

Abstract

1 We measured utility curves for the hypothetical monetary costs as a function of time
2
3 engaged in three everyday physical activities: walking, standing, and sitting. We
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5 found that activities requiring more physical exertion resulted in steeper discount
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7 curves, i.e., perceived cost as a function of time. We also examined the effects of gain
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9 vs. loss framing (whether the activity brought additional rewards or prevented losses)
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11 as well as the effects of the individual factors of gender, income, and BMI. Steeper
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13 discount curves were associated with higher income (annual household \geq median of
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15 \$45,000) and gain framing (which indicates loss aversion). There were interactions
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17 between gender and frame, and also income and frame: Females and higher income
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19 participants showed loss aversion whereas males and lower income participants were
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21 not affected by framing. Males showed less discounting in gain frames relative to
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23 females, whereas females showed less discounting in loss frame relative to males. In
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25 gain frames, higher income participants discounted more but in loss frames there was
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27 no effect of income. We also found individual tendencies for discounting across
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29 activities: if an individual exhibited steeper discounting for one activity, they were
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31 also more likely to exhibit steeper discounting for the other activities. These results
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33 have implications for designers of interventions to encourage non-exercise physical
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35 activities, suggesting that loss-framed incentives are more effective for women and
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37 those with middle class (or greater) incomes. Furthermore loss framed incentives have
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39 more uniform impact across income brackets because people discount loss frames
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41 similarly regardless of income whereas those with middle-class incomes are not as
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43 motivated by gain frames. Our results also demonstrate a general method for
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45 examining the costs of effort associated with everyday activities.
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1 We regularly make decisions about the amount of physical exertion we are willing to
2 undergo in everyday life. Is it worth walking an extra 10 minutes to buy cheaper
3 produce? Is it worth standing in line for 20 minutes to obtain a refund? The small
4 decisions potentially add up to big health implications: lack of physical exertion in our
5 everyday activities, also known as non-exercise activity thermogenesis (NEAT), has
6 been implicated (along with increased caloric intake) as one of the main causes of
7 recent increase in obesity in first world countries (Levine, Vander Weg, Hill &
8 Klesges, 2006). Research shows that NEAT accounts for up to 2/3 of daily energy
9 expenditure when compensating for increased caloric intake (Levine, Eberhardt &
10 Jensen, 1999). It is estimated that lean individuals spend 2.5 hours per day more
11 standing and walking than obese individuals, which is an additional expenditure of
12 approximately 350 additional calories a day (Levine et al., 2006). Thus, NEAT offers
13 a promising avenue for weight management. However, it remains unknown the extent
14 to which NEAT offers an 'easy' weight management solution. While NEAT activities
15 may appear to require less concerted effort and thus appear more achievable than
16 scheduling dedicated exercise sessions, non-exercise activities still involve potential
17 'costs', such as physical or mental effort, unpleasant experiences (e.g., boredom,
18 discomfort), and time.

19 The costs associated with activities can be evaluated using recent frameworks in
20 behaviour science, where a wide body of research has made it increasingly clear that
21 most of behaviour can be explained as a series of decisions that are underpinned by a
22 valuation of choice options. One method of assessing value is to measure expected
23 value (perceived utility) curves. Here, a binary choice task is used to determine
24 subjective indifference points. These results can be plotted as curves on a graph

1 showing different reward scenarios that perceived to be of equal preference. Typically
2 these curves show how the perceived utility of a given amount of reward is decreases
3 as a function of different amounts of some trade-off, or 'cost', which diminishes
4 perceived reward value.
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11 A large body of highly profiled research has used such perceived utility curves to
12 examine how factors of delay and uncertainty associated with a reward decrease the
13 reward's perceived value, known as delayed and probabilistic discounting. Many
14 studies have examined factors of delay and probability together (Du, Green &
15 Myerson, 2002; Estle, Green, Myerson & Holt, 2007; Green & Myerson, 2004;
16 Killeen, 2009; Rachlin, Raineri & Cross, 1991; Radu, Yi, Bickel, Gross & McClure,
17 2011; Weller, Cook, III, Avsar & Cox, 2008; Yi, de, X & Bickel, 2006; Heyman &
18 Gibb, 2006; Petry, 2012; Reynolds, 2006). Another relatively less used approach is to
19 measure utility curves to examine the perceived costs of behaviors and activities. Here
20 the utility curves represent how much less reward a person is willing to take if they
21 could avoid the behaviour, thus providing a measure of the cost of that behavior. For
22 example, if a person has equal preference for a \$90 reward and a \$100 reward that
23 also requires them to stand in line for half an hour, assuming both rewards are
24 eventually received at the same time (no difference in delay of receipt), one can
25 estimate that the cost of standing in line for half an hour costs is about \$10 in the
26 context of the \$100 reward. By measuring the indifference points for varying amounts
27 of behaviour, one can measure the perceived cost associated with different amounts
28 of behavior. Examples of behavioral costs include physical and/or mental discomfort
29 associated with the effort required, as well as the opportunity costs of time spent on
30 the behavior.
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2 In contrast to the extensive research on the costs of delayed and probabilistic rewards,
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4 there have been only a few studies examining the costs of engaging in uncomfortable
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6 behaviors and effortful activities. Here, in analogy to the terms probabilistic and
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8 delayed discounting, researchers have used the phrase ‘effort discounting’ (Hartmann,
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10 Hager, Tobler & Kaiser, 2013; Mitchell, 2004; Reed, Gennaro Reed, Chok & Brozyna,
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12 2011). One such study examined the cost of decision making (Reed et al., 2011),
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14 where discounting (i.e., perceived cost) was observed as the number of options
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16 increased. Other studies have examined discounting in response to intensity of
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18 physical effort (e.g., squeezing of hand dynamometer) (Hartmann et al., 2013), and
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20 have found this differed for smokers and non-smokers (Mitchell, 1999) and cigarette
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22 deprived smokers (Mitchell, 2004). Discounting in response to effort has also been
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24 examined for the hypothetical task of cleaning Japanese bathtubs (Sugiwaka &
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26 Okouchi, 2004), and found that discounting in relation to numbers of tubs cleaned was
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28 not related to delay discounting, nor measures of reformative self control.
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39 Typically, previous studies in probabilistic and delayed discounting (Du, Green &
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41 Myerson, 2002; Estle, Green, Myerson & Holt, 2007; Green & Myerson, 2004;
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43 Killeen, 2009; Rachlin, Raineri & Cross, 1991; Radu, Yi, Bickel, Gross & McClure,
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45 2011; Weller, Cook, III, Avsar & Cox, 2008; Yi, de, X & Bickel, 2006; Heyman &
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47 Gibb, 2006; Petry, 2012; Reynolds, 2006), as well as effort discounting (Sugiwaka &
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49 Okouchi, 2004; Reed et al., 2011; Mitchell, 2004) (with the exception of (Hartmann et
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51 al., 2013)), have found discount curves to follow a characteristically hyperbolic
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53 function:
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$$57 Y=A/(1+bX)^S \quad (1)$$

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1 where Y represents the subjective value of the reward of amount A , b is the parameter
2 that governs the rate of discounting, X is some increasing currency of cost, and S is
3 the scaling of the curve. One benefit of fitting curves to this function is that the
4 parameters allows researchers to quantify severity of discounting, which is how
5 rapidly reward values decline as a function of increasing cost X . Another method for
6 quantifying the amount of discounting is to calculate the area under the
7 experimentally measured discounting curve (Myerson, Green & Warusawitharana,
8 2001; Estle et al., 2007). Here, the area under two consecutive subjective value points
9 is computed according to the trapezoid rule as follows:
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$$21 \quad (b-a)(f(a)+f(b))/2 \quad (2)$$

22 where a and b are subjective values at consecutive points. The area under the curve is
23 then obtained by adding together the area under all consecutive subjective value
24 points. This area can also be used to capture how steeply the reward was discounted,
25 with smaller areas indicating greater discounting.
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36 In our current work, motivated by the ubiquity of non-exercise activity and its
37 relevance to weight, we use the method of measuring perceived utility curves to
38 examine the following question: How costly do people perceive everyday non-
39 exercise physical activities to be? In particular we measured discounting as a function
40 of time engaged in three primary everyday physical activities that vary in terms of
41 physical exertion required: walking, standing in line, and waiting while sitting. We
42 also examined the effects of framing because research has shown that people react
43 differently to choice scenarios involving losses vs. gains, such as the phenomenon of
44 loss aversion, where losses have been found in some circumstances to be more
45 psychologically powerful than gains of equal magnitude (Banks, Salovey, Greener,
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1 Rothman, Moyer, Beauvais et al. 1995; McCormick & McElroy, 2009; O'Keefe &
2 Jensen, 2008; O'Keefe & Jensen, 2009; Volpp, John, Troxel, Norton, Fassbender &
3 Loewenstein, 2008). Finally, we also examined discounting is influenced by the
4 individual variables of income, gender, and whether one is overweight. To address
5 these questions we measured discount curves for time spent in various activities, as
6 has been done in previous work mentioned above (Sugiwaka & Okouchi, 2004; Reed
7 et al., 2011; Field, Santarcangelo, Sumnall, Goudie & Cole, 2006; Mitchell, 2004).

18 **Method**

19 *Participants*

20 Online participants (n=166) recruited from Amazon Mechanical Turk were paid \$0.50
21 to complete the experiment. The location of participants was restricted to the US
22 because we wanted to reduce confounds due to English comprehension and culture
23 and US was the largest user base on Amazon Turk. Six participants did not pass our
24 criteria of paying adequate attention established by our catch trials (see below),
25 leaving us with 160 participants total, 78 of which were male. Random assignments
26 into loss vs. gain framing conditions (see below) resulted in 39 males in each of the
27 two conditions. The age of participants ranged from 18-70 years and the median age
28 was 31. Participants' mean BMI = 26.6 with SD =6.6. Total number of overweight
29 participants (BMI>25) was 84. Overweight was determined by the cut-off BMI
30 stipulated on sites from major health organizations such as National Health Services
31 (2013) and the Center for Disease Control and Prevention (2013). Previous work has
32 found that self-report of BMI has been found to be valid for epidemiological studies
33 but needs more careful adjustments when trying for precise measures of obesity
34 prevalence (Gorber, Tremblay, Moher & Gorber, 2007; McAdams, Dam & Hu, 2007).
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1 As our study only aims to compare differences in activity costs between overweight
2 vs. non-overweight individuals and we do not require precise measures of obesity
3 prevalence, we feel self-report is sufficient for the nature of our study.
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8 9 *Procedure*

10 We measured discount curves of hypothetical monetary value as a function of amount
11 of time engaged in the everyday activities of walking, standing in line, and sitting and
12 waiting, using methods from previous work discounting work (Du et al., 2002; Estle
13 et al., 2007; Hartmann et al., 2013). Engagement in all activities was compared with a
14 baseline of not having to participate in any activity. The online experiment was built
15 using FLASH. Participants were informed that the study aimed to measure the cost of
16 engaging in activities for varying lengths of time relative to monetary rewards.
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19 Participants were presented with the following hypothetical scenario: they had won a
20 local lottery and have just arrived at a local lottery center to provide their ticket, name,
21 and address details so that a check can be mailed to them. They were told that under
22 all circumstances, a check would be mailed to them and guaranteed to arrive three
23 weeks from the current day. Thus, the temporal delay with which participants would
24 receive their reward does not vary and is constant across all scenarios. (See Green et
25 al., (2005) for measurements of discounting by comparing delayed rewards.) On each
26 trial participants chose between two hypothetical monetary rewards, a lesser reward
27 associated with the non-costly baseline of being able to provide their details
28 immediately and return home, and a greater reward associated with spending time
29 engaged in one of our physical activities: walking X minutes to another nearby centre
30 (where they could provide details immediately), standing in line for X minutes, or
31 sitting and waiting for X minutes. We evaluated the cost engaging in activities for
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1 X=15, 30, 60, and 120 minutes. For each activity we also examine the effects of
2 framing: whether the activity was required to achieve additional rewards (gain frame)
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4 or to prevent additional losses (loss frame).
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9 We measured discounting as a function of time spent in activity using a 2 x 3 mixed
10 experimental design with framing as between-participant variable (gain vs. loss) and
11 activity (walking, standing, sitting) as the within-participant variable. Participants
12 were assigned randomly to gain vs. loss frames. In gain frames participants were told
13 in their hypothetical scenario that they had been given the lower value reward
14 associated with the baseline (i.e., the default was no activity), but could choose to
15 engage in the activity to receive the greater reward. In loss frames participants were
16 told that they had been given the higher value reward associated which required them
17 to engage in the activity to receive (i.e., the default was to engage in activity), but as
18 an option they could choose to engage in no activity to receive the lesser reward.
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34 Participants in both framing conditions were presented with all three costly activities
35 for each of the four time periods (12 scenarios total). The amount of greater reward
36 was fixed at \$111 and the lesser reward varied using a six-step stair case procedure
37 (Du et al., 2002) to determine the monetary value of participating in each of the three
38 activities for each of the four time periods. This means that for each choice within a
39 particular activity-duration condition, the text on the screen always remained the same
40 except for the amount associated with the smaller win then was increased or decreased
41 based on their previous choice. Each participant answered 72 trials (6 stair case x 4
42 time periods x 3 activities).
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An example of a trial with the hypothetical scenario in the gain frame for the costly activity of standing in line for 15 minutes is as follows:

‘Congratulations! You have won \$109 in a local lottery. You need to go to your local lottery center to provide your ticket, name and address details so that a check can be mailed to you. When you arrive at the center to provide your details, you are told you are able to provide your details immediately .

Alternatively, you can stand in line for 15 minutes in order to provide your details for a greater award of \$111. Under both options, the check is guaranteed to arrive at the same time on a date three weeks from now.

Which option would you prefer?

Participants then chose between two radio buttons corresponding to each of the two options. The following is an example of a loss frame for walking for 30 minutes:

‘Congratulations! You have won \$111 in a local lottery. You need to go to your local lottery center to provide your ticket, name and address details so that a check can be mailed to you. When you arrive at the center to provide your details, you are told you will have to walk to another center 30 minutes walk away in order to provide your details. Upon arrival, you will be able to provide your details immediately.

1 Alternatively, you can provide your details immediately, but for a smaller
2 award of \$109. Under both options, the check is guaranteed to arrive at the
3 same time on a date three weeks from now. Which option would you
4 prefer?
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11 Participants viewed trials pertaining to the same activity all in one block. The order in
12 which each of the three activity blocks were presented was randomized across
13 participants. For a given activity, the order of presentations of time periods of effort
14 exertion was also randomized across participants. For each time period and activity,
15 participants made six choices of different pairs of hypothetical monetary amounts, in
16 which the amount of reward for the no-cost activity option was adjusted
17 using a staircase procedure to quickly converge on the amount of reward given for the
18 no-cost activity that was equal in subjective value of the reward when the costly
19 activity was required (see (Du et al., 2002) for a more detailed description of this
20 procedure).
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39 Three practice trials, showing the three example activities, preceded the main
40 experiment. During the main experiment, after each of the three activity scenarios, a
41 catch trial appeared, which presented a similar choice scenarios but offered a choice
42 between a lesser amount to be picked up after a delay of some days versus a greater
43 amount that could be picked up immediately. As mentioned above, six participants
44 who did not always choose the greater immediate amount in all three catch trials were
45 excluded from analysis. At the end of the experiment, participants were asked to
46 provide their weight in pounds and height in inches, from which BMI was calculated.
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58 They were also asked for demographic information of age, gender, and total annual
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1 household income before taxes, measured as a choice between equally spaced bands
2 starting from ‘up to \$9000’, and then in equally spaced incremental bands of \$15,000,
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4 with the final band being \$75,000+. We also asked the following self-reported
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6 questions relating to satisfaction with time for enjoyable activities, overall health, and
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8 energy: “Overall, how satisfied are you with the time you have to do things you like
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10 doing?”, “Overall how satisfied are you with your physical health”, and “Overall, how
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12 much energy did you have yesterday?”. We gathered responses on 11 point scales, i.e.,
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14 0 (Completely Not satisfied) to 10 (Completely Satisfied) and 0 (Completely not
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16 energetic) to 10 (Completely energetic).
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24 **Results**

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26 Statistical analysis was performed on the area under the curve corresponding to
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28 subjective values as a function of time engaged in activities, calculated using Equation
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30 2. As mentioned in the introduction, this area provides a measure of how steeply the
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32 reward was discounted (Myerson et al., 2001; Estle et al., 2007). There was no
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34 correlation for areas under discount curves with any of the three activities and age,
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36 $p > .4$, satisfaction with time for doing enjoyable activities, $p > .50$, satisfaction with
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38 overall health, $p > .18$, and energy levels $p > .18$. Thus these measures were dropped
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40 from further analysis. There was a significant correlation in which greater household
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42 income was negatively related to area under discounting curves for standing $r(158) =$
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44 $-.2$, $p = .013$ and sitting $r(158) = -.17$, $p = .028$. This means higher income people tended
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46 to be more willing to give up additional money, which is unsurprising. We included
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48 income as a variable in our analysis by splitting participants into a binary income
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50 variable: those who reported earning at least or more than the band containing the
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52 median US household income, \$45,000-\$55,000 (US Census Bureau, 2014), and
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1 those who earned less. We used participant BMI to categorize individuals into a
2 binary variable of 'BMI', corresponding to overweight (BMI>25) or healthy weight
3 (BMI <=25). To compare discounting was influenced by the factors of activity, frame,
4 income, gender, and BMI, discount areas were entered into a 3 x 2 x 2 x 2 x 2
5 (activity x frame x income x gender x BMI) analysis of variance (ANOVA) with
6 activity as a within-participant variable.
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17 Results showed main effects of activity, frame, and income: Steeper discount curves
18 were associated with more physically demanding activities, gain frames and higher
19 incomes. There was no significant effect of BMI, though a trend was observed for
20 association between overweight and greater discounting. There was also an interaction
21 between frame and income: Higher income participants showed loss aversion whereas
22 lower income participants did not discount differently between gain and loss frames.
23 In gain frames, higher income participants discounted more than lower income
24 participants whereas in loss frames, income did not affect discounting. While there
25 was no main effect of gender, $p=.9$, there was a significant interaction between frame
26 and gender: Females showed loss aversion (less discounting in loss frame compared
27 to gain frames) whereas males did not. No other interactions were significant, $p>.15$.
28 Statistics and further details for these results are provided below.
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51 We found a significant main effect for activity $F(2, 159)= 19.8$, $MSE=.95$, $p<.0001$.
52 Post-hoc t-tests on area data for activity showed that discount curves for walking were
53 significantly steeper than those for standing, $t(159)=6.3$, $p<.0001$, and sitting,
54 $t(159)=11.08$, $p<.0001$. Discount curves for standing were also significantly steeper
55 than those for sitting, $t(159)=9.00$, $p<.0001$. These are all significant under the
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1 Bonferroni adjustment criteria on post-hoc significance tests for multiple (three-way)
 2 comparisons. Thus, as expected, there was an overall trend where discounting
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 4 increased with the amount of physical effort required: walking was the most steeply
 5 discounted (M= 0.74, SD= 0.20) followed by standing in line (M= 0.81, SD= 0.15),
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 7 followed by sitting (M= 0.87, SD= 0.12). There also was a significant effect of
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 9 framing in which participants discounted gain frames (M=.78, SD=.19) more than loss
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 11 frames (M=.83, SD=.15), $F(1,159)=10.83$, $\eta_p^2=.023$, $p=.0011$. This indicates loss
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 13 aversion, meaning that participants were reluctant to lose money and therefore more
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 15 willing to engage in activities to prevent losses than to receive gains. See Figure 1.
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24 ----Figure 1 Here-----
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29 There was a main effect of income, $F(1,159)=4.22$, $MSE=.11$, $\eta_p^2=.009$, $p=.041$,
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 31 reflecting the fact that participants with incomes <\$45,000, were more willing to put
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 33 in effort to ensure higher amounts of money as shown by their significant greater
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 35 areas under discount curves (M= 0.82, STD=.16) compared to participants with
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 37 incomes >=\$45,000 (M=.78, STD=.18). Post-hoc t-tests for each activity individually
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 39 showed marginal effect of income-based differences for standing, $F(1,159)=3.55$,
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 41 $p=.060$, and sitting, $F(1,159)=3.55$, $p=0.060$, but no effect for walking, $p=.37$. See
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51 -----Figure 2 here-----
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56 There was also a significant interaction between income and frame $F(1,459)=4.41$,
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 58 $MSE=.15$, $p=.036$, A post-hoc t-test between frames for higher income participants
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1 showed a significant effect of frame (marginally significant when Bonferroni
2 adjusted), $t(159)=11.24$, $p=.001$ ($M=.72$, $STD=.21$ for the gain frame, and $M=.82$,
3 $STD=.14$ for the loss frame), whereas frame effects lower income participants was
4 not significant, $p=.23$ ($M=.81$, $STD=.17$ for the gain frame and $M=.83$. $STD=.15$ for
5 the loss frame). Thus higher income participants were more likely to show loss
6 aversion whereas lower income participants were equally willing to put in effort for
7 both gains and losses. When viewing this interaction through the effects of income
8 within a specific frame, we find in the gain frame low income participants, showed
9 significantly less discounting compared high income participants, $F(1,159)=10.0$,
10 $MSE=.33$, $p=.0018$. However, in the loss frame, there was no difference in
11 discounting based on income, $p=.63$. See Figure 3.

12 -----Figure 3 Here-----

13 While we had expected overweight participants to discount more than non-overweight
14 participants, this effect was not significant $p=.08$. (Though there is a trend in this
15 direction). See Figure 4.

16 ---Figure 4 Here-----

17 While there was no main effect of gender, $p=.9$, there was a significant interaction
18 between gender and frame, $F(1,459)=13.6$, $MSE=.33$, $p=.0002$. Post-hoc t-tests
19 revealed that females showed significantly less discounting for loss frames relative to
20 gain frames (loss aversion) $t(159)=17.7$, $p<.0001$, whereas there was no significant
21 difference between gain and loss frames for men, $p=.45$. Also, in the gain frame, there
22 was a marginally significant tendency (when Bonferroni corrected) for males to
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1 discount less than females $t(159)=5.44, p=.02$, whereas in the loss frame there was a
2 significant tendency for females to discount less than males $t(159)=8.41, p=.0041$.
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4 Thus male participants were more motivated by the gain frame relative to female
5 participants and vice versa. See Figure 5.
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11 -----Figure 5 Here-----
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16 We also found there were overall trends for individual tendencies towards activity
17 discounting. Discounting across activities was highly correlated by participant. This
18 meant that if a person showed more discounting for one type of activity (smaller area),
19 they were also more likely to show more discounting for another type of activity. In
20 particular, the correlation values between areas under discount curves for different
21 activity pairs were as follows: between areas for walking and standing in line, $r(158)$
22 = .72, $p < .0001$; for walking and sitting, $r(158) = .68, p < .0001$; for standing and
23 sitting, $r(119) = .81, p < .0001$.
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39 Following previous work, we fit our data to the hyperboloid function in Equation 1. In
40 our study X is the time engaged in the activity. When fit to the group level data using
41 the mean indifference points for each activity-frame utility curve, the hyperbolic
42 equation accounted for more than 99.9% of the variance for all three types of activity
43 discounting, under both loss and gain frames. When fit to the individual participant
44 data, the mean R^2 was greater than 98% for each of the activity-frame combinations
45 with an overall average of 94%. The good fit to a hyperbolic function is consistent
46 with that found in other effort discounting studies (Sugiwaka & Okouchi, 2004; Reed
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1 et al., 2011; Mitchell, 2004), though inconsistent with other studies that have found
2 parabolic fits (Hartmann et al., 2013).
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6 **Discussion**

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9 This is the first study to estimate discount curves and perceived costs as a function of
10 time spent engaging in various everyday non-exercise physical activities. We found
11 that activities that require more physical effort, as defined by rate of energy
12 expenditure per unit time (Nutrstrategy, 2012), are discounted more steeply, and thus
13 people would have to be paid more to engage in more exertive activities. This has
14 implications for the design of interventions to encourage NEAT behaviors. Based on
15 our study, averaging results over all times and frames, the costs of walking, standing,
16 and sitting are about approximately \$0.46, \$0.37 and \$0.27 per minute respectively
17 when measured relative to not having to do any other specified activity. When
18 compared to sitting for the equivalent amount of time, the costs of walking and
19 standing are about \$0.20 and \$.10 per minute respectively. The cost of walking over
20 standing is about \$.10. These are rough estimates based on our study which is limited
21 by its hypothetical nature, the specific \$111 baseline value we chose, and the specific
22 lottery scenario we used. The extent to which these measured costs would be for
23 different amounts of base money, and in the context of real monetary and behavioral
24 settings will have to be explored in future work.
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51 Our results show that subjective costs of activities increases depending on the level of
52 physical exertion, and are affected by framing, income, and gender. There was no
53 significant effect of BMI, though there was a small trend for overweight participants
54 to discount more. Thus not all NEAT activities are equal for all people. We found that
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1 activities had diminishing unit costs over time (the longer the time spent the lower the
2 cost per minute). This result is actually rather counterintuitive as one might imagine
3 that the difficulty of effort should increase with time, not decrease. Indeed such
4 increase in effort costs over amount of effort was found in previous work where
5 parabolic effort discount curves were measured for the task of squeezing a hand
6 dynamometer (Hartmann et al., 2013), where effort amount was measured as percent
7 of maximum strength. However, other studies, where effort was measured as a
8 function of maximum strength for the reward of cigarettes for smokers (Mitchell,
9 2004), the number of bathtubs cleaned (Sugiwaka & Okouchi, 2004), and the number
10 of options to choose from (Reed et al., 2011) did find hyperbolic discount curves .
11 The fact that we found our discounting rates to be hyperbolic (i.e., decrease over
12 time) could have been due to various reasons. One reason may be a perceptual
13 difference effect, where the difference between 15 vs. 30 minutes feels more
14 significant compared to the difference between 120 vs. 110 minutes (though we did
15 not test the 110 minute measure). Another reason is that there may be diminishing
16 willingness to part with money, where people become increasingly less willing to give
17 up money and the amount given up increases.

18 Our results also showed loss aversion, which is related to a bias for the status-quo:
19 People were more willing to engage in an activity to avoid losing money compared to
20 gaining money. While our results found an overall effect of loss aversion, the
21 interaction effects suggest that loss aversion is primarily driven by women and higher
22 income people. Gender differences in discounting have been observed in previous
23 work (Kirby & Maraković, 1996; Yankelevitz, Mitchell & Zhang, 2012; Weller et al.,
24 2008). Also, a previous study had found that obese women were more likely to show

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greater delay discounting relative to non-obese women but this effect did not occur in men (Weller et al., 2008). While our study did not find any significant interaction between gender and BMI, we did find women to be significantly loss averse whereas men were not. This is related to previous studies that found more women than men to be loss averse in a lottery task (Brooks & Zank, 2005) and also, to the extent that losses are perceived as higher risk than gains, is related to the many studies have found that females tend to be more risk averse in general (Eckel & Grossman, 2008). Our findings that loss aversion was shown in females and not males may lend some insight into the mixed results on framing found in previous work: In particular, loss aversion has been found to be not universal across health behaviors and a recent meta-analyses reports that some health behaviours are not significantly affected by gain-versus-loss frames (O'Keefe & Jensen, 2008; O'Keefe & Jensen, 2009). However, loss-framed messages have been found more effective than gain-framed messages for female health behaviors such as participation in mammography (Banks et al., 1995), and self-examination for breast cancer (McCormick & McElroy, 2009).

Loss aversion was also significant for those with incomes at the median and above, whereas those with lower incomes did not discount differently between gain and loss frames. Furthermore, the difference in discounting between higher and lower income participants was only evident in the gain frame, whereas there was no difference in discounting with income in the loss frame. This suggests that higher income people have the 'luxury' to indulge in their loss aversion whereas the greater marginal utility of monetary value for lower income people means that their discounting behaviour was independent of frame. Our results, in combination with previous findings, suggest

1 that loss aversion is a useful strategy particularly when prompting behavior change in
2 women and those with middle class (and greater) incomes.
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7 We also found that higher income individuals (\geq median income) tended to discount
8 more than lower income individuals overall. This is unsurprising as a given monetary
9 amount likely has greater marginal utility for lower income people. Another
10 possibility is that higher income people may have less time. However, when we ran a
11 Pearson's correlation between income and reported time for enjoyable activities, we
12 found a positive relationship between income and time for activities $r=.26$ and
13 $p=.0009$. Thus, higher income people didn't appear to have less (self-reported) extra
14 time, but instead it is possible they valued their time more, perhaps because they earn
15 more per unit time.
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31 There may have been initial reason to hypothesize that overweight individuals may
32 discount more because overweight individuals will need to expend more energy to
33 perform a given activity compared to healthy weight individuals and also because
34 previous studies have found that overweight and obese individuals may be more
35 impulsive than their leaner counterparts (Weller, Cook, Avsar & Cox, 2008; French,
36 Epstein, Jeffery, Blundell & Wardle, 2012). However the effect of BMI was not
37 significant in our study, even though there was a trend in the expected direction. Thus,
38 a similar level of monetary incentive for NEAT activities appears to be sufficient for
39 both obese and healthy weight individuals.
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1 Finally, we found that individuals showed an overall tendency for activity
2 discounting: if they exhibited steeper discounting for one activity, they were also
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4 more likely to exhibit steeper discounting for the other activities. While this may
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6 reflect individual tendencies to feel the cost of effort, these individual tendencies may
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8 also be due to personal views on the general factor of the opportunity cost of time.
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10 Even though we found that discounting did not correlate with reported satisfaction
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12 with time available for enjoyable activities, it is still highly possible that time
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14 opportunity costs played a significant role in individual discount rates.
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21 There is much scope for further studies on this topic to extend our current work. For
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23 example, there may be other factors that might affect individual discounting for
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25 activities that were not examined here, which can be examined in future studies.
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28 Furthermore, our study measured BMI, which is often used as a screening measure for
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30 health, but is not most accurate measure for of actual health. While we did ask for
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32 self-reported satisfaction with health, this is also a weak measure. Thus further work
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34 is needed to investigate in more depth how discounting of physical effort is associated
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36 with health. Another limitation of our study was that it was based on self-reported
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38 BMI and previous work has shown there are systematic biases to such self-reported
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40 values (Gorber et al., 2007).
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48 In addition to the specifics of our findings, we hope that this work demonstrates how
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50 activity discount curves can also readily be measured, and thus in future work, can be
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52 applied as widely as probabilistic and delay discounting. Though hypothetical
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54 laboratory measured costs have been shown to correlate with behavior, future studies
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56 may also use incentive compatible designs to determine the costs of activities in real
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1 behavioural settings. These results have implications for the design and
 2 communication of public health interventions to promote NEAT behaviours and
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 4 policies targeting behaviours where any kind of effort or displeasure demotivates
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 6 individuals to engage (e.g., the perceived experiential cost for searching for
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 8 employment which often involves much sitting and waiting and standing in long and
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 10 boring queues to get the forms and be interviewed).
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1 Figure 1: Subjective value of rewards as a function of sustained activity over time.

2 Group mean of subjective value of \$111 in monetary reward plotted as a function of
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4 time spent in an activity (walking, standing in line, or sitting and waiting) required to
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6 receive the reward as opposed to no activity. The solid and dashed curved lines
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8 represent a hyperboloid discounting function fit to the group mean data for gain and
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10 loss frames for each type of costly activity using a nonlinear, least squares algorithm.
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12 Discounting areas were significantly different between all activity pairs and also
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14 significantly different between gain and loss frames.
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22 Figure 2: Mean and standard error of areas under curves for discounting as a function
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24 of time engaged in activities of walking, standing, and sitting for participants with
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26 income equal to and above \$45,000 vs. below. Post-hoc t-tests for each activity
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28 individually showed marginal effects of income-based differences for standing,
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30 $p=.060$, and sitting, $p=0.060$, but no effect for walking, $p=.37$.
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36 Figure 3: Mean and standard error of areas under curves for participants with incomes
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38 greater than or equal to median income and less than median income. Higher income
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40 participants show significant loss aversion whereas lower income participants do not.
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42 In the gain frame, higher income participants discounted significantly more than
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44 lower income participants. However, in the loss frame, income did not affect the
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46 amount of discounting.
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56 Figure 4: Mean and standard error of areas under curves for discounting as a function
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58 of time engaged in activities of walking, standing, and sitting for overweight and non-
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1 overweight participants. While a trend is observed for overweight participants to
2 discount more, this is not statistically significant.
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8 Figure 5: Mean and standard error of areas under curves for male and female
9 participants. Female participants show significant loss aversion whereas male
10 participants do not. In the gain frame, males discounted less than females whereas in
11 the loss frame females discounted less than males.
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Figure 1

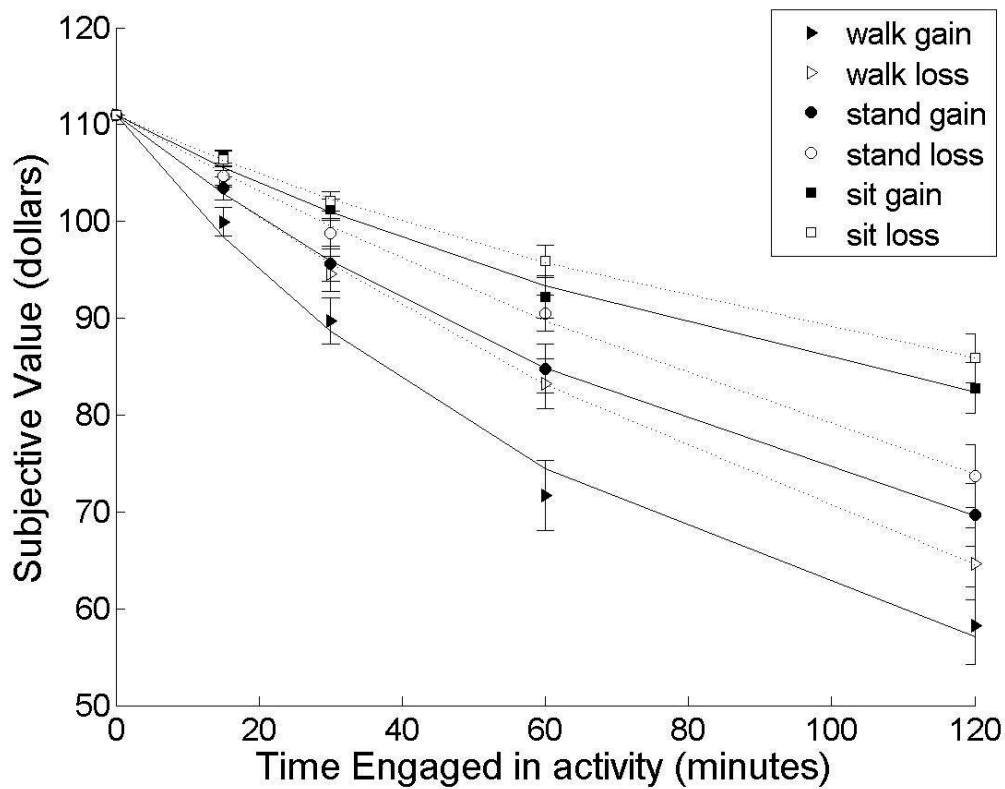


Figure 1: Subjective value of rewards as a function of sustained activity over time.

Group mean of subjective value of \$111 in monetary reward plotted as a function of time spent in an activity (walking, standing in line, or sitting and waiting) required to receive the reward as opposed to no activity. The solid and dashed curved lines represent a hyperboloid discounting function fit to the group mean data for gain and loss frames for each type of costly activity using a nonlinear, least squares algorithm. Discounting areas were significantly different between all activity pairs and also significantly different between gain and loss frames.

Figure 2

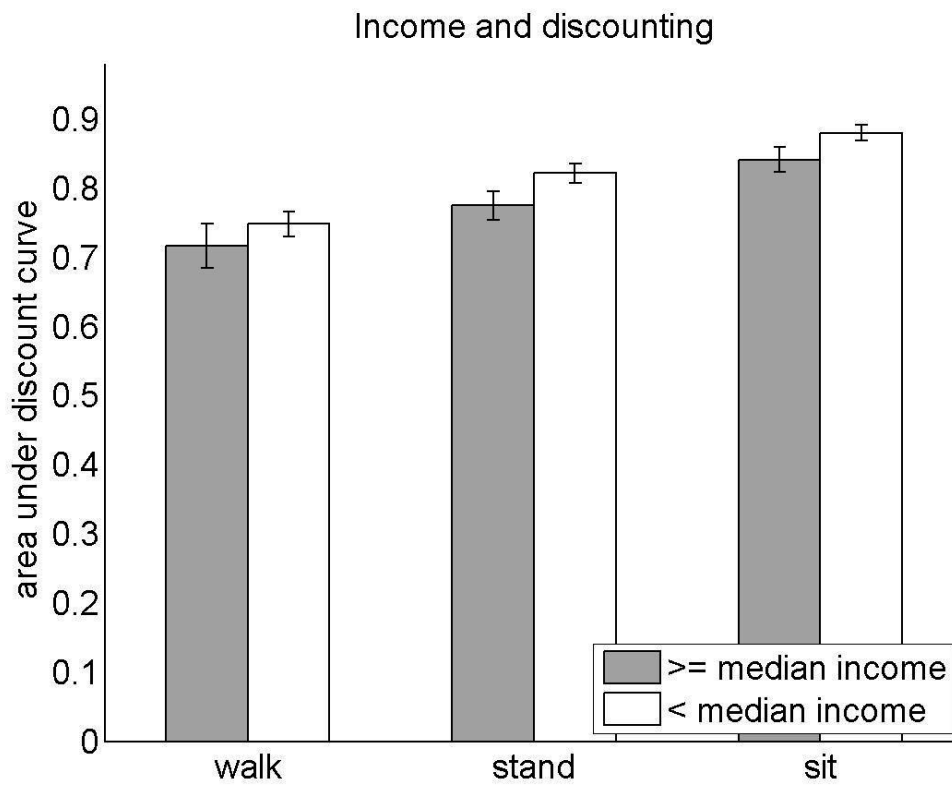


Figure 2: Mean and standard error of areas under curves for discounting as a function of time engaged in activities of walking, standing, and sitting for participants with income equal to and above \$45,000 vs. below. Post-hoc t-tests for each activity individually showed marginal effects of income-based differences for standing, $p=.060$, and sitting, $p=0.060$, but no effect for walking, $p=.37$.

Figure 3

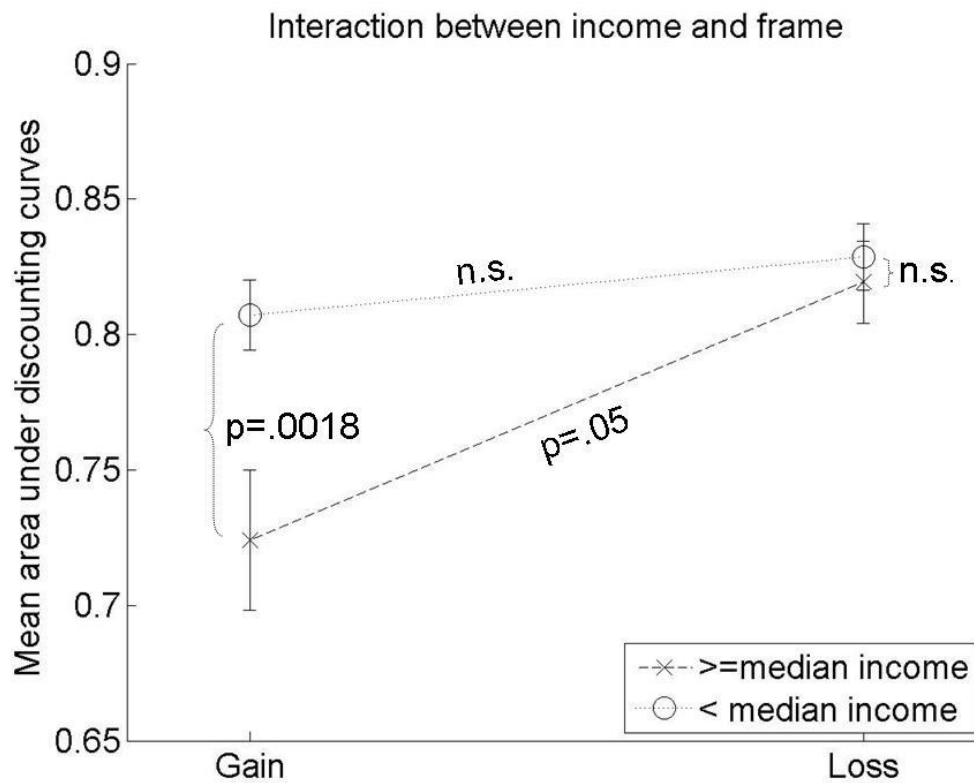


Figure 3: Mean and standard error of areas under curves for participants with incomes greater than or equal to median income and less than median income. Higher income participants show significant loss aversion whereas lower income participants do not. In the gain frame, higher income participants discounted significantly more than lower income participants. However, in the loss frame, income did not affect the amount of discounting.

Figure 4

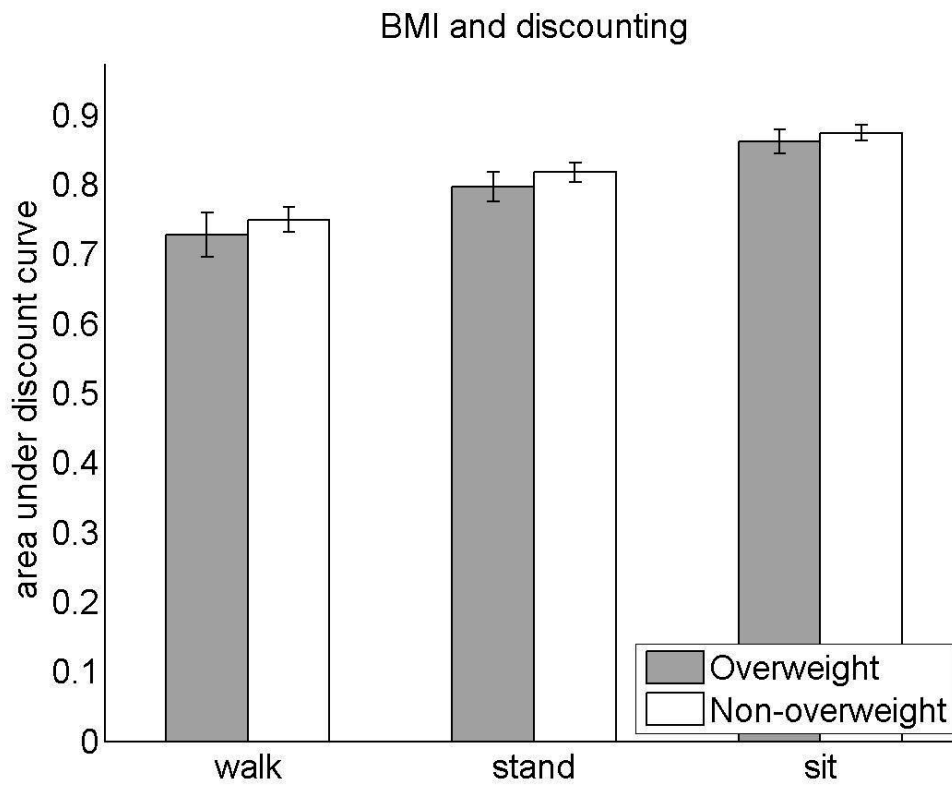


Figure 4: Mean and standard error of areas under curves for discounting as a function of time engaged in activities of walking, standing, and sitting for overweight and non-overweight participants. While a trend is observed for overweight participants to discount more, this is not statistically significant.

Figure 5

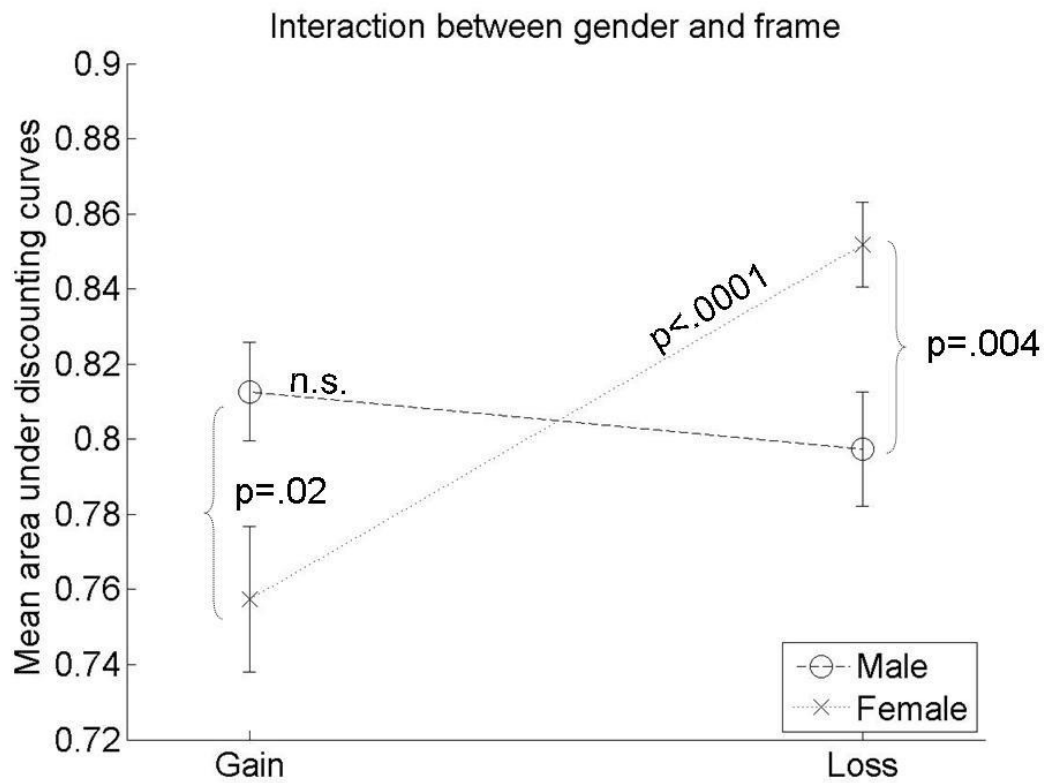


Figure 5: Mean and standard error of areas under curves for male and female participants. Female participants show significant loss aversion whereas male participants do not. In the gain frame, males discounted less than females whereas in the loss frame females discounted less than males.

The study does not require ethics approval. It was an anonymous online survey and participants were allowed to quit the survey at any time without penalty.