided only after a predetermined delay whereas the smaller amount could be accessed as soon as the child rang a bell to bring the experimenter back into the room. After a brief test to ensure the child understood the contingencies of the procedure, the experimenter would read to the child:

if you wait until I come back by myself then you can have this one

[pointing to the preferred object]. . . If you don't want to wait you can ring the bell and bring me back any time you want to. But if you ring the bell then you can't have this one [pointing to the preferred object], but you can have that one [pointing to the less preferred object].

Most famously in a longitudinal study with 94 preschool children, Mischel, Shoda, and Peake (1988) found that children's ability to delay gratification in preschool strongly predicted social and academic competency, verbally fluency, rationale thinking skills, planning skills, and ability to cope with stress and frustration 10 years later in adolescence.

Individuals working in the field of behavioral economics have created and revised a similar procedure to delayed gratification known as delay discounting. The procedure evaluates how individuals make choices between a smaller reward to be received now and a larger reward to be received following a delay. Although conceptually similar (Epstein, Salvy, Carr, Dearing, & Bickel, 2010), delayed gratification and delay discounting procedures may not be measuring the same phenomena (Callan, Shead, & Olson, 2011). Regardless, early evidence from delayed gratification research likely helped spur what is today an ever-growing literature on delay discounting (Bickel, MacKillop, Madden, Odum, & Yi, 2015).

Delay discounting has been used to describe how the subjective value of a reward declines as a function of the delay to the receipt of that reward (Bickel, Jarmolowicz, Mueller, Gatchalian, & McClure, 2012; Rachlin & Green, 1972). The rate at which the value of a reinforcer decreases, as a function of the delay to its receipt, is derived from a hyperbolic model first used by Mazur (1987).

(1)

$$V = \frac{A}{1 + k D}$$

As set forth by Mazur (1987), discounting rate is estimated via a non-linear regression with V as the present value of the reward (A), at delay (D), with *(k)* as a free parameter that equates to discount rate.

Although all individuals tend to discount delayed rewards to some extent, a propensity to excessively discount the value of delayed rewards (i.e. have high *k* values), has been linked to a wide range of clinical problems such as obesity (Bickel et al., 2014; Epstein et al., 2010; Jarmolowicz et al., 2014), pathological gambling (Dixon, Marley, & Jacobs, 2003), high risk sexual behavior (Chesson et al., 2006; Herrmann, Hand, Johnson, Badger, & Heil, 2014; Jarmolowicz, Bickel, & Gatchalian, 2013; Jarmolowicz, Lemley, Asmussen, & Reed, 2015; M.W. Johnson & Bruner, 2011; Lawyer, 2008; Lawyer & Schoepflin, 2013), mental health disorders (Rounds, Beck, & Grant, 2007), and in particular, substance abuse (Bickel, Jarmolowicz, Mueller, Gatchalian, et al., 2012; Bickel, Jarmolowicz, Mueller, Koffarnus, & Gatchalian, 2012). Further, individuals suffering from comorbid clinical issues tend to have higher rates of discounting than those with one or no clinical problems (Fields, Sabet, Peal, & Reynolds, 2011; Petry & Casarella, 1999). When comparing discounting rates of substance abusers who pathologically gambled versus substance abusers who did not, for example, Petry and Casarella (1999) found that the comorbid group discounted monetary outcomes at significantly higher rates than the substance abuse-only group. Lastly, individual discounting rates for money tend be correlated with those for other outcomes be they food (Davis, Patte, Curtis, & Reid, 2010), drugs (Kirby, Petry, & Bickel, 1999b), sex (Jarmolowicz et al., 2013), or even commodities such as CDs and books (Charlton & Fantino, 2008). In conjunction, these findings suggest that an excessive preference for immediate rewards may be indicative of a trans-

disease process (Bickel, Jarmolowicz, Mueller, Koffarnus, et al., 2012; Bickel & Mueller, 2009). Specifically, the process of excessively delay discounting for one maladaptive behavior is likely relevant in the understanding of other behavioral disorders (Bickel, Jarmolowicz, Mueller, Koffarnus, et al., 2012). Such parsimony may allow for particularly productive basic and translational research efforts.

Despite the growing number of articles on delay discounting, few studies have evaluated delay discounting of health related outcomes and fewer still have studied delay discounting of pro-health behaviors. Often, in comparing control and clinical groups, researchers target disparities in discounting rates using monetary outcomes (Bickel, Yi, Kowal, & Gatchalian, 2008; Jarmolowicz et al., 2013; Petry, 2001) Several studies, however, have demonstrated robust relations between rates of delay discounting for money and a multiple pro-health behaviors. In particular, researchers have found relations between delay discounting rates and physical activity. Physical activity (PA), or moderate to vigorous intensity aerobic activity (Division of Nutrition, 2015), has demonstrated effects on several clinical problems typically associated with delay discounting (e.g. obesity, substance abuse, mental health disorders). In a study with 422 hypertensive adults, for example, Axon, Bradford, and Egen (2009) found that just a .6% increase in rate of delay discounting was linked with a reduced likelihood of participants engaging in pro health behaviors such as healthy eating and PA behaviors. Similarly, in a population level survey (i.e. n=1,200), Bradford (2010) reported that higher relative rates of discounting for money was related to lower probabilities of changing a variety of pro-health behaviors recommended by participants' doctors ranging from pap smears, cancer screens, to engaging in more PA. Garza, Harris, and Bolding (2013) also found that higher rates of discounting related to engaging in fewer pro-health behaviors such as putting on sun screen, wearing a seatbelt, and engaging in PA. Interestingly, with the exception of socio-demographic measures, PA is the only of these pro-health behaviors to be evaluated in all three of the above mentioned studies.

Although PA interventions help in treating a variety of clinical issues, their relation to alcohol consumption is hotly debated, prompting the need for novel methodological approaches. Part of the confusion stems from evidence that PA is both positively and negatively related to alcohol use. In a study by Murphy and colleagues (1986), for example, alcohol consumption in heavy drinkers was measured before and after either an eight week treatment of meditation, physical exercise, or no a treatment control condition. The authors found that those in the physical exercise and meditation groups drank fewer alcoholic drinks per week after the intervention compared to those in the control group. By contrast, a growing number of population level studies have reported mild to moderate levels of alcohol consumption positively relating to PA (French, Popovici, & Maclean, 2009; Lisha, Sussman, Fapa, & Leventhal, 2012). Further confounding the situation is evidence in population level studies that PA and alcohol use tend to exhibit a U-shaped relation wherein mild to moderate alcohol consumption relates to increased levels of PA but high levels of PA relate to low levels of alcohol consumption (Lisha et al., 2012). Such findings call into question the validity of overarching statements that PA and alcohol consumption are positively associated. One potential method of better discerning how PA and alcohol use might relate is to understand how individuals make decisions regarding the two variables. Oddly, few studies have evaluated how performance on decision making tasks might relate to both PA and alcohol use. Decision making tasks may also be useful because DSM-V criteria for alcohol abuse pertain to decision making lapses and a loss of self-control. In particular, such decision making lapses appear as giving up a long term reward (e.g. health, work success) for a lesser immediate reward (alcohol consumption). Decision making processes may provide a more in depth look at the factors that influence choices surrounding physic The use of delay discounting, therefore, may have face validity for explaining potential relations between PA and alcohol use.

Unfortunately, few have evaluated potential interplay between delay discounting and PA, and the overall findings are mixed (Audrain-McGovern et al., 2004; Axon, Bradford, & Egan, 2009; Bradford, 2010; Daugherty & Brase, 2010; Lambourne, 2005; Li, 2010; Smith, 2010). In a sample of 360 undergraduate students, for example, Smith (2010) found no direct relation between PA frequency, effort, intensity, or time spent in PA. Lambourne (2005) reported that discounting rates for money were only significantly correlated with PA measures when analyzing participants who reported being "motivated to exercise." Three factors that may have contributed to these inconsistent findings are worth noting. First, the above mentioned studies with null effects assessing delay discounting and PA used samples with a narrow range of activity levels. This may have been in part due to using undergraduate samples with narrow distributions of PA levels compared to a more typical population in regards to socio-demographic variables. Second, such samples were void of clinical problems typically associated with delay discounting. In conjunction, the range of discounting rates (Independent Variable) and fitness levels (Dependent Variable) were restricted leading to a lack of sensitivity, and as a result, a lack of connection between the variables. Lastly, discounting rates for health related rewards tend to be unrelated to those for monetary rewards (Chapman, 1996; Chapman, Nelson, & Hier, 1999; Petry, 2003), and researchers have yet to find any intermediary variables that reliably connect the two. Ideally, such a variable could link the two forms of delay discounting with PA levels to create a more systematic explanation of the interplay between delayed rewards and PA. An understanding of how making decisions regarding health rewards and monetary rewards relates to PA may provide an improved foundation within treatment settings (e.g. PA treatment adherence or PA treatment success).

The above limitations may be addressed in part by assessing decision making in individuals with moderate fitness levels to individuals with high fitness levels and by evaluating such individuals via a discounting for PA procedure. In addition, assessing those who engage in PA at a breadth of different levels may help to provide a more sensitive comparison between PA and discounting rates. Such a comparison may be furthered by incorporating a discounting assessment specifically for PA, in addition

to one for money which has previously proven fruitful in the study of specific domains (Lawyer, 2008; Petry, 2003). In studying delay discounting of money and erotica use, for example, Lawyer (2008) found that steeper rates of discounting of erotica use was associated with higher levels of sexual compulsivity. Individuals classified as "erotica users" discounted monetary outcomes at higher rates than "non-erotica users" helping to separate individuals into potential clinical and non-clinical samples. A discounting for PA assessment may help to uncover similar findings that affectively sort individuals into clinical and non-clinical samples.

Although there are many forms of PA, long-distance running, specifically marathon and ultra-marathon running, is an increasingly common and often times extreme form of cardio-vascular activity. Although numerous studies have demonstrated positive effects of PA on mental health symptoms (Josefsson, Lindwall, & Archer, 2014) and substance abuse (Wang et al., 2014), long distance runners such as ultra-marathon runners display structurally disturbing behavior such as running for more than 24 hours and eating, sleeping, urinating, and defecating on the road or trail. This potential paradox may be better understood by comparing delay discounting of monetary and running related rewards to clinical measures (e.g. alcohol or cigarette use). This study therefore measured both hypothetical money and running (i.e. minutes of running) related rewards to allow for an initial exploration of whether high rates of discounting for minutes of running is a clinically healthy or unhealthy indicator. Further, the current study asked participants about how they value running in monetary units (i.e. U.S. dollars) to potentially bridge the gap between discounting of money and discounting of minutes of running. Lastly, in order to study runners who were likely to value time spent running, participants in the current study were either an ultra (40 miles or 100 kilometers), full (26.2 miles), or half-marathon (13.1) runner signed up to race the following day.

Methods

Participants, Settings, and Materials

As detailed in Table 1, the final sample consisted of 40 trail runners (This includes 14 participants running the ultra-marathon, and 26 participants running either the half or full marathon race. Half-marathon races were 13.1 miles, full-marathon races, 26.2 and ultra-marathon races were either 40 or 60 miles long).

Participants were recruited in-person at a local community center near a large mid-western university. Recruitment for, and participation in the current experiment occurred at this community center where participants registered for their respective races that took place the next day. Individuals who signed up for the race were required by the sponsoring organization to pick up their race day materials and check-in prior to the race. Researchers asked participants if they would like to participate in an experiment on running behavior after they completed their check-in process. Participants were not provided any explicit rewards contingent on completing the experimental tasks, however, all individuals in the area were offered water and Gatorade regardless of whether or not they participated in the current experiment. All participants completed the experimental tasks in less than 15 minutes.

The experimental task occurred on a large rectangular table that was placed adjacent to the race organization's check in tables. Participants completed all tasks seated at this table and no more than 5 participants completed the current experiment at any one time. After completing a written consent (see Appendix A), participants completed a standard demographic survey (see Appendix B) which also included questions regarding whether or not participants smoked cigarettes and how many drinks on average they consumed per week.

Procedure

Running Behavior Questionnaire. Following the completion of the written consent and demographics form, participants were asked to complete the running behavior questionnaire (see Appendix C). In this questionnaire, participants reported first whether or not they engaged in less than 2 hours of cardio-vascular activity per week. This question was used to differentiate participants who engaged PA from those who did not. No participants, however, indicated they engaged in fewer than 2 hours of cardio-vascular activity per week. The second question, "how many minutes of running are worth $100 to you" was used to establish an equivalency value equating minutes of running with US dollars. This measure was used as a factor variable in statistical analyses and was also used to establish the specific reward amounts used in the Running Choice Questionnaire (RCQ; see below for details). The third question, "how many times and how many miles a week do you run?" was used to garner self-reported running consumption per week. The fourth question asked participants to circle any of the running related events they experienced that were listed. Specifically, participants chose from, in order, personal goal-setting, race based goal-setting, running with 1 or more fellow runners, "runner's high," relief of anxiety, stress, or other mental health symptoms, and weight-loss. Lastly, participants circled which race they had signed up to participate in the following day. Specifically, the race options were listed, in order, as: 10M, Half, 20M, 26.2M, 50K, 40M, 100K.

Monetary Choice Questionnaire (MCQ). A Monetary Choice Questionnaire (MCQ see appendix D), the Running Choice Questionnaire (RCQ see appendix E), and a third behavioral economic task (not reported in the present document) were counterbalanced across participants. The Monetary Choice Questionnaire is a 27 item questionnaire that presents participants with a hypothetical choice between a smaller amount of money now versus a larger amount of money following a delay. The questions for the MCQ are based on the commonly used hyperbolic function (Mazur, 1987). All

participants were read the below instructions aloud and the instructions were written on the paper form as written below:

For each of the next 27 choices, please circle which hypothetical reward you would prefer: the smaller reward today, or the larger reward in the specified number of days. While you will not actually receive the rewards, pretend you will actually be receiving the amount you indicate and answer honestly.

As detailed in table 2, the MCQ uses 23 different delay amounts across 27 questions. Further, 8 different *k* value ranges and two end point values are used which correspond to the proportional difference between immediate and delayed reward amounts. Small, medium, and large magnitude values are used across each of these 10 discounting rates (*k* values). Participants completed the questionnaire via paper and pencil and were provided the following instructions:

Running Choice Questionnaire (RCQ). The Running Choice Questionnaire (RCQ; see appendix E) was identical to the Monetary Choice Questionnaire (Kirby, Petry, & Bickel, 1999a), except it was translated from dollars to minutes of running, and the equivalency value reported by participants in the Running Behavior Questionnaire, "How many minutes of running are worth $100 to you?" was used to establish equivalent values between minutes of running and money. Participant responses (e.g. 2 hours or 120 minutes) were entered into an algorithm derived from the Monetary Choice Questionnaire (Kirby et al., 1999a) in order to calculate the relative differences in reinforcer magnitude of the commodity under study (i.e. minutes of running). As detailed in Table 2, the reward amounts for RCQ were gathered by taking the equivalency value (x) for each participant and multiplying it by 10% of the reward amounts typically used for the smaller sooner and larger later rewards in the MCQ. If a participant valued 200 minutes of running as equal to $100 minutes, for example, then for question 1 of the RCQ, the participant

would choose between 68 (200 x .34) minutes of running today and 70 (200 x .35) minutes of running in 186 days. This process was repeated for each question as seen in Table 2.

Data Analysis

Rates of discounting *(k)* for money and minutes of running were calculated through the use of a MCQ Automated Scorer (http://tinyurl.com/MCQTool). The tool determines the switchover point between the immediate and delayed rewards for each participants. For each participant, geometric means of natural logs *(k)* were assessed at each indifference point. Choices between immediate and delayed rewards occurred across small, medium, and large magnitudes for both dollars and minutes of running, as determined by each participant's equivalency value for how many minutes of running were worth $100. Each magnitude probed nine levels of delays so that a separate k value could be determined for each magnitude level (Kirby et al., 1999a). Average natural log *(k)* for minutes of running and money was compared between running groups for small, medium, and large magnitudes.

In order to create the variable, "running valuation," $100 was divided by the equivalency value for each participant (i.e. number of minutes of running worth $100) to arrive at a dollar value per minute of running (e.g. an equivalency score of 50 would equate to $2/minute). This value was then log transformed to achieve more normally distributed data.

No measures in Table 4 were normally distributed with the exception of natural log *(k)* for the MCQ and natural log *(k)* for the RCQ. T-tests were therefore performed when comparing across running groups for the MCQ and RCQ k values whereas Mann-Whitney U tests were performed for the other non-normally distributed measures. Specifically, the tests were comparing ultra-marathon runners to half/full marathon runners in regards to the group averages for self-reported running experiences, total self-reported running experiences, self-reported miles run per week, natural log *(k)* for the MCQ, and natural log *(k)* for the RCQ. The proportion of participants reporting running experiences are marked for the six

running experiences in parentheses and standard deviations are noted in parentheses for total self-reported running experiences per group, natural log *(k)* for the MCQ, natural log *(k)* for the RCQ, and reported weekly miles ran per group. Comparisons across groups were performed using Mann-Whitney U tests with the exception of the variables of natural log *(k)* for the MCQ and natural log *(k)* for the RCQ which were calculated using parametric t-tests. Lastly, as noted in figure captions, each figure and statistical test includes data from participants who completed all relevant components of that analysis or graphical depiction.

Results

Across all participants (see Figure 1), pairwise t-tests revealed statistically significant differences between discounting rates of money and minutes of running at small (t= 3.69, p= <.001), medium (t=3.55, p= <.001), and large reward magnitudes (t= 3.45, p= <.001). Discounting for minutes of running was effectively measured as demonstrated by an average consistency score of 80% (sd =0.17). Discounting for money was similarly successful with an average consistency score of 77% (sd = 0.18). A non-significant magnitude effect (i.e. higher relative rates of discounting observed at lower reward amounts compared to higher reward amounts) was observed for both rewards, however, the direction of the effect was synonymous with what is typically observed (i.e. higher rates of discounting at lower reward magnitudes).

As the top panel of Figure 2 shows, individuals who discounted delayed minutes of running at higher rates (median split) consumed fewer drinks per week on average (2.8) compared to those who discounted delayed minutes of running at lower rates [(7.2) (t=2.74, p=0.010)]. By contrast, the bottom panel of Figure 2 details that there were no significant relations between rates of money discounting and alcoholic consumption.

A median split based on the number of alcoholic drinks per week was performed to form two groups. The low drinks group consisted of those individuals who reported drinking 4 or fewer drinks per

week and the high drinks consisted of those who reported drinking more than 4 drinks per week. As Figure 3 shows, low drinkers (median split) discounted minutes of running at significantly higher rates than money ($p = <.001$). There is no such difference in the high drinks group ($p =0 .775$). In addition, low drinkers discounted minutes of running at higher relative rates than high drinkers ($p= <0 .001$), although the same is not true for discounting of money across the two groups ($p =0.487$).

Discounting rates for minutes of running and money were not correlated when analyzing the entire sample. Discounting rates for the two rewards were, however, positively correlated ($r= 0.56$, $p= 0.026$) for those participants in the high drinks group in contrast to those in the low drinks group (Figure 4).

Table 3 details corollary statistics for running valuation, discounting rates for money, discounting rates for running, and number of alcoholic drinks consumed per week. Running valuation was significantly correlated to both discounting rates for money and minutes of running, despite no direct relation between the two forms of discounting. Running valuation was also significantly negatively correlated to alcoholic drinks consumed per week. In other words, higher dollar value per minute of running equated to fewer self-reported alcoholic drinks consumed per week.

Figure 5 displays discounting rates for money and running based on high vs. low relative running valuation (split via the median). Although there appears to be a difference in discounting rates between those participants with high vs. low running valuation, the Mann Whitney U was not quite statistically significant ($p=0.067$). Interestingly, however, those participants with higher relative valuation for running did report higher rates of discounting for running ($p=0.007$).

In an effort to further evaluate how discounting rates for money and running relate to running valuation, Figure 6 displays how log transformed running valuation correlates to discounting rates for money and minutes of running. Notably, higher rates of discounting for minutes of running corresponded to higher valuations for running, whereas lower valuations of running related to higher rates of

discounting for money. Visually, Figure 6 details a potential inverse relation between discounting rate for money and that for minutes of running, despite the lack of a significant direct correlation observed between the two variables. A partial correlation, however, was used to test the null hypothesis that there is no significant correlation between discounting rate for money and minutes of running after controlling for the overlap of running valuation. Indeed, there was a statistically significant partial correlation between discounting rate for money and minutes of running when controlling for the overlap of running valuation [(30) r=0.351, p=0.049]. Results of the partial correlation between the two forms of discounting, juxtaposed with the results of the zero order correlation [(40) r=0.163, p=0.314], suggest that running valuation had a significant effect on the strength of the relation between money discounting and running discounting.

Table 4 reveals that ultra-marathon runners reported running significantly more weekly miles than half/full marathon runners (p=0.002) and more running experiences (p=0.034), there were no significant differences between the groups in natural log *(k)* on the MCQ, natural log *(k)* on the RCQ, or any of the individual running experiences. There were still no significant differences between groups on the MCQ, RCQ, and the individual running experiences when splitting the race groups into three groups (i.e. ultra, full, half marathon groups), although the lack of significant findings may have been due to only seven participants having signed up for the full-marathon race. The only significant relation between any self-reported running experience and any other non-running experience variable was a positive correlation between reporting setting race goals and number of reported miles run per week (r=0.412, p=0.002).

Discussion

The goal of the current experiment was to use the MCQ and a novel RCQ to evaluate long-distance runners' valuation of delayed and immediate rewards. In that vein, the current study is the first to my knowledge to successfully evaluate delay discounting of PA (cf. sexual discounting; (Jarmolowicz et al., 2015; M.W. Johnson & Bruner, 2011; Lawyer, 2008). Further, the RCQ demonstrated levels of consistency typically observed (i.e. > 75%) with procedures evaluating discounting of monetary rewards (Kirby & Marakovic, 1996). In the current study, consistency was calculated by finding the k value most consistent with the participant's choices, and then reporting the number of choices consistent with that particular k value. Rates of discounting for minutes of running were significantly greater than for those with money at small, medium, and large reward magnitudes, which is also in line with previous studies comparing discounting of money to that of an alternative reward (M. W. Johnson, Bickel, & Baker, 2007; Lawyer, 2008; Petry, 2001). There are six further points I would like to make regarding the present data.

The RCQ is the first delay discounting questionnaire to our knowledge to use equivalency values between two rewards to inform reward amounts. Although previous studies have utilized a similar equivalency procedure to study drug (Madden, Petry, Badger, & Bickel, 1997), health (Odum, Madden, & Bickel, 2002), and sexual outcomes (Lawyer, 2008) , the current study is the first to utilize an equivalency measure in a discounting questionnaire. Such a procedure allows for the flexibility to use individualized discounting questionnaires in non-convenient locations such as field studies. Equivalency values in the present experiment were also relevant as an independent variable separate from both forms of discounting. Individuals' running valuation, for example, was related to both running discounting, money discounting, and alcoholic drinks consumed per week. Although running valuation and discounting rate for running were both correlated with alcoholic drinks, the correlations were moderate (r between .3 and .5), suggesting that the two measures are uniquely related to alcohol consumption. Further, discounting rates for money and running are correlated only when accounting for the overlap of running valuation,

which suggests that the equivalency measure did indeed successful translate the value of the two rewards. Future research might find such a technique particular useful in delay discounting procedures of previously unstudied rewards, or with rewards that may be difficult to monetize.

Although a considerable amount of research has demonstrated links between higher rates of delay discounting and maladaptive behavior (Bickel, Jarmolowicz, Mueller, Koffarnus, et al., 2012), the current study is the first to our knowledge to report a link between higher relative rates of discounting for a reward (i.e. running) and a desirable clinical outcome (i.e. roughly 1/3rd fewer alcoholic drinks per week). Typically, delay discounting for monetary rewards and non-monetary rewards (e.g. food, sex, drugs) are linked to undesirable clinical outcomes [e.g. overeating (Epstein et al., 2010; Jarmolowicz et al., 2014), sexual risk (Jarmolowicz et al., 2013; Jarmolowicz et al., 2015; M.W. Johnson & Bruner, 2011), substance abuse (Bickel, Jarmolowicz, Mueller, Koffarnus, et al., 2012; Kirby et al., 1999b)], or demonstrate that higher rates of discounting for money and/or the clinical reward correspond to current clinical status [clinical, former clinical, or control sample (Petry, 2001)]. Future research, however, might explore whether the relation between higher rates of running discounting (i.e. a pro-health behavior) and a desirable clinical outcome (i.e. fewer self-reported alcoholic drinks consumed per week) observed in the current study can be replicated with other pro-health behaviors [e.g. mindfulness (Morrison, Madden, Odum, Friedel, & Twohig, 2014)].

The current data do not speak directly to why higher rates of discounting for running were associated with fewer alcoholic drinks consumed per week, however, there are two points on this topic worth noting. First, lower running values (e.g. $0.10/minute) and a propensity to choose the larger later reward for running may indicate a strong pattern of valuing duration of running at the expense of other costs. With low running valuation, for example, an individual is specifying that they need to run for longer durations, at the expense of time, in order to obtain an experience equally valuable to $100. Similarly, those same participants tend to choose longer durations of running in the form of the larger

delayed reward for exercise. Individuals who fit this profile may spend more time per week exercising than those who do not to the point where their time spent exercising comes at the expense of other important activities such as time with their family. Second, discounting rates for money and running were only correlated (positively) for those participants in the low drinks group. Typically, discounting rates for health related rewards do not correlate with those for money (Chapman & Elstein, 1995; Chapman et al., 1999; Petry, 2003), which stands in contrast to most other rewards (Odum, 2011). This discrepancy between discounting correlations for high and low drinkers in the current study can be explained, however, when accounting for differences in running valuation between participants. Running valuation is also significantly related to the number of alcoholic drinks consumed per week, running, and money discounting, suggesting that how individuals value minutes of exercise may be a crucial variable in evaluating how delay discounting, physical exercise, and clinical outcomes interact.

Results from the present experiment suggest a potential interplay between running valuation, discounting for monetary rewards, and discounting for running rewards. As previously mentioned, those who preferred smaller immediate rewards for exercise were more likely to have higher running valuations, and in turn, lower rates of discounting for monetary rewards. Conversely, those who preferred larger later rewards for running tended to have low running valuations and higher relative rates of discounting for money. An intermediary role of running valuation may help in better understanding the relation between discounting rates for health rewards and those for money. While encouraging, firm conclusions regarding the interplay between running valuation, both forms of discounting, and alcohol consumption are premature for the current study. Researchers, however, may find use with these measures in future research endeavors.

Interestingly, although ultra-marathon runners self-reported more running experiences and weekly miles run than half/full marathon runners, there were no significant differences between the groups on discounting rates of money or running. Further, self-reported miles run per week was not

related to any variable in the current study except for race group which stands in contrast of variables such as discounting rate for money and running, running valuation, and self-reported alcoholic drinks consumed per week. Juxtaposed with the robust interactions between the above behavioral economic variables and alcoholic drinks, the lack of significant findings with the variable miles run per week suggests that how individuals make intertemporal choices for hypothetical PA and monetary outcomes (i.e. on the RCQ and MCQ), not how much individuals engage in PA, may be more relevant in understanding treatment adherence and treatment success related to PA. In the current study, there were several examples of pairs of runners who self-reported a similar number of miles run per week. In each case, however, one of the runners discounted running at higher relative rates (and discounted money at lower relative rates) than the other and their differences typically extended to number of alcoholic drinks consumed per week. How participants allocated their hypothetical choices for the two delay discounting tasks might relate to how they actually allocate and prioritize their running behavior. Future researchers might therefore find utility in measuring rates of discounting for running and money before, during, and following a PA intervention. Such efforts might contribute to the prediction, and eventual control, of treatment adherence and success in PA interventions.

Lastly, limitations of the current study provide promising avenues for future research. For example, future research should incorporate a demographically matched control group or participants who do and do not exercise regularly. The average of 40 miles run per week calculated in the current study is clearly above average, however, 25% of the participants were below 20 miles 25% were above 75 miles allowing for a fair amount of breadth in amount of reported weekly PA. Further, reported miles run per week was unrelated to any other measure suggesting that miles run may be a less sensitive variable than discounting of exercise or exercise valuation. Further, future studies might incorporate larger samples sizes than the present study in order to provide increased statistical strength, however, the statistically significant findings discovered in the present study lend potential credence to future studies using similar

procedures. The current study used hypothetical as opposed to real rewards for money and running. Future studies might incorporate real rewards, however, previous studies have found a close correspondence between hypothetical and real rewards (M. W. Johnson & Bickel, 2002; Kirby et al., 1999b), even at the neural level (Bickel, Pitcock, Yi, & Angtuaco, 2009). Lastly future research should incorporate more sensitive clinical measures to gather information regarding alcohol use and potentially mental health status. Despite the encouraging relation between higher rates of discounting for running and fewer reported alcoholic drinks per week, drinks per week alone is not sufficient to make strong statements regarding clinical status of participants.

Conclusion

In conclusion, the current exploratory study used a novel running discounting task in conjunction with a standard money discounting questionnaire to study addiction related behaviors in half, full, and ultra-marathon runners. Discounting for running, similar to most other non-monetary rewards, was discounted at noticeably higher rates than money in addition to achieving typical consistency scores. The current study suggests two distinct profiles of runners reflected by both forms of discounting, a measure of running valuation, and self-reported alcoholic drinks consumed per week. One such profile prefers immediate running rewards, higher valuations for running, and reports drinking fewer alcoholic drinks per week whereas the second profiles prefers delayed running rewards, lower valuations for running, and reports drinking roughly eight times more alcoholic drinks per week. Preference for smaller amounts of running now may result in displacement of competing behaviors, some of which may be consumption of alcohol. The current study cannot speak directly to what underlies the findings between both forms of discounting, running valuation, and alcoholic drinks, however, future studies may elucidate this question and others via the RCQ.

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Table I

	All participants (n=36)	**Ultra-marathoners (n=13)**	**Half and full marathoners (n=23)**
Age	36.69 (12.42)	39.46 (11.43)	35.13 (12.68)
Sex			
Male	19 (52.77%)	7 (53.84%)	12 (52.17%)
Female	17 (47.22%)	6 (46.15)	11 (47.82%)
BMI	23.86 (3.29)	22.62 (1.90)	24.56 (3.68)
Race/Ethnicity			
White/Caucasian	33 (91.67%)	11 (84.61%)	22 (86.67%)
Black/African	0	0	0
American			
Hispanic	2 (5.55%)	1 (7.69%)	1 (4.34%)
Asian	1 (5.55%)	1 (7.69%)	1 (4.34%)

Note: Mean values, with standard deviations are in parentheses are displayed for demographic variables for all participants, ultra-marathon runners, and half/full marathon runners. Income statistics were not reported as large portions of all groups declined to report income information. One individual identified as Hispanic and White/Caucasian in the half/full marathon group.

Table 2

Order	Monetary Choice Questionnairre			Running Choice Questionnaire (x = participant equivalency value of how many minutes of running are worth $100)		
	Choice	*k*	Rank	Choice	*k*	Rank
13	$34 today, or $35 186 days from now?	0.00016	1	(x *.34) minutes today or (x *.35) minutes 186 days from now?	0.00016	1
1	$54 today or $55 117 days from now?	0.00016	1	(x *.54) minutes today or (x *.55) minutes 117 days from now?	0.00016	1
9	$78 today or $80 162 days from now?	0.00016	1	(x *.78) minutes today or (x *.80) minutes 162 days from now?	0.00016	1
20	$28 today or $30 179 days from now?	0.0004	2	(x *.28) minutes today or (x *.30) minutes 179 days from now?	0.0004	2
6	$47 today or $50 160 days from now?	0.0004	2	(x *.47) minutes today or (x *.50) minutes 160 days from now?	0.0004	2
17	$80 today or $85 157 days from now?	0.0004	2	(x *.80) minutes today or (x *.85) minutes 157 days from now?	0.0004	2
26	$22 today or $25 136 days from now?	0.001	3	(x *.22) minutes today or (x *.25) minutes 136 days from now?	0.001	3
24	$54 today or $60 111 days from now?	0.001	3	(x *.54) minutes today or (x *.60) minutes 111 days from now?	0.001	3
12	$67 today or $75 119 days from now?	0.001	3	(x *.67) minutes today or (x *.75) minutes 119 days from now?	0.001	3
22	$25 today or $30 80 days from now?	0.0025	4	(x *.25) minutes today or (x *.30) minutes 80 days from now?	0.0025	4
16	$49 today or $60 89 days from now?	0.0025	4	(x *.49) minutes today or (x *.60) minutes 89 days from now?	0.0025	4
15	$69 today or $85 91 days from now?	0.0025	4	(x *.69) minutes today or (x *.85) minutes 91 days from now?	0.0025	4
3	$19 today or $25 53 days from now?	0.006	5	(x *.19) minutes today or (x *.25) minutes 53 days from now?	0.006	5
10	$40 today or $55 62 days from now?	0.006	5	(x *.40) minutes today or (x *.55) minutes 62 days from now?	0.006	5
2	$55 today or $75 61 days from now?	0.006	5	(x *.55) minutes today or (x *.75) minutes 61 days from now?	0.006	5
18	$24 today or $35 29 days from now?	0.016	6	(x *.24) minutes today or (x *.35) minutes 29 days from now?	0.016	6
21	$34 today or $50 30 days from now?	0.016	6	(x *.34) minutes today or (x *.50) minutes 30 days from now?	0.016	6
25	$54 today or $80 30 days from now?	0.016	6	(x *.54) minutes today or (x *.80) minutes 30 days from now?	0.016	6
5	$14 today or $25 19 days from now?	0.041	7	(x *.14) minutes today or (x *.25) minutes 19 days from now?	0.041	7
14	$27 today or $50 21 days from now?	0.041	7	(x *.27) minutes today or (x *.50) minutes 21 days from now?	0.041	7
23	$41 today or $75 20 days from now?	0.041	7	(x *.41) minutes today or (x *.75 minutes 20 days from now?	0.041	7
7	$15 today or $35 13 days from now?	0.1	8	(x *.15) minutes today or (x *.35) minutes 13 days from now?	0.1	8
8	$25 today or $60 14 days from now?	0.1	8	(x *.25) minutes today or (x *.60) minutes 14 days from now?	0.1	8
19	$33 today or $80 14 days from now?	0.1	8	(x *.33) minutes today or (x *.80) minutes 14 days from now?	0.1	8
11	$11 today or $30 7 days from now?	0.25	9	(x* .11) minutes today or (x *.30) minutes 7 days from now?	0.25	9
27	$20 today or $55 7 days from now?	0.25	9	(x *.20) minutes today or (x *.55) minutes 7 days from now?	0.25	9
4	$31 today or $85 7 days from now?	.25	9	(x *.31) minutes today or (x *.85) minutes 7 days from now?	0.25	9

Note: Question order, delays, k value, k value rank and reward amounts for each question are detailed for both the MCQ and RCQ. For the RCQ, the number of minutes worth $100 for each participant was inputted as x and multiple by 10% of the immediate and delayed reward amount used in the standard version for the 27-item Kirby.

Table 3

	Ln (Running Valuation)	**Ln *(k)* Running**	**Ln *(k)* Money**	**Drinks/Week**
Ln (Min Running Valuation)	_____	_____	_____	_____
Ln *(k)* Min of Running	.343** (n=33)	_____	_____	
Ln *(k)* Money	-.409* (n=33)	.162 (n= 40)	_____	_____
Alcoholic Drinks/Week	-.412** (n=29)	-.319** (n=35)	.199 (n=35)	_____

Note: Correlation coefficients and sample sizes are displayed for all possible pairings of the variables natural log of running valuation, natural log of rate of discounting *(k)* of minutes of running, natural log of rate of discounting *(k)* for money, and number of alcoholic drinks consumed per week using Pearson's Correlation Coefficient. One asterisk represents a p-value of less than .05 and two asterisks represents a p-value less than .001.

Table 4

	Ultra-marathon (n=14)	**Half and full marathon (n=24)**	**Mann-Whitney U**
Personal goal setting	80% (12/15)	85% (22/26)	p=.769
Race based goal-setting	73% (11/15)	54% (14/26)	p=.292
Running with 1 or more fellow runner	80% (12/15)	38% (10/26)	p=.210
Runners "high"	73% (11/15)	42% (11/26)	p=.292
Relief of anxiety, stress, or other mental health symptoms	87% (13/15)	85% (22/26)	p=.424
Weight-loss	47% (7/15)	35% (9/26)	p= .726
Avg. combined experiences	4.4 *(.35)*	3.5 *(.28)*	**p= .016*
MCQ [Ln *(k)*]	-4.62 *(1.75)*	-5.28 *(1.65)*	*p=.146*
RCQ [Ln *(k)*]	-3.65 *(2.27)*	-3.76 *(1.39)*	*p=.392*
Avg. mileage/week (standard error)	52 *(6.83)*	34 *(5.83)*	***p=.001*

* p <.05
** p< .005

Note: Averages per group are reported for the variables of self-reported running experiences, total self-reported running experiences, self-reported miles run per week, natural log *(k)* for the MCQ, and natural log *(k)* for the RCQ. Proportion of participants reporting running experiences are marked for the six running experiences in parentheses and standard deviations are noted in parentheses for total self-reported running experiences per group, natural log *(k)* for the MCQ, natural log *(k)* for the RCQ, and reported weekly miles ran per group. Comparisons across groups were performed using Mann-Whitney U tests with the exception of the variables of natural log (k) for the MCQ and natural log (k) for the RCQ which were calculated using parametric t-tests.

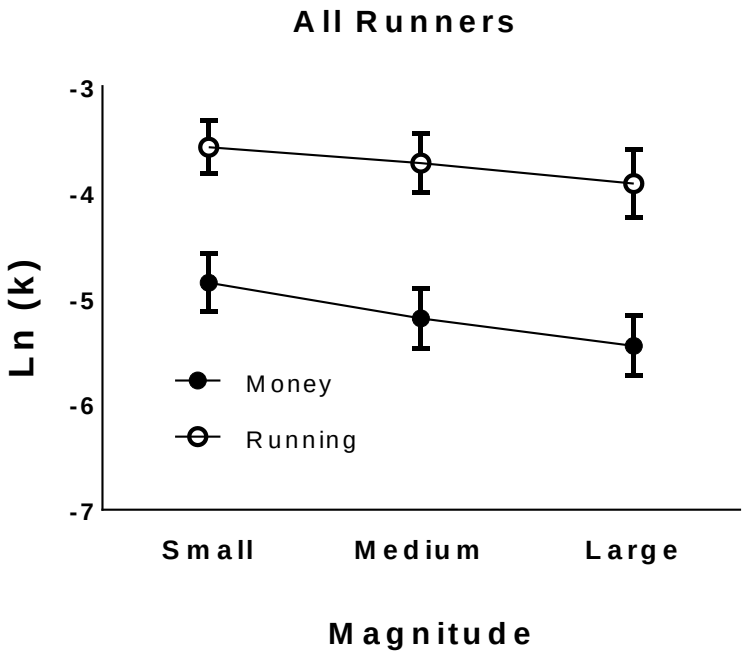

Figure 1

Delay discounting of minutes of running and money are plotted for all participants (n=40) across small, medium, and large magnitude rewards (x-axis). Discounting rates [ln *(k)*] for money are denoted by closed circles and minutes of running by open circles (y-axis). ($F(1, 240) = 38.02$, $p = < .000$). All participants that reported delay discounting for both tasks were included.

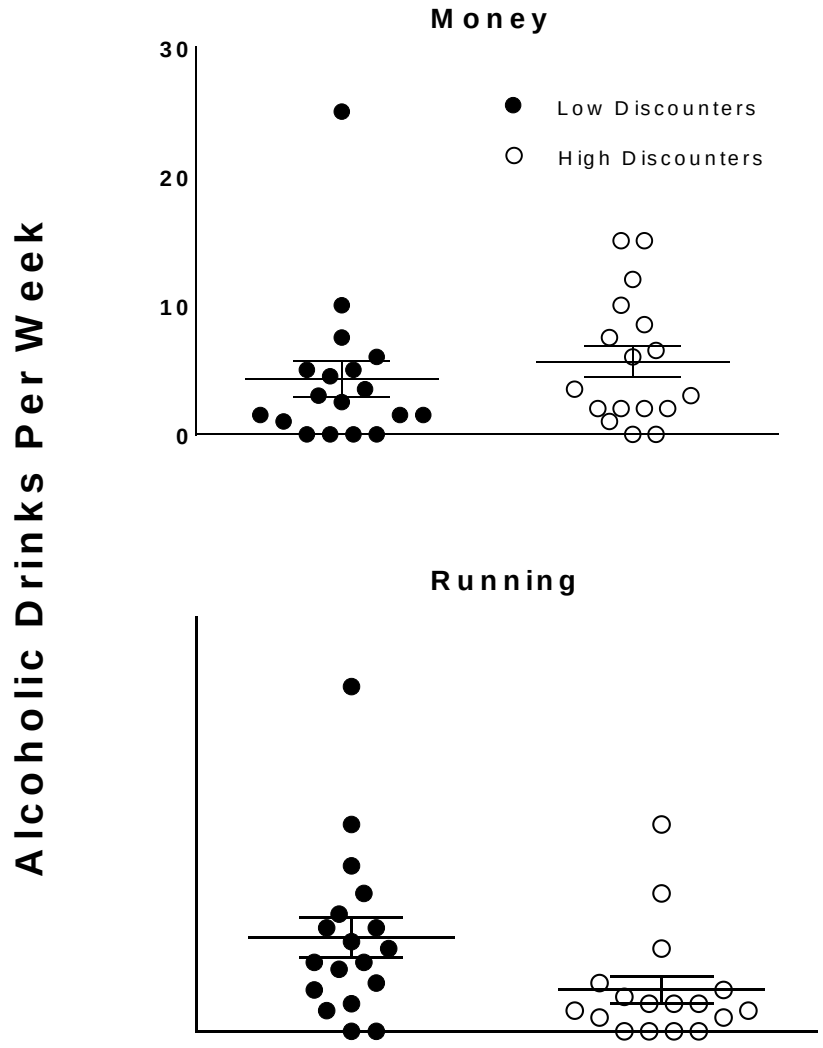

Figure 2

The top panel sorts individual participants (n=35) into high (n=17, open circles) and low discounters (n=18, closed circles) of money via a median split (x-axis) in relation to the number of alcoholic drinks consumed per week (y-axis). The bottom panel is identical to the top panel except with discounting of minutes of running (n=35). A total of 35 participants were included as 35 participants completed both delay discounting tasks and reported alcohol consumption.

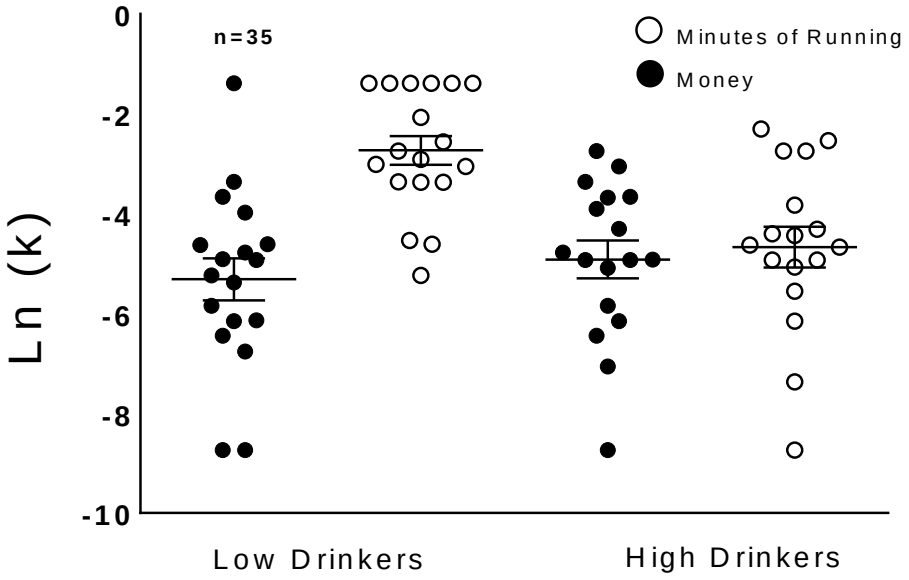

Figure 3

Each participant who reported number of alcoholic drinks consumed per week and both discounting questionnaires (n=35) was split into low and high drinking groups (median split at 3 drinks/week) and their discounting rates [ln *(k)*] for money (closed circles) and minutes of running (open circles) are depicted on the left hand side of the graph if they were low drinkers (n=18), and the right hand side if they were high drinkers (n=17). A total of 35 participants were included as 35 participants completed both delay discounting tasks and reported alcohol consumption.

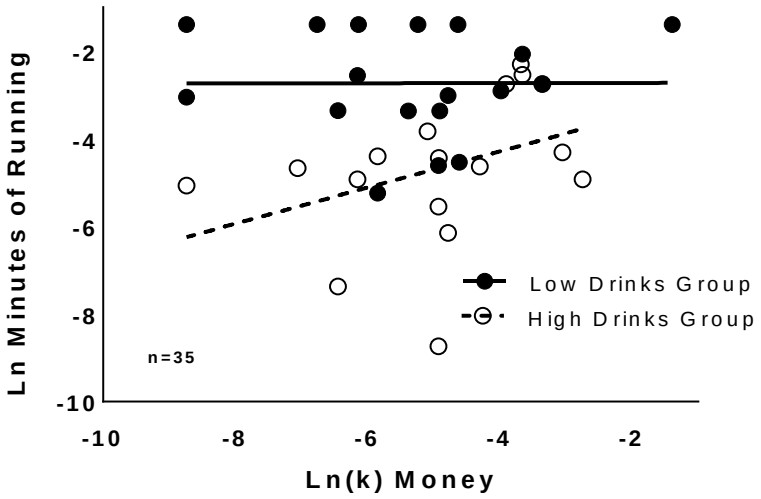

Figure 4

Simple regression analyses between discounting rate [ln *(k)*] for money (x-axis) and minutes of running (y-axis) are displayed for individuals in the low drinks group (closed circles, n=18) and high drinks group (open circles with dashed line, n=17). A total of 35 participants completed delay discounting tasks and reported alcohol consumption.

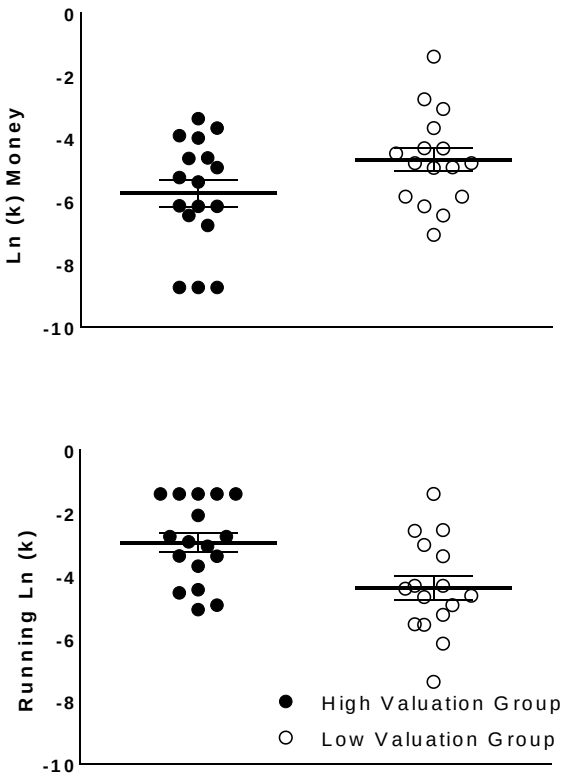

Figure 5

Equivalency values (i.e. “how many minutes are worth $100?”) for each participant who also completed both discounting forms were divided by $100 to arrive at minutes/$ unit price for the value of minutes of running. Higher values represent greater valuations in $ per minute of running. The natural log of these values was calculated to create “running valuation” (x-axis). Both panels sort participants into a high valuation (n= 17) group denoted by closed circles and a low valuation (n= 16) group denoted by open circles via a median split. Via a Mann-Whitney U test, the top panel displays a non-significant difference in discounting rates of money between high and low valuation groups (p=.067) and the bottom panel a statistically significant difference between discounting rates for running between high vs. low running valuation groups (p=.002). A total of 33 participants completed equivalency measures and delay discounting tasks.

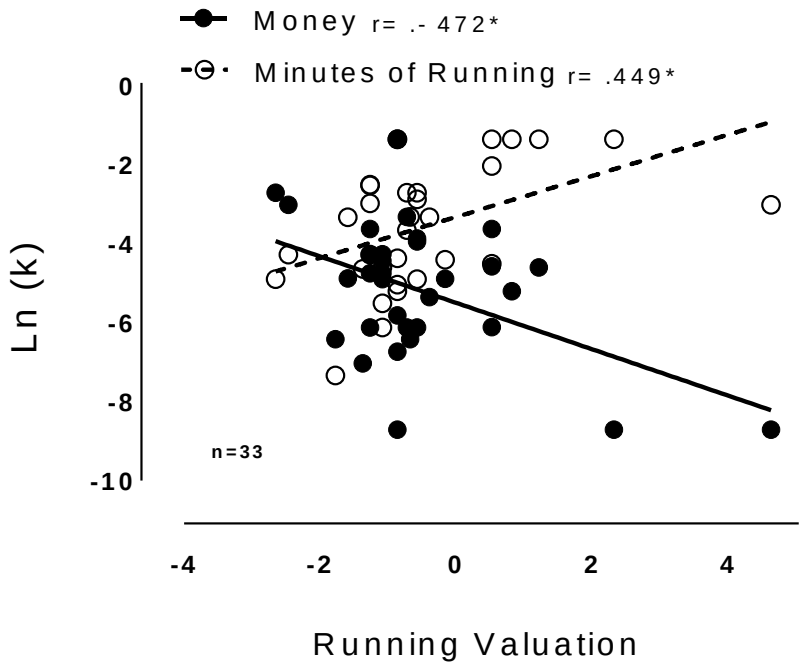

Figure 6

Simple regression analyses compare discounting rates [ln *(k)*] for individual participants (y-axis, n=33) in relation to running valuation. Rate of discounting for money (closed circles) and minutes of running (open circles) are both plotted for each participant as they relate to running valuation. A total of 33 participants completed equivalency measures and delay discounting tasks.

Appendix A

Survey of Decision Making in Long Distance Runners

The Department of Applied Behavior Science at the University of Kansas supports the practice of protection for human subjects participating in research. The following information is provided for you to decide whether you wish to participate in the present study. You should be aware that even if you agree to participate, you are free to withdraw at any time without penalty.

We are conducting this study to better understand decision making in those who run regularly versus those who do not. This will entail your participation in decisions regarding hypothetical decisions. You will also answer basic demographic questions (e.g., your age, sex, etc.) and a few questions pertaining to activity. Your participation is expected to take approximately 5 minutes to complete. The content of the decision making survey and two questionnaires should cause no more discomfort than you would experience in your everyday life.

Although participation may not benefit you directly, we believe that the information obtained from this study will help us gain a better understanding of potential benefits of running on decision making behavior. Your participation is solicited, although strictly voluntary. Your name will not be associated in any way with the research findings. Your identifiable information will not be shared unless (a) it is required by law or university policy, or (b) you give written permission. Any identifiable information obtained will be kept in a locked filing cabinet in a locked office in the Dole Center for Human Development.

If you would like additional information concerning this study before or after it is completed, please feel free to contact us by phone or mail.

Completion of the decision making survey and two questionnaires indicates your willingness to take part in this study and that you are at least 18 years old. If you have any additional questions about your rights as a research participant, you may call (785) 864-7429 or write the Human Subjects Committee Lawrence Campus (HSCL), University of Kansas, 2385 Irving Hill Road, Lawrence, Kansas 66045-7563, email irb@ku.edu.

Sincerely,

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Appendix B

KU CENTER FOR APPLIED NEUROECONOMICS
Department of Applied Behavioral Science

Subject Code: _____

Demographics Questionnaire

Age: _____

Sex: _____

Race/Ethnicity (Circle all that apply):

Caucasian (white)

African American

Hispanic

Asian

Native American

Other

I prefer not to answer

Height: _____

Weight: _____

Marital status (Circle one):

Single, never married

Married

Separated

Divorced

Widowed

Monthly income (U.S. Dollars): _____

How many cigarettes do you smoke per day?

How many alcoholic beverages do you consume per week?

Appendix C

Subject Code: _____

Running Questionnaire

1. Do you engage in less than 2 hours of cardio activity per week?

2. How many minutes of running are worth $100 to you?

3. How many times and how many miles a week do you run?

4. Circle all of the following that you experience related to your running

    a. Personal goal-setting

    b. Race based goal-setting

    b. Running with 1 or more fellow runners

    c. “Runner’s high”

    d. Relief of anxiety, stress, or other mental health symptoms

    d. Weight-loss

5. Please circle the distance for the race you are signed up for:

    10M

    Half

    20M

    26.2M

    50K

    40M

    100K

Appendix D

(Does not include all 27 items)

Subject code: _____

KU CENTER FOR APPLIED NEUROECONOMICS
Department of Applied Behavioral Science
Reed & Jarmolowicz, 2013
Adapted from: Kirby et al., 1999

For each of the next 27 choices, please circle which hypothetical reward you would prefer: the smaller reward today, or the larger reward in the specified number of days. While you will not actually receive the rewards, pretend you will actually be receiving the amount you indicate and answer honestly.

Would you rather have?

54	dollars	today,	OR	55	dollars	117	days from now
55	dollars	today,	OR	75	dollars	61	days from now
19	dollars	today,	OR	25	dollars	53	days from now
31	dollars	today,	OR	85	dollars	7	days from now
14	dollars	today,	OR	25	dollars	19	days from now
47	dollars	today,	OR	50	dollars	160	days from now
15	dollars	today,	OR	35	dollars	13	days from now
25	dollars	today,	OR	60	dollars	14	days from now

Appendix E

(Does not include all 27 items)

Subject code: _____

KU CENTER FOR APPLIED NEUROECONOMICS
Department of Applied Behavioral Science

Reed & Jarmolowicz, 2013
Adapted from: Kirby et al., 1999

For each of the next 27 choices, please circle which hypothetical reward you would prefer: the smaller reward today, or the larger reward in the specified number of days. While you will not actually receive the rewards, pretend you will actually be receiving the amount you indicate and answer honestly.

Would you rather have?

54	minutes running	today,	OR	55	minutes running	117 days from now
55	minutes running	today,	OR	75	minutes running	61 days from now
19	minutes running	today,	OR	25	minutes running	53 days from now
31	minutes running	today,	OR	85	minutes running	7 days from now
14	minutes running	today,	OR	25	minutes running	19 days from now
47	minutes running	today,	OR	50	minutes running	160 days from now
15	minutes running	today,	OR	35	minutes running	13 days from now
25	minutes running	today,	OR	60	minutes running	14 days from now
78	minutes running	today,	OR	80	minutes running	162 days from now