Monetary cost for time spent in everyday physical activities

Hsu, AS; Vlaev, I

Abstract

We measured utility curves for the hypothetical monetary costs as a function of time engaged in three everyday physical activities: walking, standing, and sitting. We found that activities requiring more physical exertion resulted in steeper discount curves, i.e., perceived cost as a function of time. We also examined the effects of gain vs. loss framing (whether the activity brought additional rewards or prevented losses) as well as the effects of the individual factors of gender, income, and BMI. Steeper discount curves were associated with higher income (annual household >=median of $45,000) and gain framing (which indicates loss aversion). There were interactions between gender and frame, and also income and frame: Females and higher income participants showed loss aversion whereas males and lower income participants were not affected by framing. Males showed less discounting in gain frames relative to females, whereas females showed less discounting in loss frame relative to males. In gain frames, higher income participants discounted more but in loss frames there was no effect of income. We also found individual tendencies for discounting across activities: if an individual exhibited steeper discounting for one activity, they were also more likely to exhibit steeper discounting for the other activities. These results have implications for designers of interventions to encourage non-exercise physical activities, suggesting that loss-framed incentives are more effective for women and those with middle class (or greater) incomes. Furthermore loss framed incentives have more uniform impact across income brackets because people discount loss frames similarly regardless of income whereas those with middle-class incomes are not as motivated by gain frames. Our results also demonstrate a general method for examining the costs of effort associated with everyday activities.

We regularly make decisions about the amount of physical exertion we are willing to undergo in everyday life. Is it worth walking an extra 10 minutes to buy cheaper produce? Is it worth standing in line for 20 minutes to obtain a refund? The small decisions potentially add up to big health implications: lack of physical exertion in our everyday activities, also known as non-exercise activity thermogenesis (NEAT), has been implicated (along with increased caloric intake) as one of the main causes of recent increase in obesity in first world countries (Levine, Vander Weg, Hill & Klesges, 2006). Research shows that NEAT accounts for up to 2/3 of daily energy expenditure when compensating for increased caloric intake (Levine, Eberhardt & Jensen, 1999). It is estimated that lean individuals spend 2.5 hours per day more standing and walking than obese individuals, which is an additional expenditure of approximately 350 additional calories a day (Levine et al., 2006). Thus, NEAT offers a promising avenue for weight management. However, it remains unknown the extent to which NEAT offers an 'easy' weight management solution. While NEAT activities may appear to require less concerted effort and thus appear more achievable than scheduling dedicated exercise sessions, non-exercise activities still involve potential 'costs', such as physical or mental effort, unpleasant experiences (e.g., boredom, discomfort), and time.

The costs associated with activities can be evaluated using recent frameworks in behaviour science, where a wide body of research has made it increasingly clear that most of behaviour can be explained as a series of decisions that are underpinned by a valuation of choice options. One method of assessing value is to measure expected value (perceived utility) curves. Here, a binary choice task is used to determine subjective indifference points. These results can be plotted as curves on a graph showing different reward scenarios that perceived to be of equal preference. Typically these curves show how the perceived utility of a given amount of reward is decreases as a function of different amounts of some trade-off, or ‘cost’, which diminishes perceived reward value.

A large body of highly profiled research has used such perceived utility curves to examine how factors of delay and uncertainty associated with a reward decrease the reward’s perceived value, known as delayed and probabilistic discounting. Many studies have examined factors of delay and probability together (Du, Green & Myerson, 2002; Estle, Green, Myerson & Holt, 2007; Green & Myerson, 2004; Killeen, 2009; Rachlin, Raineri & Cross, 1991; Radu, Yi, Bickel, Gross & McClure, 2011; Weller, Cook, III, Avsar & Cox, 2008; Yi, de, X & Bickel, 2006; Heyman & Gibb, 2006; Petry, 2012; Reynolds, 2006). Another relatively less used approach is to measure utility curves to examine the perceived costs of behaviors and activities. Here the utility curves represent how much less reward a person is willing to take if they could avoid the behaviour, thus providing a measure of the cost of that behavior. For example, if a person has equal preference for a $90 reward and a $100 reward that also requires them to stand in line for half an hour, assuming both rewards are eventually received at the same time (no difference in delay of receipt), one can estimate that the cost of standing in line for half an hour costs is about $10 in the context of the $100 reward. By measuring the indifference points for varying amounts of behaviour, one can measure the perceived cost associated with different amounts of behavior. Examples of behavioral costs include physical and/or mental discomfort associated with the effort required, as well as the opportunity costs of time spent on the behavior.

In contrast to the extensive research on the costs of delayed and probabilistic rewards, there have been only a few studies examining the costs of engaging in uncomfortable behaviors and effortful activities. Here, in analogy to the terms probabilistic and delayed discounting, researchers have used the phrase ‘effort discounting’ (Hartmann, Hager, Tobler & Kaiser, 2013; Mitchell, 2004; Reed, Gennaro Reed, Chok & Brozyna, 2011). One such study examined the cost of decision making (Reed et al., 2011), where discounting (i.e., perceived cost) was observed as the number of options increased. Other studies have examined discounting in response to intensity of physical effort (e.g., squeezing of hand dynamometer) (Hartmann et al., 2013), and have found this differed for smokers and non-smokers (Mitchell, 1999) and cigarette deprived smokers (Mitchell, 2004). Discounting in response to effort has also been examined for the hypothetical task of cleaning Japanese bathtubs (Sugiwaka & Okouchi, 2004), and found that discounting in relation to numbers of tubs cleaned was not related to delay discounting, nor measures of reformative self control.

Typically, previous studies in probabilistic and delayed discounting (Du, Green & Myerson, 2002; Estle, Green, Myerson & Holt, 2007; Green & Myerson, 2004; Killeen, 2009; Rachlin, Raineri & Cross, 1991; Radu, Yi, Bickel, Gross & McClure, 2011; Weller, Cook, III, Avsar & Cox, 2008; Yi, de, X & Bickel, 2006; Heyman & Gibb, 2006; Petry, 2012; Reynolds, 2006), as well as effort discounting (Sugiwaka & Okouchi, 2004; Reed et al., 2011; Mitchell, 2004) (with the exception of (Hartmann et al., 2013)), have found discount curves to follow a characteristically hyperbolic function:

$Y=A/(1+bX)^S$ (1)

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

$$(b-a)(f(a)+f(b))/2 \qquad (2)$$

where a and b are subjective values at consecutive points. The area under the curve is then obtained by adding together the area under all consecutive subjective value points. This area can also be used to capture how steeply the reward was discounted, with smaller areas indicating greater discounting.

In our current work, motivated by the ubiquity of non-exercise activity and its relevance to weight, we use the method of measuring perceived utility curves to examine the following question: How costly do people perceive everyday non-exercise physical activities to be? In particular we measured discounting as a function of time engaged in three primary everyday physical activities that vary in terms of physical exertion required: walking, standing in line, and waiting while sitting. We also examined the effects of framing because research has shown that people react differently to choice scenarios involving losses vs. gains, such as the phenomenon of loss aversion, where losses have been found in some circumstances to be more psychologically powerful than gains of equal magnitude (Banks, Salovey, Greener, Rothman, Moyer, Beauvais et al. 1995; McCormick & McElroy, 2009; O'Keefe & Jensen, 2008; O'Keefe & Jensen, 2009; Volpp, John, Troxel, Norton, Fassbender & Loewenstein, 2008). Finally, we also examined discounting is influenced by the individual variables of income, gender, and whether one is overweight. To address these questions we measured discount curves for time spent in various activities, as has been done in previous work mentioned above (Sugiwaka & Okouchi, 2004; Reed et al., 2011; Field, Santarcangelo, Sumnall, Goudie & Cole, 2006; Mitchell, 2004).

Method

Participants

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

As our study only aims to compare differences in activity costs between overweight vs. non-overweight individuals and we do not require precise measures of obesity prevalence, we feel self-report is sufficient for the nature of our study.

Procedure

We measured discount curves of hypothetical monetary value as a function of amount of time engaged in the everyday activities of walking, standing in line, and sitting and waiting, using methods from previous work discounting work (Du et al., 2002; Estle et al., 2007; Hartmann et al., 2013). Engagement in all activities was compared with a baseline of not having to participate in any activity. The online experiment was built using FLASH. Participants were informed that the study aimed to measure the cost of engaging in activities for varying lengths of time relative to monetary rewards. Participants were presented with the following hypothetical scenario: they had won a local lottery and have just arrived at a local lottery center to provide their ticket, name, and address details so that a check can be mailed to them. They were told that under all circumstances, a check would be mailed to them and guaranteed to arrive three weeks from the current day. Thus, the temporal delay with which participants would receive their reward does not vary and is constant across all scenarios. (See Green et al., (2005) for measurements of discounting by comparing delayed rewards.) On each trial participants chose between two hypothetical monetary rewards, a lesser reward associated with the non-costly baseline of being able to provide their details immediately and return home, and a greater reward associated with spending time engaged in one of our physical activities: walking X minutes to another nearby centre (where they could provide details immediately), standing in line for X minutes, or sitting and waiting for X minutes. We evaluated the cost engaging in activities for

X=15, 30, 60, and 120 minutes. For each activity we also examine the effects of framing: whether the activity was required to achieve additional rewards (gain frame) or to prevent additional losses (loss frame).

We measured discounting as a function of time spent in activity using a 2 x 3 mixed experimental design with framing as between-participant variable (gain vs. loss) and activity (walking, standing, sitting) as the within-participant variable. Participants were assigned randomly to gain vs. loss frames. In gain frames participants were told in their hypothetical scenario that they had been given the lower value reward associated with the baseline (i.e., the default was no activity), but could choose to engage in the activity to receive the greater reward. In loss frames participants were told that they had been given the higher value reward associated which required them to engage in the activity to receive (i.e., the default was to engage in activity), but as an option they could choose to engage in no activity to receive the lesser reward. Participants in both framing conditions were presented with all three costly activities for each of the four time periods (12 scenarios total). The amount of greater reward was fixed at $111 and the lesser reward varied using a six-step stair case procedure (Du et al., 2002) to determine the monetary value of participating in each of the three activities for each of the four time periods. This means that for each choice within a particular activity-duration condition, the text on the screen always remained the same except for the amount associated with the smaller win then was increased or decreased based on their previous choice. Each participant answered 72 trials (6 stair case x 4 time periods x 3 activities).

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.

> Alternatively, you can provide your details immediately, but for a smaller award of $109. 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 viewed trials pertaining to the same activity all in one block. The order in which each of the three activity blocks were presented was randomized across participants. For a given activity, the order of presentations of time periods of effort exertion was also randomized across participants. For each time period and activity, participants made six choices of different pairs of hypothetical monetary amounts, in which the amounts the amount of reward for the no-cost activity option was adjusted using a staircase procedure to quickly converge on the amount of reward given for the no-cost activity that was equal in subjective value of the reward when the costly activity was required (see (Du et al., 2002) for a more detailed description of this procedure).

Three practice trials, showing the three example activities, preceded the main experiment. During the main experiment, after each of the three activity scenarios, a catch trial appeared, which presented a similar choice scenarios but offered a choice between a lesser amount to be picked up after a delay of some days versus a greater amount that could be picked up immediately. As mentioned above, six participants who did not always choose the greater immediate amount in all three catch trials were excluded from analysis. At the end of the experiment, participants were asked to provide their weight in pounds and height in inches, from which BMI was calculated. They were also asked for demographic information of age, gender, and total annual household income before taxes, measured as a choice between equally spaced bands starting from ‘up to $9000’, and then in equally spaced incremental bands of $15,000, with the final band being $75,000+. We also asked the following self-reported questions relating to satisfaction with time for enjoyable activities, overall health, and energy: “Overall, how satisfied are you with the time you have to do things you like doing?”, “Overall how satisfied are you with your physical health”, and “Overall, how much energy did you have yesterday?”. We gathered responses on 11 point scales, i.e., 0 (Completely Not satisfied) to 10 (Completely Satisfied) and 0 (Completely not energetic) to 10 (Completely energetic).

Results

Statistical analysis was performed on the area under the curve corresponding to subjective values as a function of time engaged in activities, calculated using Equation 2. As mentioned in the introduction, this area provides a measure of how steeply the reward was discounted (Myerson et al., 2001; Estle et al., 2007). There was no correlation for areas under discount curves with any of the three activities and age, $p>.4$, satisfaction with time for doing enjoyable activities, $p>.50$, satisfaction with overall health, $p>.18$, and energy levels $p>.18$. Thus these measures were dropped from further analysis. There was a significant correlation in which greater household income was negatively related to area under discounting curves for standing $r(158)=-.2$, $p=.013$ and sitting $r(158)=-.17$, $p=.028$. This means higher income people tended to be more willing to give up additional money, which is unsurprising. We included income as a variable in our analysis by splitting participants into a binary income variable: those who reported earning at least or more than the band containing the median US household income, $45,000-$55,000 (US Census Bureau, 2014), and those who earned less. We used participant BMI to categorize individuals into a binary variable of 'BMI', corresponding to overweight (BMI>25) or healthy weight (BMI <=25). To compare discounting was influenced by the factors of activity, frame, income, gender, and BMI, discount areas were entered into a 3 x 2 x 2 x 2 x 2 (activity x frame x income x gender x BMI) analysis of variance (ANOVA) with activity as a within-participant variable.

Results showed main effects of activity, frame, and income: Steeper discount curves were associated with more physically demanding activities, gain frames and higher incomes. There was no significant effect of BMI, though a trend was observed for association between overweight and greater discounting. There was also an interaction between frame and income: Higher income participants showed loss aversion whereas lower income participants did not discount differently between gain and loss frames. In gain frames, higher income participants discounted more than lower income participants whereas in loss frames, income did not affect discounting. While there was no main effect of gender, p=.9, there was a significant interaction between frame and gender: Females showed loss aversion (less discounting in loss frame compared to gain frames) whereas males did not. No other interactions were significant, p>.15. Statistics and further details for these results are provided below.

We found a significant main effect for activity F(2, 159)= 19.8, MSE=.95, p=<.0001. Post-hoc t-tests on area data for activity showed that discount curves for walking were significantly steeper than those for standing, t(159)=6.3, p<.0001, and sitting, t(159)=11.08, p<.0001. Discount curves for standing were also significantly steeper than those for sitting, t(159)=9.00, p<.0001. These are all significant under the

Bonferroni adjustment criteria on post-hoc significance tests for multiple (three-way) comparisons. Thus, as expected, there was an overall trend where discounting increased with the amount of physical effort required: walking was the most steeply discounted (M= 0.74, SD= 0.20) followed by standing in line (M= 0.81, SD= 0.15), followed by sitting (M= 0.87, SD= 0.12). There also was a significant effect of framing in which participants discounted gain frames (M=.78, SD=.19) more than loss frames (M=.83, SD=.15), F(1,159)=10.83, η_p^2=.023, p=.0011. This indicates loss aversion, meaning that participants were reluctant to lose money and therefore more willing to engage in activities to prevent losses than to receive gains. See Figure 1.

----Figure 1 Here-------

There was a main effect of income, F(1,159)=4.22, MSE=.11, , η_p^2=.009, p=.041, reflecting the fact that participants with incomes <$45,000, were more willing to put in effort to ensure higher amounts of money as shown by their significant greater areas under discount curves (M= 0.82, STD=.16) compared to participants with incomes>=$45,000 (M=.78, STD=.18). Post-hoc t-tests for each activity individually showed marginal effect of income-based differences for standing, F(1,159)=3.55, p=.060, and sitting, F(1,159)=3.55, p=0.060, but no effect for walking, p=.37. See Figure 2.

------Figure 2 here---------

There was also a significant interaction between income and frame F(1,459)=4.41, MSE=.15, p=.036, A post-hoc t-test between frames for higher income participants showed a significant effect of frame (marginally significant when Bonferroni adjusted), t(159)=11.24, p=.001 (M=.72, STD=.21 for the gain frame, and M=.82, STD=.14 for the loss frame), whereas frame effects lower income participants was not significant, p=.23 (M=.81, STD=.17 for the gain frame and M=.83. STD=.15 for the loss frame). Thus higher income participants were more likely to show loss aversion whereas lower income participants were equally willing to put in effort for both gains and losses. When viewing this interaction through the effects of income within a specific frame, we find in the gain frame low income participants, showed significantly less discounting compared high income participants, F(1,159)=10.0, MSE=.33, p=.0018. However, in the loss frame, there was no difference in discounting based on income, p=.63. See Figure 3.

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

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

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

While there was no main effect of gender, p=.9, there was a significant interaction between gender and frame, F(1,459)=13.6, MSE=.33, p=.0002. Post-hoc t-tests revealed that females showed significantly less discounting for loss frames relative to gain frames (loss aversion) t(159)=17.7, p<.0001, whereas there was no significant difference between gain and loss frames for men, p=.45. Also, in the gain frame, there was a marginally significant tendency (when Bonferroni corrected) for males to discount less than females t(159)=5.44, p=.02, whereas in the loss frame there was a significant tendency for females to discount less than males t(159)=8.41, p=.0041. Thus male participants were more motivated by the gain frame relative to female participants and vice versa. See Figure 5.

--------Figure 5 Here-----

We also found there were overall trends for individual tendencies towards activity discounting. Discounting across activities was highly correlated by participant. This meant that if a person showed more discounting for one type of activity (smaller area), they were also more likely to show more discounting for another type of activity. In particular, the correlation values between areas under discount curves for different activity pairs were as follows: between areas for walking and standing in line, $r(158) = .72$, $p < .0001$; for walking and sitting, $r(158) = .68$, $p < .0001$; for standing and sitting, $r(119) = .81$, $p < .0001$.

Following previous work, we fit our data to the hyperboloid function in Equation 1. In our study X is the time engaged in the activity. When fit to the group level data using the mean indifference points for each activity-frame utility curve, the hyperbolic equation accounted for more than 99.9% of the variance for all three types of activity discounting, under both loss and gain frames. When fit to the individual participant data, the mean R^2 was greater than 98% for each of the activity-frame combinations with an overall average of 94%. The good fit to a hyperbolic function is consistent with that found in other effort discounting studies (Sugiwaka & Okouchi, 2004; Reed et al., 2011; Mitchell, 2004), though inconsistent with other studies that have found parabolic fits (Hartmann et al., 2013).

Discussion

This is the first study to estimate discount curves and perceived costs as a function of time spent engaging in various everyday non-exercise physical activities. We found that activities that require more physical effort, as defined by rate of energy expenditure per unit time (Nutristrategy, 2012), are discounted more steeply, and thus people would have to be paid more to engage in more exertive activities. This has implications for the design of interventions to encourage NEAT behaviors. Based on our study, averaging results over all times and frames, the costs of walking, standing, and sitting are about approximately \$0.46, \$0.37 and \$0.27 per minute respectively when measured relative to not having to do any other specified activity. When compared to sitting for the equivalent amount of time, the costs of walking and standing are about \$0.20 and \$.10 per minute respectively. The cost of walking over standing is about \$.10. These are rough estimates based on our study which is limited by its hypothetical nature, the specific \$111 baseline value we chose, and the specific lottery scenario we used. The extent to which these measured costs would be for different amounts of base money, and in the context of real monetary and behavioral settings will have to be explored in future work.

Our results show that subjective costs of activities increases depending on the level of physical exertion, and are affected by framing, income, and gender. There was no significant effect of BMI, though there was a small trend for overweight participants to discount more. Thus not all NEAT activities are equal for all people. We found that activities had diminishing unit costs over time (the longer the time spent the lower the cost per minute). This result is actually rather counterintuitive as one might imagine that the difficulty of effort should increase with time, not decrease. Indeed such increase in effort costs over amount of effort was found in previous work where parabolic effort discount curves were measured for the task of squeezing a hand dynamometer (Hartmann et al., 2013), where effort amount was measured as percent of maximum strength. However, other studies. where effort was measured as a function of maximum strength for the reward of cigarettes for smokers (Mitchell, 2004), the number of bathtubs cleaned (Sugiwaka & Okouchi, 2004), and the number of options to choose from (Reed et al., 2011) did find hyperbolic discount curves . The fact that we found our discounting rates to be hyperbolic (i.e., decrease over time) could have been due to various reasons. One reason may be a perceptual difference effect, where the difference between 15 vs. 30 minutes feels more significant compared to the difference between 120 vs. 110 minutes (though we did not test the 110 minute measure). Another reason is that there may be diminishing willingness to part with money, where people become increasingly less willing to give up money and the amount given up increases.

Our results also showed loss aversion, which is related to a bias for the status-quo: People were more willing to engage in an activity to avoid losing money compared to gaining money. While our results found an overall effect of loss aversion, the interaction effects suggest that loss aversion is primarily driven by women and higher income people. Gender differences in discounting have been observed in previous work (Kirby & Marakoviç, 1996; Yankelevitz, Mitchell & Zhang, 2012; Weller et al., 2008). Also, a previous study had found that obese women were more likely to show 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 that loss aversion is a useful strategy particularly when prompting behavior change in women and those with middle class (and greater) incomes.

We also found that higher income individuals (>=median income) tended to discount more than lower income individuals overall. This is unsurprising as a given monetary amount likely has greater marginal utility for lower income people. Another possibility is that higher income people may have less time. However, when we ran a Pearson's correlation between income and reported time for enjoyable activities, we found a positive relationship between income and time for activities $r=.26$ and $p=.0009$. Thus, higher income people didn't appear to have less (self-reported) extra time, but instead it is possible they valued their time more, perhaps because they earn more per unit time.

There may have been initial reason to hypothesize that overweight individuals may discount more because overweight individuals will need to expend more energy to perform a given activity compared to healthy weight individuals and also because previous studies have found that overweight and obese individuals may be more impulsive than their leaner counterparts (Weller, Cook, Avsar & Cox, 2008; French, Epstein, Jeffery, Blundell & Wardle, 2012). However the effect of BMI was not significant in our study, even though there was a trend in the expected direction. Thus, a similar level of monetary incentive for NEAT activities appears to be sufficient for both obese and healthy weight individuals.

Finally, we found that individuals showed an overall tendency for activity discounting: if they exhibited steeper discounting for one activity, they were also more likely to exhibit steeper discounting for the other activities. While this may reflect individual tendencies to feel the cost of effort, these individual tendencies may also be due to personal views on the general factor of the opportunity cost of time. Even though we found that discounting did not correlate with reported satisfaction with time available for enjoyable activities, it is still highly possible that time opportunity costs played a significant role in individual discount rates.

There is much scope for further studies on this topic to extend our current work. For example, there may be other factors that might affect individual discounting for activities that were not examined here, which can be examined in future studies. Furthermore, our study measured BMI, which is often used as a screening measure for health, but is not most accurate measure for of actual health. While we did ask for self-reported satisfaction with health, this is also a weak measure. Thus further work is needed to investigate in more depth how discounting of physical effort is associated with health. Another limitation of our study was that it was based on self-reported BMI and previous work has shown there are systematic biases to such self-reported values (Gorber et al., 2007).

In addition to the specifics of our findings, we hope that this work demonstrates how activity discount curves can also readily be measured, and thus in future work, can be applied as widely as probabilistic and delay discounting. Though hypothetical laboratory measured costs have been shown to correlate with behavior, future studies may also use incentive compatible designs to determine the costs of activities in real behavioural settings. These results have implications for the design and communication of public health interventions to promote NEAT behaviours and policies targeting behaviours where any kind of effort or displeasure demotivates individuals to engage (e.g., the perceived experiential cost for searching for employment which often involves much sitting and waiting and standing in long and boring queues to get the forms and be interviewed).

REFERENCES

Banks,S.M., Salovey,P., Greener,S., Rothman,A.J., Moyer,A., Beauvais,J., & Epel,E. (1995). The effects of message framing on mammography utilization. *Health Psychology 14*(2), 178.

Brooks,P., & Zank,H. (2005). Loss averse behavior. *Journal of Risk and Uncertainty 31*(3), 301-325.

Center for Disease Control and Prevention. Center for Disease Control and Prevention on Obesity. http://www.cdc.gov/obesity/adult/defining.html . 2013.
Ref Type: Electronic Citation

Du,W., Green,L., & Myerson,J. (2002). Cross-cultural comparisons of discounting delayed and probabilitic rewards. *Psychological Record 52* 479-492.

Eckel,C.C., & Grossman,P.J. (2008). Men, women and risk aversion: Experimental evidence. *Handbook of experimental economics results 1* 1061-1073.

Estle,S.J., Green,L., Myerson,J., & Holt,D.D. (2007). Discounting of monetary and directly consumable rewards. *Psychol.Sci. 18*(1), 58-63.

Field,M., Santarcangelo,M., Sumnall,H., Goudie,A., & Cole,J. (2006). Delay discounting and the behavioural economics of cigarette purchases in smokers: the effects of nicotine deprivation. *Psychopharmacology 186*(2), 255-263.

French,S.A., Epstein,L.H., Jeffery,R.W., Blundell,J.E., & Wardle,J. (2012). Eating Behavior Dimensions: Associations With Energy Intake And Body Weight: A Review. *Appetite*.

Gorber,S.C., Tremblay,M., Moher,D., & Gorber,B. (2007). A comparison of direct vs. self-report measures for assessing height, weight and body mass index: a systematic review. *Obesity Reviews 8*(4), 307-326.

Green,L., & Myerson,J. (2004). A discounting framework for choice with delayed and probabilistic rewards. *Psychol.Bull. 130*(5), 769-792.

Green,L., Myerson,J., & Macaux,E.W. (2005). Temporal discounting when the choice is between two delayed rewards. *Journal of Experimental Psychology: Learning, Memory, and Cognition 31*(5), 1121.

Hartmann,N., Hager,M., Tobler,N., & Kaiser,S. (2013). Parabolic discounting of monetary rewards by physical effort. *Behavioural processes 100* 192-196.

Heyman,G.M., & Gibb,S.P. (2006). Delay discounting in college cigarette chippers. *Behavioural pharmacology 17*(8), 669-679.

Killeen,P.R. (2009). An additive-utility model of delay discounting. *Psychol.Rev. 116*(3), 602-619.

Kirby,K.N., & Marakoviç,N.N. (1996). Delay-discounting probabilistic rewards: Rates decrease as amounts increase. *Psychonomic Bulletin & Review 3*(1), 100-104.

Kivetz,R. (2005). Promotion Reactance: The Role of EffortReward Congruity. *Journal of Consumer Research 31* 725-736.

Kurniawan,I.T., Guitart-Masip,M., & Dolan,R.J. (2011). Dopamine and effort-based decision making. *Front Neurosci. 5* 81.

Levine,J.A., Eberhardt,N.L., & Jensen,M.D. (1999). Role of nonexercise activity thermogenesis in resistance to fat gain in humans. *Science 283*(5399), 212-214.

Levine,J.A., Vander Weg,M.W., Hill,J.O., & Klesges,R.C. (2006). Non-Exercise Activity Thermogenesis The Crouching Tiger Hidden Dragon of Societal Weight Gain. *Arteriosclerosis, Thrombosis, and Vascular Biology 26*(4), 729-736.

McAdams,M.A., Dam,R.M., & Hu,F.B. (2007). Comparison of Self-reported and Measured BMI as Correlates of Disease Markers in US Adults. *Obesity 15*(1), 188.

McCormick,M., & McElroy,T. (2009). Healthy choices in context: How contextual cues can influence the persuasiveness of framed health messages. *Judgment and Decision Making 4*(3), 248-255.

Mitchell,S.H. (1999). Measures of impulsivity in cigarette smokers and non-smokers. *Psychopharmacology 146*(4), 455-464.

Mitchell,S.H. (2004). Effects of short-term nicotine deprivation on decision-making: delay, uncertainty and effort discounting. *Nicotine & Tobacco Research 6*(5), 819-828.

Myerson,J., Green,L., & Warusawitharana,M. (2001). Area under the curve as a measure of discounting. *J Exp.Anal.Behav. 76*(2), 235-243.

National Health Services. NHS Choices. http://www.nhs.uk/Livewell/loseweight/Pages/BodyMassIndex.aspx . 2013.
Ref Type: Electronic Citation

Nutristrategy. Calories burned during work, occupation, and hobbies. http://www.nutristrategy.com/caloriesburnedwork.htm . 2012.
Ref Type: Electronic Citation

O'Keefe,D.J., & Jensen,J.D. (2008). Do loss-framed persuasive messages engender greater message processing than do gain-framed messages? A meta-analytic review. *Communication Studies 59*(1), 51-67.

O'Keefe,D.J., & Jensen,J.D. (2009). The Relative Persuasiveness of Gain Framed and Loss Framed Messages for Encouraging Disease Detection Behaviors: A Meta Analytic Review. *Journal of Communication 59*(2), 296-316.

Petry,N.M. (2012). Discounting of probabilistic rewards is associated with gambling abstinence in treatment-seeking pathological gamblers. *Journal of abnormal psychology 121*(1), 151-159.

Rachlin,H., Raineri,A., & Cross,D. (1991). Subjective probability and delay. *J Exp.Anal.Behav. 55*(2), 233-244.

Radu,P.T., Yi,R., Bickel,W.K., Gross,J.J., & McClure,S.M. (2011). A mechanism for reducing delay discounting by altering temporal attention. *J.Exp.Anal.Behav. 96*(3), 363-385.

Reed,D.D., Gennaro Reed,F.D., Chok,J., & Brozyna,G.A. (2011). The Tyranny of Choice: Choice overslad as a possible instance of effort discounting. *The Psychological Record 61*(4), 3.

Reynolds,B. (2006). A review of delay-discounting research with humans: relations to drug use and gambling. *Behavioural pharmacology 17*(8), 651-667.

Sugiwaka,H., & Okouchi,H. (2004). Reformative self control and discounting of reward value by delay or effort. *Japanese Psychological Research 46*(1), 1-9.

US Census Bureau. Historical Income Tables: Households, Table H-6, Regions-by Median and Mean Income, All Races. US Census Bureau (2012) . 2014. 14-1-2014.
Ref Type: Electronic Citation

Volpp,K.G., John,L.K., Troxel,A.B., Norton,L., Fassbender,J., & Loewenstein,G. (2008). Financial incentive based approaches for weight loss. *JAMA: the journal of the American Medical Association 300*(22), 2631-2637.

Weller,R.E., Cook,E.W., III, Avsar,K.B., & Cox,J.E. (2008). Obese women show greater delay discounting than healthy-weight women. *Appetite 51*(3), 563-569.

Weller,R.E., Cook,E.W., Avsar,K.B., & Cox,J.E. (2008). Obese women show greater delay discounting than healthy-weight women. *Appetite 51*(3), 563-569.

Yankelevitz,R.L., Mitchell,S.H., & Zhang,Y. (2012). Gender differences in factors associated with alcohol drinking: Delay discounting and perception of others drinking. *Drug and alcohol dependence 123*(1), 273-276.

Yi,R., de,l.P., X, & Bickel,W.K. (2006). The combined effects of delay and probability in discounting. *Behav.Processes 73*(2), 149-155.

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: 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: 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: 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: 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.

Figure 1

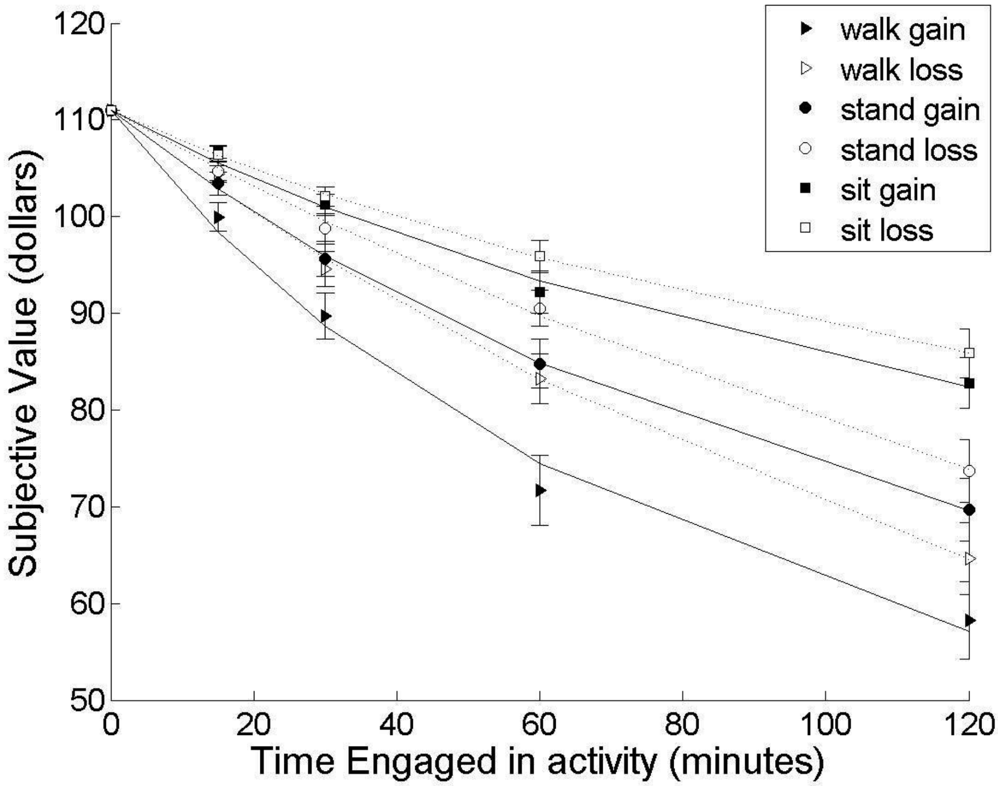

Figure 1: Subjective value of rewards as a function of sustained activity over time. Group mean of subjective value of $111 in monetary reward plotted as a function of time spent in an activity (walking, standing in line, or sitting and waiting) required to receive the reward as opposed to no activity. 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

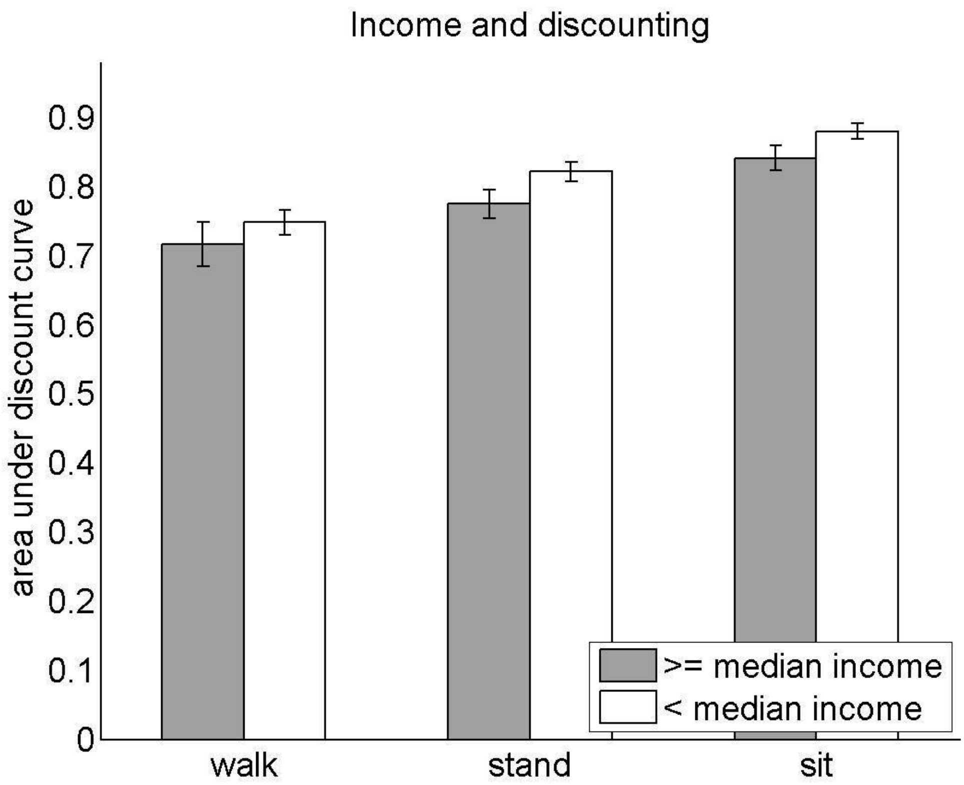

Figure 2: Mean and standard error of areas under curves for discounting as a function of time engaged in activities of walking, standing, and sitting for participants with income equal to and above $45,000 vs. below. Post-hoc t-tests for each activity individually showed marginal effects of income-based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

Figure 3

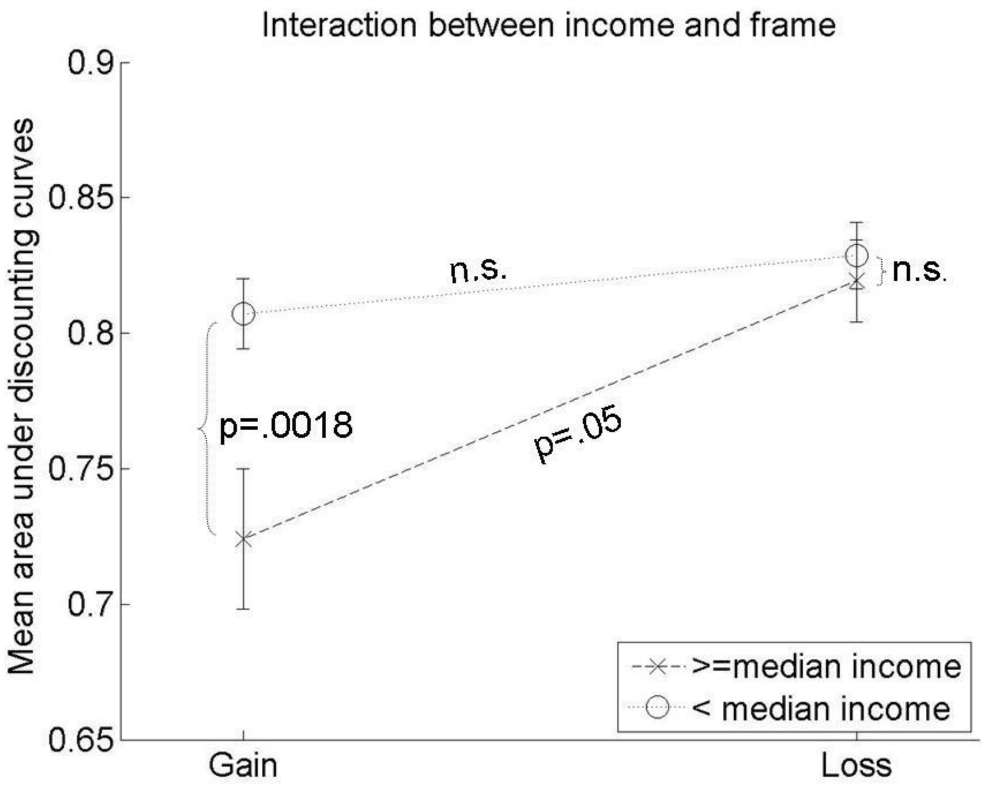

Figure 3: Mean and standard error of areas under curves for participants with incomes greater than or equal to median income and less than median income. Higher income participants show significant loss aversion whereas lower income participants do not. In the gain frame, higher income participants discounted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

Figure 4

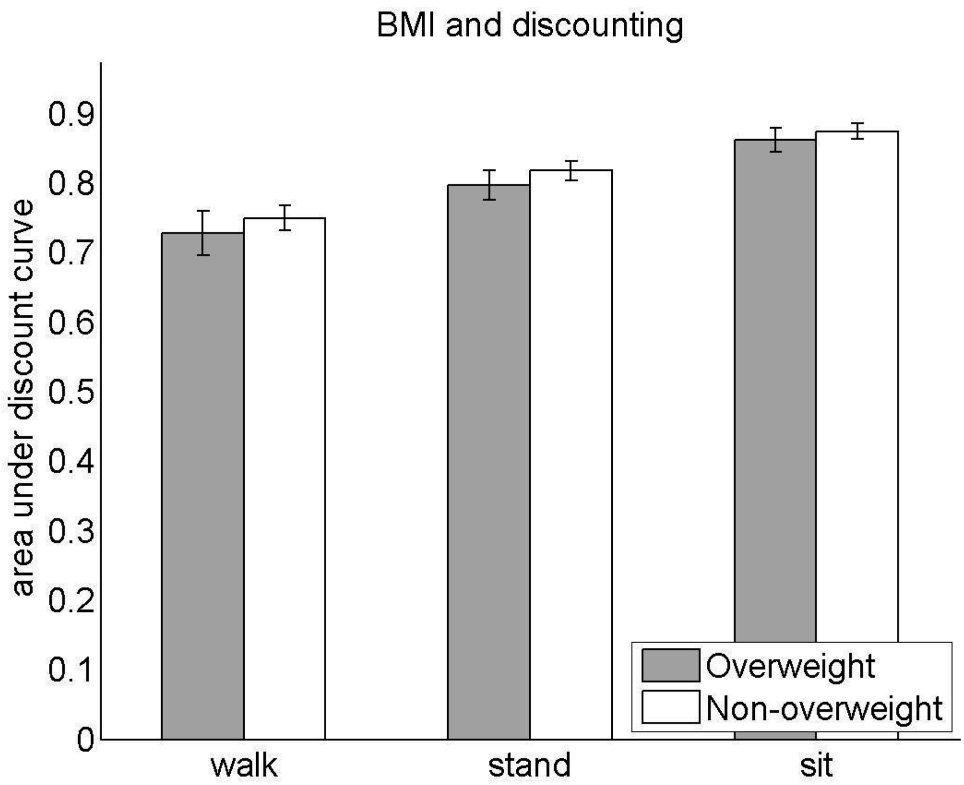

Figure 4: Mean and standard error of areas under curves for discounting as a function of time engaged in activities of walking, standing, and sitting for overweight and non-overweight participants. While a trend is observed for overweight participants to discount more, this is not statistically significant.

Figure 5

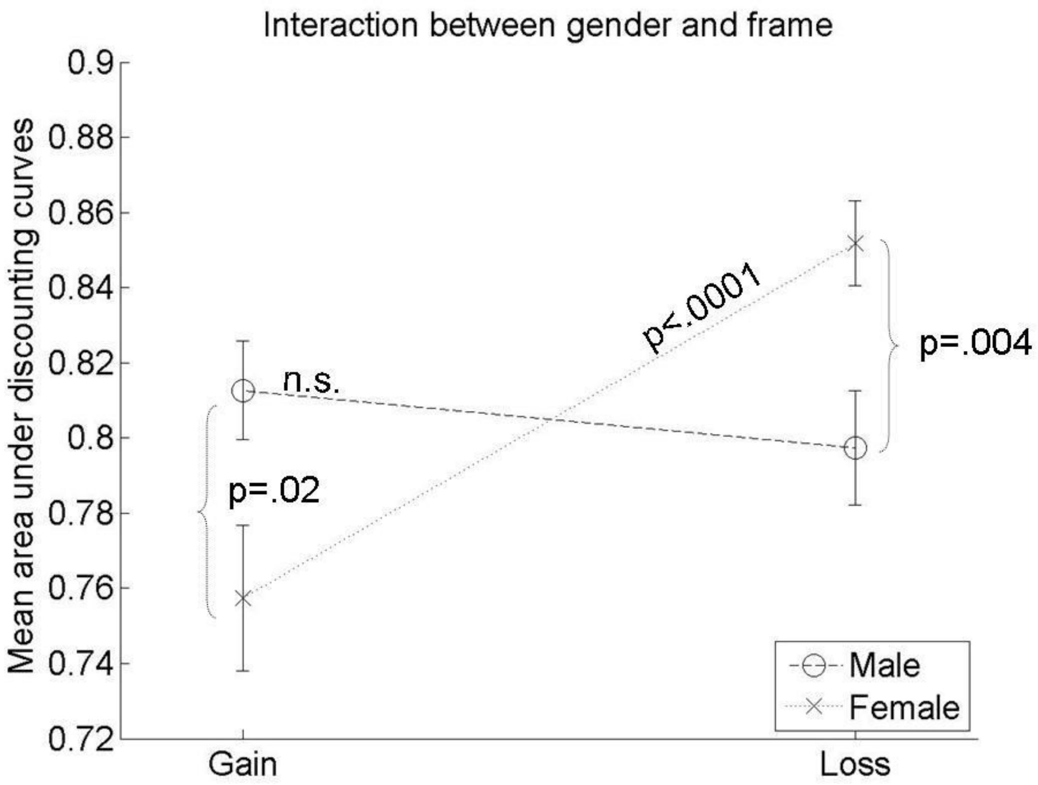

Figure 5: Mean and standard error of areas under curves for male and female participants. Female participants show significant loss aversion whereas male participants do not. In the gain frame, males discounted less than females whereas in the loss frame females discounted less than males.

***Ethics approval/Statement EA not required**

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.