Journal of Experimental Psychology: General
2009, Vol. 138, No. 3, 329–340

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0096-3445/09/$12.00 DOI: 10.1037/a0016433

Discounting Future Green: Money Versus the Environment

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In 3 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 3 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 2 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.

Keywords: temporal discounting, intertemporal choice, environment, health, money

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 10 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 10 years have passed, or the institution that was promising the $300 may no longer exist in 10 years' time. Furthermore, psychological factors such as impatience or lack of self-control also play a role; that is, 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, p. 705). 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 nonhuman animals (Frederick, Loewenstein, & O'Donoghue, 2002; Mazur, 1987), such that we discount at a relatively greater rate (per unit of time) when considering short delays than when considering longer ones. Recent research has attributed this pattern of discounting to two neural processing systems, the so-called beta and delta systems (McClure, Ericson, Laibson, Loewenstein, & Cohen, 2007; McClure, Laibson, Loewenstein, & Cohen, 2004; 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), whereas the delta system represents the more rational, reasoned discounting of future outcomes (per unit of

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Support for this research was provided by National Science Foundation Grants SES-0345840 and SES-0820496 to the Center for Research on Environmental Decisions and by the Center for the Decision Sciences.

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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 something later (the *accelerate–delay asymmetry*; Loewenstein, 1988; Weber et al., 2007). People 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 (i.e., receipt of a $1,000 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 (i.e., 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 (Her Majesty's Treasury, 2004; Lebègue, Hirtzman, & Baumstark, 2005; Lind, 1982), in practice government agencies often use different discount rates in different sectors of the economy (Lind, 1982; Spackman, 1991). As Henderson and Bateman (1995) noted, 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, 1996b, 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, Böhm and Pfister (2005) reported 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- or 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 and Hendrickx (2007) concluded 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 articles 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 (Frederick et al., 2002; Thaler, 1981), 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 noted, 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 nonmonetary 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, 1996a, 1996b; Chapman & Elstein, 1995), 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 1 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 timescale (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 semipermanent 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 (Frederick, 2006; Gregory, Lichtenstein, & Slovic, 1993; Schkade & Payne, 1994). 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 pile-ups (a loss). Choices in all cases involved an immediate option and an option with a 1-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 versus 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 (Gattig & Hendrickx, 2007; Nicolaij & Hendrickx, 2003; Svenson & Karlsson, 1989). We also hypothesized that within-domain discount rates would be more highly correlated than between-domains discount rates, based on Chapman's domain-dependence findings (Chapman, 1996a, 1996b, 2003; Chapman & Elstein, 1995; Chapman, Nelson, & Hier, 1999). 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 he or she valued future financial gains, presumably because time preferences may be different in each domain.

Method

Participants. We recruited 90 participants online via classified ads for a study on decision making and compensated them $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 min (mean completion time was 31 min), and 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 make sense only if they preferred more losses or fewer gains (i.e., preferring $150 now to $250 in 1 year yet also preferring $230 in 1 year to $150 now). All further analyses were based on the data from the 65 remaining participants.[1]

The sample was 66% female and 34% male, with an average age of 31 years ($SD = 9.2$). Fifty-two percent were married and 54% had children. Twenty-seven percent were students, 62% had a

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

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 (e.g., a choice between receiving $250 today or receiving $370 1 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 (one gain, one 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) × 2 (monetary vs. environmental: within) × 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.) 1 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 0.9 times the present value (e.g., $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 1 year in the future. Similar titration and free-response questions were used to determine the indifference point between immediate and future payment.

Air gain and 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 1 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 due to the improvements, traffic congestion would also be reduced, benefiting those who would still drive cars or bicycles. The transit authority planned to implement the improvement immediately for 60 days but was also considering doing it 1 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 1 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 the 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 (Frederick et al., 2002; Kirby, 1997; Kirby & Marakovic, 1995; Mazur, 1987; Myerson & Green, 1995), 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 six scenarios are summarized in Figure 1. The smaller standard error bars in Figure 1 for the monetary scenarios versus the other scenarios partly reflect the fact that the number of observations ($n = 65$) was twice as large for monetary as for the air quality ($n = 31$) and other environmental ($n = 34$) scenarios.

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 1 year,

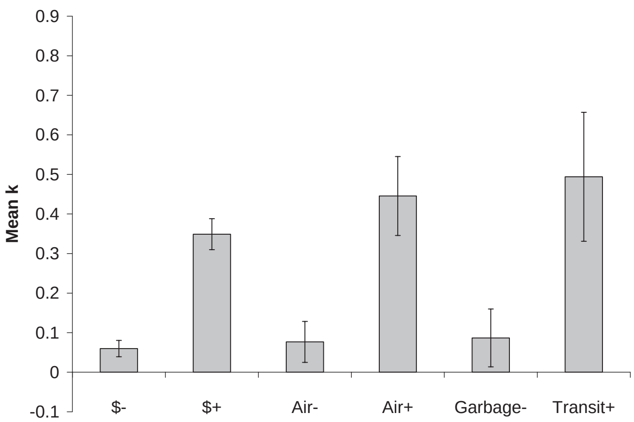

Figure 1. Mean discount parameters (*k*) for monetary and environmental gains (plus signs) and losses (minus signs) in Study 1. Error bars are ±1 *SE*.

whereas losing \$250 now was equivalent to losing only \$265 in 1 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 ($k = 0.09$, $SD = 0.43$), $t(33) = 2.4$, $p < .05$. For example, participants would prefer 31 days (or more) of better air quality in 1 year's time to 21 days of immediately better air quality, but would prefer only 23 days (or less) of future worse air quality to 21 days of immediately worse air quality. Although no significant differences were found in pairwise comparisons of gains or losses between domains, the large standard deviations and low sample sizes meant that we had sufficient power (.80) to detect only fairly large differences ($d = 1.2$ or larger), so we could neither reject the null hypothesis nor conclude that there were not any meaningful differences between domains.

A 2 (valence: positive or negative) × 2 (domain: monetary vs. environmental) repeated-measures analysis of variance (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 × 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 nondiscounting for environmental scenarios, we computed the proportion of zero or negative discounting in each domain. Although 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 pairwise 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 remained significant (this also occurred 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, whereas 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.

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 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

Table 1
Pearson Correlations of Discount Parameters for Gains and Losses in Monetary and Environmental Outcomes in Study 1

Outcome	\$–	\$+	Air–	Air+	Garbage–	Transit+
\$–	—					
\$+	−.20	—				
Air–	.38*	.23	—			
Air+	−.19	.68**	.25	—		
Garbage–	.41*	.46**			—	
Transit+	−.13	.41*			.15	—

Note. Plus and minus signs indicate gains and losses, respectively. \$ = monetary situation.
* $p < .05$. ** $p < .01$.

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

Although 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, 1996b; Chapman & Elstein, 1995; 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. Toward 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.” (The correct answer is 5.) Presumably, people who are able to (or who 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. We recruited 167 participants from the 10 zip codes in the United States with the worst average air quality (as measured by the Air Quality Index [AQI], explained below in the scenario subsections); these were mainly in California and Arizona. Participants were recruited and paid in the same manner as in Study 1. Using the same criteria as Study 1, we dropped the data from 6 noncompleters, 6 who completed the study in less than 10 min (mean completion time was 38 min), and 37 participants who failed our careful-response criteria, leaving data from 118 participants for analysis.

The sample was 55% female and 45% male, with an average age of 38 years ($SD = 13$). Forty-nine percent were married, and 50% had children. Thirteen percent were students, 85% had a college degree of some kind, and the median household income was $50,000–$99,999. Seventy-five percent of participants indicated they had heard of the AQI prior to the study, but only 40% were familiar with it. Ninety-seven percent of participants indicated they had experienced changes in air quality.

Procedure. All participants responded to six scenarios: monetary gain and loss, air quality gain and loss, and health gain and 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, provided demographic information, and completed the CRT (Frederick, 2005).

Monetary gain and 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 and loss scenarios. Although the air quality cover stories were similar to those used in Study 1, the dependent 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 Los Angeles 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 1 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 1 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 1 year in the future and last a different (generally longer) amount of time. Although 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 1 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 allowed for a maximum discount parameter of only $k = 2.25$ (equivalent to a 1-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 six 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

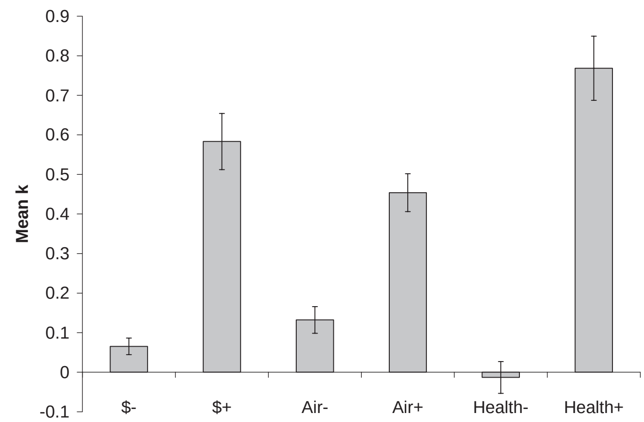

Figure 2. Mean discount parameters (*k*) for monetary, air quality, and health gains (plus signs) and losses (minus signs) in Study 2. Error bars are ±1 *SE*.

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, that is, 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, $t(170) = 2.9$, $p < .01$.

In more concrete terms, participants were on average indifferent between gaining $250 immediately or $395 in 1 year, losing $250 immediately or losing $267.50 in 1 year, a 40-point improvement in air quality immediately or 58 points in 1 year, a 40-point deterioration in air quality immediately or 45.2 points in 1 year, 12 weeks of improved health immediately or 21.2 in 1 year, and 12 weeks of worse health immediately or 11.9 in 1 year.

A 2 (valence: positive or negative) × 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 × 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 × 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 were 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 × 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 general linear models 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 ps $>$ .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 nonsignificantly 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.

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. Eighty-eight percent 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 nonmonetary outcomes of the environmental scenarios used in this study were valued more highly than the monetary outcomes of the financial scenarios.

Table 2
Pearson Correlations of Discount Parameters for Gains and Losses in Money, Air Quality, and Health in Study 2

Outcome	$–	$+	Air–	Air+	Health–	Health+
$–	—					
$+	.05	—				
Air–	.10	.24*	—			
Air+	.03	.26**	.29**	—		
Health–	.39**	−.02	.08	−.04	—	
Health+	−.06	.35**	.22*	.35**	.09	—

Note. Plus and minus signs indicate gains and losses, respectively. $ = monetary situation.
* $p < .05$. ** $p < .01$.

Discussion

A sample of respondents living in areas with poor air quality expressed their intertemporal preferences for hypothetical monetary, air quality, and health scenarios that 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 1-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 or her 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 domains and within valence were stronger than correlations within valence and between domains. 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.

[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 1 year in the future). However, the order, format, and wording of the response options were different, and the participants were recruited from different populations. For example, in Study 1 the titration items were ordered from low to high, whereas 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 of those 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.

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 that is known to affect intertemporal preferences (Guyse et al., 2002; Hsee et al., 1991; Loewenstein & Sicherman, 1991). 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 nonmonetary 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 should not 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. We recruited 185 participants in the same manner as in Study 1. Using the same criteria as in Studies 1 and 2, data were dropped from 5 noncompleters, 2 who completed the study in less than 10 min (mean completion time was 32.5 min), and 32 who failed our careful-response criteria, leaving data from 146 participants for analysis.

Procedure. All participants responded to two monetary scenarios (gain and loss) and two 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.

We assessed indifference points in the same manner as in Studies 1 and 2, using a combination of titration and free–response measures. 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 *SD*s 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) × 2 (valence: within) × 2 (delay: between) × 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 × Domain interaction, $F(1, 141) = 5.6$, $p < .05$, $\eta_p^2 = .04$, and an Order × Domain × Valence interaction that approached significance, $F(1, 141) = 3.3$, $p < .1$, $\eta_p^2 = .02$, indicated that participants tended to discount the first scenario they saw significantly more, regardless of whether it was a financial gain or an 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*s > .1), a trend for a three-way interaction between domain, valence, and delay suggested that air quality gains were discounted marginally more than monetary gains (i.e., more impatience for improved air quality than money) at a 1-year delay but marginally less at a 10-year delay, $F(1, 141) = 2.3$, $p = .13$, $\eta_p^2 = .02$. While there was not a main effect of delay on mean discount rates, this does not mean that

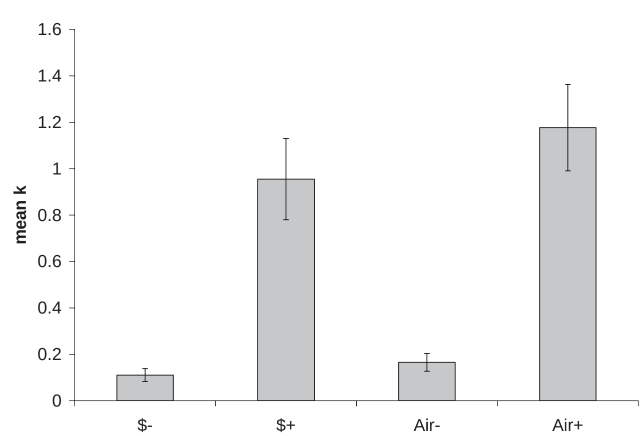

Figure 3. Mean discount parameters (*k*) for streams of monetary and air quality gains (plus signs) and losses (minus signs) in Study 3. Error bars are ±1 *SE*.

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.

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 correlated with discounting of worse air quality. Correlations between gains and losses were generally weak.

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 1 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 that participants considered streams of money rather than lump sums. As before, correlations were stronger within sign (and cross domain) than within domain (and cross sign).

General Discussion

The research in this article 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 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, p. 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

Table 3
Pearson Correlations of Discount Parameters for Gains and Losses in Streams of Money and Air Quality in Study 3

Outcome	$–	$+	Air–	Air+
$–	—			
$+	.08	—		
Air–	.42**	.09	—	
Air+	−.03	.21*	.17*	—

Note. Plus and minus signs indicate gains and losses, respectively. $ = monetary situation.
* $p < .05$. ** $p < .01$.

domains (Chapman, 1996b; Chapman & Elstein, 1995; Chapman et al., 1999). However, these studies mostly examined only 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 on 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 has 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 than 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 (Johnson & Bickel, 2002; Kirby, 1997).

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 to 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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Received July 28, 2008
Revision received May 4, 2009
Accepted May 4, 2009 ■