Temporal Discounting of Losses

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ABSTRACT

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This dissertation presents a series of five papers to better understand how to measure discounting, how and why discounting of losses differs from discounting of gains, and how to apply research on discounting to public policy. Paper 1 compares two common methods of measuring discounting – titration and matching – with a dynamic "multiple staircase" method adapted from psychophysics. Paper 2 examines the robustness of the sign effect across financial, environmental, and health domains. Paper 3 explores the interaction of sign and magnitude, and offers an explanation for why losses reverse or eliminate the magnitude effect. Paper 4 investigates an explanation for the sign effect: that dread looms larger than pleasurable anticipation, and Paper 5 offers an integrative approach to intertemporal choice, with recommendations for environmental policy. Taken together, these investigations suggest that discounting of losses is both quantitatively and qualitatively different from discounting of gains. Across domains and methods losses are discounted much less than gains and losses eliminate (or reverse) the magnitude effect. These behavioral differences occur because "dread" of losses is more pronounced than pleasurable anticipation of gains. In other words, people dislike having losses hanging over their heads more than they enjoy looking forward to positive events. For this reason, while people almost universally want to have gains immediately (due to impatience and other reasons), people are divided about losses – sometimes preferring to realize them immediately, and sometimes preferring to postpone them. Theories and policies involving intertemporal choice must distinguish between losses and gains if they hope to accurately describe and predict people's choices.

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Dedication

I would like to dedicate this dissertation to my parents, Jim and Elizabeth, and to my wife, Kirstin.

Introduction

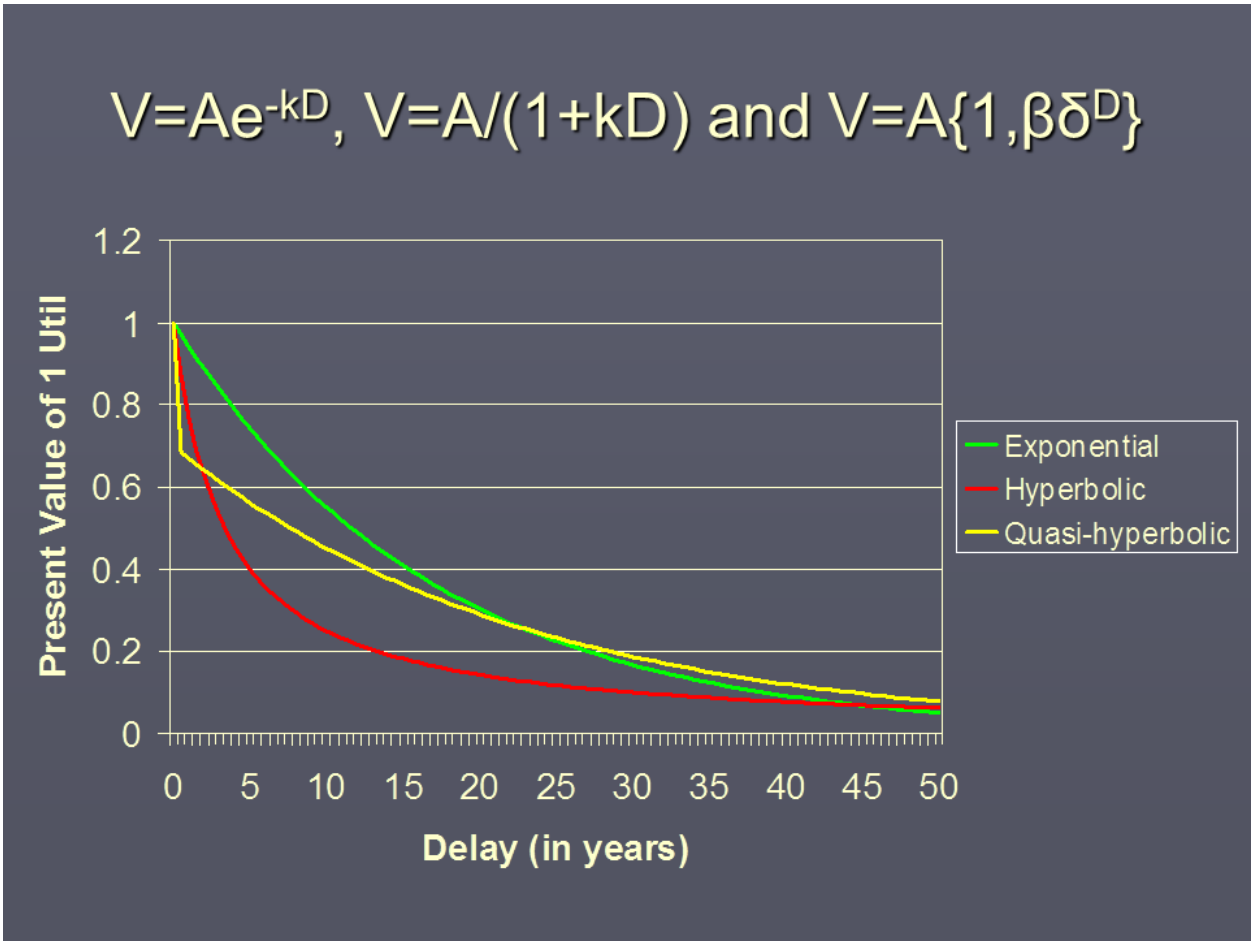
Throughout life, we are constantly making decisions about what to experience now, and what to put off until later. For example, when we buy something, should we pay right away with cash or a debit card, or do we put it on a credit card and postpone payment until the future? When deciding what to have for dinner, do we choose something that is delicious (but unhealthy), or something that will bring us future health benefits? When facing such choices, people generally *discount* future outcomes, and there are several reasons for doing so: the future is uncertain, we expect to have more free time and money in the future, and we are often simply impatient.

Several models have been developed to describe the way that people should make or do make intertemporal tradeoffs. Currently, the exponential, hyperbolic, quasi-hyperbolic, and area-under-the-curve models are the most popular. The exponential equation is $V=Ae^{-kD}$, where V is subjective value, A is the future amount, e = 2.718..., k is the discount rate, and D is the delay in years. For example, with a 10% discount rate, the promise of getting $50 in two years is subjectively worth only $40.94 today (the equation with numbers plugged in is $40.94 = 50*2.718^{-.1*2}$). This continuously compounded exponential model is the rational standard for discounting. However, a growing literature has documented that people's actual choices are typically fit better by a hyperbolic model, V=A/(1+kD), where V is subjective value, A is the future amount, k is the discount rate, and D is the delay (which can be in any units). In this model, value drops off sharply, but then plateaus as delay increases. More recently, a hybrid, quasi-hyperbolic (or "beta-delta") model has been proposed, $V = A\{1,ß\delta^{D}\}$, where V is the subjective value, A is the future amount, ß and δ are discount parameters. The model has a discontinuity between anything that is "now" and anything in the future. Things that are

immediately available are worth their full value (i.e., "1"), whereas delayed outcomes are discounted by a fixed amount (i.e., "ß<1") as well as an amount that scales with delay (i.e., "δ"). The "delta" (i.e., δ) component of the model represents a rational, exponential discounting process, while the beta (i.e., "ß") component represents irrational impatience to have things immediately. While intuitively compelling, this model has not received as much empirical support as the (more parsimonious) hyperbolic model, and it carries no normative weight. See Figure 1, below, for a comparison of these three models.

Figure 1

A visual comparison of the exponential, hyperbolic, and quasi-hyperbolic discounting models.



More recently, a supposedly theory-free way of describing intertemporal preference has been proposed: the area-under-the-curve (or AUC). Using this method, intertemporal indifference points are elicited experimentally and then connected with straight lines, and the area under these lines is summed and expressed as a fraction of 1, where an AUC of 1 means that time has no impact on value, while an AUC near zero would indicate extreme impatience.

Many contextual factors affect people's discount rates, including the sign effect, magnitude effect, direction effect, preference for improving sequences, and preference for spread. The sign effect (Thaler, 1981) describes the fact that gains are discounted more than losses. For example, when faced with a choice between getting $5 today or $5 in a year, almost everyone would choose the immediate $5, whereas when choosing between losing $5 today or in a year, so people prefer the immediate loss and some prefer the future loss. The direction effect (Loewenstein, 1988; Weber et al, 2007) is the fact that people are biased in favor of the default time of payment or receipt. So, for example, if offered the choice between getting $10 today or $11 in a year, and the default is to get the immediate $10 (with the possibility of delaying consumption), most people will choose that option, whereas if the default is the future $11 (with the possibility of accelerating consumption), most people will choose that option. The magnitude effect describes the fact that discount rates are generally lower for larger amounts (Thaler, 1981). For example, when choosing between getting $10 today or $12 in a year, most people will prefer the $10 today, but when choosing between $10,000 today or $12,000 in a year, more people will prefer the future $12,000. When faced with sequences of outcomes, such as an income profile or health profile, most people prefer an improving sequence (given that the overall average is the same) (Chapman, 1996). This runs contrary the traditional discounting phenomenon, where the future is down weighted. Another anomaly that appears with sequences

is the preference for spread: when asked to schedule positive events, such as dinners out a nice restaurants, people often prefer to space them out over time, rather than having all the good things as soon as possible (Frederick, 2008).

While all these discounting "anomalies" have been thoroughly documented, process data to understand why these happen are few and far between. This has been especially lacking for the sign effect, because not only are losses discounted less than gains, but losses also reverse or eliminate the typical magnitude and direction effects. No mainstream models of discounting currently explain or predict this pattern of preferences. Furthermore, methods for measuring discount rates are not standardized within the field, and little is known about how different measurement methods influence discounting, and which methods are to be preferred.

With this in mind, this dissertation presents a series of five papers to better understand how to measure discounting, how and why discounting of losses differs from discounting of gains, and how to apply research on discounting to public policy. Paper 1 compares two common methods of measuring discounting – titration and matching – with a dynamic "multiple staircase" method adapted from psychophysics. Paper 2 examines the robustness of the sign effect across financial, environmental, and health domains. Paper 3 explores the interaction of sign and magnitude, and offers an explanation for why losses reverse or eliminate the magnitude effect. Paper 4 investigates an explanation for the sign effect: that dread looms larger than pleasurable anticipation, and Paper 5 offers an integrative approach to intertemporal choice, with recommendations for environmental policy.

Taken together, these investigations suggest that discounting of losses is both quantitatively and qualitatively different from discounting of gains. Across domains and methods

losses are discounted much less than gains and losses eliminate (or reverse) the magnitude effect. These behavioral differences occur because "dread" of losses is more pronounced than pleasurable anticipation of gains. In other words, people dislike having losses hanging over their heads more than they enjoy looking forward to positive events. For this reason, while people almost universally want to have gains immediately (due to impatience and other reasons), people are divided about losses – sometimes preferring to realize them immediately, and sometimes preferring to postpone them. Theories and policies involving intertemporal choice must distinguish between losses and gains if they hope to accurately describe and predict people's choices.

Paper 1: How to measure discount rates? An experimental comparison of three methods.

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Abstract

Time preferences for financial and air quality gains and losses at delays of up to 50 years were elicited using three different methods: matching, fixed-sequence choice titration, and a dynamic "multiple staircase" choice method. Results indicate that the choice-based methods are prone to influencing participants' discount rates through the magnitude and order of options presented to participants. However, choice-based methods are easier for participants to understand and are better at predicting consequential intertemporal choices such as smoking. No consistent advantages were found for the multiple staircase over simple titration. Implications for best practice are discussed.

How to measure discount rates? An experimental comparison of three methods.

Throughout life, people are constantly making choices about what to do or have immediately, and what to put off until later. Whenever someone chooses an immediate benefit at the expense of a larger delayed benefit, that person is said to exhibit *temporal discounting* (Samuelson, 1937). Similarly, if someone chooses to avoid an immediate loss in favor of a larger, later loss (for example, postponing a credit-card payment), this represents discounting as well. Laboratory measures of discounting can predict many important real-world behaviors, including credit card debt, smoking, exercise, body-mass index, and infidelity (Chabris, Laibson, Morris, Schuldt, & Taubinsky, 2008; Meier & Sprenger, 2010; Reimers, Maylor, Stewart, & Chater, 2009).

Despite the growing popularity of research on temporal discounting, there is relatively little consensus or empirical research on measurement techniques and best practices. a comprehensive review paper on discounting (Frederick, Loewenstein, & O'Donoghue, 2002) noted a huge heterogeneity in discount rates between studies, and hypothesized that variability in measurement methods might have been a major cause. 52% of studies used *choice-based* measures, 31% used *matching*, and 17% used another method.

Measuring discount rates: Choice vs matching

Choice-based methods generally present participants with a series of binary comparisons and use these to infer an indifference point which is then converted into a discount rate. For example, suppose a participant is presented with a choice between receiving $10 immediately or $11 in one year, and he chooses the immediate option, and that subsequently the participant must decide between $10 or $12 in one year, and he chooses the future option. This pattern of choices

implies that the participant would be roughly indifferent between $10 today and $11.50 in one year. This indifference point can then be converted into a discount rate using a number of different models (discussed below). For example, using the normative, continuously-compounded exponential model, this would yield a discount rate of 14%. The matching method, in contrast, asks for the indifference point directly. For example, it might ask the participant what amount "X" would make him indifferent between $10 immediately and $X in one year.

How do results from these two methods compare? Ahlbrecht & Weber (1997) and Read & Roelofsma (2003) tested both methods in within-subjects designs and found that matching yielded lower discount rates than choice. Why does this happen? One hypothesis is that in choice people are motivated to take the earlier amount, and pay relatively more attention to the delay, while for matching they are more likely focus on the amounts and attempt to balance the two attributes (Tversky, Sattath, & Slovic, 1988). However, neither of the previously mentioned studies manipulated order, so it is difficult to know whether experience with the matching task influenced participants' answers on the choice task. Frederick (2003) compared seven different elicitation methods for current vs future lives, in a mixed design. He also found that matching produced lower discount rates than choice, but again, order effects were not explored. He speculated that the choice task creates demand characteristics: offering the choice between different amounts of immediate and future lives implies that one ought to discount them to some extent -- "otherwise, why would the experimenter be asking the question." In contrast, the matching method makes no suggestions as to what amounts are appropriate.

Further evidence that choice options can bias discount rates comes from a pair of studies comparing two different variations on a choice-based measure. One version presented choices with amounts in ascending order, and the other presented amounts in descending order. The

order affected discount rates, such that participants were more patient when answer the questions in descending order (Robles & Vargas, 2008; Robles, Vargas, & Bejarano, 2009).

While these studies describe some interesting differences between the methods, they offer little guidance regarding which technique researchers ought to use. One perspective would argue that because preferences are constructed, the results from different measures are equally valid expressions of people's preferences, and it is impossible to choose a best measure. However, if researchers are interested in predicting and explaining real-world behaviors in other contexts, this provides an objective metric by which to make a judgment. While several studies have shown this link for choice-based techniques, we are not aware of any studies examining how well matching predicts consequential decisions.

Another question concerns how these different elicitation techniques perform with non-traditional delays and outcomes. Most studies have focused on financial delays in the range of 6 months to a few years, but many consequential real-world intertemporal choices, such as retirement savings, smoking, or environmental decisions, involve much longer delays and diverse consequences.

The Current Research

We compared matching with choice-based methods of eliciting discount rates, in a mixed design. Half the participants completed matching, then choice, while the other half did the opposite order. This allowed us to analyze the data as both within and between subjects. Within each measurement technique, delays varied from one year to fifty years. Also, all participants completed both a hypothetical financial discounting scenario as well as an air quality discounting

scenario. Outcome sign was manipulated between subjects, such that half the participants considered current vs future gains, while the other half considered current vs future losses.

Within the choice-based condition, we compared two different techniques: fixed-sequence *titration* and a dynamic *multiple staircase* method. While the titration method presented participants with a pre-set list of choices, the multiple staircase method (described in detail in Appendix C) dynamically selected choice options based on participants' previous answers, to funnel in on participants' indifference points more efficiently. Within the titration condition, we manipulated presentation order to be from low-to-high or high-to-low.

At the end of the survey, we presented participants with a consequential choice between $100 today or $200 next year, and randomly paid out two participants for real money. We also asked participants whether they smoked or not, to get a consequential life choice.

We compared the measurement methods in four different categories: ability to detect inattentive participants, differences in central tendency and variability, ease of use for participants, and ability to predict consequential intertemporal choices. We predicted that the multiple staircase method would be best at detecting inattentive participants, because we designed it partly with this purpose in mind. We predicted that the choice based methods would show higher discount rates than the matching method, based on the results from previous research discussed above. We predicted that the choice based methods would be easier for participants to understand and use, based on anecdotal evidence from our own previous research indicating that participants often have a hard time with the concept of indifference, and have a hard time picking a number "out of the air" without any reference. Finally, we predicted that the choice based methods would be better at predicting the consequential choices, because there is a

natural congruence in using choice to predict choice, and because previous studies have established the efficacy of choice-based methods but none have been published in support of matching.

Methods

516 participants (68% female, mean age=38, *SD*=13) were recruited online for a study on decision making and randomly assigned to an experimental condition. Participants in the gain condition read the following hypothetical scenario:

> Imagine the city you live in has a budget surplus that it is planning to pay out as rebates of $300 for **each** citizen. The city is also considering investing the surplus in endowment funds that will mature at **different possible times** in the future. The funds would allow the city to offer rebates of a different amount, to be paid at different possible times in the future. For the purposes of answering these questions, please assume that you will not move away from your current city, even if that is unlikely to be true in reality.

The full text all the scenarios can be found in Appendix A. After reading the scenario, participants then indicated their intertemporal preferences in one of three different ways. In the matching condition, participants filled in a blank with an amount that would make them indifferent between $300 immediately and another amount in the future (see Appendix B for examples of the questions using each measurement method). Participants answered questions about three different delays: 1 year, 10 years, or 50 years. Although many participants might expect to be dead in 50 years, the scenario described future gains that would benefit everyone in their city, so it was hoped that those future gains would still have meaning to participants. In the titration condition, participants made a series of choices between immediate and future amounts, at each delay. Because the same set of choices were presented for each delay (see Appendix B for the list of choices), the choice set offered a wide range values, to allow for high discount rates

at long delays. The order of the future amounts was balanced between participants, such that half answered lists with amounts going from low to high (as in Appendix B), and others were presented with amounts going from high to low. In the multiple staircase, participants also made a series of choices between immediate and future amounts. Unlike the simple titration method, these amounts were selected dynamically, funneling in on the participants indifference points. Choices were presented one at a time (unlike titration, which presented all choices on one page). Also unlike titration, the questions from the three delays were interleaved in a random fashion. The complete multiple staircase method is described in detail in Appendix C.

In all conditions progress in the intertemporal choice task was indicated with a progress bar. Also in all conditions, participants could refer back to the scenario as they were answering the questions. After completing the intertemporal choice task, participants were asked "What things did you think about as you answered the previous questions? Please give a **brief** summary of your thoughts:" This was done to get some qualitative measure of the process participants went through while responding to the questions.

Next, participants answered the same intertemporal choice scenario using a different measurement method. Those who initially were given a choice-based measure (titration or multiple staircase) subsequently completed a matching measure, while those who began with matching then completed a choice-based measure. In other words, all participants completed a matching measure, either before or after completing a choice-based measure. This design was chosen because the matching measure is relatively quick for participants to complete, so it was easy to include it in all conditions.

Subsequently, participants were given an attention check, very similar to the Instructional Manipulation Check (Oppenheimer, Meyvis, & Davidenko, 2009), which ascertained whether or not participants were reading instructions.

After that, participants read an environmental discounting scenario, the full text of which can be found in Appendix A. This asked them to choose between an immediate amount of money, and a change in air quality that would happen at different times. In other words, participants were asked how much the change in air quality was worth, depending on the delay. There were four different delays in the air quality scenario: immediate, 1 year, 10 years, and 50 years. Again, it was hoped that the 50-year delayed change in air quality would still be meaningful to participants because it would affect the residents of the city they lived in.

Next, participants completed demographics, including a question about whether they were a smoker or not. Finally, participants completed a consequential measure of intertemporal choice, in which they chose between receiving $100 immediately or $200 in one year (note that participants in the loss condition still chose between two gains in this case, due to the fact that it would be difficult to execute losses for real money). Participants were informed that two people would be randomly selected and have their choices paid out for real money, and this indeed happened.

Results and Discussion

Detecting inattentive participants

In most psychology research, and especially in online research, there are often participants that do not pay much attention and/or do not respond carefully. It is helpful, therefore, if measurement methods can detect these participants. The multiple staircase method

had two built in check questions (described above) to detect such participants. The titration method can also detect inattention, by looking for instances of switching back and forth, or switching perversely. For example, if a participant preferred $475 in one year over $300 today, but preferred $300 today over $900 in one year, this would be a sign of inattention. It is nearly impossible for a single matching measure to detect inattention, but with multiple measure at different time points, matching may identify those participants who show a non-monotonic effect of time. For example, if the one year indifference point (with respect to $300 immediately) is $5000, the ten year indifference point is $600, and the fifty year indifference point is $500000, this would be evidence of inattention.

As described above, each participant also completed another attention check, which was very similar to the Instructional Manipulation Check (Oppenheimer, et al., 2009). As this measure has been empirically shown to be effective for detecting inattentive participants, we compared the ability of each measurement method to predict IMC status.

Correlations between the IMC test and of attention each measure's test of attention revealed that while neither matching, r=.07, p>.1, nor titration, r=.06, p>.1 were able to detect inattentive participants, the multiple staircase method had modest success, r=.19, p<.05. Overall, then, most methods were poor at detecting inattentive participants, but the multiple staircase method was superior to the others.

For all of the following analyses, we only wanted to compare those participants who were paying attention and reading instructions. Therefore, we excluded those participants who failed the IMC, leaving 316 participants for further analysis.

Differences in central tendency and variability

Indifference points were computed for each participant and time delay as follows: in matching, the number given by participants was used directly. In titration, the average of the values around the switch point was used. For example, if a participant preferred $300 immediately over $475 in ten years, but preferred $900 in ten years over $300 immediately, the participant was judged to be indifferent between $300 immediately and $687.50 in ten years. In multiple staircase, the average of the established upper bound and lower bound was used, in a similar manner to titration. These indifference points were then converted to discount rates, using three different popular equations: exponential, hyperbolic, and area under the curve. The continuously compounded exponential discount rate (Samuelson, 1937) is $V=Ae^{-kD}$, where V is the present value, A is the future amount, e is the constant (2.718...), D is the delay in years, and k is the discount rate. This is the normative model of discounting. The hyperbolic model (Mazur, 1987) is $V=A / (1+kD)$, where V is the present value, A is the future amount, D is the delay (often in years), and k is the discount rate. This hyperbolic model has been found to descriptively model discounting data better than the exponential model. The third discounting equation we used was the area under the curve (AUC) metric, which sets the present value equal to one and the longest delay equal to one and computes the fraction that future amounts are worth by computing the area under the curve of the indifference points (Myerson, Green, & Warusawitharana, 2001), by summing $(x_2-x_1)*[(y_2+y_1)/2]$ for each indifference point, where x_1 is the sooner time point, x_2 is the later time point, y_1 is the sooner amount, and y_2 is the later amount. This generally yields a fraction between 1 and 0 where lower numbers mean more discounting. The AUC is supposedly a theory-free measure of discounting behavior. It is important to note that in addition to the differences in theory and explanatory power, these three models also differ in the ways that they transform the data. For example, while the AUC

minimizes extreme discounting, it *magnifies* extreme negative discounting. For example, if someone reports that they would pay $5 for an increase in air quality starting today, but $15 for an increase in air quality starting in one year, this would yield an AUC of 10, which is quite extreme given that the scale normally yields values between 1 and 0.

Because order effects were observed (which we describe below), the majority of the analyses to follow will focus on the first measurement method that participants completed. This leaves 154 in the matching condition, 82 in the titration condition, and 80 in the multiple staircase condition. Discount rates from each condition are summarized in Table 1. Because skew and outliers were sometimes pronounced, this table lists median and interquartile range in addition to mean and standard deviation.

As is clear from Table 1, many different stories can be told from the data depending on the measurement method and discounting model used. For example, when using the exponential formula, the titration method shows the largest standard deviation for financial gains, whereas when using the AUC formula, the matching method shows the largest standard deviation. Yet, there are some consistencies across measurements methods and equations. In *all* cases, whether using matching, titration or multiple staircase; exponential discounting, hyperbolic discounting or AUC; means or medians; financial gains were always discounted more than financial losses (when looking at Table 1, recall that AUC is reverse scored relative to the other measures).

Table 1

Means, standard deviations, medians, and interquartile ranges (IQRs) for three methods of measuring discount rates (matching, multiple staircase, and titration) for financial gains and losses. Discount rates are summarized for three popular discounting equations: the continuously

compounded exponential model, the hyperbolic model, and the area under the curve (AUC). Note that for the first two models, higher numbers mean more discounting, while with the AUC lower numbers mean more discounting.

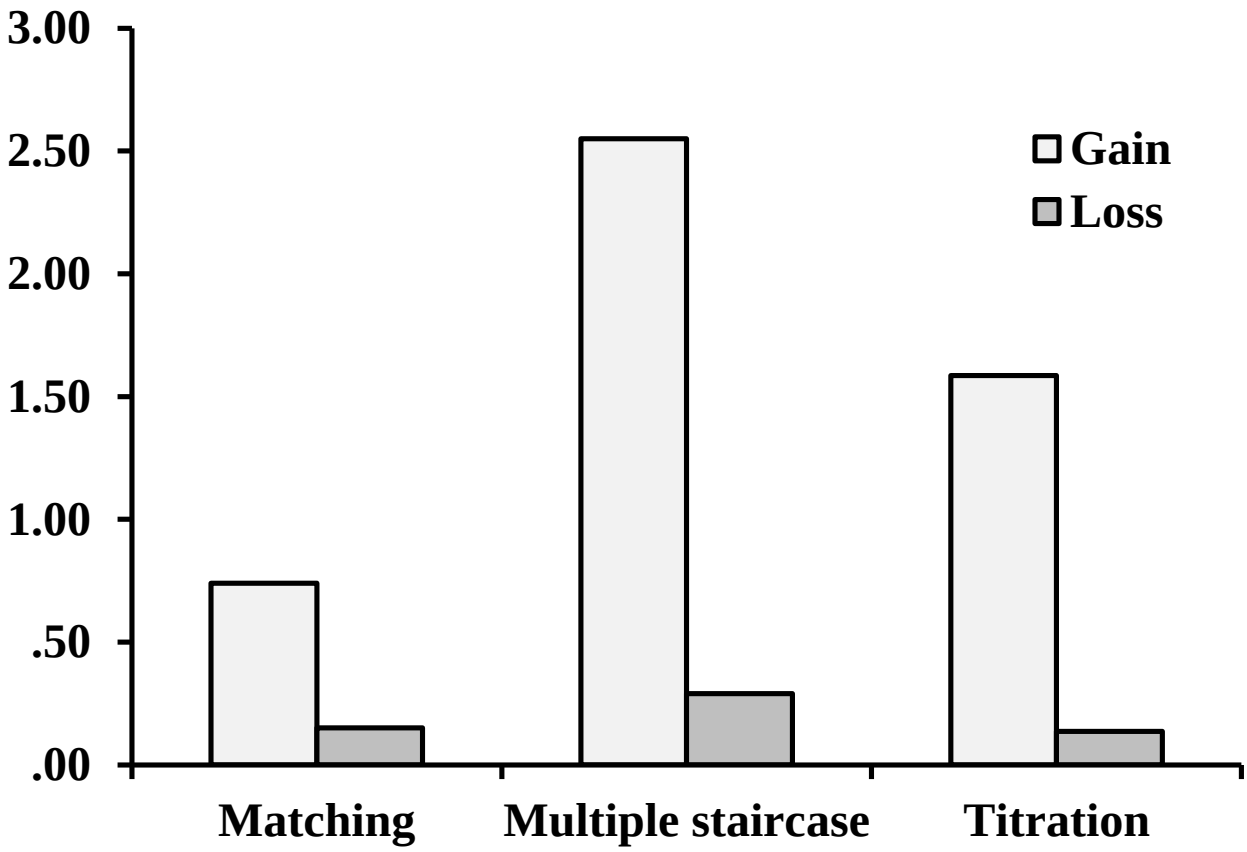
Financial Outcome	Exponential Discount Rate				Hyperbolic Discount Rate				Area Under the Curve			
	Mean	SD	Median	IQR	Mean	SD	Median	IQR	Mean	SD	Median	IQR
matching, gain	.24	.21	.23	.23	2.47	8.53	.74	1.11	.43	1.38	.17	.20
m-stairs, gain	.46	.38	.34	.37	6.03	16.01	2.55	2.14	.13	.08	.11	.12
titration, gain	.41	.52	.18	.30	10.27	34.43	1.59	3.07	.16	.10	.15	.15
matching, loss	.08	.33	.08	.21	.53	1.47	.15	.41	4.93	32.77	.44	.36
m-stairs, loss	.22	.26	.12	.23	1.29	2.92	.29	.53	.35	.27	.25	.32
titration, loss	.27	.51	.10	.24	3.69	14.29	.14	.58	.60	.65	.40	.61

Because most psychological studies of discounting employ the hyperbolic model, our further analyses will focus on this model. As this model is subject to skew and outliers, we will primarily use non-parametric statistics. Also, we feel that this approach (median hyperbolic discount rates) best represents the overall pattern of data.

As seen in Figure 1, discount rates measured with the choice based methods (titration and multiple staircase) were generally higher than discount rates measured with matching, and this was particularly true for gains. A Kruskal-Wallis non-parametric ANOVA run on the gain data confirmed significant effect of measurement method on discount rates, $p<.001$, and another Kruskal-Wallis test run on losses found a significant effect of measurement method there as well, $p<.05$.

Figure 1

Median hyperbolic discount rates for financial gains and losses as measured with matching, multiple staircase, or titration.

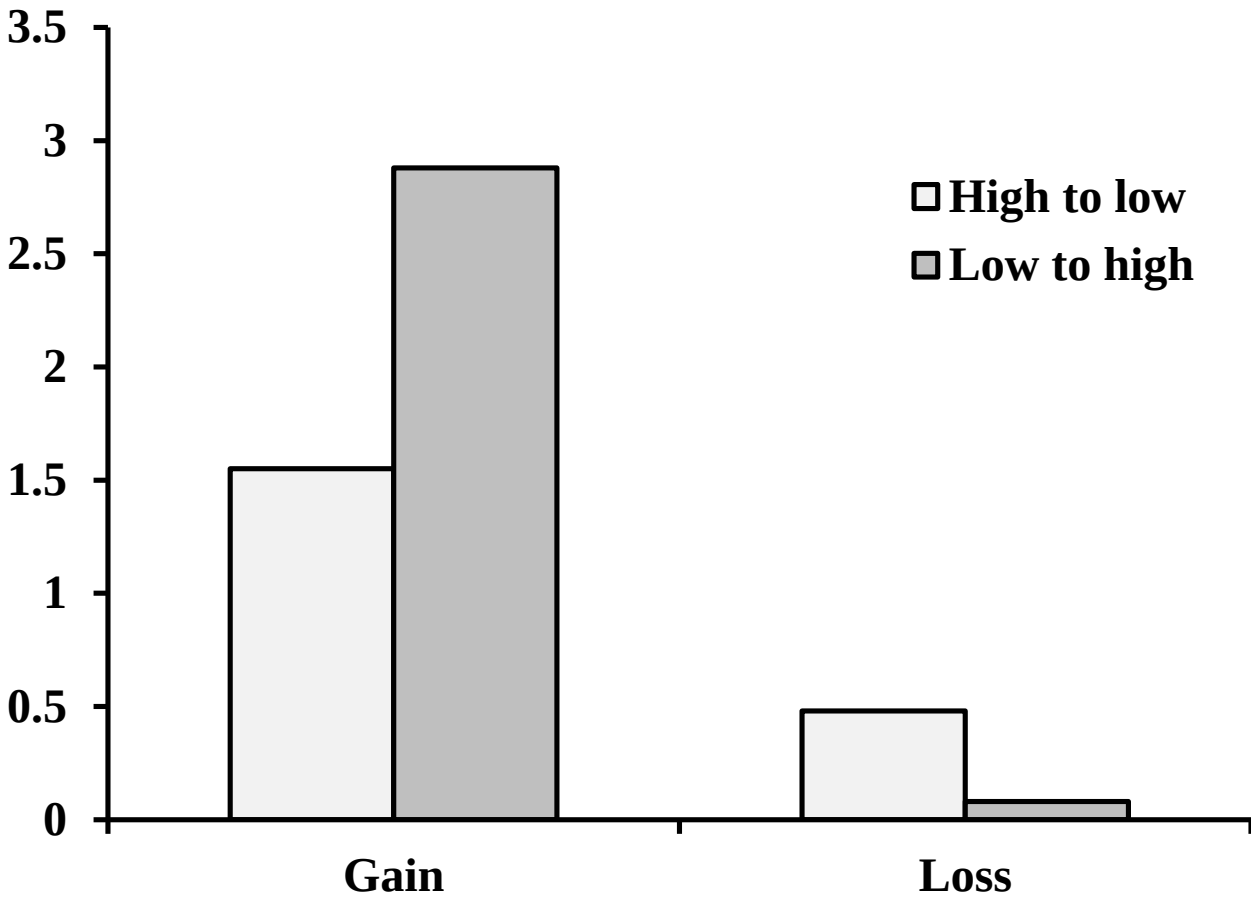


We hypothesized that these difference in discount rates were partly a function of anchoring or demand characteristics. In other words, the extreme options sometimes presented to participants (such as a choice between $300 today and $85,000 in one year) may have suggested that these were reasonable choices, and so encouraged higher discount rates. For comparison, an earlier study from our same lab (Hardisty & Weber, 2009, Study 1) with the same participant pool using titration for financial outcomes presented participants with a much smaller range of options ($250 today vs $230 to $410 in one year) and yielded much lower discount rates: .28 for gains, and .04 for losses, compared with 1.59 for gains and .14 for losses in the present study. It

seems, then, the range of options presented to participants affected their discount rates by suggesting reasonable options as well as by restricting what participants could or could not actually express. We also tested for the influence of the options presented to participants by comparing the two orderings, high-to-low and low-to-high. As summarized in Figure 2, this ordering manipulation did indeed affect responses. In particular, participants tended to perseverate on the side they started out on. So, for example, a participant who began with a choice between receiving $300 immediately or $250 in the future would begin by choosing the immediately amount, and stay with it for a little while, thus exhibiting a high discount rate (ie, greater impatience). In contrast, a participant who was first presented with receiving $300 immediately vs $85,000 in the future would begin by selecting the future option, and continue to choose more future options, thus showing a low discount rate. Losses showed the same effect, which translates into discount rates in the opposite manner. For example, a participant who begins with a choice between paying $300 now or $250 in the future will likely choose the future amount, and continue choosing to pay in the future, which ultimately leads to a higher discount rate.

Figure 2

Median hyperbolic discount rates for financial gains and losses as measured with titration, broken down by the order in which future amounts were presented: high to low, or low to high.

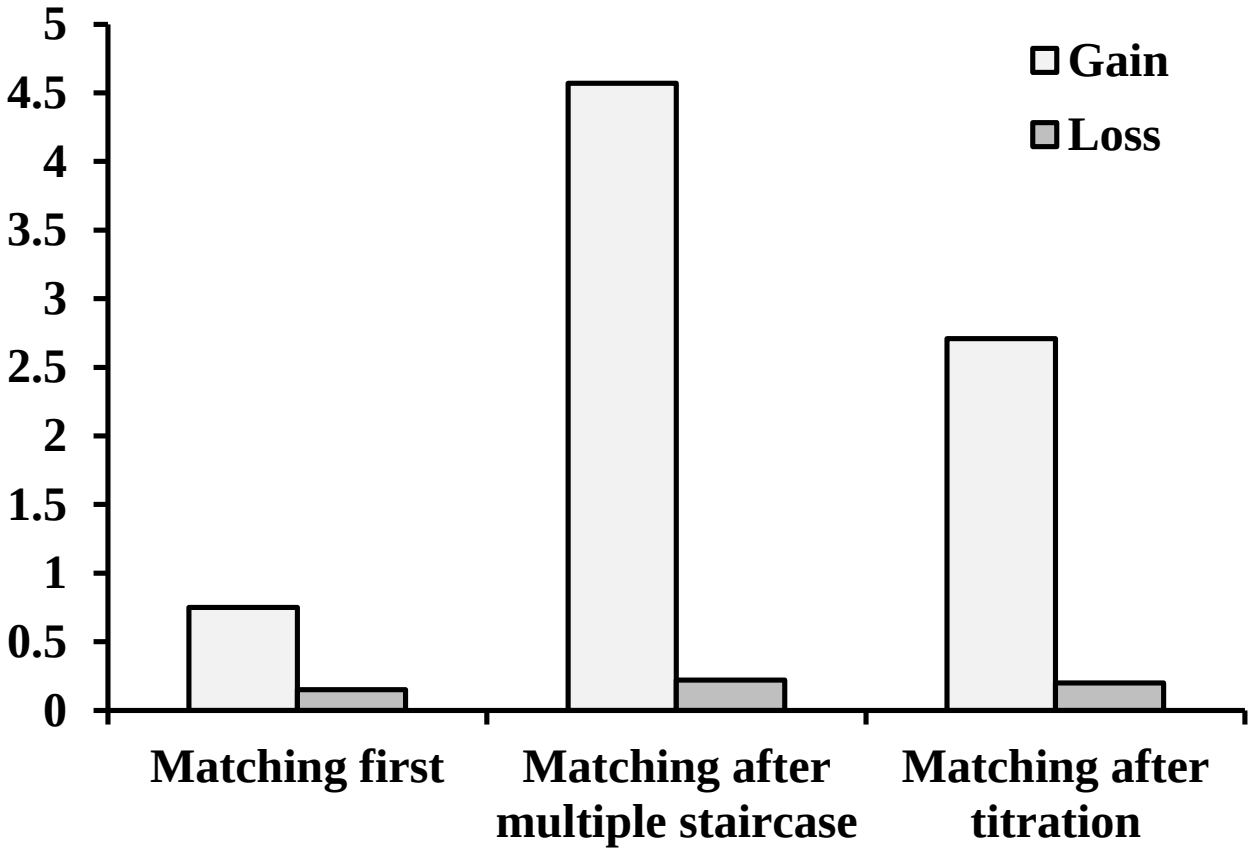


A Mann-Whitney U test comparing the high-to-low and low-to-high orderings for gains was significant, $p<.01$. A similar test comparing the two orderings for losses was not significant, $p>.1$, but was in the predicted direction.

While discount rates were generally much higher when using the choice based methods, we feel that this was due to the large range of options that we presented to participants, and it would be possible to obtain the opposite pattern of results if only small amounts were used. Further evidence for this comes from a within-subjects analysis comparing the different methods: although all participants completed a matching measure, some did it before a choice method, and some did it after a choice method. Comparing these participants reveals a significant effect of order, as seen in Figure 3.

Figure 3

Median hyperbolic discount rates for financial gains and losses as measured with matching, broken down by whether participants did the matching task before or after one of the choice based measurement methods.



A Kruskal-Wallis test confirmed that participants who answered the choice-based measures first gave higher discount rates than those who did matching first, both for gains, $p<.001$, and for losses, $p=.05$.

Just as the mean and median discount rates yielded from the choice-based methods were higher than those yielded from the matching method, so too was the spread of the distributions from the choice-based methods larger. For example, the interquartile range (IQR) from the matching method for gains was 1.1, compared with 2.1 from multiple staircase and 3.1 from titration. Similarly, the IQR for matching losses was only .41, compared with .53 from multiple

staircase and .58 from titration. It is likely that the same factors which led to the higher medians in the choice-based methods also produced the greater IQR.

Discount rates for the air quality outcomes where computed by comparing how much participants valued the immediate change in air quality vs the future change in air quality. For example, if someone would pay $100 to avoid an immediate deterioration in air quality, but only pay $90 to avoid a deterioration starting in one year, then the hyperbolic discount rate for that participant would be (100-90)/(90*1), or .11. Perhaps as a result of the immediate amount being variable in addition to the future amounts, this made the variances in discount rates quite large for the air quality outcomes, as seen in Table 2. Also, some participants were confused, particularly in the matching condition (discussed below), so the discount rates in Table 2 probably do not represent participants' true preferences. Therefore, we will not analyze them very closely, except to note that the same general trends are seen here as well as for the financial outcomes: choice-based methods generally produced higher discount rates than matching, and often had higher variability as well.[1]

[1] The astute reader may notice that overall, discount rates for the air quality outcomes are lower than those for the financial outcomes. This may seem to contradict Hardisty & Weber (2009), who found little difference in discount rates between financial and environmental outcomes. We believe this is due to the fact the 2009 paper used within-domain measures of discounting (air quality now vs a different amount of air quality in the future), while the present study uses a between domain measure of discounting (how many dollars is air quality worth now vs later). An unpublished study by our lab showed that this is indeed the case. We speculate that many participants hold a moral conviction that environmental things ought to be worth the same amount no matter when they happen, and so many participants show zero discount rates when using this procedure. In contrast, the 2009 paper showed that the vast majority of participants prefer a smaller improvement in air quality now over a larger one in the future, thus showing standard temporal discounting behavior.

Table 2

Means, standard deviations, medians, and interquartile ranges (IQRs) for three methods of measuring discount rates (matching, multiple staircase, and titration) for air quality gains and losses. Discount rates are summarized for three popular discounting equations: the continuously compounded exponential model, the hyperbolic model, and the area under the curve (AUC). Note that for the first two models, higher numbers mean more discounting, while with the AUC lower numbers mean more discounting.

Air Quality Outcome	Continuously Compounded Exponential Discount Rate				Hyperbolic Discount Rate				Area Under the Curve			
	Mean	SD	Median	IQR	Mean	SD	Median	IQR	Mean	SD	Median	IQR
matching, gain	-.13	.40	.00	.33	.05	.36	.00	.29	17.24	47.30	1.00	8.53
m-stairs, gain	.35	.50	.21	.49	68.53	319.7	1.16	15.63	.30	.34	.14	.38
titration, gain	.18	.27	.05	.35	1.35	3.62	.31	.69	.51	.36	.41	.39
matching, loss	-.02	.25	.00	.20	.08	.30	.00	.21	8.56	50.35	1.00	1.87
m-stairs, loss	.11	.29	.02	.08	3.53	15.22	.03	.19	.73	.56	.72	.67
titration, loss	.04	.22	.00	.05	9.12	58.53	.00	.15	1.51	3.18	1.00	.53

Overall, then, we have evidence that the options presented to participants in the choice-based methods affected the discount rates that they expressed. While matching has the advantage of not providing any anchors or suggestions to participants, it is nonetheless still quite susceptible to influence from other sources. This is not a particularly novel finding, as theories and findings of constructed preference (Johnson, Haubl, & Keinan, 2007; Weber et al., 2007) and coherent arbitrariness (Ariely, Loewenstein, & Prelec, 2003) are plentiful. However, it has not received much attention in intertemporal choice. Many differences in discount rates between

studies may be explained by differences in the amount and order of options that experimenters presented to participants.

Ease of use for participants

Another factor in determining which method to use is how easy it is for participants to complete. Qualitative evidence from piloting and from participants' comments indicated that participants often had a hard time understanding and answering the matching questions. They had a hard time picking a number "out of the air", and also had a hard time understanding the concept of indifference points. While the titration method was relatively easy for participants to answer, they found the multiple staircase method quite onerous. Even though the number of questions was smaller than for titration, participants perceived it to be longer. It was difficult for participants to switch back and forth between different timescales, and participants had trouble answering the later questions, which were often quite near their indifference points and so were difficult to decide on.

Quantitative evidence to support these observations came from participants' responses to the environmental scenario. The rational response was to value future improvements or deterioration in air quality less than immediate improvements or deterioration in air quality. For example, if someone is willing to pay $200 for an immediate improvement in air quality, then they should not be willing to pay as much for an improvement that would begin in fifty years. We calculated the proportion of participants that valued the fifty year change more than the immediate change, and found that it happened 38% of the time with matching, 11% of the time with multiple staircase, and 7% of the time with titration. Pairwise proportion tests indicated that both of the choice-based methods showed less confused responses than the matching method, $p<.001$. Qualitative data reinforced that the matching participants were indeed making confused

mistakes when responding to the environmental scenario, rather than expressing their true preferences. For example, one typical participant wrote "This was confusing to me. I would pretty much always take better air quality over a financial incentive. I wasn't clear whether this would mean putting a high value on the rebate option now or in the future." Our interpretation is that it is difficult for participants to pull dollar values out of the air, and while this is somewhat manageable when participants only have to think about different amounts of money at different times, it becomes extremely difficult to do when participants have to consider tradeoffs between air quality and money at different points in time. Therefore, although 38% of the participants in our matching sample showed negative discount rates, we believe that these were nearly all errors in responding.

Predicting consequential choices

Perhaps most importantly, researchers are interested in understanding real, consequential choices that people make. We therefore compared the ability of discount rates from the hypothetical scenarios to predict two consequential choices. First, we used the 1-year hyperbolic discount rate to predict whether participants would choose to receive $100 today or $200 in the future (and some participants were randomly selected and paid out for real money). Due to skew and outliers in the distributions, we used the non-parametric Spearman's rho. As seen in Table 2, the correlations were always positive, meaning that participants with higher discount rates were more likely to choose the immediate $100. The choice based methods clearly outperformed the matching method, and this makes intuitive sense: predicting a choice will be easier with a choice-based measure than a fill-in-the-blank measure. The better predictive power may also stem from the fact that participants found it easier to understand and respond to the choice-based measures of discounting.

We then looked at the ability of these discount rates to predict a real life choice: whether participants were a smoker or not. As seen in Table 2, the choice-based methods were sometimes able to predict this (with higher discount rates correlated with smoking), while the matching method was not. Oddly, the multiple-staircase method was better at predicting smoking rates with discount rates for gains, while titration was better at predicting using discount rates for losses. We don't have a good explanation for this difference.

Table 3

*Non-parametric correlations (Spearman's rho) between hypothetical discount rates measured in different ways and consequential intertemporal choices. The † symbol indicates p<.1 two-tailed, * indicates p<.05, and ** indicates p<.01.*

	Choosing a $100 gain now over $200 in one year	Smoking
matching, gain	.07	-.04
m-stairs, gain	.33*	.40**
titration, gain	.67**	.00
matching, loss	.16	.16
m-stairs, loss	.28†	.06
titration, loss	.26†	.41**

These results suggest that researchers who are interested in predicting consequential intertemporal choices should employ choice-based methods. It's possible that matching might be better for predicting those real-life situations that require the person to name a number, such as deciding how much to contribute to a retirement plan, or how quickly to pay down a debt. This remains to be tested in future research.

Conclusions

Choice-based measures of discounting are a double-edged sword, to be used carefully. On one hand, they outperform matching at predicting consequential intertemporal choices. On the other hand, the options (and order of options) that researchers use will influence participants' answers, so experimental design and interpretation must be done with care. Differences in discount rates observed between studies may be attributed to differences in elicitation technique, consistent with long-established research on risky choice that has come to the same conclusion (Lichtenstein & Slovic, 1971; Tversky, et al., 1988).

Overall, discount rates elicited from choice-based methods were higher than those from matching, consistent with previous research (Ahlbrecht & Weber, 1997; Frederick, 2003; Read & Roelofsma, 2003). We agree with Frederick (2003) that this probably happens because the choice based methods implicitly suggest high discount rates to participants, while matching has less demand characteristics. However, it should easily be possible to design a study with a choice-based measure of discounting that would elicit lower discount rates than matching techniques, simply by choosing a range of choice options that is extremely low. When doing within-subjects analysis, we found strong order effects; participants gave very different responses to the matching questions depending on whether they completed them before or after a choice-based method. Therefore, future research on methods should be careful to account for this.

In in comparison with the standard, fixed-sequence titration method, we did not find compelling advantages for the multiple staircase method we developed. This is consistent with another recent study on dynamic vs fixed sequence choice, which also found no major

differences (Rodzon, Berry, & Odum, 2011). In some ways, it is disappointing that our attempt to improve measurement was unsuccessful. However, the good news is that the simple titration measure, which is much more convenient to implement, still remains one of the best methods.

While we have focused on choice and matching techniques, because have been most commonly used in the literature, it should be noted that many other techniques have recently been tested and compared, including intertemporal allocation, evaluations of sequences, and intertemporal auctions (Frederick & Loewenstein, 2008; Guyse & Simon, working paper; Olivola & Wang, working paper). All of these investigations have found difference in discount rates based on the elicitation technique.

In terms of best practices for studying temporal discounting, our recommendation for now is to use the measurement method most congruent with the real-world phenomenon one hopes to explain or understand. When in doubt, a choice-based method should be used, because it has shown the best predictive power so far. However, care must always be taken when considering the choice options presented to participants, as these will undoubtedly influence the observed discount rates.

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Appendix A: Full text of the discounting scenarios

Financial Gain

Imagine the city you live in has a budget surplus that it is planning to pay out as rebates of $300 for **each** citizen. The city is also considering investing the surplus in endowment funds that will mature at **different possible times** in the future. The funds would allow the city to offer rebates of a different amount, to be paid at different possible times in the future. For the purposes of answering these questions, please assume that you will not move away from your current city, even if that is unlikely to be true in reality.

Financial Loss

Imagine the city you live in has a budget shortfall that it is planning to cover through a one-time fee of $300 for **each** citizen. The city is also considering covering the shortfall using fixed-interest bonds that will mature at **different possible times** in the future. Offering these bonds would require the city to charge the citizens a different amount, to be paid when the bonds mature. For the purposes of answering these questions, please assume that you will not move away from your current city, even if that is unlikely to be true in reality.

Environmental Gain

Imagine the current air quality (measured by number and size of particulates) in your area is neither particularly good nor especially bad. The local government has a budget surplus that it will either return to the citizens as rebates, or spend to enact various policy and infrastructure changes that will lead to a permanent improvement in air quality. Once the changes are put into place, the air will feel surprisingly clean and fresh.

Policy changes will include stricter emissions standards for factories and power plants; the city will compensate those factories and power plants for any costs incurred. Infrastructure changes will include using a fleet of cleaner-burning, more fuel-efficient vehicles in place of those currently used in the public transportation system and by city employees.

We are **not** interested in how you feel about specific measures meant to improve air quality. Rather, we are interested in knowing how much this improved air quality would be worth to you, depending on when the change is implemented. The following questions will ask about your preference between receiving a sum of money as a rebate now, or having noticeably improved air quality starting at different possible times, now or in the future. For the purposes of these questions, please assume you will continue to live in your current city, even if that is unlikely to be true in reality.

Environmental Loss

Imagine the current air quality (measured by number and size of particulates) in your area is neither particularly good nor especially bad. The local government has a budget shortfall that it will either cover by charging the citizens, or reduce spending on various policy and infrastructure repairs, leading to a permanent deterioration in air quality. Once the changes are put into place, the air will feel surprisingly dirty and stale.

Policy changes will include weaker emissions standards for factories and power plants; the city will earn more in taxes from those factories and power plants, as their profits will increase under the weaker standards. Infrastructure changes will include using a fleet of cheap, less fuel-

efficient vehicles in place of those currently used in the public transportation system and by city employees.

We are **not** interested in how you feel about specific measures affecting the air quality. Rather, we are interested in knowing how much it would be worth to you to avoid this worsened air quality, depending on when the change is implemented. The following questions will ask about your preference between paying a sum of money as a one-time fee now, or having noticeably worsened air quality starting at different possible times, now or in the future. For the purposes of these questions, please assume you will continue to live in your current city, even if that is unlikely to be true in reality.

Appendix B: Sample questions from each of the measurement methods and scenario types

Matching, Financial Gain

How much would a rebate **one year** from now have to be in order to make it equally attractive as $300 **now**?

Please fill in the amount that would make the following options equally attractive.

A. Receive $300 **immediately**.

B. Receive $____ **one year** from now.

Matching, Financial Loss

How much would a tax **one year** from now have to be in order to make it as unattractive as paying $300 **now**?

Please fill in the amount that would make the following options equally unattractive.

A. Pay $300 **immediately**.

B. Pay $____ **one year** from now.

Titration, Financial Gain

Please choose the option that you prefer in each pair.

What if the rebate were to be paid **one year** from now?

A1.	Receive $300 **immediately**	Receive $250 **one year** from now
A2.	Receive $300 **immediately**	Receive $475 **one year** from now
A3.	Receive $300 **immediately**	Receive $900 **one year** from now
A4.	Receive $300 **immediately**	Receive $1,750 **one year** from now
A5.	Receive $300 **immediately**	Receive $3,300 **one year** from now
A6.	Receive $300 **immediately**	Receive $6,400 **one year** from now
A7.	Receive $300 **immediately**	Receive $12,000 **one year** from now
A8.	Receive $300 **immediately**	Receive $23,500 **one year** from now
A9.	Receive $300 **immediately**	Receive $45,000 **one year** from now

A10.	○ Receive $300 **immediately**	○ Receive $85,000 **one year** from now

Titration, Financial Loss

Please choose the option that you prefer in each pair.

What if the tax were to be paid **one year** from now?

A1.	○ Pay $300 **immediately**	○ Pay $250 **one year** from now
A2.	○ Pay $300 **immediately**	○ Pay $475 **one year** from now
A3.	○ Pay $300 **immediately**	○ Pay $900 **one year** from now
A4.	○ Pay $300 **immediately**	○ Pay $1,750 **one year** from now
A5.	◉ Pay $300 **immediately**	○ Pay $3,300 **one year** from now
A6.	○ Pay $300 **immediately**	○ Pay $6,400 **one year** from now
A7.	○ Pay $300 **immediately**	○ Pay $12,000 **one year** from now
A8.	○ Pay $300 **immediately**	○ Pay $23,500 **one year** from now
A9.	○ Pay $300 **immediately**	○ Pay $45,000 **one year** from now
A10.	○ Pay $300 **immediately**	○ Pay $85,000 **one year** from now

Multiple Staircase, Financial Gain

Which option do you prefer:

○ Receive $300 **now**	OR	○ Receive $7,700 **one year from now**

Multiple Staircase, Financial Loss

Which option do you prefer:

○ Pay $300 **now**	OR	○ Pay $7,736 **one year from now**

Matching, Environmental Gain

What amount of money now would be as valuable to you as getting improved air quality starting **one year from now**? In other words, how much would a rebate have to be in order to make it difficult or impossible for you to choose whether you would prefer getting that amount of money immediately or getting the cleaner air in one year?

Please fill in the amount that would make the following options equally attractive.

(NOTE: $0 would indicate that improved air quality is worthless to you.)

A. Improved air quality starting **one year from now**.

B. Receive $____ **immediately**.

Matching, Environmental Loss

Paying what amount of money now would be as costly to you as suffering worse air quality starting **one year from now**? In other words, how much would a tax have to be in order to make it difficult or impossible for you to choose whether you would prefer paying that amount of money immediately or suffering the dirty air in one year?

Please fill in the amount that would make the following options equally unattractive.

(NOTE: $0 would indicate that air quality is worthless to you.)

A. Worse air quality starting **one year from now**.

B. Pay $____ **immediately**.

Titration, Environmental Gain

What if the improved air quality were to start **one year from now**?

B1.	Receive $20 **immediately**.	Permanently improved air quality starting **one year from now**.
B2.	Receive $50 **immediately**.	Permanently improved air quality starting **one year from now**.
B3.	Receive $130 **immediately**.	Permanently improved air quality starting **one year from now**.
B4.	Receive $325 **immediately**.	Permanently improved air quality starting **one year from now**.
B5.	Receive $800 **immediately**.	Permanently improved air quality starting **one year from now**.
B6.	Receive $2,100 **immediately**.	Permanently improved air quality

		starting **one year from now**.
B7.	Receive $5,200 **immediately**.	Permanently improved air quality starting **one year from now**.
B8.	Receive $13,000 **immediately**.	Permanently improved air quality starting **one year from now**.
B9.	Receive $33,000 **immediately**.	Permanently improved air quality starting **one year from now**.
B10.	Receive $85,000 **immediately**.	Permanently improved air quality starting **one year from now**.

Titration, Environmental Loss

What if the worse air quality were to start **one year from now**?

B1.	Pay $20 **immediately**.	Permanently worse air quality starting **one year from now**.
B2.	Pay $50 **immediately**.	Permanently worse air quality starting **one year from now**.
B3.	Pay $130 **immediately**.	Permanently worse air quality starting **one year from now**.
B4.	Pay $325 **immediately**.	Permanently worse air quality starting **one year from now**.

B5.	Pay $800 **immediately**.	Permanently worse air quality starting **one year from now**.
B6.	Pay $2,100 **immediately**.	Permanently worse air quality starting **one year from now**.
B7.	Pay $5,200 **immediately**.	Permanently worse air quality starting **one year from now**.
B8.	Pay $13,000 **immediately**.	Permanently worse air quality starting **one year from now**.
B9.	Pay $33,000 **immediately**.	Permanently worse air quality starting **one year from now**.
B10.	Pay $85,000 **immediately**.	Permanently worse air quality starting **one year from now**.

Multiple Staircase, Environmental Gain

What if the improved air quality were to start **one year from now**?

B1.	Receive $20 **immediately**.	Permanently improved air quality starting **one year from now**.
B2.	Receive $50 **immediately**.	Permanently improved air quality starting **one year from now**.
B3.	Receive $130 **immediately**.	Permanently improved air quality starting **one year from now**.

B4.	Receive $325 **immediately**.	Permanently improved air quality starting **one year from now**.
B5.	Receive $800 **immediately**.	Permanently improved air quality starting **one year from now**.
B6.	Receive $2,100 **immediately**.	Permanently improved air quality starting **one year from now**.
B7.	Receive $5,200 **immediately**.	Permanently improved air quality starting **one year from now**.
B8.	Receive $13,000 **immediately**.	Permanently improved air quality starting **one year from now**.
B9.	Receive $33,000 **immediately**.	Permanently improved air quality starting **one year from now**.
B10.	Receive $85,000 **immediately**.	Permanently improved air quality starting **one year from now**.

Multiple Staircase, Environmental Loss

What if the worse air quality were to start **one year from now**?

B1.	Pay $20 **immediately**.	Permanently worse air quality starting **one year from now**.
B2.	Pay $50 **immediately**.	Permanently worse air quality starting **one year from now**.

B3.	Pay $130 **immediately**.	Permanently worse air quality starting **one year from now**.
B4.	Pay $325 **immediately**.	Permanently worse air quality starting **one year from now**.
B5.	Pay $800 **immediately**.	Permanently worse air quality starting **one year from now**.
B6.	Pay $2,100 **immediately**.	Permanently worse air quality starting **one year from now**.
B7.	Pay $5,200 **immediately**.	Permanently worse air quality starting **one year from now**.
B8.	Pay $13,000 **immediately**.	Permanently worse air quality starting **one year from now**.
B9.	Pay $33,000 **immediately**.	Permanently worse air quality starting **one year from now**.
B10.	Pay $85,000 **immediately**.	Permanently worse air quality starting **one year from now**.

Appendix C: The multiple staircase method

For the financial scenario, the future amount each staircase was bounded by $250 on the low end, and $100,000 on the high end. The immediate amount was always fixed at $300. Each staircase began with a choice between $300 immediately and an amount in the future that was

roughly 7.5% of the maximum amount ($100,000). This was chosen based on pretesting, determining that this would reach indifference points quickly for most participants. The actual future amount was jittered by a random amount (up to 1% greater or less than the desired amount) and rounded to the nearest dollar so that amounts would not be exactly the same among the various staircases. Therefore, the first question most participants saw was something like a choice between $300 immediately or $7548 in 1 year.

Subsequent questions in each staircase were chosen dynamically based on the participant's response to the previous question. The future amount was chosen to be 80% of the between the previous amount and the maximum or minimum, as appropriate. For example, if, in the first question, the participant preferred $300 today over $7,548 in the future, the next choice might be between $300 today and $1,709 in 1 year (again, the future amount is jittered). Alternately, if the participant initial preferred the future $7,548 over $300 today, the next question might be a choice between $300 today and $81,510 in one year. This 80% method was chosen rather than bisection (50%) because it was found based on pretesting that this reached indifference points faster: at short delays, most indifference points were relatively low, while at long delays indifference points were relatively high, and the 80% method allowed the staircase to reach the extremes of the scale more quickly.

Each staircase consisted of seven questions chosen in this manner, plus two questions to check for attention and/or railroading.[2] The first check was mean to test for consistency, and was chosen by taking the amount from the first question and adding or subtracting 2% to make an "easy" question. For example, if the participant initially chose $300 today over $1,709 in one

[2] Railroading would be if a participant made a mistake when answering the first question. If this happened, the subsequent questions would be unlikely to get near his/her indifference point.

year, the first check might be a choice between $300 today and $1,743. Clearly, the participant would be expected to choose the immediate $300 on the check question as well. The second check was meant to test whether the participant was always choosing the immediate option or always choosing the future option, without thinking. Therefore, the "correct" answer to the second check question was always designed to be the opposite of the answer given to the first question. This second check question posed the $300 immediate against an extremely large or small future amount, as appropriate (it was either the scale minimum divided by 2, or the scale maximum times 200). For example, if the participant initially chose $300 today over $1,709 in one year, the second check question might ask about $300 today or $20,000,000 in one year. On the other hand, if the participant initially chose $1,709 in the future, the second check might ask about $300 today vs $125 in the future.

Thus, each staircase consisted of nine questions total: seven regular questions, and two check questions. The check questions were the fifth and eighth questions, respectively. Pretesting indicated that participants enjoyed the check questions because they were easy to answer, giving them a break from the questions near their indifference points, which were difficult to answer.

The *multiple* part of the multiple staircase method came from the fact that three different scales were interleaved, one for each delay, in random order. So, participants were answering questions about 1-year, 10-year, and 50-year delays, in random order.

As a sample, here are the options that might be presented to one participant based on their choices. Note that each choice was presented one at a time, in contrast to the titration method, where all the options were presented on one page. The option the hypothetical participant chooses in each case is indicated with an X:

X Receive $300 now OR Receive $7,786 **fifty years from now**

Receive $300 now OR Receive $7,771 **one year from now** X

Receive $300 now OR Receive $7,737 **ten years from now** X

X Receive $300 now OR Receive $1,739 **ten years from now**

Receive $300 now OR Receive $1,764 **one year from now** X

X Receive $300 now OR Receive $82,087 **fifty years from now**

X Receive $300 now OR Receive $548 **one year from now**

Receive $300 now OR Receive Receive $6,574 **ten years from now** X

Receive $300 now OR Receive $96,620 **fifty years from now** X

X Receive $300 now OR Receive $2,690 **ten years from now**

X Receive $300 now OR Receive $311 **one year from now**

Receive $300 now OR Receive $85,257 **fifty years from now X**

X Receive $300 now OR Receive $5,747 **fifty years from now**

Receive $300 now OR Receive $9,688 **one year from now** X

Receive $300 now OR Receive $9,708 **ten years from now** X

Receive $300 now OR Receive $3,501 **ten years from now** X

X Receive $300 now OR Receive $356 **one year from now**

Receive $300 now OR Receive $84,733 **fifty years from now** X

Receive $300 now OR Receive $513 **one year from now** X

Receive $300 now OR Receive $82,385 **fifty years from now** X

Receive $300 now OR Receive $2,845 **ten years from now** X

X Receive $300 now OR Receive $125 **one year from now**

Receive $300 now OR Receive $20,176,000 **fifty years from now** X

X Receive $300 now OR Receive $126 **ten years from now**

X Receive $300 now OR Receive $2,832 **ten years from now**

Receive $300 now OR Receive $81,424 **fifty years from now** X

X Receive $300 now OR Receive $478 **one year from now**

The environmental multiple staircase was identical to the financial multiple staircase, but with two changes. The first was that there were four staircases (immediate, 1-year, 10-year, and 50-year) rather than three. The other was that the minimum amount was set to $0, based on pretesting which found that some participants placed a very low willingness-to-pay or willingness-to-accept for air quality.

Paper 2: Discounting future green: Money vs. the environment

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KEYWORDS: Temporal Discounting, Intertemporal Choice, Environment, Health, Money

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Abstract

In three studies, participants made choices between hypothetical financial, environmental, and health gains and losses that took effect either immediately or with a delay of 1 or 10 years. In all three domains, choices indicated that gains were discounted more than losses. There were no significant differences in the discounting of monetary and environmental outcomes, but health gains were discounted more and health losses were discounted less than gains or losses in the other two domains. Correlations between implicit discount rates for these different choices suggest that discount rates are influenced more by the valence of outcomes (gains vs. losses) than by domain (money, environment, or health). Overall, results indicate that *when controlling as many factors as possible,* at short to medium delays, environmental outcomes are discounted in a similar way to financial outcomes, which is good news for researchers and policy makers alike.

Discounting future green: Money versus the environment

The future is less important than the present. This is the story told both by rational, economic models of how we should deal with delayed outcomes and by descriptive, psychological models of how we actually deal with them. This makes sense for many reasons. For example, getting $250 today is generally worth more than getting $300 in ten years (even adjusting for inflation) because the immediate $250 could be invested in the meantime, and would yield more than $300 with accumulated interest after 10 years. Time delay also introduces a host of uncertainties that reduce the value of the promised outcome in a similar way to probabilistic receipt of outcomes in a lottery. You might die before the ten years have passed, or the institution that was promising the $300 may no longer exist in ten years' time. Furthermore, psychological factors such as impatience or lack of self control also pay a role, i.e., you may want to get the money right away ("pure time preference"). The rate at which future outcomes are devalued is known as the discount rate.

Understanding the factors that affect discounting is critical for analysis of decisions involving tradeoffs between present and future benefits (or costs). For example, at the individual level, prudent pension investment choices are often inhibited by temporal near-sightedness (Thaler & Benartzi, 2004). At a policy level, leading economists assert that "the biggest uncertainty of all in the economics of climate change is the uncertainty about which interest rate to use for discounting" (Weitzman, 2007). While much of this debate has evolved around the philosophical and ethical issues that might dictate what discount rate(s) *should* be used to make cost-benefit calculations for different courses of action in such policy contexts, behavioral research on the *actual* discount rates implicit in people's intertemporal decisions is necessary to understand how citizens and voters will perceive intertemporal tradeoffs between financial and

environmental gains and losses and how they will thus react to public policy proposals. What are the best ways to help people save more for retirement, lose weight, or preserve a healthy environment for their children?

Rational, economic models of discounting dictate that all future outcomes should be discounted at a continuously compounded, exponential rate. This rate is generally chosen based on the rate of return on conservative investments available in the financial markets, something around 6%. This rate incorporates uncertainty, potential opportunity costs, and the increasing standard of living (including technological advancement). All goods and services (including health, air quality, etc) are considered potentially tradable with money, thus all future outcomes should be discounted at the same rate.

In contrast to this economic model, many other factors typically drive people's actual evaluation of future outcomes. The most notable is a strong desire, all other things being equal, to get things now (aka positive pure time preferences or temporal myopia). This present bias leads to a hyperbolic pattern of discounting in both human and non-human animals (Mazur, 1987; Frederick, Loewenstein & O'Donoghue, 2002), such that we discount at a relatively greater rate (per unit of time) when considering short delays than when considering longer ones. Recently, this pattern of discounting is thought to result from two neural processing systems, so-called beta and delta systems (McClure, Laibson, Loewenstein & Cohen, 2004; McClure, Ericson, Laibson, Loewenstein & Cohen, 2007; Viscusi, Huber & Bell, 2008), although other results are more consistent with a single system (Glimcher & Kable, 2007; Kable & Glimcher, 2007). The beta system represents our emotional, affect based preference for immediate outcomes (now vs not now), while the delta system represents the more rational, reasoned

discounting of future outcomes (per unit of delay) based on uncertainty and (projected) increased future resources.

In addition to present bias, several other robust "irrational" phenomena have been documented in descriptive studies (for a review, see Frederick et al., 2002): people discount gains more than losses (the "sign effect", Thaler, 1981), discount large outcomes less than small ones (the "magnitude effect," Thaler, 1981), and discount more when the default is to receive something now than when the default is to receive it later (the "accelerate-delay" asymmetry, Loewenstein, 1988; Weber et al., 2007). We also prefer improving sequences to declining ones with the same average (Hsee, Abelson & Salovey, 1991; Loewenstein & Sicherman, 1991), and prefer to spread positive experiences out over time rather than experience them all immediately (Loewenstein & Prelec, 1993).

Domain Differences in Time Preferences?

While the vast majority of studies of discounting have examined preferences for financial gains (ie, receipt of a $1000 now or in a year's time), little is known about whether the models and insights developed from this line of research apply equally well to other domains (ie, better air quality in a year's time). Rational-economic models assume explicitly and many behavioral models assume implicitly that while discount rates may vary between individuals, reflecting their differing time preferences, a given individual or government should and does use the same discount rate for future outcomes in different domains. Yet despite the fact that government offices often attempt to set a single official discount rate for use in evaluating all long term projects and investments (Lind, 1982; Her_Majesty's_Treasury, 2004; Lebègue, Hirtzman & Baumstark, 2005), in practice government agencies often use different discount rates in different sectors of the economy (Lind, 1982; Spackman, 1991). As Henderson and Bateman (1995) note,

although "differing discount rates may be the result of government and agency policy manipulation by narrow interest groups… it is equally possible that the general public will is being correctly expressed…" (p 416).

A parallel can be drawn from intertemporal choice to risky choice, where the dominant rational-economic assumption continues to be that risk attitude (i.e., the discounting of an outcome as a function of how likely or unlikely it is expected to occur) can vary between individuals, but that a given individual should exhibit the same level of risk aversion to outcomes in all domains (after adjusting for differences in the marginal value of outcomes in different domains). Contrary to that assumption, however, it has become well established empirically that the risk attitudes of individuals differ quite strongly across different domains (Weber, Blais & Betz, 2002). Preferences are multiply determined, and these multiple factors (such as domain familiarity, cultural norms for risk taking, etc) vary by domain. In the small number of studies that have examined temporal discounting for outcomes other than in the financial domain (contrasting them to health outcomes), domain dependencies of various sorts have also been reported (Chapman, 1996a; b; 2003). Recent theoretical developments also suggest that different goals (e,g., financial vs. social, vs. environmental goals) may be discounted at different rates (Krantz & Kunreuther, 2007).

A few previous studies have examined the discounting of environmental outcomes and made comparisons to the discounting of financial outcomes, but did not control for possible confounding factors. For example, Bohm & Pfister (2005) report data suggesting that temporal discounting is lower for environmental outcomes than for financial outcomes. Their scenarios presented participants with potential environmental losses to be incurred by others, whereas the typical financial discounting study presents participants with monetary gains that are available to

the participant him/herself. The low discount rates observed may thus have been due to the difference in valence (as gains are typically discounted more than losses, Thaler, 1981) or the difference between who was affected by the consequences (others vs. self). Similarly, in a brief review of temporal discounting studies, Gattig & Hendrickx (2007) conclude that discounting is less pronounced for environmental risks than for other domains, noting that a substantial proportion of participants (in the range of 30% to 50%) do not discount environmental risks at all. However, none of the papers reviewed directly compared monetary and environmental outcomes nor did they control for potentially confounding factors such as the valence of outcomes.

Why is the valence of outcomes important? Just as risk attitudes differ between gain and loss decisions (Kahneman & Tversky, 1979; Tversky & Kahneman, 1981), with risk aversion for gains and risk seeking for losses, so has discounting been found to differ for outcomes that are seen as gains and those seen as losses. For desirable outcomes, immediate receipt is attractive and delaying immediate receipt needs to be compensated. For undesirable outcomes (like traffic tickets), immediate receipt is unattractive and thus people should be willing to pay a premium to put such events off, discounting the delayed payment of traffic fines in the same way they would discount the delayed receipt of gift certificates. However, observed discount rates for losses are typically far smaller than those for gains (Thaler, 1981; Frederick et al., 2002), presumably because additional factors are at play, such as the desire to get the unpleasant event out of the way, rather than having it hanging over one's head (Loewenstein, 1987). Note that a positive time preference -- desiring to experience something now rather than later, all other things being equal -- translates formally into a higher discount rate for gains but a *lower* discount rate for losses.

To the best of our knowledge, only one empirical study has controlled for the sign of outcomes when comparing intertemporal preferences for monetary and environmental outcomes (Guyse, Keller & Eppel, 2002). It found that graduate business students preferred increasing (graphically represented) *sequences* of air and water quality but decreasing sequences for income. However, as the authors note, business school students are trained in net present value computations and know that the "right" answer for monetary sequences is to prefer the decreasing profile (with the highest initial payout). Thus, this population may not be representative of the general public.

Given the lack of research directly comparing discounting of monetary and environmental outcomes, one may look to discounting of other non-monetary domains, such as health, for evidence that nonmonetary dimensions like environmental outcomes may be discounted differently. Based on a series of studies, Chapman (2003) concluded that although on average, across respondents and conditions, mean discount rates for money and health outcomes were similar, and the same contextual factors known to influence financial discount rates (length of delay, and magnitude and valence of outcomes) also affected the discount rates for health outcomes (Chapman & Elstein, 1995; Chapman, 1996a; b), discount rates were, in fact, domain dependent. In particular, Chapman found that correlations of discount rates within a domain (roughly .6 to .8) were typically higher than correlations of discount rates between domains (.1 to .4). In other words, if someone steeply discounted a small financial gain delayed by one year, that person was likely to discount other financial gains (of different amounts, at different delays) relatively steeply as well. In contrast, this same person might discount health outcomes much less steeply (while the opposite pattern could be true for someone else).

The Present Research

In order to investigate possible domain differences in time preference, it is necessary to control for the multiple factors that typically distinguish intertemporal decisions involving environmental outcomes from those involving monetary outcomes. Specifically, environmental outcomes typically affect multiple people (rather than only the decision-maker), on a longer time-scale (sometimes exceeding the lifetime of the decision maker), and are often less familiar and more ambiguous than typical monetary outcomes. Furthermore, environmental outcomes often result in semi-permanent changes in the state of the world (changes in what economists would call streams of consumption) rather than a one-time consumption event. In other words, as typically studied in laboratory studies, the utility from receiving a monetary reward is assumed to be experienced at one point in time, whereas the utility from an environmental outcome such as an improvement in water quality or the extinction of a species is often experienced over a long period of time.

The present research endeavored to examine domain differences while controlling for these confounding factors as much as possible. The values of environmental goods are often measured (and the implicit discount rate inferred) by "pricing them out" through contingent valuation (Mitchell & Carson, 1989), which relies on the perception of respondents that environmental outcomes can be easily valued in and exchanged for dollars (and vice versa). However, this may not be a valid assumption (Gregory, Lichtenstein & Slovic, 1993; Schkade & Payne, 1994; Frederick, 2006). For example, when asked to assign a monetary value (e.g., their willingness-to-pay) to some environmental consequence, respondents often express the strength of their attitudes (protecting the environment is important), or express what they consider a fair contribution, rather than communicating the result of a cost/benefit analysis reflecting the magnitude and value of the environmental outcome (Schkade & Payne, 1994). Thus, discount

rates assessed through contingent valuation may be very misleading. In contrast, and following the methodology of the health discounting literature, the studies we present here assessed discount rates using within domain measures.

Study 1

In the first study, we compared discounting of monetary gains and losses with discounting of four environmental scenarios: air quality gains, air quality losses, mass transit gains, and garbage pileups (a loss). Choices in all cases involved an immediate option and an option with a one-year time delay. Efforts were made to control for commonly confounded factors, including timescale, uncertainty, who was affected (although discount rates in hypothetical scenarios for oneself and others may not differ in any case, see Cairns & van der Pol, 1999; Pronin, Olivola & Kennedy, 2008), and one-time consumption vs. a change in consumption streams.

In making our predictions, we faced a conflict between two theoretic traditions. While classic economic models (Samuelson, 1937) assert that financial and environmental outcomes should be discounted at the same rate, more recent psychological theories contend that different domains prime diverse goals (e.g., material, social, moral-ethical) with different intertemporal preferences (Krantz & Kunreuther, 2007; Weber, In Press). Do common mechanisms underlie the valuation of all future events? Or is the extensive research on discounting of economic gains inapplicable to discounting of environmental outcomes? After all, while the most common rationale for discounting economic gains is the possibility of investment in the marketplace, many people believe that, as an ethical matter, environmental benefits should not lose value simply because they are realized in the future.

These domain differences in opportunities for alternative investment and ethical considerations led us to predict that environmental outcomes would be discounted less than financial outcomes, consistent with previous findings and conjectures (Svenson & Karlsson, 1989; Nicolaij & Hendrickx, 2003; Gattig & Hendrickx, 2007). We also hypothesized that within-domain discount rates would be more highly correlated than between-domain discount rates, based on Chapman's domain dependence findings (Chapman & Elstein, 1995; Chapman, 1996a; b; Chapman, Nelson & Hier, 1999; Chapman, 2003). In other words, if you wanted to know how much someone valued future environmental gains, it would be difficult to predict based only on knowing how much she valued future financial gains, presumably because time preferences may be different in each domain.

Method

*Participants***.** 90 participants were recruited online via classified ads for a study on decision making, and were compensated $8 for their participation. We excluded the data from 6 participants who did not complete the study, from 3 participants who completed the study in less than 10 minutes (mean completion time was 31 minutes), and data from 16 participants whose responses to the titration items (described below) switched back and forth more than once, or switched in a manner that would only make sense if they preferred more losses or less gains (i.e., preferring $150 now to $250 in one year yet also preferring $230 in one year to $150 now). All further analyses area based on the 65 remaining participants.[1]

Participants were 66% female, with an average age of 31 (*SD* = 9.2). 52% were married, and 54% had children. 27% were students, 62% had a college degree of some kind, and the median household income was $35,000 - $49,999.

Procedure. After answering questions for an unrelated study, participants considered hypothetical financial and environmental scenarios in which they made a series of choices between immediate and future outcomes (for example, a choice between receiving $250 today or receiving $370 one year in the future). All participants responded to four scenarios: two monetary scenarios (one gain, one loss), and two environmental scenarios (one gain, one loss), in counterbalanced order. For the environmental scenarios, participants randomly completed either two air quality scenarios (gain and loss) or a mass transit improvement (gain) scenario and garbage pile-up (loss) scenario. Finally, all participants provided demographic details. Thus, the study had a 2 (gain vs loss: within) X 2 (monetary vs environmental: within) X 2 (air quality vs transit & garbage: between) design.

Monetary Gain Scenario. Participants read the text, "Imagine you just won a lottery, worth $250, which will be paid to you immediately. However, the lottery commission is giving you the option of receiving a different amount, paid to you one year from now." They then answered 10 binary choice questions, where they chose between winning $250 immediately or winning $410 (or $390, or $370, etc) one year in the future. This *titration* procedure was used to elicit the point at which participants were indifferent between present and future gains. For this and all other titration measures, the scale went from roughly 1.6 to .9 times the present value (for example, $410 to $230). Following the titration, participants answered the following question: "Please fill in the number that would make you indifferent between the following two options: A. Win $250 immediately. B. Win $___ one year from now." A single indifference point for each participant was obtained from titration using the point at which he or she switched from preferring the future option to preferring the present option, unless the participant maxed out the titration scale, in which case the free response measure was used.

Monetary Loss Scenario. Participants were told to imagine they got a parking fine which they could pay immediately or one year in the future. Similar titration and free response questions were used to determine the indifference point between immediate and future payment.

Air Gain & Loss Scenarios. Participants were told to imagine the local county government was considering a temporary change to its emissions policy to study the effects of air quality on human health and the local wildlife. The particulate output of nearby factories and power plants would be immediately reduced [increased] for a period of three weeks, after which time the air quality would return to its former level, but the government was also considering making the change one year in the future, for a different length of time. Titration and free response items were used as before, with choices such as "Improved air quality immediately for 21 days, or improved air quality one year from now for 35 days." Participants were asked to consider only their personal preference (for improved [worse] air quality immediately or in the future) as they made their choices. Subsequently, to get a sense of how much they valued the air quality relative to the money, participants were asked whether they would choose to gain [lose] $250 or would choose improved [worse] air quality for 21 days.

Mass Transit (gain) Scenario. Participants were told to imagine the local transit authority had a temporary budget surplus which they were required to spend in the next 18 months, which would be used to improve the frequency, hours, and cleanliness of buses, trains, and subways. Furthermore, as more people would be expected to use mass transit, traffic congestion would also be reduced, benefiting those who drive cars or bicycles. The transit authority planned to implement the improvement immediately for 60 days, but was also considering doing it one year in the future for a different length of time. Participants responded to titration and free response items as before, and were again asked to consider only their personal preference. Subsequently,

participants chose between receiving $250 immediately or having improved transit immediately for 60 days.

Garbage Pile-Up (loss) Scenario. Participants were told to imagine the local sanitation workers union was planning to strike, which would lead to garbage and litter piling up on the streets and a bad smell. The union was planning to strike immediately for 21 days but was also considering striking one year in the future, for a different length of time. As before, titration and free response measures were used and participants were asked to consider only their personal preference. Subsequently, participants chose between paying $250 immediately or having garbage in the streets for 21 days.

Results

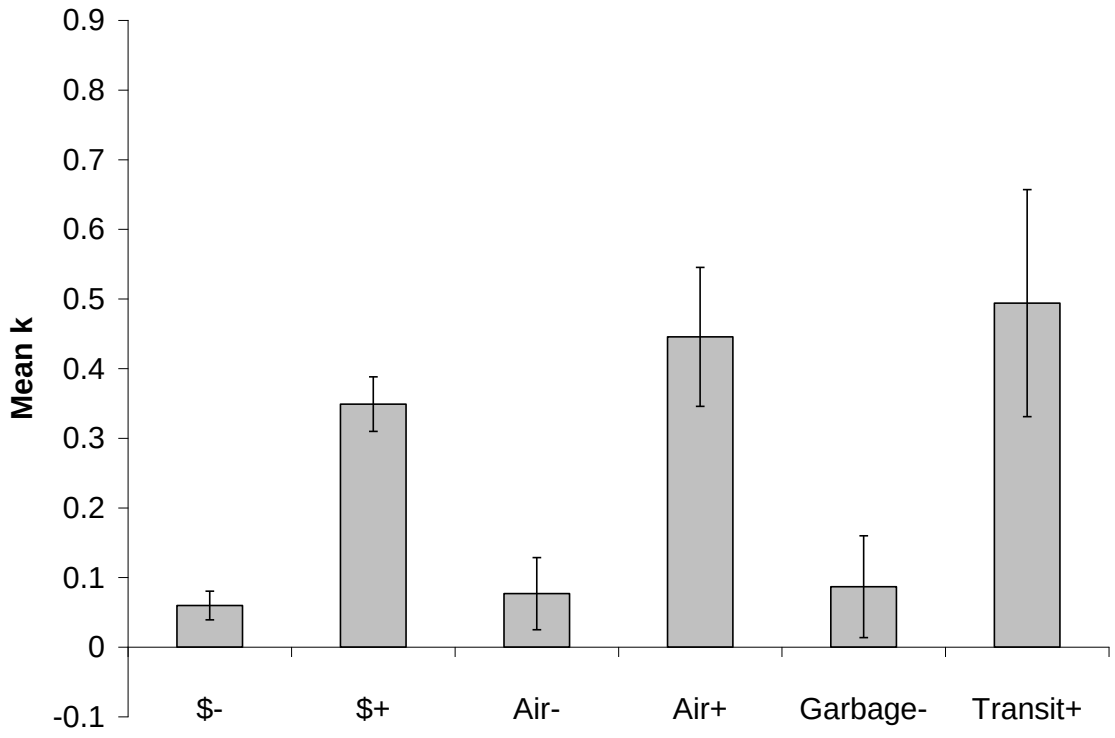
As described above, a combination of titration and free response measures were used to obtain a single indifference point for each scenario. To enable comparisons between scenarios and domains, these indifference points were converted to discount parameters using the hyperbolic discounting formula $V = A / (1+kD)$, where V = present value, A = future amount, D is the delay (typically in years), and k is a fitted parameter. This equation can be solved for k, the discount parameter that indicates how much someone values future outcomes relative to present outcomes. A k of zero means the present and future are valued equally. Positive values of k indicate that future outcomes are discounted (the more so, the larger k), meaning that decision maker prefers to receive gains now rather than later, or prefers to receive losses later rather than now. Negative values of k, on the other hand, indicate negative discounting, meaning that the decision maker prefers to receive gains later rather than now, or prefers to receive losses now rather than later. We chose this hyperbolic model because of its simplicity, considerable descriptive support (Mazur, 1987; Kirby & Marakovic, 1995; Myerson & Green, 1995; Kirby,

1997; Frederick et al., 2002), and relatively balanced treatment of positive and negative time preference (unlike an exponential discounted utility transformation, which minimizes extreme positive discounting but magnifies extreme negative discounting).

Mean discount parameters for each of the 6 scenarios are summarized in Figure 1. The smaller standard error bars in Figure 1 for the monetary scenarios partly reflect the fact that the number of observations (n = 65) is twice as large as for the air quality (n = 31) and other environmental (n = 34) scenarios.

Figure 1.

Mean discount parameters for monetary and environmental gains and losses in Study 1. Error bars are +/- one standard error.



Participants discounted monetary gains, k = 0.35 (*SD* = 0.32), more than losses, k = 0.06 (*SD* = 0.17), a significant difference, $t(64)=6.0$, $p < .001$, corresponding to a large effect size, $d = 4.6$. In more concrete terms, participants indicated that getting $250 now was roughly equivalent to getting $337.50 in one year, while losing $250 now was only equivalent to losing $265 in one year. Similarly, participants discounted air quality gains, k = 0.45 (*SD* = 0.56), more than losses, k = 0.08 (*SD* = 0.29), $t(30)=3.7$, $p = .001$, and discounted mass transit improvement, k = 0.49 (*SD* = 0.95), more than garbage pile-ups, k = .09 (*SD* = 0.43), $t(33)=2.4$, $p < .05$. For example, participants would prefer 31 days (or more) of better air quality in one year's time to 21 days of immediately better air quality, but would only prefer 23 days (or less) of future worse air quality to 21 days of immediately worse air quality. Although no significant differences were found in pair-wise comparisons of gains or losses between domains, the large standard deviations and low sample sizes meant that we only had sufficient power (.80) to detect fairly large differences (d = 1.2 or larger), so we could neither reject the null hypothesis nor conclude that there weren't any meaningful differences between domains.

A 2 (valence: positive or negative) x 2 (domain: monetary vs environmental) repeated-measures ANOVA confirmed the main effect of valence, $F(1,64) = 28.3$, $p < .001$, but not domain, $F(1,64) = 2.2$, $p = .14$, or the interaction, $F(1,64) = 1.2$, $p = .27$. Entering order effects into the model revealed that although the order of presentation of domain had no effect, participants discounted significantly more (for both domains and for gains and losses) when gains were presented first, $F(1,63) = 7.5$, $p < .01$. Entering age as a covariate, an (unpredicted) age by valence interaction indicated that older individuals responded to valence more strongly, discounting gains more and losses less, $F(1,63) = 9.07$, $p < .01$. Gender, marital status, number of children, education, occupation, and income each had no significant effect.

For comparison with previous studies which reported high rates of non-discounting for environmental scenarios, we computed the proportion of zero or negative discounting in each domain. While few individuals (see proportions in parentheses) exhibited zero or negative discounting for monetary (.00), air quality (.03), or mass transit (.06) gains, a substantial proportion displayed this pattern of preferences for monetary (.28), air quality (.35), and garbage (.35) losses. While differences between proportions for gains and losses were significant (all pair-wise comparisons significant at $p < .01$ or better), there were no (within-valence) differences between domains. Thus, while almost no one was indifferent to date of receipt of rewards or preferred to receive them later rather than now, a substantial number of participants preferred to incur losses immediately rather than later or were indifferent with respect to when the loss occurred. Even when removing zero and negative discounting values from the results, the sign effect remains significant (and also in Studies 2 and 3).

As seen in Table 1, discounting of monetary gains was correlated with discounting of air quality gains and transit gains, while discounting of monetary losses was correlated with discounting of air quality losses and garbage pile-ups (note that discounting of air quality could not be correlated with discounting of transit and garbage, as this was a between-subjects manipulation). Discount rates for gains and losses within each domain were not significantly correlated. In other words, discount rates were correlated for same-valence items but not different-valence items, regardless of domain.

Table 1

*Pearson correlations of discount parameters for gains and losses in monetary and environmental outcomes, in Study 1. * = p < .05, ** = p < .01*

	$-	$+	air-	air+	garbage-

$+	-.2			
air-	.38*	.23		
air+	-.19	.68**	.25	
garbage-	.41*	.46**		
transit+	-.13	.41*		.15

Only 10% of participants said they would prefer the immediate improved air quality for 21 days over receiving $250, while 42% said they would rather pay $250 than have worse air quality for 21 days. Similarly, 15% reported preferring 60 days of improved mass transit to the $250, and 35% said they would rather pay the $250 rather than have 21 days of garbage in the streets. These differences in choice proportions suggest that the degree of loss aversion (i.e., the observation that losses of a given magnitude hurt more than gains of the same magnitude provide pleasure) described by prospect theory (Tversky & Kahneman, 1992) was, in fact, stronger for the environmental outcomes than for financial outcomes (the gain or payment of $250), consistent with other studies (Novemsky & Kahneman, 2005).

Discussion

When presented with monetary and environmental gain and loss scenarios that were written to control confounding factors, participants discounted gains substantially more than losses but did not discount environmental outcomes significantly more or less than monetary outcomes. The valence difference was stronger between subjects; participants who were presented with gains first tended to discount all outcomes more overall, likely exhibiting greater discounting for gains and then endeavoring to remain somewhat consistent in their responses to other scenarios. Thus, in support of economic theories, it appears that time preference was similar for monetary and environmental outcomes.

As in previous studies on discounting of environmental losses, a substantial number of participants exhibited zero or negative discounting of environmental losses. However, a similar

proportion of participants showed this preference for monetary losses, thus suggesting that the pattern of results observed in previous studies may have been due more to the valence of the outcomes than the domain. Reinforcing this perspective, very few participants displayed zero or negative discounting of environmental gains. Recall that for losses, negative discounting implies that a participant would rather experience a larger, sooner loss than a smaller, later loss.

As in previous studies, discounting was moderately correlated between domains. This means that knowing how much someone valued future monetary gains relative to immediate monetary gains allows one to predict how much that participant valued future environmental gains relative to immediate environmental gains. However, correlations between discounting of gains and losses were quite low, so knowing how much someone discounted environmental gains tells little about how much they discounted environmental losses. In summary, the correlation data suggest that at both the individual subject level and averaged across subjects, discounting is influenced quite strongly by the valence of outcomes but not so much by their domain.

Study 2

While the lack of significant differences between environmental and monetary domains was somewhat surprising, null results are always difficult to interpret. We therefore ran a second study, with several objectives. Most importantly, we wanted to see if our null results with respect to domain differences would replicate with greater statistical power. One way of demonstrating such power was to replicate other domain differences previously demonstrated in prior research. In Study 2, we therefore compared the discounting of monetary and environmental outcomes with the discounting of health outcomes. Previous research has demonstrated that at short delays (1 year or less) health gains are discounted more than monetary gains (Chapman & Elstein, 1995; Chapman, 1996b; Chapman et al., 1999) while health losses are discounted less than monetary losses (Chapman, 1996b). What drives this difference? Perhaps the visceral detail of the health scenarios drives up irrational, temporally myopic,

positive time preference (the "beta system" in quasi-hyperbolic models). This greater desire to have things now then translates into greater discount rates for gains and lower discount rates for losses, relative to the more abstract financial and environmental scenarios.

The second objective of Study 2, then, was to establish whether the lack of difference in discounting between monetary and environmental outcomes observed in Study 1 was due to idiosyncrasies of the (fairly abstract) scenarios employed or was a more general effect. Towards this end, we designed new air quality scenarios, using a standard, real world measure of air quality, and we recruited participants from areas with poor air quality. Through these measures, we hoped to generalize the results of Study 1 to an environmental scenario that might be more realistic to knowledgeable participants.

Finally, the third objective of Study 2 was to explore the role of individual differences in predicting discounting of environmental outcomes. Previous research has demonstrated that scores on the Cognitive Reflection Test (CRT) predict discounting of monetary gains but not of positive or negative health events such as getting a massage or submitting to dental work (Frederick, 2005). The CRT is meant to measure the ability to inhibit fast but inaccurate answers to questions such as "A bat and a ball cost $1.10. The bat costs $1.00 more than the ball. How much does the ball cost? ___ cents." Presumably, people who are able to (or enjoy) carefully reflecting on the CRT questions are also more willing to wait for monetary rewards. In contrast, the CRT does not predict time preferences for health events, presumably because these preferences are relatively more affectively (rather than cognitively) driven. We therefore administered the three-item CRT to participants to see whether it would predict discounting of monetary and environmental gains but not health outcomes.

Method

Participants. 167 participants were recruited from the 10 ZIP-codes in the country with the worst average air quality (as measured by the AQI, explained below in Scenarios); these were

mainly from California and Arizona. Participants were recruited and paid in the same manner as Study 1. Using the same criteria as Study 1, data were dropped from 6 non-completers, 6 who completed the study in less than 10 minutes (mean completion time was 38 minutes), and 37 participants who failed our careful-response criteria, leaving 118 participants for analysis.

Participants were 55% female, with an average age of 38 (*SD* = 13). 49% were married, and 50% had children. 13% were students, 85% had a college degree of some kind, and the median household income was $50,000 - $99,999. 75% of participants indicated they had heard of the AQI prior to the study, but only 40% were familiar with it. 97% of participants indicated they had experienced changes in air quality.

Procedure. All participants responded to 6 scenarios: monetary gain & loss, air quality gain & loss, and health gain & loss. Order was partially counterbalanced, such that the three scenarios in each valence (gain or loss) were always presented together, with the gain scenarios appearing first half of the time. While the ordering of the air and health scenarios was balanced (appearing either first or third), the monetary scenario was always presented second in each group. After responding to the scenarios, participants answered questions about their experience with each domain and demographic questions, and completed the CRT (Frederick, 2005).

Monetary Gain & Loss Scenarios. Although the basic scenarios were the same as those used in Study 1, the ordering and formatting of the titration options were changed to a format that seemed more natural. Also, the free response questions asked participants to "fill in the number that makes the following two options equally [un]attractive" rather than using the Study 1 language "fill in the number that would make you indifferent between the following two options," because several participants in Study 1 mentioned being confused by the reference to "indifference."

Air Gain & Loss Scenarios. Although the air quality cover stories were similar to those used in Study 1, the dependant variable was different. The Air Quality Index (AQI), a 0 to 500 continuous air quality measure employed by the U. S. Environmental Protection Agency (2003), was used to specify different degrees of improvement or deterioration in air quality. AQI forecasts are reported in the weather sections of newspapers in polluted areas (such as the LA Times), so it was plausible that participants would already be familiar with it. Before the first air quality scenario, a one page explanation of the AQI was presented to all participants. In the loss scenario, participants were told to imagine that the local AQI average was 90 (in the "moderate" range -- note that higher numbers signify more pollutants), and a temporary emissions policy change would worsen air quality either immediately or one year in the future. Titration and free response measures were again used, with choices such as "40 point deterioration in air quality, starting immediately, or 64 point deterioration in air quality, starting 1 year from now." In the gain scenario, participants were told to imagine the local AQI average was 130, and air quality would be improved by 40 points (or a different amount in one year). As the best possible AQI value is 0, the maximum possible improvement was therefore 130, so participants' indifference points for gains (and hence discount rates) had a ceiling. As in Study 1, participants were also asked to choose between gaining [losing] $250 and better [worse] air quality for 3 weeks.

Health Gain Scenario. In a scenario adapted from Chapman (1996b), participants were told to imagine they were in poor health and could choose between two treatments, one of which would take effect immediately and result in health improvements for a specified length of time or another which would take effect one year in the future and last a different (generally longer) amount of time. Although Chapman (Chapman, 1996b) used health improvements lasting 1 to 8 years, we used health improvements lasting around 12 weeks, based on pretesting indicating that

these would be valued more closely to the outcomes in the monetary and air quality scenarios. Again, titration and free response measures were used to assess indifference points between immediate and later choice options and to infer the discount parameter k. As with the other scenarios, participants also chose between gaining $250 and having improved health for 12 weeks.

Health Loss Scenario. In this scenario, also adapted from Chapman (1996b), participants were told to imagine they were in full health and could choose between two diseases, one of which would take effect immediately and last for 12 weeks and the other which would take effect in one year but last longer. Questions and amounts were equivalent to those used for the health gain scenario.

Results

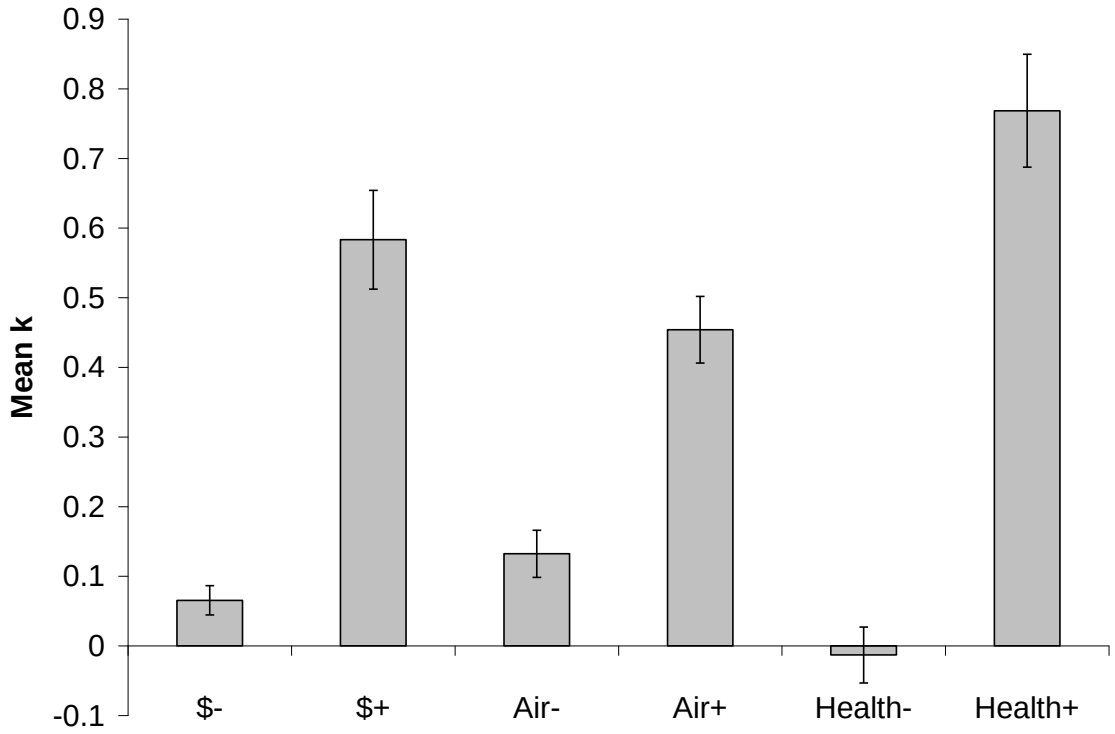
As mentioned above, the air quality gain scenario used only allowed for a maximum discount parameter of k = 2.25 (equivalent to a one-year discount rate of 69%). To fairly compare discounting across scenarios and domains, we therefore capped all discount parameters at 2.25 or -2.25. In other words, any score beyond that range was set to 2.25 or -2.25, as appropriate. Six percent of scores were capped in this way.

Mean discount parameters for each of the 6 scenarios are shown in Figure 2. As in Study 1, gains were discounted significantly more than losses, with all gain/loss t-tests highly significant and effect sizes of d = 1.6 to 2.0. Also as in Study 1, air quality gains were not discounted significantly differently from monetary gains (although there was a trend for monetary gains to be discounted more), nor were air losses discounted significantly differently from monetary losses. In contrast, health gains, k = 0.77 (SD = 0.88), were discounted significantly more than monetary gains k = 0.58 (SD = 0.77), $t(117) = 2.1$, $p < .05$, and air

quality gains k = 0.45 (*SD* = 0.52), $t(117) = 4.0$, $p < .001$. Furthermore, health losses, k = -0.01 (*SD* = 0.44), were discounted less than monetary losses, k = 0.07 (*SD* = 0.23), $t(117) = 2.1$, $p < .05$, and air quality losses, k = 0.13 (*SD* = 0.37), $t(117) = 2.9$, $p < .01$. However, these differences were only modest, with effect sizes ranging from $d = 0.2$ to 0.5, i.e., substantially smaller than effect sizes for outcome valence. Although not predicted, discount rates for monetary gains were significantly higher in Study 2 than in Study 1, $t(170) = 2.9$, $p < .01$.

Figure 2.

Mean discount parameters for monetary, air quality and health gains and losses in Study 2. Error bars are +/- one standard error.



In more concrete terms, participants were on average indifferent between gaining $250 immediately or $395 in one year, losing $250 immediately or losing $267.5 in one year, a 40 point improvement in air quality immediately or 58 points in one year, a 40 point deterioration in air quality immediately or 45.2 points in one year, 12 weeks of improved health immediately or 21.2 in one year, and 12 weeks of worse health immediately or 11.9 in one year.

A 2 (valence: positive or negative) x 3 (domain: monetary vs air quality vs. health) repeated-measures ANOVA confirmed the main effect of valence, $F(1,117)=114.4$, $p < .001$, indicating that gains were discounted more than losses, and the valence by domain interaction, $F(2,116)=12.7$, $p < .001$, indicating that the effect of valence was greater for health outcomes. Upon entering order effects into the model, participants discounted significantly more when gains were presented first, $F(1,111)=18.0$, $p < .001$, as in Study 1. Entering age as a covariate, the valence by age interaction (observed in Study 1) was not significant, $F(1,114) = 1.7$, $p = .19$, but showed a trend in the same direction. Gender, marital status, number of children, education, occupation, and income each had no significant effect.

CRT data was missing from 3 participants due to a technical error. Entering the CRT as a covariate in the ANOVA revealed a main effect of CRT, $F(1,113) = 5.0$, $p < .05$, indicating that individuals who scored higher discounted less, and a CRT by valence interaction, $F(1,113) = 5.7$, $p < .05$, indicating that while higher CRT scores were associated with less discounting of gains, there was no relationship between CRT and discounting of losses. In other words, if participants were intelligent and patient enough to give correct answers on the CRT, they were also likely to be patient for future gains and thus value present and future gains more equally, yet they were no more or less likely than average to want to postpone losses. While simple GLMs confirmed the power of CRT to predict discounting of monetary gains, $F(1,114) = 4.8$, $p < .05$, no relationship was found between CRT and discounting of health gains, $F(1,114) = 0.4$, $p = .51$, or between CRT and discounting of losses in any domain, all $p > .2$,

thus replicating prior research (Frederick, 2005). Also, the CRT predicted discounting of air quality gains, $F(1,114) = 12.7$, $p < .01$.

Similar to Study 1, only a small proportion of individuals exhibited zero or negative discounting for monetary (.03), air quality (.10), or health transit (.07) gains, while a substantial proportion displayed this pattern of preferences for monetary (.29), air quality (.25), and health (.43) losses. Differences in these proportions between gains and losses were all significant at $p < .01$ or better. Also, zero or negative discounting occurred more often in response to the health loss scenario than the monetary loss, $p < .05$, or air loss scenarios, $p < .01$. It is important to note, however, that discount parameters for losses were more or less normally distributed (in all three studies), so (non) effects such as the inability of the CRT to predict discount rates for losses were not due merely to a lack of variance in the dependent variable.

As seen in Table 2, correlations between discount rates were similar to (though somewhat lower than) those in Study 1. Discounting of monetary gains was correlated with health gains and air gains. Likewise, discounting of monetary losses was correlated with discounting of health losses, but only non-significantly correlated with discounting of air losses. Discounting of health gains was correlated with discounting of air gains, but health losses were not significantly correlated with air losses. Within domain correlations were weak.

Table 2

*Pearson correlations of discount parameters for gains and losses in money, air quality, and health, in Study 2. * = p < .05, ** = p < .01*

	$-	$+	air-	air+	health-
$+	.05				
air-	.10	.24*			

air+	.03	.26**	.29**		
health-	.39**	-.02	.08	-.04	
health+	-.06	.35**	.22*	.35**	.09

Just as 65% of participants preferred improved air quality for 3 weeks over receiving $250, so too 63% preferred paying $250 over 3 weeks of worse air quality. 88% of participants preferred 12 weeks of improved health to $250, while 92% preferred paying $250 to 12 weeks of worse health. Thus, different from Study 1, the non-monetary outcomes of the environmental scenarios used in this study were valued more highly than the monetary outcomes of the financial scenarios.

Discussion

A sample of respondents living in areas with poor air quality expressed their intertemporal preferences for hypothetical monetary, air quality and health scenarios which were designed to control for as many factors as possible. Replicating the results of Study 1, mean discount rates did not differ significantly between air quality and monetary outcomes.[2] At the same time, we extended previous results by showing that at one-year delays health gains were discounted more than gains in money or air quality while health losses were discounted less than losses in money or air quality. This suggests that participants were indeed sensitive to the domain, giving us more confidence in the null results observed in both studies. Further supporting the idea that similar processes drive discounting of money and air quality (but not health) was the fact that the CRT predicted discounting of monetary and air quality gains but not discounting of health gains or losses in any domain. For example, someone who is impatient in answering tricky questions is also likely to be impatient for receiving money, but no different

from average in his intertemporal preferences for poor health. This shows that cognitive impatience plays a role in discounting of (relatively abstract) gains, but not in time preference for losses or (affectively charged) health outcomes, highlighting the qualitatively different processes driving discount rates for gains and losses. As in Study 1, gains were discounted much more than losses in all domains, with a substantial proportion of participants exhibiting zero or negative discounting for losses in all domains.

Also as in Study 1, correlations of discount rates between-domain and within-valence were stronger than correlations within-valence and between-domain. In other words, knowing how much someone discounted monetary gains provided some predictions about how much they discounted air quality gains and health gains, but said little about how much they discounted monetary losses. This further supports the idea that while discounting of gains may be driven by a desire for immediate gratification, a different process determines time preference for losses.

Study 3

Studies 1 and 2 compared discounting of environmental scenarios to discounting of typical financial scenarios, in an effort to see whether insights and findings from existing research may be usefully applied to the environmental domain. However, in doing so, two common differences between environmental and financial scenarios went unaddressed. First, while the money was to be received or paid as a lump sum, the environmental outcomes were to be experienced as a stream of benefits (or losses) spread out over time -- a difference which is known to affect intertemporal preferences (Hsee et al., 1991; Loewenstein & Sicherman, 1991; Guyse et al., 2002). Second, while typical research on monetary outcomes has examined short delays (in the range of a few weeks to a year), environmental outcomes are often not realized for

many years. Our third study explored these issues, while also better controlling for the subjective value of the outcomes.

Pretest

While some researchers have controlled for magnitude effects by dynamically matching monetary and non-monetary outcomes for each participant prior to assessing discount rates (Chapman, 1996b), we worried that this would bias participants by mentioning both domains before they made their first choice (thereby confounding order effects), and by suggesting that the environmental outcomes were fungible.

Therefore, we conducted an extensive contingent valuation pretest with 180 participants in which we presented the air quality scenario (used in Study 1) and a series of dichotomous choice items which required participants to choose between the immediate gain (or loss) in air quality and getting (or paying) a given amount of money. This titration assessed roughly how much participants thought the gain or loss in air quality was worth to them. We also asked participants whether they believed air quality should be tradable with money. The results revealed that participants who believed environmental goods shouldn't be fungible valued changes in air quality roughly 3 to 4 times more than those who believed that there was nothing wrong with trading air quality with money. This pretest also indicated that the gain in air quality described in Study 1 was roughly equivalent in value to receiving $8.25 per day (median indifference point), while the worsening in air quality was roughly equivalent to paying $10 per day.

Method

Participants. 185 participants were recruited were recruited in the same manner as Study 1. Using the same criteria as in Studies 1 & 2, data were dropped from 5 non-completers, 2 who

completed the study in less than 10 minutes (mean completion time was 32.5 minutes), and 32 participants who failed our careful-response criteria, leaving 146 participants for analysis.

Procedure. All participants responded to 2 monetary scenarios (gain and loss) and 2 air quality scenarios (gain and loss). Half the participants saw the environmental scenarios first, while the other half saw the reverse order. Gains were always presented before losses. The air quality scenarios were very similar to those used in Study 1, describing a 28 day improvement or worsening in air quality. The monetary gain scenario asked participants to imagine winning a lottery which would pay $9 a day for 28 days, while the loss scenario described a situation in which their house or apartment was in violation of a city ordinance and they would have to pay $9 a day for 28 days. As a between subjects manipulation, half the participants made choices between immediate and 1-year delayed outcomes, while the other half considered immediate and 10-year delays.

Indifference points were assessed in the same manner as Studies 1 and 2, using a combination of titration and free response. However, the titration items used a log scale, to allow for higher indifference points at 10-year delays. One indifference point (for monetary gain at a 10-year delay) was 8.7 standard deviations above the mean and so was omitted from subsequent analyses as an outlier.

After responding to each scenario, participants were asked to give a brief summary of their thoughts as they made their choices.

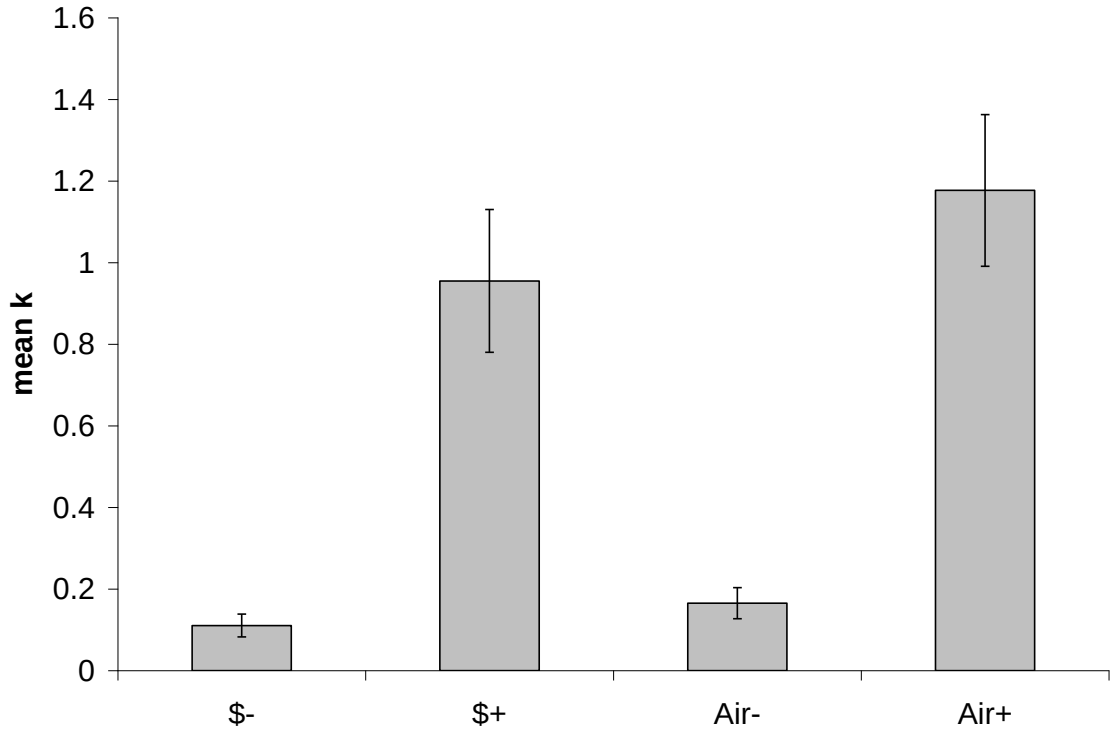
Results

As summarized in Figure 3, participants discounted gains significantly more than losses, across domains and delays. A 2 (domain, within) x 2 (valence, within) x 2 (delay, between) x 2 (order, between) repeated-measures General Linear Model revealed a main effect of valence,

$F(1,141) = 41.1$, $p < .001$, $\eta_p^2 = .23$, indicating that gains were discounted much more than losses, replicating previous studies. A significant order by domain interaction, $F(1,141) = 5.6$, $p < .05$, $\eta_p^2 = .04$, and a marginally significant order by domain by valence interaction, $F(1,141) = 3.3$, $p < .1$, $\eta_p^2 = .02$, indicated that participants tended to discount the first scenario they saw significantly more, regardless of whether it was a financial gain or environmental gain. In other words, participants showed more impatience on the first questions they considered. Although none of the other main effects or interactions had significant effects, all $p > .1$, a trend for a 3-way interaction between domain, valence, and delay suggested that air quality gains were discounted marginally more than monetary gains (ie, more impatience for improved air quality than money) at 1-year delay but marginally less at 10-year delays, $F(1,141) = 2.3$, $p = .13$, $\eta_p^2 = .02$. While there was not a main effect of delay on mean discount rates, this does *not* mean that participants discounted outcomes the same for the two delay conditions. Rather, this indicates that participants were sensitive to delay and that the hyperbolic discounting model captured their pattern of discounting well, just as in previous research on discounting of environmental outcomes (Viscusi et al., 2008). Thus, participants in our study were indifferent on average between 28 days of worse air quality starting immediately, 34 days starting in 1 year, or 58 days starting in 10 years.

Figure 3

Mean discount parameters for streams of monetary and air quality gains and losses in Study 3. Error bars are +/- one standard error.



Participants valued the environmental scenarios roughly equally to the financial scenarios. Given a choice, 51% of participants indicated they would prefer 28 days of improved air quality to 28 days of getting $9 per day, and 53% said they would prefer 28 days of worse air quality to 28 days of paying $9 per day.

As shown in Table 3, discounting of streams of monetary gains correlated with discounting of gains in air quality, and discounting of streams of monetary losses was correlated with discounting of worse air quality, correlations between gains and losses were generally weak.

Table 3

*Pearson correlations of discount parameters for gains and losses in streams of money and air quality, in Study 3. * = p < .05, ** = p < .01*

	$-	$+	Air-

$+	.08		
Air-	.42**	.09	
Air+	-.03	.21*	.17*

In their lists of thoughts about the scenarios, 20% of participants explicitly mentioned interest or returns on investment in response to the financial scenarios, while none of them mentioned this idea for the environmental scenarios. Other common thoughts concerned uncertainty ("It seems to me that immediate improvement is in order since the program might not go off the ground 10 years from now."), a positive time preference ("I want to experience immediately what the improved quality air is like"), or a belief in increased future resources ("Could use the money now and may not need it so bad in one year").

Discussion

Replicating Studies 1 and 2, valence had a huge effect on discounting rates, while domain had relatively little effect, regardless of delay and regardless of the fact participants considered streams of money rather than lump sums. As before, correlations were stronger within sign (and cross domain) then within domain (and cross sign).

General Discussion

The research in this paper on the discounting of environmental outcomes was motivated by a combination of theoretical, policy-oriented, and practical considerations. Whether a government is deciding whether the use of different discount rates for environmental and financial projects expresses the will of its people, or a local power company wants to encourage its customers to weatherize their homes (thus incurring short-term costs but long-term energy savings), it is vital to know whether financial and environmental outcomes are discounted at similar rates on average and whether the same factors found to affect discounting of financial

outcomes also affect discounting of environmental outcomes. Understanding of the discounting of environmental outcomes is especially important because issues such as global warming involve very long time horizons.

In three studies that compared discount rates for different domains while controlling as many factors as possible, similar discount rates were observed for financial and environmental outcomes. This is good news for traditional economic models of discounting which employ a single discount rate across domains. While it is possible that small domain differences would emerge with greater statistical power or for very long time periods, our results suggest that valence has a much stronger influence on discount rates than domain. Although domain differences were observed between mean discount rates for health as compared to monetary or environmental outcomes, the effect of valence was substantially greater. It is possible, then, that previous studies positing lower discount rates for environmental outcomes have misinterpreted their results, because they confounded domain with valence and delay. Indeed, some studies of discounting of environmental outcomes even explicitly "assume that the discount rate is the same for costs and for improvements" (Viscusi et al., 2008, pg 202), which is clearly not tenable given the results of our studies.

Why are discount rates so similar for financial and environmental outcomes? Economists typically contend that it is rational to discount all future outcomes at the market discount rate, because the utility from any future outcome (such as air quality) can potentially be exchanged for utility from another source, thus all outcomes are fungible, and the choices of our participants ostensibly supported this view. However, in their descriptions of what they were thinking about (Study 3), no participants mentioned market interest rates or substitutability in response to the environmental scenarios, yet the discount rates were the same (on average) as for the financial scenarios. Furthermore, even when considering financial scenarios, only a fifth of participants mentioned investment. It is therefore likely that other processes (such as impatience and concern for future uncertainty) are the major drivers of discounting in both domains.

What was different about health outcomes? At first glance, one sees more similarities between health and the environment (difficult to quantify, environmental changes often impact health, etc) than between the environment and money. However, health outcomes, and the health scenarios we used in particular, may elicit more visceral reactions from participants. The vivid descriptions of good and bad health in the scenarios originally developed by Chapman (1996b) and the topic of health in particular, may stimulate more of an affective response in participants, enhancing the beta system, leading to greater discounting of gains and lower discounting of losses (recall that by all definitions of discounting, a present bias translates into *lower* discounting of losses).

Furthermore, correlations within valence (across domain) were stronger than those within domain (across valence). This finding seems slightly at odds with previous studies of health outcomes, which reported stronger correlations within domain than between domain (Chapman & Elstein, 1995; Chapman, 1996b; Chapman et al., 1999). However, these studies mostly only examined gains. Two studies that compared discount rates for monetary and health gains and losses found insignificant correlations between them (r = .1 to .2). Furthermore, the reported high within-domain correlations (r = .7) came from responses to the same basic scenario with variations only in magnitude and delay (rather than correlating responses to two different scenarios within the same domain). Correlations between discount rates for different health gain scenarios were more modest, roughly r = .4 (Chapman et al., 1999).

Two identical situations should be discounted identically (with some noise), and as they become more dissimilar, you expect lower correlations. Therefore, based our research and previous studies, these correlations tell us that valence is a more salient contextual feature than domain. In other words, to predict how much someone discounted health gains, it is more useful to know how much they discounted monetary gains or environmental gains than to know how much they discounted health losses. Therefore, it might be more appropriate to describe the observed pattern of correlations in the literature as *context dependence* rather than domain dependence. In other words, discount rates are constructed based on the valence, domain, magnitude, time horizon, and other contextual features of a situation (Baron, 2000);

correlations between situations will be higher to the extent that these factors are similar. The good news from the present research is that discount rates assessed in the lab for one domain should be applicable to other domains and contexts, even predicting real world behaviors, as been recently found (Chabris, Laibson, Morris, Schuldt & Taubinsky, 2008).

Participants' responses to our scenarios were undoubtedly influenced by the measurement methods we used. The values used in the titration scales suggested a reasonable range of indifference points to participants and suggested the possibility of negative discounting, thus influencing subsequent responses to the free response questions. Also, participants' discount rates were influenced by the order of presentation of gain and loss scenarios, in all three studies. Furthermore, it's likely that a different question format, such as presenting sequences or asking whether the future environment is less important that today's environment, would yield a different pattern of preferences, as has been seen with questions concerning human life (Frederick, 2003). We emphasize, therefore, that our objective was not to obtain point estimates of participants' "true" discount rates, but rather to determine which factors affect discounting, and their relative strengths. Future research might examine the effects of measurement method on discount rates, for example comparing contingent valuation measures (willingness to pay for environmental outcomes now or in the future) with the within-domain measures used in the present research.

One shortcoming of the present research was its reliance on self-report responses to hypothetical scenarios. It is possible that different results would be observed if individuals were to make consequential intertemporal choices about real monetary and environmental outcomes. However, previous research comparing temporal discounting of real and hypothetical monetary rewards found no differences when controlling for magnitude (Kirby, 1997; Johnson & Bickel, 2002).

Another shortcoming of the present research was the extent to which the environmental scenarios were constructed to match the monetary and health scenarios. In a sense, the discounting results reported

here probably do not reflect discounting of environmental outcomes in the real world because the scenarios employed here differ from real environmental situations in numerous ways. Future research should attempt to construct monetary scenarios to match more typical environmental scenarios on dimensions such as their time frame, ethical considerations, or the number of people affected. Doing so will require some ingenuity, but we should continue to test the limits and assumptions of our models against diverse real world phenomena rather than resting content to study only what is experimentally simple.

Some good news for environmental policy (whether trying to represent the general will or shape individual behavior) is that the great body of research on discounting of financial outcomes should be readily applicable to discounting of environmental outcomes, as long as care is taken to account for important contextual factors such as default dates, valence, and magnitude.

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Footnotes

[1] This nature and magnitude of exclusions is typical in on-line research, which has the advantage of a broader range of participants on socio-economic variables than university lab samples, but the disadvantage of lack of supervision of the way in which responses are provided. Excluding the careless respondents makes the data cleaner, but does not alter the major trends or our conclusions.

[2] Although not predicted, discount rates for monetary gains were higher in Study 2 than in Study 1. This is somewhat surprising, because the same basic scenario was used in both studies (winning $250 immediately or another amount one year in the future). However, the order, format, and wording of the response options were different, and the participants were recruited from a different population. For example, in Study 1 the titration items were ordered from low to high, while in Study 2 they were ordered from high to low, thus the difference in discount rates between studies may have been due to anchoring on the response options. Furthermore, the median income of the participants in Study 2 was higher than the median income in Study 1, thus the difference in discount rates for $250 may be explained by the fact that (subjectively) smaller magnitude outcomes are discounted relatively more (Thaler, 1981). These possibilities highlight the importance of comparing discount rates for different domains within the same study, where factors like income are controlled for, rather than measuring discount rates for monetary scenarios in one study and environmental scenarios in another and drawing conclusions about domain differences.

Paper 3: Good or bad, we want it now: Present bias for gains and losses explains magnitude asymmetries in intertemporal choice

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Abstract

Two studies investigated the joint effects of outcome sign (gains vs. losses) and outcome magnitude (small vs. large) on delay discount rates. Whereas rational-economic theory predicts that neither sign nor magnitude of outcomes should affect discounting, different psychological mechanisms predict different patterns of main effects and interactions. Study 1 replicates the well-established magnitude effect for gains, showing that large ($1,000) gains are discounted less than small ($10) gains, but also suggests that losses may show the opposite pattern, with small losses discounted less than large losses. Study 2 firmly establishes this pattern of results and provides process data implicating present bias in both the gain and loss decisions. Present bias is well established for gains and has traditionally described a prepotent preference for immediate rewards in order to satisfy the desire for obtainable gains (i.e., desire to have gains now). Our results establish present bias also for losses, where it describes a prepotent preference for immediate losses in order to preclude the need to attend to future losses (i.e., desire to have losses over with now). Present bias predicts increased discounting of future gains, but decreased (or even negative) discounting of future losses. Since present-bias feelings do not seem to scale with the magnitude of possible gains and losses, they play a larger role, relative to other motivations for discounting, for small magnitude intertemporal decisions than for than for large magnitude intertemporal decisions. This suggests that policy efforts to encourage future oriented choices should frame outcomes as large gains or small losses.

Good or bad, we want it now: Present bias for gains and losses explains magnitude asymmetries in intertemporal choice

Whether racking up credit card debt, eating unhealthy foods, or acting in environmentally destructive ways, people often discount future consequences, wanting to have gains immediately and to postpone losses until later. In general, the farther into the future that an outcome is delayed, the more it is discounted. There are a number of factors hypothesized to contribute to the discounting of future gains (for overviews, see Frederick, Loewenstein, & O'Donoghue, 2002; Hardisty, Orlove, Small, Krantz, & Milch, working paper). A reason often noted by economists is opportunity cost: one could take the immediate $100, invest it, and have more than $101 in a year's time (Franklin, 1748; Samuelson, 1937). A second reason to discount the future is uncertainty (Prelec & Loewenstein, 1991; B. J. Weber & Chapman, 2005). For example, if offered a choice between getting $100 now or $101 in a year, one may value the $100 more because it is a sure thing, whereas the future is inherently uncertain. A third reason is resource slack (Zauberman & Lynch, 2005): most people believe that, although money is tight right now, they will have more resources in the future, so it is more useful to have the money immediately rather than later. A fourth reason to discount the future is present bias (Laibson, 1997; O'Donoghue & Rabin, 1999): people are often impatient to have gains immediately, for no rational reason.

One well-established empirical observation about discounting is the so-called "magnitude effect", that people discount *small* gains at a higher rate than *large* gains (Baker, Johnson, & Bickel, 2003; Benhabib, Bisin, & Schotter, 2010; Chapman, 1996; Chapman & Elstein, 1995; Estle, Green, Myerson, & Holt, 2006; Giordano et al., 2002; Green, Myerson, & McFadden, 1997; Kirby & Marakovic, 1995; Kirby & Marakovic, 1996; Petry, 2001; Ranieri & Rachlin,

1993; Thaler, 1981). For example, someone might choose $10 today versus $11 in a month, yet prefer to wait for $11,000 in a month rather than take an immediate $10,000, even though in both cases the later amount is 110% of the sooner amount. Two explanations for this magnitude effect are *mental accounting* and *fixed-cost present bias*.

According to the mental accounting theory (Loewenstein & Thaler, 1989), people may discount small gains more steeply because small and large gains activate different mental accounts for which different discount rates may exist. When considering a small gain, people think of it as spending money, whereas when they consider a large gain, they think of it as a potential investment. Thus, small amounts are associated with immediate consumption accounts and their typically high discount rates, whereas large amounts are associated with long-term savings accounts and their typically lower discount rates.

According to the theory of fixed-cost present bias (Benhabib, et al., 2010), people's desire to have good things right away (i.e., their present bias) appears to be worth about $4 to them, regardless of the size of the outcome under consideration or the length of the delay. As a consequence, people's impatience weighs much more heavily (in relative terms) when outcomes are small than with outcomes are large; in the context of $10 now versus $11 in a month, $4 worth of impatience is a lot, but in the context of $10,000 now versus $11,000 in a month, $4 worth of impatience is not very important.

Unfortunately, although both these theories are plausible explanations for why people might show lower discount rates for larger gains, neither can easily explain people's time preferences for small and large *losses*. The vast majority of studies of intertemporal choice have focused exclusively on current versus future gains, but it turns out that losses may not show the

magnitude effect (Baker, et al., 2003; Estle, et al., 2006). Participants in one study showed similar discount rates for $100 losses as for $100,000 losses (Estle, et al., 2006), and participants in another study showed almost no difference in discount rates between losses of $10, $100, and $1,000. These findings present a complication for the mental accounting theory. If small and large gains are considered in different accounts associated with different discount rates, why would not losses of different sizes go into different accounts with different discount rates as well? The theory of fixed-cost present bias also cannot explain this, as it predicts an equal magnitude effect for both gains and losses. Fixed-cost present bias theory predicts that people put a premium (of roughly $4) on having gains now, and a premium (again of roughly $4) on postponing losses. For example, when considering paying $10 immediately or $12 in one month, participants would be predicted to choose the future $12, because it is worth $4 to the participant to postpone bad things and only the payment of $2 additional dollars is incurred by waiting. In contrast, when choosing between $1,000 or $1,200 in one month, the same participant would be expected to choose the immediate $1,000, because the additional $200 lost from waiting is much greater than the $4 premium the participants puts on immediate welfare. In this way, Benhabib et al.'s theory predicts an equal magnitude effect for gains and losses. In both cases, it predicts lower discounting for larger amounts.

We propose an extension of present bias, in which people have a psychological desire to resolve both gains and losses immediately. In the case of gains, people want the gain immediately to satisfy their desire for positive outcomes. In the case of losses, people want to get the loss over with immediately to close their books on the loss and avoid having to allocate attention and emotional capacity (e.g., dread) to looming future losses. In both cases, we assume that this present bias is relatively insensitive to magnitude (as theorized and found by Benhabib

et al., 2010, in the domain of gains). To explain further: as we consider when to receive or pay an amount, regardless of size, we have a desire to resolve the event immediately if possible. On a psychological level, we would like to have the gain now, and we would like to get the loss over with now. If the gain or loss is a small amount, such as $10, our desire to satisfy impatience or to avoid dread is a relatively important factor. If the gain or loss is a large amount, such as $10,000, we still have the desire to resolve the event as soon as possible, but our desire to satisfy impatience or to avoid dread is a relatively *unimportant* factor. Because $10,000 is a lot of money, other factors, such as uncertainty and resource slack, become more important considerations. See Table 1 for a summary of this idea. Thus, for gains we make identical predictions as Benhabib and colleagues (2010), however we make different predictions for losses.

Table 1

Summary of major factors hypothesized to determine intertemporal preferences for gains and losses of different sizes.

Motivational Factor	**Description**	**Makes you prefer to have…**	**Causes discount rates to…**	**Scales with magnitude?**
Uncertainty	Delayed gains and losses may never be realized	Gains now and losses later	Increase for gains and losses	Yes
Opportunity cost and investment	Resources can be invested and earn interest or otherwise grow over time	Gains now and losses later	Increase for gains and losses	Yes
Resource slack	Expecting to have more resources in the future means that immediate resources are more dear than future resources	Gains now and losses later	Increase for gains and losses	Yes
Present bias	Psychological desire to resolve events immediately	Both gains and losses now	Increase for gains, decrease for losses	No
Other factors, such as social norms and ideals	Variable, but often individuals are taught they ought to delay gratification	Variable, but often postponing gains and attending to losses immediately	Variable, but often a common goal is lower discount rates	Variable

Importantly, our theory predicts that *negative* discounting of losses should occur when amounts are small enough. Negative discounting implies that outcome values intensify (i.e., positives become more positive and negatives become more negative) the further they lie in the future; in the case of losses, negative discounting means a preference to have losses sooner rather than later. For example, some people might rather pay $10 immediately rather than $9 in a year, to satisfy their desire to get the loss over with. In this case, we should observe a full *reversal* of the magnitude effect when comparing small and large losses. Although this finding was not

observed in existing studies on sign and magnitude (Baker, et al., 2003; Estle, et al., 2006), these studies did not in fact *allow* participants to express this preference. These studies always paired a smaller, sooner amount with a larger, later amount, so zero or negative discount rates were not possible.

In Study 1, therefore, we tested our prediction by presenting participants with choices between immediate and future gains and losses that were either small (around $10) or large (around $1,000). Importantly, we included choice options which allowed for negative discount rates, such as a choice between paying $10 immediately and $9 in the future. We predicted that whereas small gains would be discounted more than large gains, showing the usual magnitude effect, small losses would be discounted *less* than large losses, showing a reverse magnitude effect. We also expected losses to be discounted less than gains overall for the reasons mentioned above, as in previous studies on discount rates for gains and losses (Appelt, Hardisty, & Weber, working paper; Hardisty & Weber, 2009; Thaler, 1981).

Study 1

Method

A national sample of 58 participants (mean age=37, *SD*=13, 68% female) was recruited and run online through the virtual lab of the Center for Decision Sciences for a study on decision making. Participants were paid $7 for completing this and another study. In a 2x2 mixed design, each participant responded to two intertemporal choice scenarios, one gain and one loss, in counterbalanced order. Between subjects, participants were randomly assigned to scenarios with small or large magnitude outcomes, the same magnitude for both their gain and their loss choices.

In each scenario, participants made a series of eight hypothetical choices between a fixed immediate amount and a varying delayed amount available in six months (i.e., a choice titration was used). For example, in the small gain condition, participants were asked to choose between receiving $10 today and receiving $9 in six months, receiving $10 today and receiving $10 in six months, receiving $10 today and receiving $11 in six months, etc. The immediate amount was fixed at $10 in the small magnitude condition and $1,000 in the large magnitude condition. The delayed amounts varied from $9 to $500 and $900 to $50,000, respectively. For the complete list of choice options, see Appendix A. Hypothetical outcomes were used out of necessity, because it was not possible to execute real $50,000 losses with participants. Fortunately, several studies have shown that hypothetical intertemporal choice outcomes are consistent with and predict real outcomes (Bickel et al., 2010; Bickel, Pitcock, Yi, & Angtuaco, 2009; Chabris, Laibson, Morris, Schuldt, & Taubinsky, 2008; Shamosh et al., 2008).

Results

Data from 8 participants were excluded for careless responding, as determined by any of the following three criteria: switching back and forth on the intertemporal choice scale more than once (i.e., non-monotonic responding), perversely switching on the intertemporal choice scale (for example, choosing to receive $12 in six months rather than $10 today, and subsequently choosing $10 today rather than $14 in six months), or completing the study more than two standard deviations faster than the average natural log of completion time. This left data from 50 participants for further analysis (28 in the small magnitude condition, and 22 in the large magnitude condition).

Participants' responses were converted into intertemporal indifference pairs by taking the average of the values around the switch point. For example, if a participant chose to receive $10 today over $12 in six months, and chose $15 in six months over $10 today, then the participant was judged to be indifferent between receiving $10 today and $13.50 in six months. To easily compare discounting across magnitudes, indifference between choice options was converted into a discount rate, using the continuously compounded exponential formula $V=Ae^{-kD}$ (Samuelson, 1937), where V is the immediately available amount (e.g., $10), A is the future amount (e.g.,, $13.50), e is the constant (2.718), D is the delay in years (e.g., 6 months = 0.5), and k is a fitted parameter, the discount rate.[3]

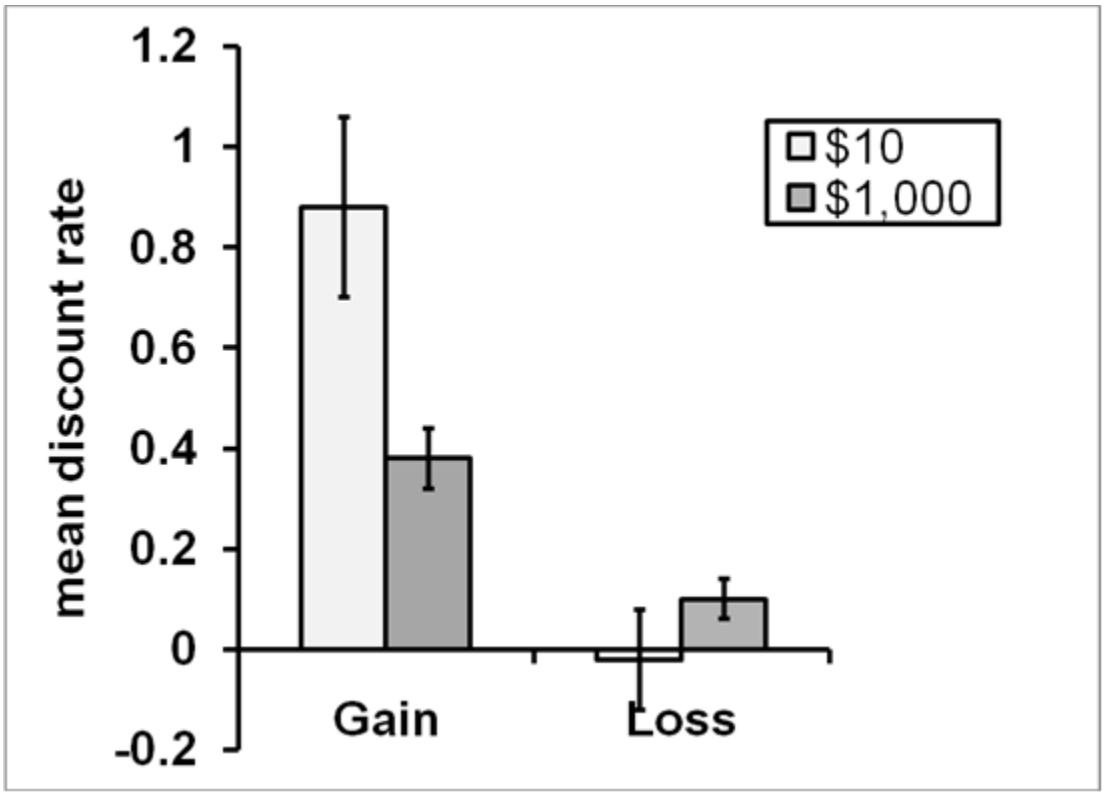
As seen in Figure 1, discount rates varied considerably depending on whether participants were considering small or large gains or losses. Although small gains (mean discount rate=0.94, *SD*=1.03) were discounted significantly more than large gains (*M*=0.38, *SD*=.33), there was a non-significant trend for small losses (*M*=-.06, *SD*=.55) to be discounted *less* than large losses (*M*=.09, *SD*=.16). A 2x2 ANOVA with sign and magnitude predicting discount rates confirmed a main effect of sign as predicted, $F(1,48)=37.0$, $p<.001$, $\eta^2=.44$; a sign by magnitude interaction as predicted, $F(1,48)=11.5$, $p=.001$, $\eta^2=.19$; but no main effect of magnitude, $F(1,48)=1.9$, $p>.1$, $\eta^2=.04$. Although a pairwise comparison of the small loss condition to the large loss condition did not find a significant difference, $t(48)=1.3$, $p>.1$, $d=.44$, sample sizes were somewhat small and the effect size was moderate, so results are inconclusive rather than indicating no difference

[3] We chose this equation (rather than the hyperbolic model or the area-under-the-curve method) because it is easily interpretable. For example, a k of .6 is the equivalent of a continuous discount rate of 60%, in the standard economic sense. Higher numbers indicate greater discounting, a k of zero means no discounting, and negative k values indicate negative discounting. As choices in this study all involved the same two time points (immediate outcomes vs. outcomes in six months), exponential and hyperbolic modeling would fit the data equally well, so there was no advantage to using the hyperbolic model, which (which is known to generally model data better than the exponential model, Kirby, 1997; Kirby & Marakovic, 1995; Mazur, 1987).

at all. The paired comparison of large and small gains was significant, $t(48)=2.5$, $p<.05$, $d=.82$, demonstrating the classic magnitude effect.

Figure 1

Mean discount rates k for small and large gains and losses, in Study 1. Error bars indicate +/- one standard error.



In concrete terms, participants considering small gains were indifferent on average between receiving $10 today and $16 in six months, whereas participants considering large gains were indifferent between receiving $1,000 today and $1,210 in six months. In contrast, participants considering small losses were indifferent between paying $10 today and $9.70 in six months, whereas those considering large losses were indifferent between paying $1,000 today and $1,070 in six months.

Notably, zero discounting and negative discounting were quite common in the small loss condition, but were fairly rare in the other conditions. Specifically, when faced with a choice between paying $10 immediately or $10 in six months, 50% of participants chose to pay immediately. In contrast, when considering large losses, only 22% expressed this preference, z=1.73, p<.10. When considering whether to receive $10 today or $10 in six months, only 11% chose the future option, and when considering $1,000 versus $1,000 in six months, 5% showed this preference.

Discussion

As predicted, there was an interaction between sign and magnitude in predicting discount rates; whereas small gains were discounted more than large gains, choices for losses eliminated or reversed this trend. As the evidence for the reversal with losses was weak, we decided to run a follow-up study with a larger sample size to see if this reversal would replicate.

Furthermore, we wanted to collect process data to test whether people's desire to resolve events immediately drives the reversal. To do this, we asked participants to list their thoughts about the intertemporal choice scenario, before they made any choices, using an established "type aloud" protocol (E. U. Weber et al., 2007). Subsequently, after making their choices, we presented participants' own thoughts back to them, and asked them to code the content of each thought. As summarized in Table 1 (above), we predicted that concerns about uncertainty and resource slack would grow more important for larger amounts, and therefore that mentions of wanting to have the gain or loss immediately for other, psychological reasons (i.e., present bias) would be proportionally less common with larger magnitudes. In other words, a fixed-cost present bias does not scale up with larger magnitudes, and so becomes proportionally less

influential. We predicted that the relative frequency of these present-biased thoughts would mediate the effect of magnitude on discount rates, in opposite directions for gains and losses. In other words, we predicted that present bias would make participants desire to resolve gains immediately and losses immediately, which results in greater discount rates for gains and lower discount rates for losses. With increased magnitude, the influence of present bias is reduced, which changes discount rates accordingly (see Figure 6 for a summary).

Study 2

Method

A sample of 224 US residents (mean age=37, *SD*=12, 76% female) was recruited and run online in the same manner as Study 1. Participants were compensated $8 for completing this study and two unrelated studies. In a 2x2 between-subjects design, participants were randomly assigned to one of four conditions: small gain, large gain, small loss, or large loss. We ran this as a between-subjects design for two reasons. One was to maximize the asymmetries in discounting observed in Study 1 between small and large gains and losses, to see if the reversal of the magnitude effect could be replicated. The second reason was because the quality and quantity of thought listings often go down sharply after the first scenario participants complete.

Participants first received training with the computerized "type aloud" interface, in which participants entered one thought at a time. Participants in the small [large] gain conditions then read the following passage:

> Imagine there was a legitimate error on your back taxes in your favor, and you will immediately **receive** $10 [$10,000] from the government. However, they are also giving you the option of receiving a different amount one year from now, instead. How much would the future amount need to be for you to choose it? The

> amount you would receive today is **$10 [$10,000]**. The amount you would receive in the future ranges from $9 [$9,000] to $35 [$35,000]. We will ask you several questions about whether you would prefer to get $10 [$10,000] today or another amount one year from today.

Participants in the small [large] loss conditions read:

> Imagine there was a legitimate error on your back taxes against you, and you must **pay** the government $10 [$10,000] immediately. However, they are also giving you the option of paying a different amount one year from now, instead. How much would the future amount need to be for you to choose it? The amount you would pay today is **$10 [$10,000]**. The amount you would pay in the future ranges from $9 [$9,000] to $35 [$35,000]. We will ask you several questions about whether you would prefer to pay $10 [$10,000] today or another amount one year from today.

All participants then listed their thoughts about the scenario, following the instruction:

> Before you indicate your preference for these choices, please tell us everything you are thinking of as you consider this decision between receiving [paying] $10 [$10,000] today or receiving [paying] a larger amount in one year.
>
> We would like you to list any thoughts, both positive and negative, that you might have about this decision. We will ask you to enter your thoughts one at a time.

Subsequently, participants made a series of ten choices between a fixed immediate amount and a varying later amount, similar to Study 1. The immediate amount was always $10 [$10,000], and the future amount ranged from $9 [$9,000] to $35 [$35,000]. The future amount was always one year in the future. For the complete list of choices, please see Appendix B.

After that, participants were presented with the thoughts they had listed earlier, one at a time, and asked to code each thought as to whether the primary topic of the thought was "Earning interest on investments" (i.e. opportunity cost), "Future uncertainty" (i.e. uncertainty), "Expecting the money will be more useful now than in the future" (i.e. resource slack), "Other:

what you want (for example, 'I want it now to get it over with')" (i.e. present bias), "Other: what you ought to do (for example, 'I should wait')" (i.e., social norms) or "None of the above." These categories correspond to the factors presented in Table 1 (above). Participants also coded whether the thought favored choosing the immediate option or the future option. Finally, participants answered demographics.

Results

The data from 25 participants were excluded because of careless responding, using the same criteria as in Study 1 and leaving data from 199 participants for analysis. We converted choices to indifference points and discount rates, again using the same procedure as for Study 1.

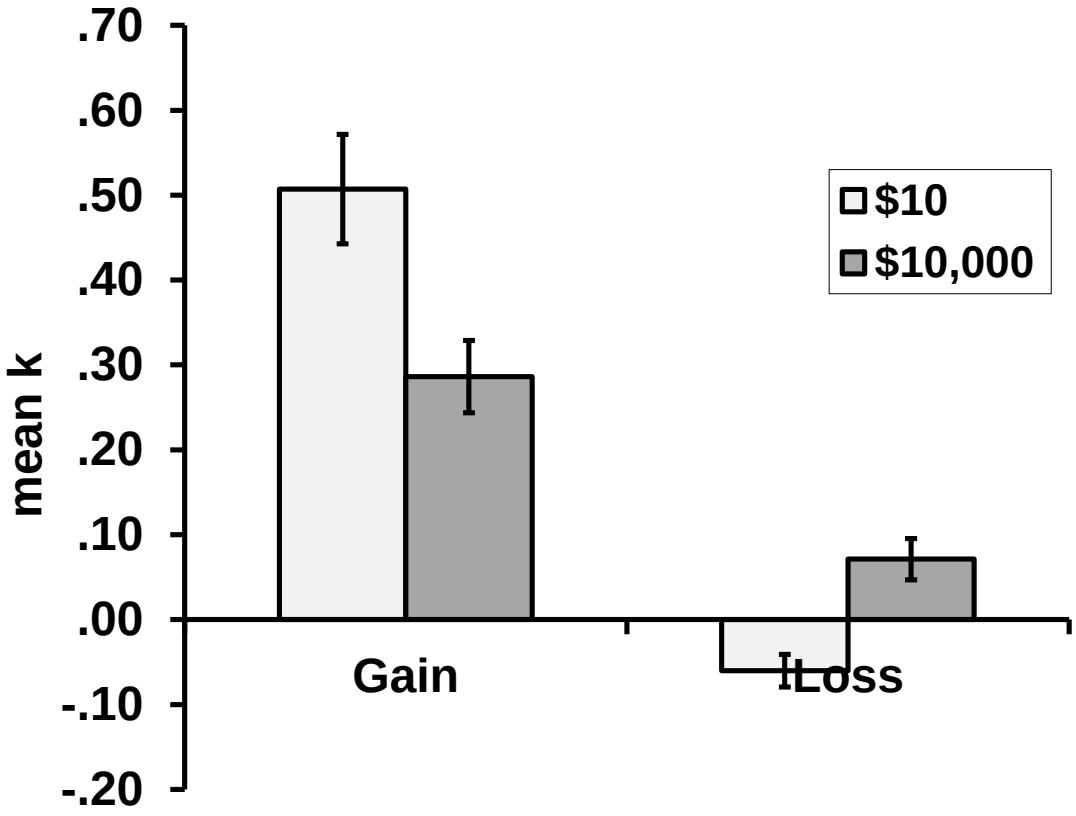
As summarized in Figure 2, participants' discount rates depended both on the sign and magnitude of the outcome, replicating the results of Study 1. Although participants discounted small gains (mean k =.51, *SD*=.45) more than large gains (*M*=.29, *SD*=.31), they discounted small losses (*M*=-.06, *SD*=.14) *less* than large losses (*M*=.07, *SD*=.17). This was confirmed with a 2x2 ANOVA using sign and magnitude to predict discount rates, which revealed a main effect of sign, $F(1,195)=86.4$, $p<.001$, $\eta^2=.31$; and a sign by magnitude interaction, $F(1,195)=17.5$, $p<.001$, $\eta^2=.08$; but did not find evidence for a main effect of magnitude, $F(1,195)=1.1$, $p>.10$, $\eta^2=.01$. Pairwise comparisons within each sign between small and large outcomes confirmed the magnitude effect for gains, $t(101)=2.9$, $p<.01$, $d=.58$, and the reverse magnitude effect for losses, $t(94)=4.2$, $p<.001$, $d=.87$.

In dollar terms, participants were on average indifferent between receiving $10 immediately and $16.60 in one year (i.e., when considering small gains), but $10,000 immediately and $13,310 (i.e., when considering large gains). In contrasts, participants were

indifferent between losing $10 immediately and $9.42 in one year (i.e., when considering small losses), but $10,000 immediately and $10,740 in one year (i.e., when considering large losses). As in Study 1, zero and negative discount rates were extremely common when considering small losses, with 78% of participants expressing this preference. In contrast, only 23% of those considering large losses, 2% of those considering small gains, and 2% of those considering large gains showed zero or negative discount rates.

Figure 2

Mean discount rates k for small versus large gains and losses, in Study 2. Error bars show +/- one standard error.

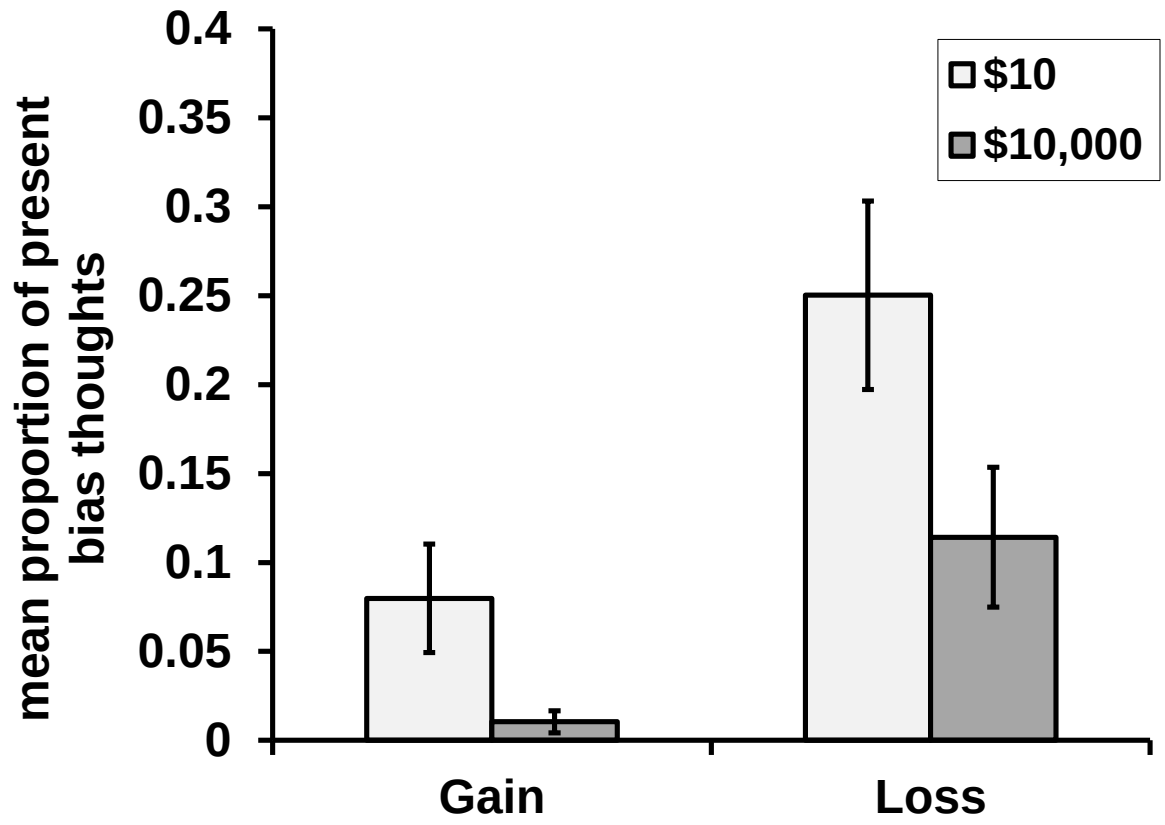


Prior to making their choices, participants listed an average of 3.4 thoughts (*SD*=2). Participants considering large magnitude outcomes listed 0.6 more thoughts than participants considering the small outcome, $t(197)=2.1$, $p<.05$, $d=.15$. This is consistent with the theory that most intertemporal motivations grow more pressing with larger magnitudes. The number of thoughts listed did not vary between gains and losses, nor was there an interaction. The number of thoughts coded as falling into the different types of thought categories described above differed depending on whether the intertemporal choice considered was between small or large gains or losses. We used the proportion of thoughts a decision maker classified as both "Other: what you want (for example, 'I want it now to get it over with')" and as favoring the immediate option as a measure of the relative prevalence of present-biased thoughts. An example of a present-biased thought provided by a participant was, "I like to manage situations that arise in my life as quickly as I can, regardless of the conditions/content."

As seen in Figure 3, the relative frequency of present-biased thoughts was significantly lower for large magnitude outcomes. A 2x2 ANOVA with sign and magnitude predicting proportion of present bias thoughts found significant main effects of magnitude, $F(1,195)=8.3$, $p<.01$, $\eta^2=.04$; and sign, $F(1,195)=14.9$, $p<.001$, $\eta^2=.07$; but not an interaction, $F(1,195)=.88$, $p>.10$, $\eta^2=.01$.

Figure 3

Mean proportion of present bias thoughts, depending on the sign and magnitude of the outcomes, in Study 2. Error bars show +/- one standard error.



In contrast, the relative frequency of other concerns such as future uncertainty and resource slack grew larger with larger magnitude outcomes, as seen in Figure 4 and Figure 5. A 2x2 ANOVA with sign and magnitude predicting proportion of thoughts about future uncertainty found a main effect of magnitude, $F(1,195)=7.8$, $p<.01$, $\eta^2=.04$, but no evidence for a main effect of sign or an interaction. Similarly, an ANOVA predicting thoughts about resource slack found a marginally significant effect of magnitude, $F(1,195)=3.7$, $p<.10$, $\eta^2=.02$, but no evidence for a main effect of sign or an interaction. Refer back to our new figure to make the point that only present-biased thoughts can possibly mediate the choice pattern we observed.

Figure 4

Mean proportion of thoughts about uncertainty, depending on the sign and magnitude of the outcomes, in Study 2. Error bars show +/- one standard error.

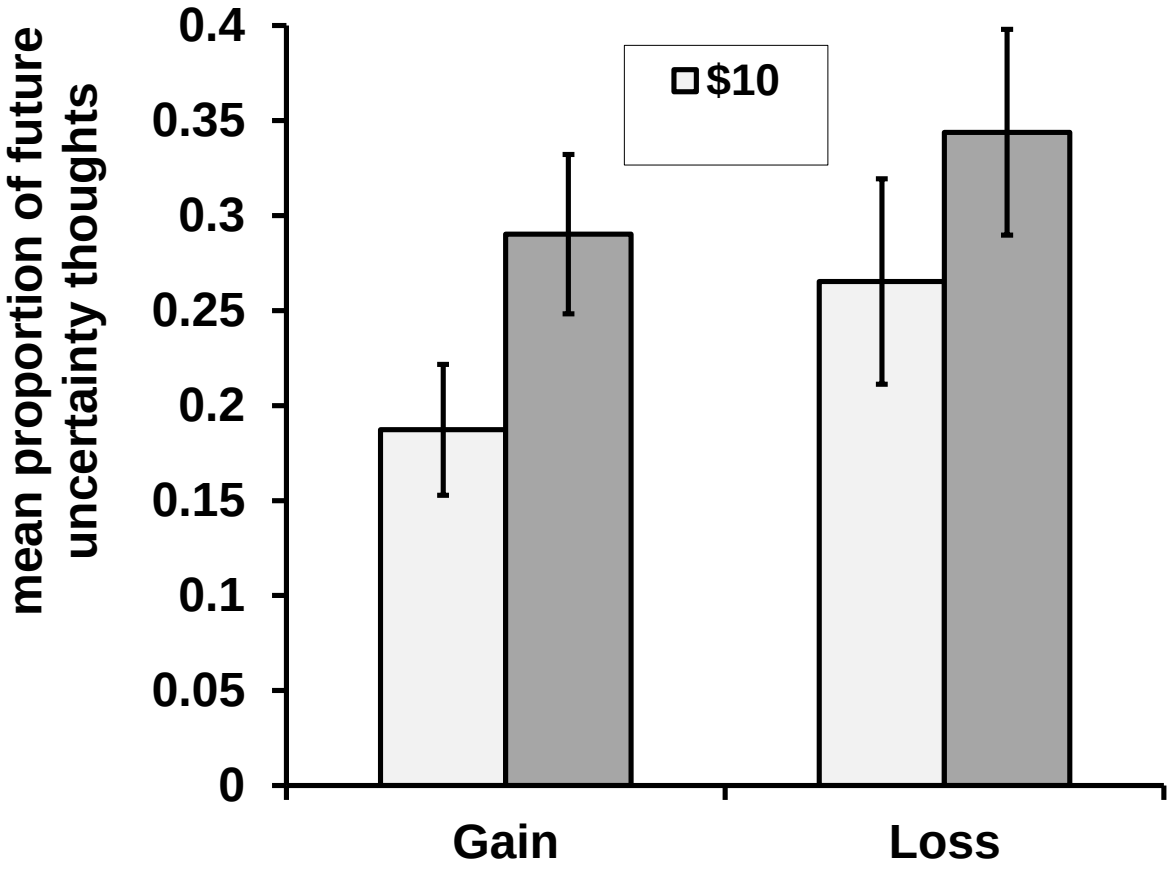
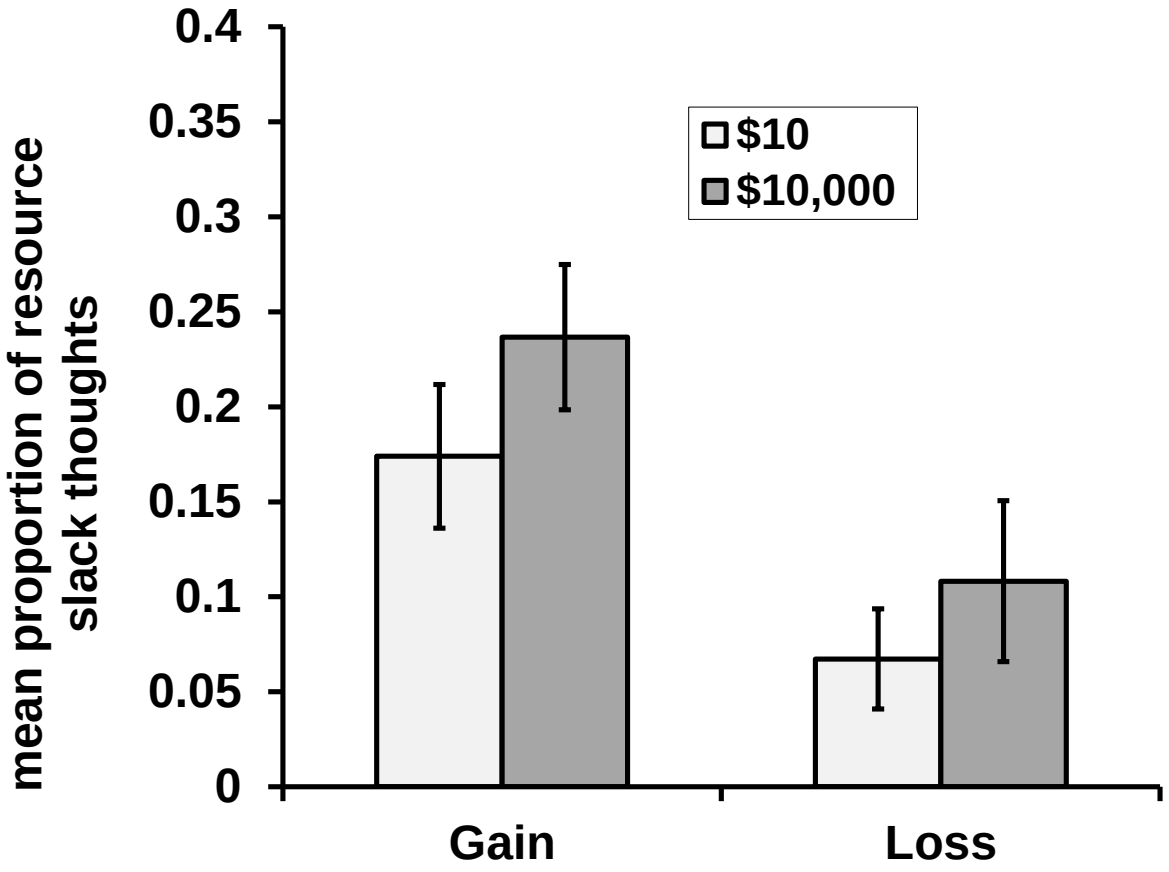


Figure 5

Mean proportion of thoughts about resource slack, depending on the sign and magnitude of the outcomes, in Study 2. Error bars show +/- one standard error.

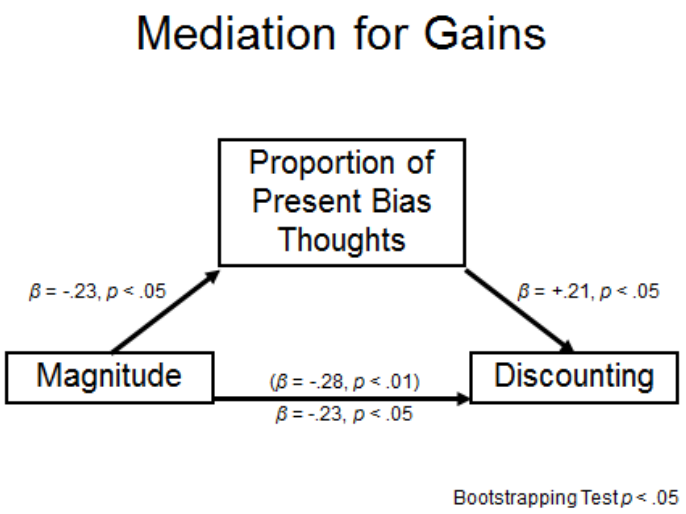


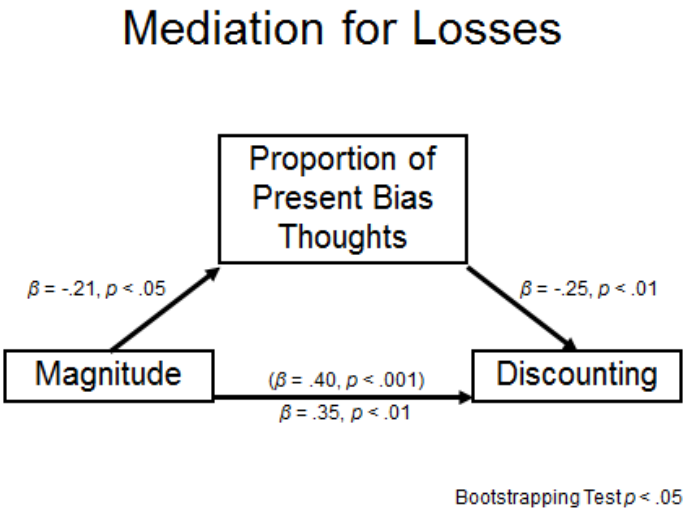
Finally, through mediation models, we tested whether the proportion of "want now" thoughts explain how sign and magnitude interact to predict discount rates, as summarized in Figure 6. We ran two separate mediation models, one for gains and one for losses. For both gain and loss choices, larger magnitude outcomes lead to a lower proportion of "want now" thoughts, and in both cases, the proportion of "want now" thoughts predicted discounting while controlling for magnitude (thus following the standard mediation model). However, as predicted and described above, the direction of the relationship between "want now" thoughts and discounting is opposite for gains and losses: more want now thoughts were associated with greater discounting of gains, but lower discounting of losses. Both mediation models were significant at $p<.05$, using a bootstrapping test with 10,000 replications, following the guidelines of Shrout &

Bolger (2002). However, effect sizes were generally small (standardized betas in the range of .2 to .25), and the mediation was clearly only partial in both cases.

Figure 6

Mediation diagrams showing magnitude having an effect on discount rates through "want now" thoughts, separately for gains and losses, in Study 2. βs show standardized betas. Note, that the relationship between "want now" thoughts and discounting is positive for gains, but negative for losses.





General Discussion

As observed in Study 1 and replicated in Study 2, losses can show a reverse magnitude effect in intertemporal choice. In other words, whereas people are more patient for large gains than small gains, they have a greater tendency to postpone large losses than small losses. Our studies are the first to demonstrate this reversal, which is most likely due to the fact that most studies of intertemporal choice do not allow participants to express zero or negative discount rates, because they take the rational-economic model of discounting as their point of departure.

We explain this reversal with a reconceptualization and generalization of present bias. We contend that in addition to people's desire to resolve intertemporal gains immediately, they also often have a psychological desire to resolve losses immediately. This present bias translates into higher discount rates for gains, and lower discount rates for losses. Furthermore, we agree with Benhabib and colleagues (2010) that this present bias does not scale with magnitude, representing a sort of "fixed cost" which becomes relatively unimportant with large magnitude outcomes. In other words, people are impatient to have gains immediatly, and people want to get losses over with as soon as possible, but this psychological concern is relatively unimportant in the face of large magnitude outcomes. For example, someone may prefer to deal with a small problem right away, but put off large problems until later. Our process data in Study 2 support this theory, showing that present bias thoughts mediate the effect of magnitude on discounting, for both gains and losses.

Our studies manipulated magnitude between subjects; it would be interesting in future studies to see if this reversal would hold in a within-subjects design. Furthermore, it would be interesting to parametrically manipulate outcome magnitude, to see at what point the reversal is

strongest and at what point it is eliminated. It would also be interesting to run a study and analysis identical to Benhabib and colleagues (2010) but with losses instead of gains, to determine if the size of the present bias for losses (the desire to get them over with immediately) is also $4, or if it is a different amount. Our intuition is that it would be smaller, based on the data in this paper showing that while negative discounting of losses does occur, most people would not choose to lose $10 today rather than $6 in the future.

Our findings may offer some guidance to policy-makers hoping to encourage responsible intertemporal decision making. Whereas patience for gains can be encouraged by focusing on a large magnitude future goal, the same strategy should not be applied to losses; people are motivated to take care of small losses immediately, but large losses may swamp this tendency and result in postponing the loss until later. This might be one reason why efforts to portray global warming as a huge future problem have been unsuccessful for motivating action. Breaking the problem down into smaller pieces might be more effective.

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Appendix A

List of options presented to participants in Study 1.

Receive $10 immediately	Receive $9 in six months
Receive $10 immediately	Receive $10 in six months
Receive $10 immediately	Receive $11 in six months
Receive $10 immediately	Receive $15 in six months
Receive $10 immediately	Receive $20 in six months
Receive $10 immediately	Receive $30 in six months
Receive $10 immediately	Receive $50 in six months
Receive $10 immediately	Receive $100 in six months
Receive $10 immediately	Receive $500 in six months

Pay $10 immediately	Pay $9 in six months
Pay $10 immediately	Pay $10 in six months
Pay $10 immediately	Pay $11 in six months
Pay $10 immediately	Pay $15 in six months
Pay $10 immediately	Pay $20 in six months
Pay $10 immediately	Pay $30 in six months
Pay $10 immediately	Pay $50 in six months
Pay $10 immediately	Pay $100 in six months
Pay $10 immediately	Pay $500 in six months

Receive $1,000 immediately	Receive $900 in six months
Receive $1,000 immediately	Receive $1,000 in six months
Receive $1,000 immediately	Receive $1,100 in six months
Receive $1,000 immediately	Receive $1,500 in six months
Receive $1,000 immediately	Receive $2,000 in six months
Receive $1,000 immediately	Receive $3,000 in six months
Receive $1,000 immediately	Receive $5,000 in six months
Receive $1,000 immediately	Receive $10,000 in six months
Receive $1,000 immediately	Receive $50,000 in six months

Pay $1,000 immediately	Pay $900 in six months
Pay $1,000 immediately	Pay $1,000 in six months
Pay $1,000 immediately	Pay $1,100 in six months
Pay $1,000 immediately	Pay $1,500 in six months
Pay $1,000 immediately	Pay $2,000 in six months
Pay $1,000 immediately	Pay $3,000 in six months
Pay $1,000 immediately	Pay $5,000 in six months
Pay $1,000 immediately	Pay $10,000 in six months
Pay $1,000 immediately	Pay $50,000 in six months

Appendix B

List of options presented to participants in Study 2.

Receive $10 immediately	Receive $9 in six months
Receive $10 immediately	Receive $10 in six months
Receive $10 immediately	Receive $10.50 in six months
Receive $10 immediately	Receive $11 in six months
Receive $10 immediately	Receive $12 in six months
Receive $10 immediately	Receive $14 in six months
Receive $10 immediately	Receive $17 in six months
Receive $10 immediately	Receive $20 in six months
Receive $10 immediately	Receive $25 in six months
Receive $10 immediately	Receive $35 in six months

Pay $10 immediately	Pay $9 in six months
Pay $10 immediately	Pay $10 in six months
Pay $10 immediately	Pay $10.50 in six months
Pay $10 immediately	Pay $11 in six months
Pay $10 immediately	Pay $12 in six months
Pay $10 immediately	Pay $14 in six months
Pay $10 immediately	Pay $17 in six months
Pay $10 immediately	Pay $20 in six months
Pay $10 immediately	Pay $25 in six months

Pay $10 immediately	Pay $35 in six months

Receive $10,000 immediately	Receive $9,000 in six months
Receive $10,000 immediately	Receive $10,000 in six months
Receive $10,000 immediately	Receive $10,500 in six months
Receive $10,000 immediately	Receive $11,000 in six months
Receive $10,000 immediately	Receive $12,000 in six months
Receive $10,000 immediately	Receive $14,000 in six months
Receive $10,000 immediately	Receive $17,000 in six months
Receive $10,000 immediately	Receive $20,000 in six months
Receive $10,000 immediately	Receive $25,000 in six months
Receive $10,000 immediately	Receive $35,000 in six months

Pay $10,000 immediately	Pay $9,000 in six months
Pay $10,000 immediately	Pay $10,000 in six months
Pay $10,000 immediately	Pay $10,500 in six months
Pay $10,000 immediately	Pay $11,000 in six months
Pay $10,000 immediately	Pay $12,000 in six months
Pay $10,000 immediately	Pay $14,000 in six months
Pay $10,000 immediately	Pay $17,000 in six months

Pay $10,000 immediately	Pay $20,000 in six months
Pay $10,000 immediately	Pay $25,000 in six months
Pay $10,000 immediately	Pay $35,000 in six months

Paper 4: Dread Looms Larger Than Pleasurable Anticipation

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Abstract

When making decisions about future events, we consider not only the pain or pleasure the event will cause us when it occurs, but also the psychological pain or pleasure of anticipating the event. In Study 1, participants reported experiencing aversive anticipation (aka dread) roughly twice as often as pleasurable anticipation (aka savoring). In particular, the anticipation of positive outcomes (gains) was sometimes pleasurable and sometimes painful (due to impatience), whereas the anticipation of negative outcomes (losses) was painful or neutral. In study 2, anticipation value was found to predict time preference. In study 3, the "dread looms larger" effect was found to persist even when controlling for loss aversion. In combination, these results may help explain the "sign effect", i.e., why losses are discounted less than gains.

Keywords: intertemporal choice, temporal discounting, framing, affect

Dread looms larger than pleasurable anticipation

Our desire to experience something now or postpone it until later reflects multiple, conceptually distinct forces. Many of these apply equally to gains and losses. For example, the uncertainty that a future event will actually happen (or that one will be alive to experience it) often provides as strong of a reason to postpone something negative as to accelerate something positive. Similarly, the interest lost by delaying a $100 reward for a year is equivalent to the interest gained by delaying a $100 loss. Despite these symmetries, laboratory studies of intertemporal choice typically find that the desire to have good things immediately is much stronger than the desire to postpone negative outcomes (Frederick, Loewenstein, & O'Donoghue, 2002; Hardisty & Weber, 2009; Thaler, 1981). The reasons for this "sign effect," however, are not yet well understood.

One hypothesis involves asymmetries in the utility (and disutility) of the anticipation of gains and losses: if dread looms larger than pleasurable anticipation, the desire to postpone losses will be weakened more than the desire to accelerate gains, thereby producing lower discounting for losses than gains. For example, many would prefer to pay a $50 bill immediately to avoid having it "hang over their head" for a month, but, by contrast, few would delay the *receiving* $50 immediately to extend the period of pleasurable anticipation – i.e., the pains of dread outweigh the pleasures of anticipation.

Preliminary data lend support to this conjecture. In one study, one hundred and three participants from Harvard's Computer Lab for Experimental Research (which draws participants about equally from Harvard's student population and residents of Boston) received $10 to complete a survey that included two questions from Loewenstein (1987): (1) What is the most

you would be willing to pay for a kiss from your favorite movie star tonight? and (2) What is the most you would be willing to pay for a kiss from your favorite movie star three days from tonight? Participants who gave different answers to these two questions (presented side by side) were asked to give a reason why.

To our surprise, just six participants indicated they would pay more for the delayed kiss, and just one mentioned pleasurable anticipation as the reason. The results suggest that pleasurable anticipation was weak or rare, or, in any case, insufficient to motivate differences in willingness to pay for a kiss at different times. By contrast, a study on dread we conducted at the University of Michigan with fifty-six undergraduates suggested that many people *would* make sacrifices to accelerate an aversive event. Specifically, among participants who indicated they would prefer eating 9 mealworms today to eating 9 next week (about two-thirds of the sample), over half of said they would maintain this preference, even if they could eat one fewer next week (8 mealworms). This study suggests a willingness to incur a more aversive experience sooner to minimize the dread.[4] Similarly, a series of recent studies by Christine Harris (2010) conclude that anticipation of dread plays an important role in intertemporal choice for losses. She demonstrated a preference reversal from dread, whereby a sooner loss would be chosen if it was available immediately, but if both options were in the future, the later loss would be chosen.

We note here that the language for discussing anticipatory emotions is somewhat impoverished. Following Loewenstein (1987), we will use the term *savoring* to refer to the pleasurable anticipation of future positive events, though the term is awkward, since it is most commonly used to refer to pleasure arising from concurrent experiences (e.g. savoring a bite of lobster) or reflecting on past experiences (e.g. savoring the team's lone Super Bowl title). We

[4] The sample was restricted to respondents who would be unwilling to eat mealworms unless compelled.

will use the term *impatience* to refer to the negative experience of waiting for something positive to occur. We will use the term *dread* to refer to the negative experience of waiting for something negative to occur. We know of no term that refers to pleasure from anticipating negative events. We suspect that this unnamed emotion is extremely rare, even for negative events respondents prefer to postpone for any number of other reasons (fear, pure time preference, uncertainty, etc.).

Discussions of the relative power of savoring and dread are rare (though see Elster & Loewenstein, 1992) and, to our knowledge, the only published empirical comparison is a paper by Loewenstein (1987) which compared movie star kisses with electric shocks. Therefore, we ran a series of three studies to more broadly explore the role of anticipation in intertemporal choice: Study 1 compared the relative prevalence of dread vs savoring, Study 2 explored whether anticipation utility predicts time preference, and Study 3 tested whether asymmetries in anticipation effects persisted when controlling for loss aversion.

Participants in our exploratory first study were asked to generate as many examples as they could summon of events they would prefer to postpone or events they would prefer to accelerate. Later, participants were asked to quantify how much pleasure [or displeasure] they would experience while waiting for each event they had listed. We predicted that dread would be more pronounced than savoring.

Study 1

Methods

Participants & Procedure

A convenience sample of 155 participants (mean age=39, *SD*=15) were recruited from decision making research laboratories at Columbia and an online pool.[5] In a 2X2 between-subjects design, respondents were randomly assigned to consider either positive or negative events, and to either give examples of events they would prefer to happen sooner, or events they would prefer to happen later.[6] Participants were required to generate at least one event, but could list as many as they wished. For each listed event, respondents were then asked "If this thing were one week away, how would you feel about anticipating it?" and responded on a 7-point bipolar scale ranging from -3 ("I would really dislike waiting for it") to 3 ("I would really like waiting for it"). We excluded thirty-five participants who failed an attention check (similar to the Instructional Manipulation Check used by Oppenheimer, Meyvis, & Davidenko, 2009).[7]

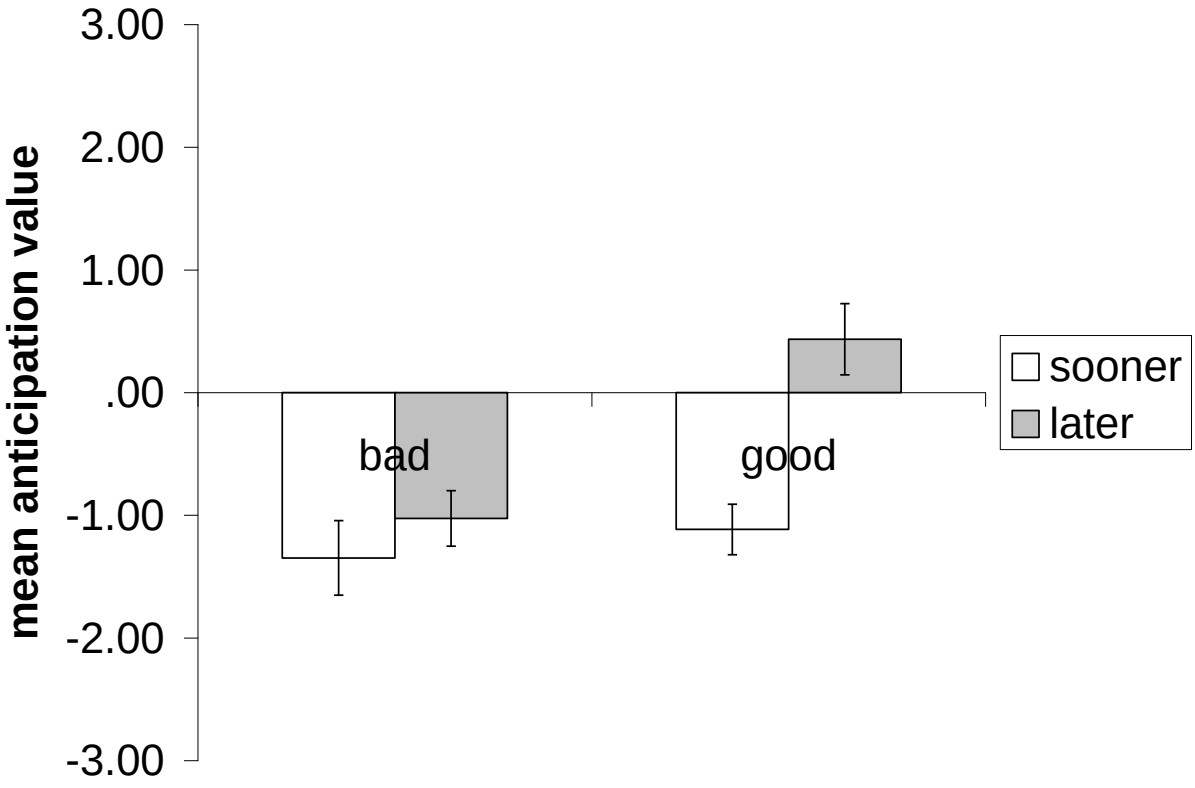
Results

Not surprisingly, for the positive events participants would prefer to postpone, they generally predicted positive anticipation utility (mean rating = +.43, *SD*=1.6) and for the positive events they'd prefer to accelerate, they generally predicted negative anticipation utility (mean= -1.1, *SD*=1.1), $t(59)=4.3$, $p<.001$. For negative events, respondents expected to suffer more for the events they'd prefer to accelerate (mean=-1.4, *SD*=1.5) than those they preferred to postpone (mean=-1.0, *SD*=1.3), though this difference was not significant . Both of these patterns are seen in Figure 1. A 2x2 ANOVA showed significant effects for sign, $F(1,113)=10.6$, p=.001, time, $F(1,113)=13.0$, p<.001, and the interaction, $F(1,113)=5.6$, $p=.02$.

[5] The only statistically significant difference between the samples was a main effect of the lab members listing more examples.
[6] For the complete text of the instructions, see Supplemental Materials A.
[7] The pattern of results with these participants included is similar but noisier.

Figure 1

Mean anticipation utility assigned by participants to their self-generated events, in each of four conditions in Study 1: good things they would prefer to experience sooner, good things they would prefer to experience later, bad things they would prefer to experience sooner, and bad things they would prefer to experience later. Error bars represent +/- one standard error.



We also compared the *frequency* with which participants classified events as having positive or negative anticipation value. As seen in Table 1, the dread was reported much more often than savoring. Overall, 69% of negative events were rated as producing dread, while only 38% of positive events were rated as producing savoring, a significant difference in proportions, z=7.7, p<001.

Table 1

Proportion of events classified by participants as provoking dread, pleasurable anticipation, or neither, depending on what type of events participants had generated (positive events vs negative events that they would prefer to happen immediately vs later).

	Positive Event		**Negative Event**		
Classification	**Prefer Now**	**Prefer Later**	**Prefer Now**	**Prefer Later**	**Average**
Negative Anticipation	74%	22%	75%	63%	58%
Neutral Anticipation	15%	14%	13%	18%	15%
Positive Anticipation	11%	64%	12%	19%	27%
Total	100%	100%	100%	100%	100%

Total N = 433 events

Discussion

While negative events usually caused, positive events on balanced sometimes produced savoring but sometimes produced impatience. It is likely that many participants considering future gains experienced a mixed emotional state, characterized by both impatience and pleasurable anticipation. This suggests an explanation for the "sign effect" conjectured above: that to the motivation to delay losses is weaker than the motivation to accelerate gains, because

delaying losses almost always imposes a cost, whereas delaying gains is at least sometimes pleasurable.

In Study 2, we examine whether anticipation utility predicts time preference, across a variety of domains. We specified twenty events (10 positive and 10 negative) for each respondent to consider, presented in random order. For each event, participants indicated when they'd want that event to occur (now, later, or don't care), rated the event's anticipation utility given a specified delay, and rated the subjective value of experiencing the event at the given delay (in other words, the future value of the event). We predicted that dread would be more common than savoring, and that anticipation value would help predict their preferences for the event's timing.

Furthermore, we investigated the robustness of the "dread looms larger" effect over time, by investigating delays of three days to five years. We hypothesized that although anticipation utility would be weaker at longer delays, as suggested by previous theory (Loewestein, 1987), the imbalance between anticipation of gains and losses would persist at all delays.

Study 2

Methods

Participants

271 US residents (mean age=42, *SD*=14) from a range of socioeconomic backgrounds were recruited and run online, and paid $7 for their participation.

Materials

Ten positive and ten negative events (listed in Table 2, below) were selected, drawn from Study 1 and the literature on anticipation and discounting. Item categories listed most frequently by participants in Study 1 were distilled into events for Study 2. We also included several classic examples from the literature, even though they were not mentioned by any participants, such as "a kiss from the movie star of your choice" or "twenty painful (but harmless) electric shocks." Thus, we included a range of events of practical as well as theoretic interest. While these events certainly do not represent *all* gain and loss events that people may experience, they do offer a broader range than is typically investigated in intertemporal choice studies.

Procedure

Participants first read a brief introduction and explanation, stating:

> The following pages will ask questions about immediate and future gains and losses. When you see the word 'immediate,' it means the very near future -- today or tomorrow. Many of the following questions will ask how you would feel **while waiting** for things. In some cases, you may enjoy the process of waiting. For example, if a special holiday is a couple weeks away, the waiting may be pleasant. Other times, you may dislike the way you feel while waiting. For example, if you are waiting for a red light to turn green, the waiting may be unpleasant.

Participants then considered all twenty events in random order. Within condition, delay was the same for all the events, and was manipulated between subjects to be either three days, one week, one month, one year, or five years. For each event, participants answered three questions, (1) "Assuming this event would definitely happen to you and you knew it were coming, **when** would you prefer it to happen?" Possible answers were "immediately", "don't care when", or "[delay

period] from now." (2) "If this event were to happen to you [delay period] from now, how positive or negative would the **event** be at that time?" Participants responded by clicking on a line (a continuous -100 to 100 measure), labeled with "extremely negative", "neutral", and "extremely positive". (3) "If this event were [delay period] away, how psychologically pleasurable or unpleasurable would the **anticipation** be? In other words, how would you feel **while waiting** for it?" Participants responded by clicking on a line (also -100 to 100) labeled with "strongly dislike the feeling of waiting", "neutral", and "strongly like the feeling of waiting." Following these responses, participants completed the attention check (same as in Study 1), the cognitive reflection test (Frederick, 2005) and some demographic questions.

Results

After excluding participants who failed the attention check, 169 participants remained.[8] Time preferences for each event were coded for use as a dependent variable: "immediately" was coded as 1, "don't care" was 0, and "[delay period] from now" was -1.

Our results, shown in Table 2 and Figure 2, can be summarized thusly: (1) Respondents generally wished to accelerate gains (mean=.52, *SD*=.34), but were indifferent with respect to the timing of losses (mean=0, *SD*=.50), replicating previous research on intertemporal preference for gains and losses. This difference was significant ($t(168)=12.2$, $p<.001$, $d=.93$. (2) The predicted *experienced utility* of events was not substantially affected by the time at which they would occur, $F(4,164)=1.5$, $p=.20$, $\eta^2=.04$. On our 7-point bipolar scale, participants rated our ten gain events as significantly more good (mean=65, *SD*=26) than the ten loss events were bad (mean= -

[8] The pattern of results with all participants included is quite similar.

53, *SD*=23). This comparison, however, is difficult to interpret, because we constructed the events being rated and did not attempt to equate them on outcome strength a priori, and because if respondents norm their ratings against other events *of the same valence* the numbers on different sides of a bipolar scale cannot be readily compared (McGraw, Larsen, Kahneman, & Schkade, 2010). (3) The anticipation of losses was judged to be much more negative (mean=-45, *SD*=30) than the anticipation of gains was positive (mean=18, *SD*=39), $t(168)=8.4$, $p<.001$, $d=.65$, replicating the results of Study 1.

Table 2

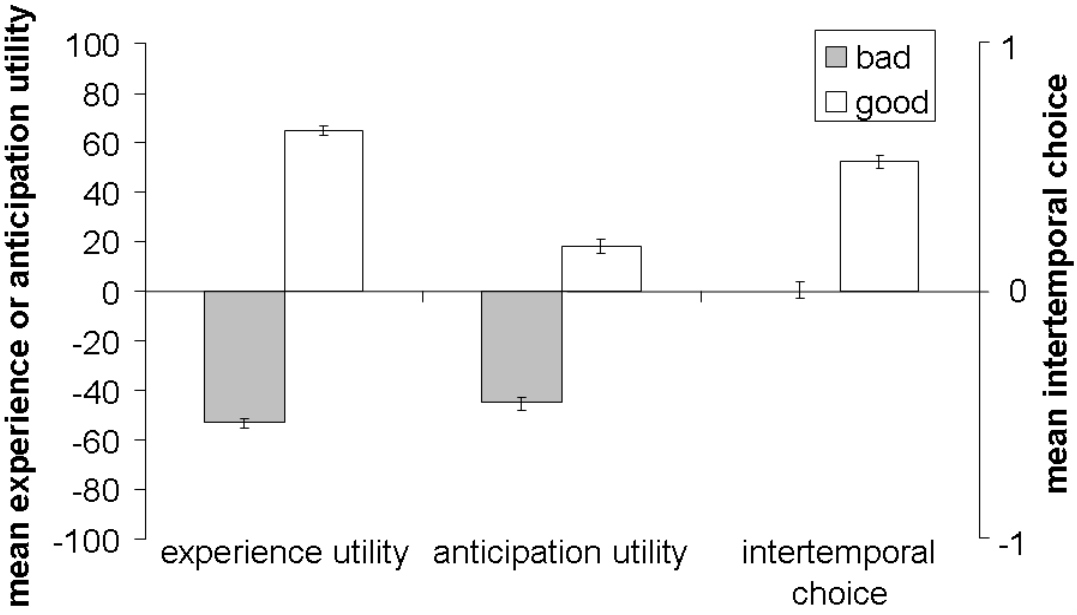
Average anticipation utilities (a) of each event, utilities of experiencing (e) each event, and intertemporal choice (c) for when to experience each event, followed by the standardized betas for anticipation utility (beta(a)) predicting intertemporal choice (c) in regression while controlling for experienced utility (e), all collapsing across time delays, in Study 2.

event	a	e	c	beta (a)
a free 5-day vacation to the destination of your choice	28	75	.19	-.40**
eating a nice meal out at a restaurant	28	59	.29	-.31**
a kiss from the movie star of your choice	22	46	.32	-.17*
receiving a good grade or performance review	21	68	.68	-.22**
getting a gift in the mail from a family member	21	64	.49	-.35**
spending time with your best friend	21	67	.44	-.21**
hour of favorite TV or book	13	52	.57	-.27**
receiving a $50 check	13	66	.78	-.17*

improved energy and health for 10 days	9	67	.69	-.31**
winning the lottery	6	83	.79	-.31**
doing difficult home cleaning and renovation for 5 days	-19	-13	.02	-.36**
an hour at the local Department of Motor Vehicles	-26	-35	.11	-.30**
paying a $50 fine	-27	-39	.02	-.28**
giving a stressful 60 minute improvised speech	-45	-37	-.10	-.20*
being sick for 10 days	-47	-65	-.15	-.32**
a painful dental procedure	-53	-63	.18	-.44**
receiving a bad grade or performance review	-55	-65	.15	-.38**
a confrontation with your co-worker or family member	-57	-60	.18	-.35**
twenty painful (but harmless) electric shocks	-58	-66	.13	-.36**
having one of your legs amputated	-63	-86	-.56	-.24**

Figure 2

Average experience utility, anticipation utility, and intertemporal choices (1 = preference for experiencing the event immediately) for the 10 gains and 10 losses in Study 2, collapsing across time delays. Error bars represent +/- one standard error.



Anticipation utility and experience utility for each event were positively correlated, but only modestly so, for gains (average r=.31) as well as losses (average r=.41) (see Table 2). This provides evidence for the convergent and divergent validity for our measure of anticipation: participants tended to report enjoying looking forward to an event more the better that was, and participants reported dreading bad things more if they were expected to be especially bad. Yet at the same time, the ratings of anticipation and experience utility were distinct in participants' ratings.

The anticipation utility of positive and negative events weakened with delay, $F(4,164)=6.0$, $p<.001$, $\eta^2=.13$, such that the anticipation of positive events grew less pleasant and the anticipation of negative events less aversive as the events were delayed farther into the future, consistent with previous theory (Loewenstein, 1987).

To more fully explore the prevalence of dread vs savoring, we coded each participant for whether they showed "dread bias" or not: we reverse coded the anticipation ratings for losses, and compared the average anticipation ratings for gains and losses for each participant. If the ratings for losses were higher than for gains, that participant was coded as exhibiting "dread bias." We found that 73% of participants showed this pattern of ratings, which was significantly greater than chance (ie, 50%), z=6.7, p<.001. We then compared the *intensity* of dread and savoring by reverse coding the ratings for losses and throwing out any scores of zero or less. Dreaded losses were rated 65 on average (SD=34), on a 1-100 scale, compared with an average of 57 (SD=33) for savored gains. To compare these ratings, we used a mixed model with a fixed effect of sign and random effects of subject and item, confirming a significant effect of sign, F(1,1914)=82.1, p<.001. However, the effect size was small, d=.24. Thus, dread was both *more common* than savoring and somewhat *stronger* when it occurred.

To see whether anticipation utility predicted intertemporal preference while controlling for event value, we ran a linear mixed model predicting time preference (coded as 1, 0, or -1, where 1 indicates “immediately”) with anticipation utility and experience utility as fixed factors and subject ID and event as random factors. This confirmed a main effect of anticipation predicting choice, b=-.004, t(3375.3)=-15.9, p<.001. The slope of -.004 indicates that greater pleasurable anticipation was associated with a preference for delaying the event, with a swing from the most negative anticipation (-100) to the most positive (100) associated with a change of -.8 scale points in time preference (roughly the difference between "immediately" and "don't care"). The mixed model also revealed a main effect of experience utility on time preference, b=.006, t(3345.6)=26.7, p<.001, indicating that participants tended to prefer positive events sooner and negative events later. Finally, a weak but significant anticipation by experience

interaction, b=.000007, t(3249.2)=2.5, p<.05, indicated that the more negative an event was judged to be, the stronger was the relationship between anticipation utility and time preference.

Subsequently, to investigate the robustness of the relationship between anticipation utility and time preference, we ran a separate regression for each event, with the results summarized in Table 2. In all 20 cases, controlling for event value, we found that individuals who found the event more pleasurable to anticipate had a greater preference for deferring it, as would be expected. The average standardized beta for anticipation utility predicting time preference (while controlling for event value) was -.30. Overall, expected anticipation utility modestly predicted time preference, thus supporting Loewenstein's (1987) model of anticipation as an important predictor of intertemporal choice.

Discussion

Consistent with the results of Study 1, dread was roughly twice as common as savoring. As in previous research, participants preferred to have gains immediately more often than they preferred to postpone losses, demonstrating the sign effect. Furthermore, the utility of *anticipating* each event predicted intertemporal preference for that event, even while controlling for the utility of *experiencing* that event. In every case, greater positive anticipation predicted a preference to postpone the event. For example, participants who enjoyed looking forward to a vacation, or who didn't mind anticipating a dental appointment, were more likely to choose to postpone those events.

To the best of our knowledge, ours is the first study that directly links ratings of anticipation utility with intertemporal preference for gains and losses. Although Harris (2010) measured dread of electric shocks, she did not find that these ratings predicted intertemporal

preference. It is difficult to know why we obtained a significant relationship while she did not, but we speculate that differences in question and response-scale wording may be important, because participants are not accustomed to rating the anticipation utility of an event. In particular, having participants rate the experience utility of the event before rating the anticipation utility may help them treat these as distinct concepts.

There was significant heterogeneity among the various gain and loss events used in this study. For example, although the strongest dread was reported for the leg amputation event, anticipation utility was only weakly predictive of time preference for that event. Understandably, participants generally preferred to delay it as much as possible, even if they dreaded it strongly. This illustrates the point that anticipation utility is only one of many factors driving intertemporal choice.

An important question concerns whether the "dread looms larger" effect is independent of the well-known fact of loss aversion: that losses loom larger than gains (Kahneman & Tversky, 1979). Although we attempted to measure and statistically control for the experience utility of each event, recent findings in risky choice (McGraw, et al., 2010) suggest that responses on each side of a bipolar scale, such as those in Study 2, may not be comparable. The theory is that when a person rates the value of an event, he first chooses one side of the scale (positive or negative), and then mentally compares the target event to other same-sign events (comparing gains with gains or losses with losses) to determine the magnitude of the value. For example, when rating how bad a painful dental procedure might be, participants are likely to compare it to the other negative events (such as the electric shocks) than to any of the positive events (such as the nice dinner out). It is difficult to know, therefore, how the gains and losses used in Study 2 compared in subjective value, and it is possible that loss aversion was the driving force behind our

observed results. In Study 3, therefore, we tested whether loss aversion might account for the "dread looms larger" effect, in two ways. As recommended by McGraw et al (2010), we used unipolar scales when measuring utility, which should detect loss aversion, enabling us to control for it statistically. Second, we presented participants with pairs of events, and then analyzed only pairs that participants themselves had judged to be equivalent.

Study 3

Participants & Procedure

A national sample of 108 participants were recruited online from Amazon's Mechanical Turk service and paid $4.55 for participating. Forty-six participants an attention check, using the same method as Study 1 and Study 2, and were excluded from further analysis. The experimental procedure was similar to Study 2, with several exceptions. First, participants read a list of all twenty events (the same as used in Study 2), to familiarize them with the range of events and facilitate comparisons between gains and losses. Then, participants were presented with one event at a time, similar to Study 1. For each event, participants were first asked, "Assuming you knew this event were coming, **when** would you prefer it to happen? Immediately, or in one week?", to which they responded on a 7-point scale from "Strongly prefer immediately" to "Strongly prefer in one week." Subsequently, participants were asked two questions to determine experience utility: "Please imagine this event happening one week from now. Would **experiencing** this event be pleasurable or unpleasurable?" and then "How strongly would **experiencing** this event affect your feelings at that time?" which they answered by clicking on a number line labeled with "not at all" on one end and "extremely" on the other. Then, participants

were asked two question to determine anticipation utility: "If this event were one week away, would the **anticipation** be psychologically pleasurable or unpleasurable? In other words, how would you feel **while waiting** for it?" and "How strongly would anticipating this event affect your feelings **while waiting** for the event?" which was answered on a continuous scale from "not at all" to "extremely". After answering these five questions for all twenty events, participants were then presented with 36 pairs of events (one gain and one loss), in random order. For each pair, participants were asked "If you could choose whether or not to experience **both** these events **immediately**, would you accept this pair?", which they answered on a 7-point scale, from "definitely yes" to "definitely no", with "unsure" in the middle. Finally, participants answered demographic questions.

Results

Participants demonstrated the sign effect, wanting to accelerate gains more strongly than they wanted to postpone losses, as confirmed by reverse coding the time preference for losses and running a repeated measures ANOVA comparing the ten loss events with the ten gain events, $F(1,61)=34.3$, $p<.001$, $\eta^2=.36$.

To analyze the experience and anticipation utility data, we combined participants' binary ratings (positive or negative) with the unipolar continuous scale, to produce a -100 to 100 scale comparable to that used in Study 2. To compare the strength of gains and losses, we reverse scored the losses. When judging the value of experiencing each event, participants rated the loss events as being worse than the gains were good, $F(1,61)=4.4$, $p<.05$, $\eta^2=.07$, thus confirming McGraw et al's (2010) theory that loss aversion is more likely to be observed with unipolar

scales. When judging the value of anticipating each event, gains averaged 22 (*SD*=52), while losses averaged -50 (*SD*=43), a significant difference, F(1,61)=43.9, p<.001, η^2=.42.

To test whether "dread looms larger" would persist when controlling for loss aversion, we ran a mixed model with sign and experience utility predicting anticipation utility, with a random effect of subject. This confirmed that losses were dreaded more than gains were savored, even while controlling for experience utility, *F*(1,1201.8)=13.9, p<.001. We then selected only pairs of gains and losses that participants were "unsure" whether they would accept. There were 128 such pairs. Among these, the average anticipation for gains was 24 (*SD*=50), compared with -57 (*SD*=34) for losses, a significant difference with a mixed model, *F*(1,215)=53.1, *p*<.001.

Finally, we found that anticipation predicted time preference while controlling for experience utility using a mixed model with random effects of subject and event, *b*=-.008, *F*(1,1234.6)=40.2, *p*<.001. Experience utility was also a significant predictor, *b*=.015, *F*(1,1215.3)=154.6, *p*<.001, but the interaction was non-significant, *p*=.55.

General Discussion

Just as research on risky choice has found that disappointment is stronger than elation (Gul, 1991) and regret is stronger than rejoicing (Zeelenberg, Beattie, van der Pligt, & de Vries, 1996), we found that dread is stronger than pleasurable anticipation in intertemporal choice. Anticipation utility predicted time preference, and was rated by participants to be stronger when the event was nearer in time, as consistent with previous theory (Loewenstein, 1987). Taken together, these results may explain the "sign effect" in intertemporal choice.

Given that dread is much more common than savoring, and that dread drives people to want to get losses over with as quickly as possible, one may wonder why procrastination seems

to be such a widespread problem. One answer is that anticipatory utility is only one of many factors driving intertemporal choice. Therefore, someone may postpone housework or other negative events for practical reasons, even though she does not enjoy having the housework hanging over her head.

Another issue is whether procrastination is in fact a larger problem than its counterpart, impulsivity. For example, if someone chooses to watch a movie now and put housework off until later, is he exhibiting impulsivity, or procrastination, or both? Finding the answer is a topic for future research: while we asked participants to consider negative and positive events in isolation, most real-world intertemporal choices involve clear tradeoffs between and immediate gain and a future loss, or vice versa. Another important future direction will be to explore the role of uncertainty in anticipation utility and intertemporal choice. In the present research, an attempt was made to control for uncertainty by telling participants that each event would happen for sure. However, it is likely that the uncertainty of future events affects – and may even reverse – the pleasures or pains of anticipation: compare, for example, the experience of waiting to receive 10 million dollars at the end of the year, vs. waiting to play a lottery that pays off 10 million dollars with a 95% probability. The first would likely be pleasurable, whereas we conjecture the latter would be aversive for most people.

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Paper 5: About time: An integrative approach to effective environmental policy.

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Abstract

Intertemporal trade-offs are inherent in most choices, and are especially salient in environmental decisions. Although psychology, anthropology, and economics each offer unique insights and findings on the mental and social processes underlying the evaluation of future events, each discipline also has its blind spots. Crafting effective policy therefore requires an integration of these three perspectives; this paper offers a concise overview and guide, intended for applied researchers and policy makers. Through three real-world examples, the contributions and integration of the three disciplines are illustrated. Ideally, each perspective feeds into the others in an iterative process, producing an integrative approach that is more than the sum of its parts.

Keywords: intertemporal choice, delay discounting, environmental policy, interdisciplinary, theory

About time: An integrative approach to effective environmental policy

1. Introduction

Countless human decisions involve the need to balance gains or losses that are immediate or near-term against other benefits or costs that are anticipated to arrive at later dates. The prosaic personal drama of staying on a diet, the decision to put away savings for retirement, the analysis of investment returns on a real estate development project, global arguments concerning the wisdom of curtailing greenhouse gas emissions in order to head off accelerating climate change – these and numerous other decisions, great and small, call on us to weigh the claims of the present against those of the future. Such challenges, which raise the issue of *intertemporal choice*, are ubiquitous.

People often choose immediate gratification at the expense of future benefits. The further off an event is, generally, the more we discount it. For example, one reason that people don't invest in profitable retirement accounts is that the costs are immediate while the benefits are far in the future (Thaler & Benartzi, 2004). Many other social ills, such as obesity (Chabris, Laibson, Morris, Schuldt, & Taubinsky, 2008; Reimers, Maylor, Stewart, & Chater, 2009), smoking (Bickel, Odum, & Madden, 1999), and over-exploitation of natural resources (Farber & Hemmersbaugh, 1993; Kortenkamp & Moore, 2006; Markandya & Pearce, 1991) can similarly be traced to temporal shortsightedness. The role of time is especially salient for environmental decisions, which have consequences that unfold over decades, centuries, or millennia. Policies that encourage long-term, sustainable choices may be crafted more readily based on an operational understanding of *how* people make intertemporal choices. This paper offers a

concise guide and recommendations for integrating the insights on intertemporal choice from three disciplines – economics, psychology, and anthropology.

1.1. Outline of the paper

Economics, psychology, and anthropology each offer distinct frameworks for decisions involving immediate and deferred outcomes. Table 1 offers a synopsis of the three approaches. Section 2 gives an overview of the contributions and shortcomings of each discipline. Section 3 illustrates an integrative approach, applying the three fields to three real-world, environmental examples: an individual choosing a light-bulb, a small business considering LEED compliant building renovations, and a population considering a new power source. Finally, section 4 concludes with a few remarks on what is, perhaps, the ultimate intertemporal environmental policy issue: climate change.

Table 1

An overview of the economic, psychological, and anthropological approaches to intertemporal choice.

	Economics	**Psychology**	**Anthropology**
Approach	Mathematically evaluate expected outcome streams over time	Choice between an immediate, small reward versus a larger, delayed reward	Culturally and institutionally defined choices and ways of reasoning
Models	Expected utility of outcome streams is maximized; utility of a **sure** stream is a weighted sum over time; weights often assumed to decline exponentially	Strategies for self-control; limitations of memory; effect of emotions; hyperbolic discounting	Cyclical time, sacred time, routine
Temporal preferences	Known, stable preference exists between any two outcome streams	Preferences are constructed in the situation; even goals are labile	Preferences are culturally determined
Method	Mathematical models with clearly specified assumptions	Experimental research	Ethnography, based on interviews and participant observation
Strength	Systematic framework to **prescribe** choices under given assumptions about utility and growth	Describes the emotional and cognitive factors that shape intertemporal choices	Explores unique cultural and institutional sources of time preference; legitimacy and consent are critical
Blind Spots	Doesn't account for contextual variability in preferences or for the way people resolve uncertainty	Weak prescription for choices; failure to take account of growth, marginal utility, cultural and institutional factors	No universally applicable guidelines for prescribing or describing choices

2.1. Intertemporal choice in Economics

Economists study how individuals allocate resources to satisfy their desires -- in other words, how individuals make decisions between various options. Economics provides methods to model and analyze decisions and offers strategies to prescribe good choices. These methods and strategies are grounded in a number of core assumptions. [9]

Economists generally treat the decision-making process as if people have innate preferences that drive how they make decisions: each individual inherently likes some things better than others. Those preferences are stable -- essentially unchanging though time, and consistent across choices. So for example, if you are confronted with a choice between three bananas and two apples, you will either prefer three bananas to two apples; or you will prefer two apples to three bananas; or, you'll be indifferent -- *always*.

Furthermore, it is assumed that people act logically and strategically on the basis of those preferences. They do not make mistakes. Individuals know what satisfies them and they choose accordingly. They try to get what they want as best they can under the circumstances they find themselves in. (Economists often recognize that people may not have all the information they need to make decisions, and, moreover, may lack the time or knowledge to obtain it.)

These core assumptions create a framework within which economists can meaningfully state, analyze, and solve problems. Since preferences in principle do not change, when an economist observes that a person's *choices* appear to exhibit inconsistencies, the economist looks

[9] In economics, as in all fields of scholarship, one finds heterodox voices that challenge, with greater or lesser skill and persuasiveness, the orthodoxies of the mainstream. The description of consumer choice theory presented here should nonetheless be recognizable to every economist as a summary of the orthodoxy as codified in nearly all undergraduate and graduate textbooks, and maintained as the background concepts of nearly all articles in the field's most selective journals.

for an external factor that might be responsible, such as changes in market prices, technology or law. So, from the viewpoint of economics, decision-making is seen as navigating problems of *constrained optimization*. People try to satisfy their innate desires in a consistent manner while strategically navigating various real-life constraints, such as economic budgets and time limitations.

In this framework, an intertemporal choice is one in which a person incurs a cost up front in order to receive benefits that will be realized later. In many respects, economists treat this type of decision problem like any other: the decision is simply a tradeoff between two goods, available at different times. That said, economists do factor in human impatience. When people want something, they prefer to have it sooner rather than later. And if they do not want something, they prefer to pay that cost later rather than sooner. People generally want to acquire benefits as quickly as possible and push off costs as far into the future as possible.

While impatience is a matter of taste, there are also perfectly rational reasons for having good things sooner and bad things later. For example, getting $100 today is better than getting $100 in ten years because the immediate $100 could be put in the bank to earn interest in the meantime. Furthermore, because most people (and nations) grow richer over time, $100 today is relatively more useful today than it will be in the future. In other words, $100 is worth more to a poor person (today) than to a rich person (in the future).

Thus, according to economic analysis, it is perfectly rational, even advisable, to *discount* future costs and benefits. Traditionally, an exponential discounting model is used (Samuelson, 1937) that functions much like an interest rate in reverse.[10] For example, with a 6% continuously

[10] Other models have been proposed and employed, most notably Laibson's (1997) "beta-delta" model. However, simple exponential discounting remains the mainstream standard.

compounded discount rate, getting $100 in ten years is worth about the same as getting $55 today.

In the examples to follow, the individual shopper choosing a light bulb, the group renovating a building and the community deciding whether or not to build a wind power plant are all, from the standpoint of economics, facing investment choices and performing investment analysis.

2.2 Intertemporal choice in Psychology

Psychologists have focused on describing the cognitive, emotional, motivational, and contextual factors that influence time preference, and particularly on *impulse control* or delay of gratification. For example, it is much easier to resist a dessert if it is out of sight or if you thought about an abstract way (Mischel & Gilligan, 1964; Mischel & Baker, 1975; Mischel, Shoda & Rodriguez, 1989; Metcalfe & Mischel, 1999; Liberman & Trope, 2008). Thus, rather than being fixed and immutable, one's time preference for immediate dessert vs future health may vary from situation to situation or from one frame of mind to another.

Importantly, this often leads to inconsistencies in time preference. For example, someone may plan a diet while at home in front of his computer, but quickly abandon it when a dessert is sitting in front of him after dinner. In general, people sharply overvalue the present, to an extent not predicted or advised by the economic model; in a review of 42 studies of discounting, 22 found discount rates of 60% or more (Frederick, 2002). Thus while economics prescribes an exponential discounting model, empirical studies have found that a hyperbolic model (showing a sharp initial decline) is significantly better for describing the intertemporal choices that both people and non-human animals actually make (Ainslie, 1974; Mazur, 1987; Kirby, 1997).

Choices between immediate and delayed rewards also depend on perceptions of delay and scale (Ainslie 1975; Zauberman et al., 2009). For example, the difference between one day from now and two days from now is much more important to people than the difference between 365 days from now and 366 days from now. This is analogous to the economists' concept of "decreasing marginal utility", except that it applies to time delays, rather than consumption amounts.

Motivational factors such as goals and preferred approaches to goal pursuit (Higgins, 1998), also contribute to the way that individuals make intertemporal choices. Kivetz and Tyler (2007) have shown that different time perspectives activate different representations of the self (idealistic vs. pragmatic), which in turn influence preferences for different kinds of benefits. Other motivational factors, like a desire to fit in with a group, to live up to the expectations of respected others, and to be evaluated positively when compared with others ("social comparison"), also likely affect intertemporal choice and suggest areas for intervention, as explained in more detail in Section 3.2.3.

Recent research has shown that time preference is also strongly affected by "decision architecture" – by the way in which a choice is posed and the order in which the alternatives are considered (e.g., McKenzie, 2004; Weber et al., 2007). For example, if a shopper purchases something online, and the default shipping option is to receive it in 5 days, the shopper will be more patient (and less willing to pay a premium to receive the item earlier) than if the default shipping option is to receive it in two days.

2.3 Intertemporal choice in Anthropology

Anthropologists analyze how people's connection to an enduring community influences the *time horizon* considered in their choice process and the long-term goals – often, community-

related – that they pursue. Long-term goals are not readily represented as economic "streams of consumption" in distinct time periods. They can include long-term preservation of objects, relationships, and species. In the environmental domain: in a community living near a glacier, many inhabitants might view melting as a massive loss, not in the sense only of period-by-period "consumption" (water, recreation, tourism, etc.) but also in a more timeless sense, the loss of its iconic value (Orlove, 2009).

Anthropological research has often focused on the cultural construction of time. In this sense, time is not the objective dimension studied by economists (as by physical scientists), nor the personally subjective dimension studied by psychologists, but a collective dimension. Many cultures emphasize the repetitive nature of time (often called "cyclical" time, though this spatial metaphor may confuse as much as it clarifies); people choose actions that are appropriate to a particular season, or a particular stage in the life-cycle, or to day or night, or to a phase in a calendar that marks ritual and secular periods. An American might want to eat turkey on Thanksgiving, whether that day falls tomorrow or in a number of months. Similarly, that American might save an old toy with the thought of giving it to some grandchild that would be born years or decades in the future; the value of the toy would not vary in any simple fashion with the interval between the present and the date of the possible birth of the grandchild.

This cultural construction of time can be important in policy-relevant arenas as well as in the more personal and familial contexts just mentioned. The residents of a town that has had a major decline in a key economic activity (such as a former lumber or mining town in the western U.S., or a rust belt town with closed factories) may frame decisions, whether in the near or distant future, in terms of shared narratives that contrast earlier periods of well-being and present impoverishment. These narratives might lead them to emphasize a return to former prosperity,

or it might lead them to seek the establishment of a new, distinctive period within local history. These frames would influence their evaluation of projects that the town would consider for the near or distant future (Hodges 2010).

2.4 Some limitations of the three approaches

Economic analyses often incorporate some degree of "positive pure time preference" (ie, impatience), assuming that humans intrinsically devalue the future. However, psychology shows that time preference can change, as people implement self-control or as contextual features change. Furthermore, economics fails to recognize that people generally consider time in a non-linear manner, treating immediate and future delays differently. Anthropology introduces the idea of long-term goals associated with community affiliations. For example, an individual may have a goal of providing a good life or a good environment for his future descendants or for future members of his community. Since this goal will not be achieved or realized until after he is dead, it is not easily captured by the standard, additive, period-by-period consumption architecture of economic analysis.

Psychology, in its emphasis on describing the factors affecting intertemporal choice, offers no clear guide for how intertemporal trade-offs *ought* to be made (other than the implicit notion that it is good to avoid inconsistencies). In addition, psychology has not systematically investigated how people conceptualize and evaluate long streams of outcomes; it offers no alternative to the period-by-period additive model of economic analysis. Furthermore, psychology has also often neglected the lessons of anthropology concerning the social goals that arise from affiliation with an enduring community.

Finally, anthropology offers neither a framework for analyzing alternative social policies over time nor any guidelines for good decision architecture at the level of the individual decision

maker. Each situation is considered afresh, to be understood on its own terms, without the help (or impediment) of a formal model. However, anthropologists recognize that the same goal could be framed in different social contexts: someone who wanted to encourage suburban homeowners to plant shade trees could emphasize the contributions to the household, to the neighborhood, to the community or even to the region or nation.

2.5 A further limitation: The problem of uncertainty

When people are *asked* why they devalue the future, a common response is that future outcomes are uncertain. Psychology and anthropology, therefore, generally treat uncertainty about future outcomes as one reason for discounting them. This seems perfectly sensible, yet it departs from standard economic analysis, which separates uncertainty sharply from temporal discounting.

The standard economic practice is to first consider all **possible** streams of future outcomes (contingent on the choices you might make); next, discount and evaluate each stream as though it were certain to occur; then, combine the utilities of the possible streams into a weighted average, where the weights are the respective probabilities of the various streams; and finally, choose the option with the highest expected utility. However, the uncertainties affecting future outcomes are often too varied and complex to be representable by a set of probabilities that sum to 1. These uncertainties involve not only rates of return on investment but also personal changes (including maturation, aging and death) as well as technological, ecological and social changes. Most such changes can scarcely be imagined, much less assigned probabilities, whether objective or subjective. Thus, while economics offers a clear guide for how one should deal with uncertainty, it is often impossible to follow in practice. Psychology

and anthropology, on the other hand, have offered no competing analytic tools for how we *ought* to deal with future uncertainty.

3. Three decisions about energy use

To better understand what each of these three disciplines can tell us about intertemporal choice, we now explore three concrete examples about energy use -- a key policy issue with important environmental consequences -- at three timescales and group sizes. We consider an individual shopping for a light bulb, a small organization deciding whether to pay for LEED certified renovations, and a population of diverse communities deciding on a new source of power. We outline each decision, then discuss how each discipline informs our understanding, and what an integrative approach might recommend.

3.1 Purchasing a light bulb

Decision Maker: Individual

Time Scale: Short

Most people have continued to buy incandescent light bulbs, rather than compact fluorescent light bulbs (CFL), despite the facts that a CFL usually costs less (if one considers its much longer lifetime) and saves considerable energy. This energy saving further reduces cost for the consumer (or whoever is paying the electricity bill). Furthermore, the energy saving reduces the hidden costs (to many) of pollutants and greenhouse gases (if the extra electric energy is generated by burning coal, oil, or natural gas). So the CFL is a triple winner. How can its low market share be explained by economics, by psychology, by anthropology, or a blend of the three? If everyone would be better off with general adoption of CFLs, what changes would each discipline (or the combination) recommend to bring this about? In point of fact,

governments world-wide have legislated energy-efficient bulbs. For example, in the U.S.A, the Energy Independence and Security Act of 2007 requires that by the year 2020, all general-purpose light bulbs be as energy efficient as current CFLs. Other jurisdictions (e.g., Canada, California) have moved even more quickly. But why has legislation been required, when the financial and environmental costs alone should have led people to make the change?

It is worth examining the details of the "triple winner" assertion: these details on the one hand show what large benefits have been foregone, in aggregate, by low adoptions of CFLs, but on the other hand, the same details also suggest why the triple winner has needed a boost from policy makers.

A 26-watt CFL has light output equivalent to a 100-watt incandescent bulb, so the energy saving is about 75%. A typical price for this CFL is about $3 - $4 and its typical lifetime about 10,000 hours. Thus the cost is about $0.35 per 1,000 hours of service. At the time CFLs were introduced, the typical 100-watt incandescent bulb cost about $0.60, with a typical lifetime of only about 1,000 hours. Its cost of $0.60 per 1,000 hours of service is higher than CFLs. (More recently, however, "long-life" incandescent bulbs have become commonly available, with little or no increase in cost, thus gaining a cost advantage over CFLs in this regard.)

It is in the area of energy expenditures that the two diverge more significantly. Operating a 26-watt CFL for 10,000 hours uses 260 kilowatt hours of energy, costing something over $26 at typical prices for electric power. The 100-watt incandescent costs about $100 for the same 10,000 hours (or even more, if electricity rates go up with usage, as is often true). The savings on a household electric bill over the lifetime of a CFL is thus much greater than any difference in up-front price (for a summary, see U.S. Department of Energy, 2010).

It is sometimes argued that people on tight budgets simply can't afford $3 to $4 to replace a light bulb. However, most of the time, people replace incandescent bulbs with stock on hand, *purchased in advance*. Thus, they readily pay the same $3 to $4 for a six-pack of incandescent bulbs.

As for greenhouse gas emissions, one kilowatt hour of home energy in the U.S. produces about 1.6 pounds of CO2 (U.S. Environmental Protection Agency, 2010). This means that over the typical 10,000 hour life of a single CFL, it will save 416 pounds of CO2 (compared with a 100-watt incandescent). For comparison, this is equivalent to driving 475 miles in a typical car in the U.S. (getting 22.6 miles/gallon; Research and Innovative Technology Administration, 2008).

3.1.2. How economists look at purchasing light bulbs

From the perspective of economics, the shopper selecting a light bulb is making an investment decision. CFL bulbs cost more than conventional ones, but they also last longer and use less electricity. So the shopper must weigh the extra cost for the CFL bulb against potential future returns--savings on electric bills and on the purchase of future light bulbs.

Economists analyze this choice as a problem of calculating return on investment. An initial upfront outlay of cash (the extra cost for the CFL bulb) will yield a return of a stream of benefits over time (reduced monthly expenditure on electricity and reduced cost of replacement bulbs). Economists can evaluate this choice just as they evaluate the purchase of a bond. Bonds too require initial capital outlay and generate a measurable rate of return. And in either case, whether or not the purchase is appropriate depends on the decision maker's cost of capital.

If the shopper is cash-constrained and is purchasing on credit, she would have to factor in the extra cost of the credit card's interest rate, weighing the cost of capital against the yield. Generally speaking, the higher the cost of capital vis-à-vis the cost of electricity, the more sensible it would be for the shopper to choose an incandescent bulb. The lower the cost of capital vis-à-vis the cost of electricity, the more reasonable it becomes to choose the CFL bulb. If the shopper is short on cash and does not have access to credit at all, if she needs the money right now, it might be sensible for her to forgo the investment even if it has a very favorable rate of return. Because people have different costs of capital, buying the CFL bulb could make financial sense for some people but not necessarily for everyone.

Suppose the decision maker cares about the environmental consequences of her choice. Economists would view the shopper as having a taste for environmental preservation and would see the feeling-of-doing-right-by-the-environment as something she consumes. The feeling-of-doing-right-by-the-environment would be a feature of the CFL bulb, which the incandescent bulb lacks. This special feature could increase the value of the bulb enough to the shopper to tilt her decision towards buying it.

If an environmental or government agency were interested in encouraging shoppers to adopt CFLs, economists might suggest trying to manipulate the relative price of the two kinds of bulbs by offering a subsidy for CFL bulbs (perhaps a promotional discount) or by taxing the incandescent ones. Lowering the upfront cost of CFLs (while the flow of future benefits remains the same) makes the percentage rate of return on that investment more attractive, and shoppers should be more inclined to buy them.

However, since the cost of CFLs is already so favorable, one would have to ask whether these interventions would work. It is difficult to understand from the economic perspective why consumers are not already purchasing CFLs in droves. The best economic explanation may be that shoppers either do not *understand* or do not *believe* the benefits of CFLs. But understanding and believing are outside the realm of economics. Consumer psychology and shoppers' lack of trust in authority are better explored by psychologists and anthropologists, respectively.

3.1.3. How psychologists look at purchasing light bulbs

We have argued already that the low adoption of CFLs is not primarily a manifestation of extreme impatience; rather, it represents a failure of understanding or of trust in calculations presented to consumers. Insofar as understanding is an issue, one effective intervention might be to make the future costs more salient: for example, a requirement that a 10-year overall cost, including electricity cost and a reasonable rate of return on investment, be displayed prominently along with the immediate purchase price (e.g., $38 for the CFL vs $128 for the incandescent bulb, along with $3.44 vs $0.60, respectively). This is similar to the way prices are displayed in some drugstores and supermarkets, with the total price displayed alongside the per-unit price, so customers can easily compare the value of a 10-oz. bottle of shampoo with that of a 12.3-oz. bottle.

A different sort of intervention would address the fact that people are generally biased in favor of the default, or status quo (Johnson & Goldstein, 2003). Whichever option shoppers consider first sways their opinion, and their subsequent decision making is influenced accordingly, reinforcing their initial reaction (Hardisty, Johnson & Weber, 2010; Johnson, Haubl, & Keinan, 2007). Currently, people generally have incandescent bulbs at home, and so consider these the default option when they go out shopping. A possible intervention, therefore,

would be to make CFLs the default in new building construction (Dinner, Johnson, Goldstein, & Liu, 2010). Similarly, asking that CFLs be positioned prominently in store displays is a traditional marketing device, which may influence shoppers' first impressions, leading them to weight more heavily the future benefits that CFLs provide. Questions of economics come back to the fore when one asks about incentives for builders to adopt or for retailers to market CFLs more vigorously.

3.1.4. How anthropologists look at purchasing light bulbs

The question of whether consumers **trust** the information provided about CFLs lies at the juncture of psychology and anthropology. There are extensive and somewhat disjoint literatures in both fields, under the heading of *persuasion* in psychology and marketing and under the headings of *trust* and *legitimacy* in sociology and anthropology. Trusting information also is closely connected to political ideology, in ways that may vary widely from one society to another.

Another point of intersection of these two fields comes under the heading of affiliations, norms, or social goals. It seems possible in the U.S., for example, it is primarily those who identify strongly as environmentalists who have purchased CFLs. The CFLs may not be perceived as a triple winner but primarily as environmental amelioration. Surveys of shoppers could determine to what extent this is so.

Anthropologists might conduct ethnographic research on the shopping activities and on the use of light bulbs to learn how people act in stores and how they use bulbs in their homes. A study of electricity use in China (Wu, 2008) showed that men, rather than women, typically purchase light bulbs, but that electric light is more important for women’s economic activities

(such as sewing clothes) than for men's, so that men and women might have different priorities in selecting bulbs. This study also showed that more expensive electric items are often purchased in stores, while less expensive ones are purchased in street markets. Men and women differ in their interactions in these two settings. This information, or similar information in other settings, could influence the design of campaigns to support CFLs.

Cultural considerations may also lead to different interventions at different places and times. A comparative study of domestic use of electric light in Oslo, Norway and Fukuoka, Japan, found that Japanese prefer to light their houses with fewer, brighter lamps, often located on the ceiling, while Norwegians place a strong value on having a larger number of smaller lamps distributed around the room (Wilhite et al., 1996). The Norwegians also dislike the white tone of most fluorescent lamps, while Japanese actively prefer it to the yellower light of incandescent bulbs. Interestingly, this study found that the average size of homes and the cost of a kilowatt-hour as a proportion of average annual income were very close in the two study cities, so economic differences do not account directly for the national differences. This study suggests that Japanese would more readily adopt CFLs, while some technical changes -- producing CFLs with a softer tone and in a variety of brightness -- could assist the uptake in Norway.

3.1.5. Encouraging consumers to buy CFLs: an integrative approach

The ideal integrative approach one uses the insights and methods of each discipline to inform the others, in an iterative process. One might start by observing and talking to shoppers as they are choosing new light bulbs. What factors are they considering? Are they mainly thinking about making trade-offs between immediate and future costs, or are they choosing based on other factors, such as tradition (buying what they have bought before), aesthetics (perhaps they prefer one kind of light to the other) or values (choosing the CFL for environmental

reasons)? One might also investigate the rational costs and benefits of different choices. Knowing the answers to these questions can subsequently inspire and inform experiments. For example, if consumers are not aware of the long term benefits of CFLs, these should be highlighted. Alternately, if tradition is the most important factor (buying what looks like what they had before), then perhaps the appearance of CFLs should be changed to match incandescent as much as possible. Of course, before scaling up a successful intervention, it should be evaluated for long-term sustainability. For example, if a new CFL bulb offers the same quality of light as incandescent bulbs but also has dramatically reduced lifespan, the increased sales of this type of CFL may or may not be worth the tradeoff, depending on how the calculations come out. If the results of an experiment do not turn out as expected, further qualitative insight from shoppers may be instructive for understanding how the intervention was perceived. In this way, the prescriptive, descriptive, and collective insights of economics, psychology and anthropology can inform each other, creating an integrative approach that is more than the sum of its parts.

3.2. Renovating a building for LEED certification

Decision Maker: Small Group

Time Scale: Medium

When companies decide to renovate their office buildings, they have the opportunity to plan renovations that would qualify them for LEED (Leadership in Energy and Environmental Design) certification. LEED certification verifies a building's overall effectiveness in energy efficiency, water efficiency, CO_2 emissions reduction, and other factors (U.S. Green Building Council, 2009), and is the most widely used and trusted environmental certification system in the U.S. (Fowler & Rauch, 2006; Ross, López-Alcalá, Scorsolini, & Small, 2007).

LEED-compliant renovation and certification typically requires a substantial up-front premium (in the form of both money and time) but brings continual future benefits for the life of the building. In a case study of a small commercial office building, LEED improvements cost an additional $7.41 per square foot, but delivered an estimated $1.38 per square foot annually in energy savings (Ross, López-Alcalá, Scorsolini, & Small, 2007). Furthermore, LEED improvements bring improved employee productivity (Kats, Alevantis, Berman, Mills, & Pearlman, 2003) and a positive image for the company. Other long-term impacts, such as reduced CO_2 emissions and reduced strain on the electricity grid, benefit future tenants of the space and society, but not the company in particular.

3.2.2. How economists make choices about building renovations

From an economist's perspective, the problem of choosing between a LEED certified building plan and a conventional one is very similar to the problem of choosing between a CFL and conventional light bulb. The building planning committee, like the light bulb shopper, is weighing an investment decision. A LEED building costs somewhat more up front to build or renovate but offers an associated return on investment (reduced energy bills over time). To evaluate whether or not LEED compliant renovations make sense, economists would compare the expected return to the cost of capital, just as they did when considering the choice of light bulbs. In this case too, if the return is sufficient compared to the cost of capital, the LEED certification makes sense. But here again the cost of capital is a key consideration. If investors are borrowing their capital at a high interest rate, their returns would also have to be high to make the choice worthwhile.

Although economists analyze the two problems in essentially the same way, the problem of LEED certification might involve a couple of additional complications. Suppose, for instance, that employees work more productively in a LEED-certified environment, or perhaps LEED certification enhances the corporate image of companies housed in the building. Economists would quantify "increased employee productivity" and "enhanced image" and factor those extra advantages into the financial analysis as increasing the stream of cash flow benefits that would accrue over time.

Although the long-term financial, energy, and social benefits of LEED certified construction and renovation are clear, LEED-certification is not always in the short-term financial interests of a particular company, given their alternatives for investment. LEED improvements are tied to a building, not to an organization. So, if the decision makers that are considering LEED certification rent rather than own the building, they would need to consider the length of their lease and intended stay. If they were to move or go out of business, they would not enjoy the long-term benefits of the improved energy efficiency.

If policy makers want to encourage the adoption of LEED improvements, economists might there advise them to work with governments and banks to offer loans that are tied to the property (one example of this practice is the PACE program; see http://pacenow.org/). These loans cover the extra upfront cost of energy improvements and are repaid by present and future tenants. Assuming the savings from efficiency and productivity are greater than the cost of loan repayment, present and future tenants would benefit. This strategy would lower the risk for the current tenant, the decision maker, making the choice of LEED certification more appealing.

If the decision makers are planning to finance the LEED building or renovation with a bank mortgage, there is another important practical consideration they will need to take into account. LEED improvements cost extra, so the decision makers are going to need to apply for a larger loan. To get the bigger loan, they will have to convince the bank to give it to them. But they are likely to run up against a practical problem here. If the bank does not have a way to figure out how LEED certification increases the value of a building or reduces the operating costs, it has no way of assimilating those benefits. (Banks in the United States currently have no framework for taking into account the potential returns these LEED improvements will provide; there is no place on a loan application form, for instance, to account for the future savings in operating costs that will accrue from these energy-efficiency improvements.) As a result, from the point of view of the bank, the extra cost of LEED certification only factors in as increased liability -- greater risk for the bank. The bank is likely to respond as it would to any increased risk: by refusing to loan the extra money or by charging a higher interest rate.

If policy makers wanted to encourage the adoption of LEED certification, they could counteract or ameliorate this problem with financial incentives. They might subsidize the actual materials that go into LEED improvements, thus making the improvements cheaper and decreasing the investor's financial risk (and in turn the risk to the bank considering the mortgage). They could also create specialized financing programs to cover the extra cost of LEED improvements. Investors could borrow the dollar amount of a conventional mortgage from their own bank, and then apply to a secondary financing organization (like a state or non-profit agency) for the extra cost of LEED improvements.

3.2.3. How psychologists make choices about building renovations

Although the future benefits of LEED improvements are delayed, and hence discounted heavily, social comparison and social goals can provide an immediate *psychological* payout. In recent field studies, providing feedback on how much energy consumers were using relative to their neighbors led to significant improvements in conservation (Handgraaf, Van Lidth de Jeude, & Appelt, working paper; Schultz, Nolan, Cialdini, Goldstein, & Griskevicius, 2007). In fact, social incentives were more effective than monetary incentives. Social goals, such as competition, are especially strong between groups (McCallum et al, 1985). Therefore, policy makers could publicize those businesses who have signed up for (or already enacted) LEED improvements. This would provide an *immediate* social incentive for other companies to sign up, balancing out the immediate financial cost. Additionally, businesses with LEED-certified buildings could advertise this to their (environmentally conscious) clients and could potentially use the long-term savings from LEED renovations as a selling point (e.g., "passing the savings on to the client"). Highlighting this potential competitive advantage could improve the attractiveness of LEED improvements, despite their initial cost.

3.2.4. How anthropologists make choices about building renovations

An ethnography of the decision processes within enterprises may reveal key insights. One recent study of building projects at a private U.S. college shows that some aspects of enterprise culture (such as satisfying the often conflicting goals of units within the enterprise or associated with it) may work against LEED improvements, others (such as an enterprise's role as a regional leader, or a manager's desire to leave a legacy) may be beneficial (Brown, 2010); it also shows that the larger goal of sustainability and the narrower goal of optimizing a score within the LEED framework often enter into conflict with each other. Moreover, anthropological studies in the closely-related area of green labeling of houses suggest the

importance of building long-term trust of new regulations. In a detailed qualitative study of a small sample of households, Gram-Hanssen et al. (2007) found that Belgians placed greater trust on energy assessments for houses than Danes did. This difference reflects both the status of the assessment (it was obligatory in Denmark but voluntary in Belgium, so Belgium excluded unmotivated people from the assessments) and the source of the assessment (Danish households received a label provided by an impersonal government agency, while Belgian households were visited personally by an engineer from a professional organization). Kosheleva and Elliott (2006) show high levels of distrust of LEED and other green labeling for buildings in Russia, which they attribute to scanty information, weak regulation and fragmentation of political authority in the post-Soviet period. These studies suggest that the routes to adoption of LEED labeling will differ from country to country and from enterprise to enterprise, and that those who promote LEED labeling should seek to build trust with decision-makers.

3.2.5 An integrative approach LEED

A policy analysis should first assess the costs and of the various LEED improvements, considering both what is best in the long term for individual buildings, and for society. If it makes sense to promote LEED, the next step might be to find out who considers it, and when, and why. For example, is it something that is considered by company executives, or proposed by architects or construction companies? Is it considered mainly for new buildings, or for renovations of existing buildings? What are people's near and long term goals when they consider LEED? Building off the answers to these questions, one can design psychological and economic interventions. For example, if the main problem is that no one has heard of LEED, a local government might offer a tax break or other incentive for architecture firms to always

introduce and explain LEED to clients. The design of this information could be tailored to prime corporate responsibility or other pro-LEED goals.

3.3. Building a Wind Farm

Decision Maker: Large Groups

Time Scale: Long

As demand for energy grows, and costs rise, state and federal policy makers are eager for new sources of power. The choice of what type of capacity to build has impacts occurring on very long time scales, outlasting the lifetime of the decision makers. The CO_2 emitted from coal plants stays in the atmosphere from 5 years to many thousand years (Intergovernmental Panel on Climate Change, 2007), and the radioactive waste from a nuclear plant remains dangerous for many thousand years.

In 2002, a private developer proposed constructing an off-short wind farm in Nantucket Sound off Cape Cod in Massachusetts. Although this Cape Wind project was endorsed at the state and federal levels, local communities and environmental groups had concerns about the long-term impact of the project on local wildlife, scenery, fishing, tourism, and energy prices. More recently, a group of Native Americans challenged the project because it would obscure the view from an ancient burial ground (Jesmer, 2009). Thus, while the wind farm was once expected to be operational in 2005, construction has been continually delayed and is currently scheduled to begin in 2011.

Clearly, the Cape Wind project involves multiple stakeholders and decision makers: local, state, federal, tribal. Unlike the previous examples discussed above (light bulb purchase

and building renovations), most of these decision makers are concerned primarily with the future, lasting consequences of the project, rather than the immediate costs.

3.3.2. How economists look at building a wind farm

From an economist's point of view, the decision about whether to build a wind farm is an investment problem analogous to the previous two examples. In this case too, the environmental benefits cost extra. The wind farm performs much worse than existing sources of power (such as the oil and gas plant which is currently powering Cape Cod). Power generated from offshore wind is projected to be roughly twice as expensive as fossil fuel sources such as coal and natural gas (U.S. Energy Information Administration, 2010). However, according to analysis by an energy consulting firm, Cape Wind would nonetheless exert a downward pressure on energy costs in the northeast through bid-stack displacement, leading to market savings of $25 million annually (La Capra Associates, 2003). Similarly, an analysis by the U.S. Department of the Interior (2008) concluded "the rate of return for the proposed site... exceeded 14%, which is greater than 10% to 12% rage that might be required by the offshore wind developer," using a 7% discount rate. The wind farm would provide public benefits through decreasing CO_2 and particulate matter emissions, diversifying the region's electricity mix, and accelerating the development of wind power nationally. Therefore, the project appears to provide a long-term benefit on the regional, national, and global levels.

Building a wind farm differs from the previous examples in an important way, however -- it affects external constituencies. Individuals or groups are going suffer costs (they will lose their view) without receiving any direct benefit or compensation. These stakeholders might use (and indeed have used) political means to block the project.

If policy makers wanted to encourage the adoption of wind farms, economists might suggest trying to make the cost of wind power more viable by manipulating the relative price of the two power sources; either subsidize the building of wind farms or tax the building of coal plants. Economists might also suggest addressing the grievances of the external stakeholders by allowing them to participate in the benefits – to compensate them, in other words. A program could be established to make judgments about which grievances are substantial and how much they should be compensated, and then make pay-outs.

It is likely, however, that compensating aggrieved constituencies for their loss of view might create new problems. No matter how high the payout, some stakeholders will demand more. There will be a challenge to figure out how to pay them the amount they really need to be paid rather than the amount they want to be paid. And it is unfortunately the case that paying off people who are aggrieved tends to create incentives for the production of more grievances.

In many ways, the Cape Wind project is a testament to the effectiveness of economic incentives for long-term development. The private developer clearly was motivated by and benefited from state and federal financial incentives. Without them, the project probably would not have even been proposed. However, disagreements with the local community led to years of delay and possible derailment of the project. Economic incentives might be improved, therefore, by giving additional immediate incentives to the local community as well as to the developer.

3.3.3. How psychologists look at building a wind farm

Psychologists don't often consider decisions of this scale and complexity. One insight psychology does offer is that intertemporal decisions by direct democracy (rather than representative democracy) can be problematic: the discount rates implied by survey research

vary wildly, depending on how options are presented (Frederick, Loewenstein, O'Donoghue, 2002). Both extremely low discount rates and extremely high discount rates are often observed, both of which would lead to disastrous policy (Weitzman, 2007). Therefore, appropriate discount rates for evaluating public projects (such as the construction of a new power plant) are best chosen by elected and appointed experts rather than by public opinion.

Psychology can also offer a solution to the NIMBY ("not in my back yard") issue by trying to remove some of the emotionality of this decision for the local community or re-construing the issue so that the associated emotions are more positive. Reframing the decision in a way that highlights the long-term and socially far-reaching advantages of the wind farm (also promoting the region as a leader) might deflect attention from the downsides to local residents.

3.3.4. How anthropologists look at building a wind farm

Two anthropological studies bear directly on the Cape Wind project. One study (Firestone et al. 2009) compared the project with a hypothetical project off the coast of Delaware; the researchers took great care to assess the difficulties of comparing a genuine possibility and a hypothetical project. It found stronger support for wind power in Delaware, though residents in both areas expressed a number of similar concerns about tourism and the scenic value of the shore. The study attributed this difference to several factors. Concern for air quality is greater in Delaware, where coal-fired power plants have significant health impacts, and sudden increases in electricity prices have also created a concern for supply. Several unique features of Nantucket Sound, the location of the Cape Wind project, may have also led Massachusetts residents to fear for the impacts of a wind energy projects more than Delaware residents did.

Brown (2007) discusses a third coastal state, New Jersey, where wind energy projects were also debated. The author reviews the state's Blue Ribbon Panel on Development of Wind Turbine Facilities in Coastal Waters. A large number of concerns were raised at this panel. The panel developed a positive view of wind energy projects when one member proposed that they consider these projects as investments in knowledge that could pay off over many years in less expensive energy and in making New Jersey a leader in this new energy source. The member found a social framing that was culturally appropriate and that gave cultural meaning to a possibly distant future. Taken together, these studies show the multiplicity of cultural values associated with wind energy, and suggest that mobilization of certain values can lead to support. Following the panel's report, wind energy projects were approved within both state and federal waters.

This study shows the advantage of involving local communities early on in the processes. In the Cape Wind project, surrounding communities were not involved in the early plans and decisions, partly because the developer proposed construction on federal waters. Local people became concerned that the developer had received privileged treatment, while they were in a disadvantaged position and unable to participate in formulating the project. This lack of participation by residents was a serious problem: though some of the local concerns (such as detrimental impact on wildlife) proved unfounded, other legitimate issues (such as loss of livelihood for local fishers) were uncovered that had not been considered by higher authorities.

Talking to people on the ground and doing ethnography thus has two types of benefits. One is improved information. The second is the trust and legitimacy derived from participatory processes. Thus, even if the final decision is not improved, involving stakeholders from an early stage brings benefits in execution down the road (Peterson et al, 2010).

3.3.5. An integrative approach to adoption of renewable power

In this case, the first step might be to identify the relevant stakeholders, including current and future residents in the local area and the world. Determining the "best" new power source will depend on many factors, including the goals of the stakeholders and costs and benefits of each option over time. (One recent study emphasizes the different temporal horizons of participants in a government-led evaluation of wind energy in Germany [Gee and Burkhard 2010].) Importantly, the preferences of the stakeholders may depend on how options are framed. For example, people might support at "surcharge" to pay for a new source of green energy, but oppose a "tax" with the same purpose (Hardisty, Johnson, & Weber, 2010). Similarly, people might reject an immediate tax when considered on its own, but still prefer it over the idea of saddling future generations with the consequences. When gathering the support of government officials for a new energy source with high initial cost but excellent long term benefits, a key consideration will be how to avoid the NIMTOF ("not in my term of office") phenomenon. What methods or interventions can be used to overcome this? Whether practical or psychological, it likely depends on the particulars of the place and the people, so an initial anthropological assessment may be instructive.

4. Conclusion: Climate change policy

Tackling climate change is perhaps the ultimate example of a complex intertemporal choice problem. It involves many kinds of decisions by actors at many group sizes (individuals, groups, and societies) on varying time horizons. The complexity of policies requires the integration of multiple dimensions. As the wind power case shows, anthropology can be useful in establishing the relevant dimensions, while psychology can assess different means of framing

alternatives along these dimensions, and economics can measure the payoff of different strategies. Effective policy must leverage each level of analysis, and ideally use each to inform the other in an integrative framework.

The million dollar question: Is it worth spending large amounts of resources now to avoid harmful climate change in the future? Rates of return on investment naturally fluctuate from time to time, but if the past is a guide to the future, it would seem virtually certain that economic "growth" will continue, so that future generations will be wealthier than our own. Thus, many argue that future generations should bear the burden of responding to the impacts of changed climate, because they will have more resources at their disposal (for example, new technologies). This argument fails, however, if there is a possibility that climate change will yield catastrophic shrinkage, rather than growth. Much depends, then, on pure time preference: on the one hand, if people intrinsically devalue the future, and if the probability of catastrophe is placed far in the future, the argument for leaving future generations to take care of themselves can perhaps still be made. On the other hand, the argument for urgent action depends both on intergenerational goals and on viewing current mitigation of climate change as important to reduce uncertainty, specifically, to reduce the probability of future catastrophic shrinkage. Overall, then, the proper response to the threat of climate change can only be determined from an integrative perspective.

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