

# The Fragility of Time: Time-Insensitivity and Valuation of the Near and Far Future

Jane E. J. Ebert

Department of Marketing and Logistics, Carlson School of Management, University of Minnesota,  
Minneapolis, Minnesota 55455, jebert@csom.umn.edu

Drazen Prelec

Sloan School of Management, Massachusetts Institute of Technology,  
Cambridge, Massachusetts 02142, dprelec@mit.edu

We propose that the temporal dimension is *fragile* in that choices are insufficiently sensitive to it, and second, such sensitivity as exists is exceptionally malleable, unlike other dimensions such as money, which are attended by default. To test this, we axiomatize a “constant-sensitivity” discount function, and in four studies, we show that the degree of time-sensitivity is inadequate relative to the compound discounting norm, and strongly susceptible to manipulation. Time-sensitivity is increased by a comparative within-subject presentation (Experiment 1), direct instruction (Experiment 3), and provision of a visual cue for time duration (Experiment 4); time-sensitivity is decreased using a time pressure manipulation (Experiment 2). In each study, the sensitivity manipulation has an opposite effect on near-future and far-future valuations: Increased sensitivity decreases discounting in the near future and increases discounting in the far future. In contrast, such sensitivity manipulations have little effect on the money dimension.

*Key words:* temporal discounting; hyperbolic discounting; intertemporal choice

*History:* Accepted by Detlof von Winterfeldt, decision analysis; received August 27, 2004. This paper was with the authors 11½ months for 1 revision. Published online in *Articles in Advance* July 25, 2007.

## 1. Introduction

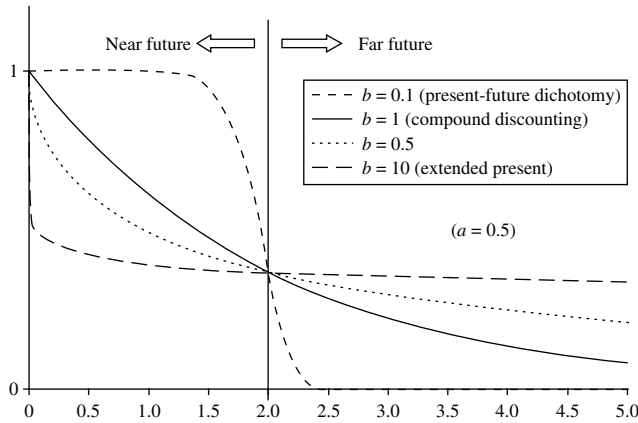
The temporal dimension is an unavoidable but problematic component of many decisions. Managers choose between long-term and short-term goals; investors choose how much money to put aside for retirement or for the deposit on a house in five years; people exercise to lose weight for an upcoming vacation or to remain healthy in later years; governments decide whether to drill for oil and satisfy demand in the near term or not to drill and preserve the environment for future generations. The value people place on different points in the future matters in such decisions, and evidence suggests that the value people place on the future is not what it should be.

Normative concerns about the valuation of future events have traditionally taken two forms. First, there is an old concern, voiced in moralistic writing as well as in economics, that humans are myopic and do not value the future enough (e.g., see discussions of this perspective by Ainslie 2001, Loewenstein 1992). Second, there is a more recent concern, grounded in experimental evidence, that the value or utility of future events is discounted according to a hyperbolic, rather than compound, function (Rachlin et al.

1991, Ainslie and Haslam 1992, Green et al. 1994, Kirby and Marakovic 1995). According to hyperbolic discounting, the discount rate associated with a fixed-time interval (e.g., a fixed delay to receive money) is not constant as required by compound discounting, but declines as the interval becomes more remote. This leads to dynamically inconsistent choices (Thaler 1981, Ainslie and Haendel 1983, Green et al. 1994), in which an individual does not choose according to plans that were optimal from an earlier vantage point. For example, someone who chooses to receive two apples in eight days over one apple in a week is likely to reverse that preference one week later, choosing one apple immediately over two the next day.

Here, supported by fresh experimental evidence, we provide a new theoretical diagnosis about the root cause of the problems with time. On our account, the temporal dimension is *fragile* in a dual sense. First, choices are insufficiently sensitive to the temporal dimension. Second, such sensitivity that exists is exceptionally malleable: Certain manipulations can easily compromise it while others can easily enhance it. In this respect, time is treated differently from other attributes, such as money or outcome quality. Unlike

**Figure 1** Plots of CS Function for Different Values of the Insensitivity Parameter ( $b$ )



a money amount, which is difficult to ignore, the temporal dimension has an “optional status”<sup>1</sup>—it can be pushed into the background or become a key concern, depending on incidental aspects of the choice situation.

Central to this account is our definition of time-sensitivity. We conceptualize sensitivity as the impact of time variation (defined by time intervals) on value variation (defined by value ratios). Our theoretical contribution is to axiomatize a constant-sensitivity (CS) discount function  $f(t) = \exp(-at)^b$ , which separates impatience from sensitivity. The  $a$ -parameter measures impatience, and also marks the boundary between the near and far future: Times shorter than  $1/a$  are in the near-future period, while those greater than  $1/a$  are in the far-future (see Figure 1, where  $a = 0.5$ ). So, greater impatience leads to more immediate discounting of value. Time-sensitivity, measured by the  $b$ -parameter, also affects discounting in a characteristic way, decreasing discounting for near-future outcomes, but increasing discounting for far-future outcomes.

Building on this parametric framework, our empirical contribution is to show that time-sensitivity is not only inadequate relative to the compound-discounting norm, but also susceptible to manipulation. In Study 1, we show that time-sensitivity, rather than discounting per se, is enhanced in a within-subject design. Consequently, discount rates measured within-subject rather than between-subject are smaller for the near future, but larger for the far future. In Study 2, we find that time-sensitivity can be compromised by requiring subjects to make a decision under time pressure. We see this selective vulnerability of the time dimension even though it is the most

important dimension, in terms of its relative weight, when subjects have unlimited time. Hence, time pressure does not simply cause subjects to focus attention on the most important attribute, as one might have supposed. In Studies 3 and 4, we demonstrate that time-sensitivity is enhanced if subjects are asked to attend to the time dimension (Study 3), or are provided with an analogue visual cue (Study 4). However, when these same manipulations are directed toward the money dimension, we do not observe any increase in the influence of money. Hence, the money dimension is attended even without specific instruction or visual bolstering of magnitude.

## 2. Time-Insensitivity

There is considerable empirical evidence that people are naturally insensitive to certain aspects of time, such as duration. In their extensive research on duration neglect, Kahneman and his colleagues have shown that people commonly underweight or even ignore the duration of an event in their evaluation of its total utility (Frederickson and Kahneman 1993, Redelmeier and Kahneman 1996) where evaluations are made either in retrospect or in prospect (Varey and Kahneman 1992, Redelmeier and Kahneman 1996). People’s insensitivity to duration seems to be partly due to a lack of attentional focus. While people typically underestimate the duration of an event (Block and Zakay 1997), they increase their estimations when their attention is directed to duration in advance (Zakay 1998). Similarly, elicitation methods such as choice, involving direct comparison of events of different duration, increase people’s sensitivity to duration relative to elicitation methods that lack direct comparison, like ratings (Ariely and Loewenstein 2000).

Insensitivity to duration seems likely to apply to insensitivity to time intervals extending from now into the future. Previous research finds that people commonly consider future events relative to a reference time-point (Loewenstein 1988, Shelley 1993), which, outside of deliberate manipulation, is likely to be “now”; and an event that occurs at future time  $X$  is also an event after a time interval from now of duration  $X$ . So, we might reasonably expect some natural insensitivity for time intervals from now into the future (also see Zauberman et al. 2007).

Duration research indicates that time-insensitivity can be alleviated by attention manipulations, but does not suggest the specific form such insensitivity might take. An extensive literature on both heuristics and dual-process theories suggests that a wide variety of judgments are often made rapidly using simple heuristics, while more effortful, systematic processing is used only if people have sufficient motivation, time,

<sup>1</sup> Soman (2001) makes a related argument in research comparing sunk costs of money and time, demonstrating routine or compulsive consideration for money compared with little attention to time.

and cognitive resources. (For reviews of these literatures, see Chaiken and Trope 1999, Gilovich et al. 2002.) A priori, we might expect several possible forms of insensitivity to arise through the application of a simplifying decisional heuristic. An extreme example would be complete insensitivity to the temporal dimension, which is equivalent to a zero discount rate over time. An interesting and distinctive feature of the temporal attribute is that complete insensitivity has some normative appeal: It is possible to argue (and it has been) that one should give equal weight to present satisfaction and (certain) future satisfaction (see Senior 1836 or, more recently in the domain of health, Gyrd-Hansen and Sogaard 1998).

An opposite, equally extreme form of insensitivity would be one in which only the present moment mattered, and all future outcomes had zero weight. This would be equivalent to the limiting case of an infinite discount rate. A less extreme variant of this would give some smaller weight to all future outcomes, irrespective of their date.<sup>2</sup> This form of insensitivity is most consistent with empirical evidence, and might result from a simple “present-future dichotomy” heuristic. Another less extreme variant could result from an “extended-present” heuristic, in which all events in a given time window, including the present moment, have equal weight, and events outside the window have zero weight.

The present-future dichotomy heuristic, in particular, is consistent with research examining the effects of cognitive resources on discounting. In two studies by Ebert (2001), people made valuations of rewards available almost immediately (in 1 day) or in the far future (in 1 year). With their cognitive resources restricted by time pressure or by the imposition of an interfering task, they showed considerable discounting of far-future rewards, suggesting that discounting of the far future is relatively effortless and rapid, consistent with applying a present-future dichotomy heuristic. With more cognitive resources, subjects’ far-future valuations decreased further, showing increased discounting. Assuming that subjects with more cognitive resources could better attend to future time and so showed greater time-sensitivity, these results imply, first, that time-insensitive subjects do discount the future, and, second, that increased sensitivity leads to increased discounting in the far future. Both implications are consistent with the form of insensitivity resulting from a present-future dichotomy heuristic.

### 3. The Constant-Sensitivity (CS) Discounting Model

We now develop a parametric model of discounting that can efficiently accommodate the normative

<sup>2</sup> Kirby (1997) describes similar simplified discounting behavior shown in a discounting study.

compound-discounting case, as well as the different forms of time-insensitivity that were just described. We start with the observation that compound (or exponential) discounting implies a unit “elasticity” of log-discount factors with respect to time:

$$f(t) = \exp(-at)$$

or

$$-\log f(t) = at,$$

hence

$$\log(-\log f(t)) = \log a + \log t$$

or

$$d(\log(-\log f(t)))/d(\log t) = 1.$$

In other words, a 1% increase in delay to reward implies a 1% reduction in log-discounted-present-value of the reward. Given that unit elasticity defines compound discounting, it is natural to interpret lower-than-unit elasticities as indicating insufficient time-sensitivity relative to compound discounting. If elasticity is constant and equal to  $b > 0$ , then the discount function has the *constant-sensitivity* form:

$$d(\log(-\log f(t)))/d(\log t) = b$$

or

$$-\log f(t) = (at)^b$$

or

$$f(t) = \exp(-(at)^b). \quad (1)$$

Here, a 1% increase in delay to reward implies a  $b\%$  reduction in log-discounted-present-value of the reward. Smaller values of  $b$  indicate greater time-insensitivity, with  $b \sim 0$  being the limiting case of complete time-insensitivity. We write  $f(t) = \exp(-(at)^b)$ , rather than  $f(t) = \exp(-at^b)$ , to allow for a cleaner separation of time-sensitivity and impatience; in the latter formulation, a change in  $b$ —produced, for example, by an experimental manipulation of sensitivity—would also uniformly compress or expand the time scale ( $t \rightarrow t^b$ ), forcing a compensating adjustment in  $a$  even if there was no change in the underlying impatience level.

This discount function also can be derived from a simple axiom, a generalization of the stationarity condition (that, as is well known, gives rise to the normative exponential case; see Fishburn and Rubinstein 1982). Stated at the level of preference between simple (one-outcome) prospects, stationarity requires that preferences between dated outcomes are not affected when all dates are pushed back by a constant amount. Hence, if  $(x, t)$  denotes the acquisition of outcome  $x$  at time  $t$ , then stationarity implies that  $(x, t) \sim (y, s)$

if and only if  $(x, t+r) \sim (y, s+r)$ , for any dates  $t, s, r$ . In words, (1 apple, now) equals (2 apples, tomorrow) if and only if (1 apple, in 6 days) also equals (2 apples, in 7 days).

Actual preferences tend to violate stationarity in the “hyperbolic” direction, where, if one apple today was indeed worth two apples tomorrow, then one would normally observe a preference for two apples in seven days over one apple in six days, on the grounds that the difference between today and tomorrow is relatively greater than the difference between waiting six and seven days. (This has also been called “decreasing impatience,” as in Prelec 2004.) It is as if a constant time interval looms larger when positioned closer to the present moment. To make both options equally attractive, one would have to expand the interval between the smaller and larger outcome, e.g., by pushing back the two apples from seven days to, say, 10 days. This would imply that the difference between the first pair of dates—today and tomorrow—is about the same as the difference between the second pair of dates—six days and 10 days.

Our alternative axiom allows for such violation of stationarity, but insists that the degree of nonstationarity is independent of time scale:

*Temporal Scale Invariance:* For any outcomes  $x, y, z$ , and dates  $t, s, r, q$ , the indifference pair  $(x, t) \sim (y, s)$  and  $(x, r) \sim (y, q)$  implies:  $(x, \lambda t) \sim (z, \lambda s)$  if and only if  $(x, \lambda r) \sim (z, \lambda q)$ , for all  $\lambda > 0$ .

For example, if we find that (1 apple, now) equals (2 apples, tomorrow) and (1 apple, in 6 days) equals (2 apples, in 10 days) then scale invariance implies that (1 apple, now) equals (3 apples, in 1 week) if and only if (1 apple in 6 weeks) equals (3 apples in 10 weeks). The force of the condition is that whether the difference between one pair of dates (0 versus 1) is perceived as larger than the difference between another pair of dates (6 versus 10) does not depend on the time scale over which the dates are defined (in this case, days or weeks). It follows from the scale invariance axiom that the discount function has the *constant-sensitivity* form, Equation (1). The proof is presented in the appendix to this paper; however, it is straightforward to check that the function satisfies temporal scale invariance. Suppose that we find a pair of time intervals given by dates:  $\lambda t > \lambda s$  and  $\lambda r > \lambda q$ , such that:  $(x, \lambda t) \sim (z, \lambda s)$  and  $(x, \lambda r) \sim (z, \lambda q)$ . In that case,  $u(x)f(\lambda t) = u(z)f(\lambda s)$ , and  $u(x)f(\lambda r) = u(z)f(\lambda q)$ , which implies that the two intervals induce the same discount factor, equal to relative utility of the two outcomes,  $u(z)/u(x)$ :  $f(\lambda t)/f(\lambda s) = f(\lambda r)/f(\lambda q) = u(z)/u(x)$ . If the discount function has the form (1), it then follows that  $\exp(-(a\lambda t)^b)\exp(-(a\lambda q)^b) = \exp(-(a\lambda r)^b)\exp(-(a\lambda s)^b)$  or  $(at)^b + (aq)^b = (ar)^b + (as)^b$ , which is independent of the scale factor  $\lambda$ .

Hence, whether two intervals have the same discount factor does not depend on the scale of the intervals.

Qualitatively, for  $b < 1$ , the constant-sensitivity function resembles the hyperbola, which has been studied extensively. However, (1) has two advantages over the hyperbola. First, the function captures sensitivity with a single parameter,  $b$ , while the second parameter,  $a$ , establishes the theoretically important boundary between the near and the far future, where  $1/a$  provides the temporal window for which discounting is enhanced (near future) or diminished (far future) by time-insensitivity. Second, unlike the hyperbolic, the constant-sensitivity function has the convenient linear form, shown already in the derivation of (1),

$$-\log(-\log f(t)) = -b \log a - b \log t.$$

Therefore, if we measure discount factors  $f(t)$  at different points in time  $t$ , then the slope of the OLS regression of  $-\log(-\log f(t))$  against  $\log t$  provides an estimate of the time-sensitivity parameter,  $b$ . Figure 1 displays the constant-sensitivity function for different values of the sensitivity parameter.

We now present four studies that test this functional form and examine how the time-sensitivity parameter responds to experimental manipulation. Each study elicits valuations for future rewards. We use a simple monetary reward in Experiment 1, restaurant meals in Experiment 2, and products from an online store in Experiments 3 and 4. In each study, we show that the degree of time-sensitivity is inadequate relative to the compound-discounting norm and susceptible to manipulation. Using three manipulations, we attempt to increase time-sensitivity by a comparative within-subject presentation (Experiment 1), direct instruction (Experiment 3), or provision of an analogue visual cue for time (Experiment 4). With a final manipulation, time pressure (Experiment 2), we attempt to reduce time-sensitivity as in Ebert (2001). In each study, based on the form of our constant-sensitivity function, we expect the sensitivity manipulation to have an opposite effect on near-future and far-future valuations. That is, a manipulation of sensitivity that increases discounting in the near future (by decreasing sensitivity, i.e., parameter  $b$ ), should decrease discounting in the far future (and vice-versa). This is our critical empirical hypothesis that is tested in each of the four studies.

## 4. Demonstrating the Effects of Changing Time-Sensitivity

### 4.1. Experiment 1: Presentation Manipulation

In the first and simplest study, we present the future times of reward availability either within- or between-subjects. The premise here is that varying the time

dimension within-subjects draws attention to it, relative to varying it between-subjects, by allowing and inviting comparison across rewards (similar to the use of a choice relative to a ratings response in Ariely and Loewenstein 2000; also see Griffin et al. 1990; Abele and Petzwold 1998 for similar manipulations with presentation mode). We expect subjects in the “within” presentation condition to be more time-sensitive than “between” subjects, with a larger time-sensitivity parameter,  $b$ , that is closer to 1, resulting in an interaction between presentation mode and future time, where subjects in the within condition show reduced discounting for the near future and enhanced discounting for the far future relative to those in the between condition.

#### 4.2. Experiment 1: Method

Three hundred and nine subjects (122 female, 187 male; mean age 20.7 years,  $SD = 3.3$ ) completed a brief questionnaire in return for a \$2 convenience store certificate. They provided the present value of an \$80 cash “windfall” prize that they would receive at a specified future time (according to their assigned experimental condition). To improve their understanding of the discounting question, subjects were first asked to indicate a preference for (a) immediate, (b) delayed receipt of the prize, or (c) an indifference to delay, implying, respectively, a valuation for the future that is (a) lower than \$80, (b) greater than \$80, or (c) equivalent to \$80. They then completed the valuation statement appropriate to their assigned condition, such as: “Either \$\_\_\_ today or \$80.00 in 3 months would be equally attractive to me.”

For the experimental conditions, there were five Future times: *in 1 day, in 1 week, in 1 month, in 3 months, and in 1 year*, presented either *between-* or *within-*subjects. Between subjects valued the certificate for only one future time (their assigned condition), and Within subjects valued the certificate at each of the five future times (presented in one of two counterbalanced random orders). In addition to its effect on attention to future time, a within-subjects presentation of future time suggests a range of possible future times, and this could make the certificates easier to value, i.e., more “evaluable” (Hsee 1996), also increasing time-sensitivity. To check for this potential effect, all subjects were also randomly assigned to either an *informed* condition (told that the cash windfall “is sent to winners at different times: Either in 1 day, in 1 week, in 1 month, in 3 months, or in 1 year”) or to a *not informed* condition (informed of the prize they had won, i.e., mentioning only one future time for between-subject conditions). Subjects were randomly assigned evenly across these 12 conditions: 2 Information conditions  $\times$  6 (5 Between plus 1 Within).

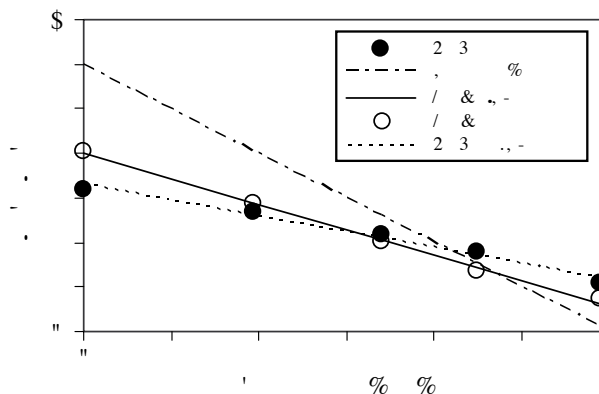
#### 4.3. Experiment 1: Results

*Excluding data.* Eleven inconsistent subjects were excluded from the analyses. Of these, 10 stated a preference for an immediate prize but gave higher valuations for delayed prizes, and one preferred a later prize but gave lower values for delayed prizes.

In this, and in subsequent studies, we also excluded subjects who put a higher value on a delayed rather than immediate cash prize. Here, 10 subjects (3%) expressed a consistent preference for a delayed prize, both in the initial choice and in their valuations. We exclude these “negative discounters” because our hypotheses are about discounting, and the factors that affect the structure of the discount function. Subjects may value future cash more for a variety of reasons (savoring, self-control, and so on), but these reasons are not the proper subject of our study. Exclusion of negative discounters also makes our results more comparable to most other discounting studies, which commonly employ methods that require positive discounting or whose response scales exclude options that would indicate negative discounting (e.g., Green et al. 1997, Chapman and Coups 1999, Collier and Williams 1999, Alessi and Petry 2003). For robustness, we also conducted our analyses including negative discounters, and obtained very similar results with no change in our conclusions.

*Valuations.* Figure 2 shows a plot of  $-\log(-\log f(t))$  against  $\log t$  for each valuation condition, with the constant-sensitivity function fitted to the mean discount factors for each future time. The slopes of the lines correspond to the  $b$ -parameter estimates for each condition. A line of slope 1, corresponding to compound (exponential) discounting, is also provided as a comparison. We see that both lines have slopes much less than one and that the slope for the Between condition is lower than the slope for the Within condition as expected, indicating less time-sensitivity.

Figure 2 Experiment 1: Log-Log Discount Factor Against Log Future Times, Fitted CS Functions and Compound Discounting Benchmark



In both cases, the constant-sensitivity function provides a nearly perfect fit to the aggregate data.

To compare the Between and Within presentations statistically, we treated the Within condition valuations as independent observations, with each subject providing five observations. This produces a conservative test of the Within/Between presentation manipulation. By contrast, a repeated-measures analysis would be more powerful as long as there are positive correlations between valuations for different future times (Kenny and Judd 1986, Rosenthal and Rosnow 1991). These correlations were positive (varying from 0.23 to 0.88; all but one significant at the 0.05 level).

Valuations for all subjects were submitted to a 2 (Presentation: Between, Within)  $\times$  5 (Future time: 1 day, 1 week, 1 month, 3 months, 1 year)  $\times$  2 (Information: Informed, Not informed) ANOVA. The predicted Presentation  $\times$  Future time interaction was significant (see Table 1; including negative discounters,  $p < 0.03$ ). As expected, relative to Within subjects, Between subjects showed greater sensitivity to differences in time for prize receipt, with greater discounting of near-future rewards and reduced discounting of far-future rewards, confirmed by  $t$ -tests for each future time (significant for 1 year, 3 months, and 1 day;  $p$ s  $< 0.06$ ).

The information manipulation had little effect, beyond a marginally significant interaction with presentation mode. Examination of the means showed little effect of this manipulation for subjects in the Between condition ( $M_{\text{Informed}} = 69.93$ ,  $M_{\text{Not informed}} = 69.24$ ) for any future times, suggesting that simply

mentioning the range of times was not sufficient to increase attention to future time for these subjects. However, for Within subjects, who were already more attentive to future time, this information seemed to reinforce attention to future time, leading to greater discounting for the far future: The lower valuation overall for the informed condition ( $M_{\text{Informed}} = 65.30$ ,  $M_{\text{Not informed}} = 68.59$ ) was driven by change in the far-future conditions only, though the 3-way interaction did not reach significance ( $p = 0.14$ ).

#### 4.4. Experiment 1: Conclusion

Eliciting present values via a comparative response method (i.e., within subjects) has the effect of reducing discounting for the near future and increasing discounting for the far future. This dual impact is fully captured by differences in our sensitivity measure,  $b$ , where the within condition subjects are more time-sensitive. Both groups have  $b$  parameters considerably less than 1, i.e., they are time-insensitive relative to the compound-discounting function. These results were robust to including negative discounters in the analysis.

#### 4.5. Experiment 2: Time Pressure Manipulation

We now replicate the results of Experiment 1 by restricting the time available for judgment, a manipulation used by Ebert (2001). We adapt the Ebert time pressure manipulation to a different valuation method, conjoint analysis, which requires people to make trade-offs between attributes. To our knowledge, Sultan and Winer (1993) is the only previous application to discounting. The conjoint approach

**Table 1** Summary of Main Results Across Experiments

Analysis	Experiment 1 (Presentation)	Experiment 2 (Time pressure)	Experiment 3 (Attention)	Experiment 4 (Visual cue)
<b>ANOVA</b>				
Effect of future time	$F(4, 456) = 55.39, p < 0.001,$ $\eta^2 = 0.57$	$F(3, 219) = 42.06, p < 0.001,$ $\eta^2 = 0.60$	$F(3, 183) = 50.99, p < 0.001,$ $\eta^2 = 0.67$	$F(3, 363) = 230.03, p < 0.001,$ $\eta^2 = 0.81$
Predicted interaction	$F(4, 456) = 2.77, p = 0.03,$ $\eta^2 = 0.15$	$F(3, 219) = 3.53, p = 0.02,$ $\eta^2 = 0.21$	$F(3, 183) = 3.23, p = 0.03,$ $\eta^2 = 0.22$	$F(3, 363) = 2.57, p = 0.05,$ $\eta^2 = 0.14$
Other effects significant at 0.10 level	Presentation, $F(1, 456) = 4.96,$ $p = 0.03, \eta^2 = 0.10$ Presentation $\times$ Information, $F(1, 456) = 2.82, p = 0.09,$ $\eta^2 = 0.08$	None	None	None
<b>CS-function</b>				
$b$ estimates*				
Aggregate level estimate	Within: 0.57 Between: 0.35	Unlimited: 0.60 Restricted: 0.27	Time-focus: 0.43 No focus: 0.23 Value-focus: 0.32	Time-cue: 0.57 No cue: 0.44 Value-cue: 0.42
Individual level (mean of individual estimates)		Unlimited: 0.47 Restricted: 0.18	Time-focus: 0.43 No focus: 0.25 Value-focus: 0.36	Time-cue: 0.60 No cue: 0.45 Value-cue: 0.42

\*Aggregate level  $b$ -estimates are calculated by fitting the constant-sensitivity function to the mean discount factors for each future time. For the individual level, the constant-sensitivity function is fitted to the discount factors for each subject, and the mean of these individual  $b$ -estimates is reported.

allows estimation of both parametric and non-parametric discount functions, as well as attribute utility functions at the level of individual subjects. We can therefore precisely assess how the discount coefficients and utilities are affected by the time pressure manipulation. We expected the results for the restricted time and unlimited time conditions to replicate, respectively, the results of the time-insensitive condition (Between) and the more time-sensitive condition (Within) in Experiment 1.

#### 4.6. Experiment 2: Method

One hundred undergraduate students (41 female, 59 male; mean age 24.3 years, SD = 9.4 years) individually rated their preferences for gift certificates for local restaurants and were compensated \$5. Subjects first studied menus of the five restaurants for at least four minutes, then were instructed to arrange a randomly ordered set of 15 certificates on a 100-point scale presented on a large cardboard sheet by first placing their favorite at 100 and then placing the remaining certificates on the scale to indicate their preference for each in proportion to their favorite. Subjects were randomly assigned to complete the task either with *Restricted time* (in only one minute) or with *Unlimited time* (unlimited time with a minimum of six minutes).<sup>3</sup> The certificates presented information on three attributes (in randomized order): *Restaurant* establishment (one of five local ethnic restaurants); *Future time* from which the certificate would be valid (1 day, 1 week, 1 month, 3 months, or 1 year), and *Meal size* (Main course, Main course and appetizer, Main course for two). The combinations of these *attribute levels* was determined using a *D-Optimal* designer, which minimizes the generalized variance of the utility estimates. Two certificate sets were devised (A and B) and used, counterbalanced across the two valuation time conditions.

#### 4.7. Experiment 2: Results

*Calculation of utilities (or part-worths) for each attribute.* The underlying preference model that we estimate treats utility as a ratio scale, and decomposes the utility of a certificate into a product of the attribute utilities, or:

$Utility(Certificate)$

$$= u(Restaurant) \times u(Meal size) \times (Discount factor).$$

The ratio scale interpretation was induced by asking subjects to rate certificates “in proportion” to their favorite, which was assigned a rating of 100. For example, a rating for Certificate 1 twice that for Certificate 2 is interpreted as twice the utility of Certificate 2: For two certificates with the same meal size and same

restaurant, differing only in future time, with Certificate 1 available in one week and Certificate 2 available in three months, we can infer a discount factor for three months as 50% that for one week, implying a loss of half the certificate value if postponed from one week to three months.

Formally, to derive the utilities, we encoded each certificate with dummy variables ( $x_{ijk}$ ) for each attribute level  $j$  of each attribute  $k$  for each certificate  $i$  (Green and Wind 1975, Green and Srinivasan 1978).<sup>4</sup> Dummy variable,  $x_{ijk}$ , was equal to 1 if certificate  $i$  offered attribute level  $j$  on attribute  $k$ , and was equal to 0 otherwise (so a certificate valid in 1 week had a dummy variable of 1 for the 1 week attribute level of the future time attribute, and 0 for the remaining attribute levels of the future time attribute). In the multiplicative model, the utility of a certificate  $i$ , given by rating  $r_i$ , is the product of the utilities of the three attributes for that certificate,

$$r_i = \prod_{jk} u_{jk}^{x_{ijk}},$$

where  $u_{jk}$  is the utility of attribute level  $j$  on attribute  $k$ . (Note that  $u_{jk}^{x_{ijk}} = u_{jk}$  if  $x_{ijk} = 1$ , and  $u_{jk}^{x_{ijk}} = 1$  if  $x_{ijk} = 0$ , so the formula only multiplies utilities that apply to certificate  $i$ .) A logarithmic transformation makes the multiplicative preference model additive:

$$\log r_i = \sum_{jk} x_{ijk} \log u_{jk},$$

and allows us to estimate log-utilities  $\log u_{jk}$  using ordinary least squares.<sup>5</sup> So for each subject, we used OLS regression of their 15 certificate ratings against the 10 dummy variables for the attribute levels to estimate the log-utilities for the attribute levels. Exponentiation transforms these estimates back into estimates of the multiplicative utilities. For the time attribute, the utilities are just the discount factors, which we normalize so that the discount factor for one day equals +1, which means that  $u_{jk}$  for the time dimension (i.e.,  $k = \text{future time}$ ) are estimates of the discount factor for a specific future time  $j$  relative to one day. For the restaurant attribute, because subjects’ preferences for the five restaurants varied, we organized the utilities for each subject into descending order and labeled them as first, second, third, fourth, and fifth favorite restaurants. This made it possible to estimate changes in preference as a function of restaurant rank across subjects.

<sup>4</sup> Thus, the certificates were encoded using 10 dummy variables: 4 to represent the 5 attribute levels of the restaurant attribute, plus 4 for the 5 attribute levels of the future time attribute, plus 2 for the 3 attribute levels of the meal attribute.

<sup>5</sup> In using a separable model, we are following the usual assumption in conjoint estimation, which is to treat the attributes as independent unless there are clear intuitions about attribute interaction.

<sup>3</sup> A pretest established that subjects usually completed their ratings in fewer than six minutes.

*Negative discounters.* From the five estimated future time utilities for each subject, we identified 23 subjects who exhibited a negative time preference (i.e., one-half or more of their future time utility estimates indicated a preference for delay, i.e., discount factors greater than 1). Although positive discounting is much more common, negative discounting has been obtained for some stimuli including restaurant meals (e.g., if presented as part of a sequence, as in Loewenstein and Prelec 1991, or where people savor delayed positive events, as in Loewenstein 1987). So, as in Experiment 1, for robustness, we also conducted our analyses including negative discounters. We obtained very similar results with no change in our conclusions.

*The effect of restricted time on the future time attribute.* According to our hypothesis, restricting time for valuation should lead to less time-sensitivity and so more discounting (or lower valuations) of near-future events and less discounting (or higher valuations) of far-future events, producing an interaction between response time and future time. A 4 (Future time: 1 week, 1 month, 3 months, 1 year) × 2 (Response time: Restricted or Unlimited) × 2 (Certificate Set: A or B) ANOVA on subjects' future time log-utility estimates revealed this interaction ( $p = 0.02$ ; including negative discounters,  $p = 0.01$ ) in the predicted direction (see Figure 3).

Applying the constant-sensitivity function to the aggregate data for the two response-time conditions as in Experiment 1, we find less time-sensitivity in the restricted than in the unlimited time condition (Figure 3). Both  $b$  estimates are far below the normative (compound function) value of 1.00 (see Table 1). If the constant-sensitivity-function is estimated at the individual level, using individual OLS regressions of  $-\log(-\log f(t))$  against  $\log t$  to estimate  $b$  for each subject, the mean estimates of  $b$  are again both lower

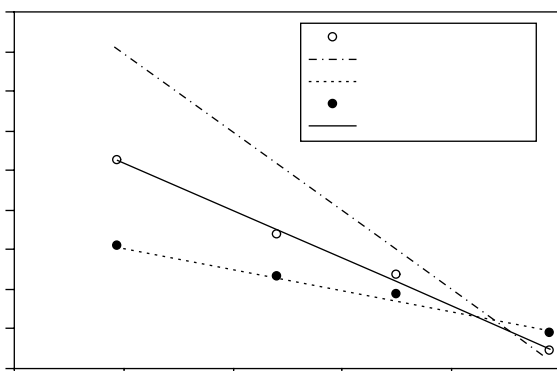
than 1 ( $ps < 0.02$ ), where the time-sensitivity estimate with restricted time is significantly smaller than that with unlimited time ( $t(74) = 3.57, p = 0.002, r = 0.35$ ; Kruskal-Wallis nonparametric test,  $p = 0.004$ ).<sup>6</sup> The impatience parameter,  $a$ , did not change significantly with restricted time (by  $t$ -test or Kruskal-Wallis,  $ps > 0.20$ ), and was uncorrelated with  $b$  ( $r_s = 0.02$ ).

Therefore, both the results comparing the mean discount factors and those comparing  $b$  parameters show that time pressure changes the structure of the discount function, promoting less time-sensitivity (i.e., more “hyperbolic”) discounting. As before, this means relatively more discounting of near-future outcomes and less discounting of far-future outcomes.

*Analyses of utilities for the other attributes (restaurant and meal size).* We conducted separate ANOVA analyses, similar to that for the future time attribute, on the restaurant and meal size utilities, respectively, to elucidate the effect of restricting time for valuation. Only the utilities for restaurants showed an effect of the response time manipulation: The interaction with response time was significant,  $F(4, 292) = 2.53, p = 0.04, \eta^2 = 0.18$  (though  $p = 0.16$  when including negative discounters). The overall influence of the restaurant attribute, i.e., mean (max. log-utility – min. log-utility), was greater with restricted response time (see Figure 4). However, the opposite was true for the future time attribute, which had greater influence with unlimited time for valuation (Figure 3). This result is important because it suggests that subjects with restricted time did not simply rely more heavily on the most important attribute (i.e., future time), as one might have supposed. Instead, their attention appeared to be transferred from the future time attribute to the restaurant attribute.

*Internal consistency of valuations across conditions.* Subjects seemed able to perform the valuation task adequately under time pressure: Measures of internal consistency, calculated for each subject as the correlation between the predicted preference ratings for the 15 certificates (i.e., the estimated utilities) and their actual preference ratings, did not differ with valuation time (by  $t$ -test,  $p = 0.62$ ;  $p = 0.94$  including negative discounters).

**Figure 3** Experiment 2: Log-Log Discount Factor Against Log Future Times, Fitted CS Functions and Compound Discounting Benchmark

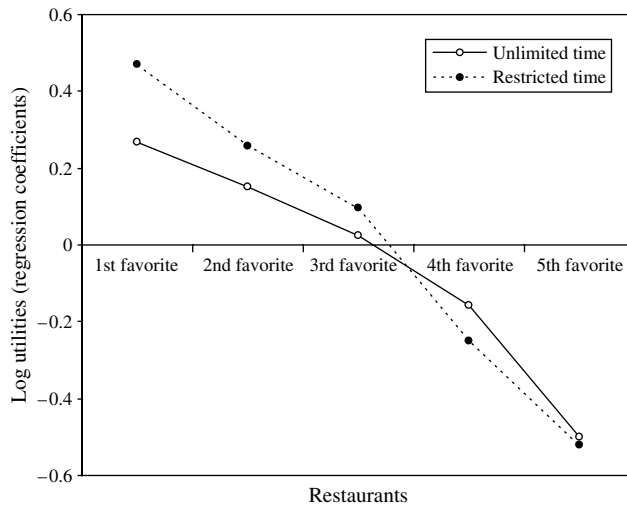


**4.8. Experiment 2: Conclusion**

Making valuations under time pressure changed the structure of the discounting function in a manner consistent with our main hypothesis, with opposite effects on discounting for the near and far future. Subjects with unlimited decision time were more time-sensitive, and showed relatively less discounting of

<sup>6</sup> For negative discounters,  $-\log(-\log f(t))$  is undefined, so we cannot make individual estimates of  $b$  for them.

**Figure 4** Experiment 2: Mean Restaurant Utilities



certificates available in the near future and more discounting of certificates available in the far future. However, in both conditions, discounting functions were time-insensitive relative to the normative compound function. Subjects' impatience appeared to be independent of their time-sensitivity: The  $a$  parameter was not changed significantly by this manipulation and was uncorrelated with the time-sensitivity  $b$  parameter across subjects.

While a normative approach would predict more exponential-like (i.e., compound) discounting with unlimited decision time, it might also predict less discounting in general. While this occurs for the near future, discounting in the far future increases, supporting our hypothesis that people are insensitive to the temporal dimension such that they overdiscount the near future and underdiscount the far future. This result has been obtained using two different manipulations, which change time-sensitivity in different directions, and using two different response methods. Again, the effects of the manipulation on future time valuations were robust to inclusion of negative discounters in the analyses.

## 5. Is Time Special? The Effects of Attention and Visual Cues on Monetary Value and Future Time

In Experiment 2, future time was the most important attribute when response time was unlimited. However, time pressure did not simply cause subjects to focus their attention on the most important attribute, as we might have expected. Instead, subjects appear to have shifted attention away from future time to the other attributes.

In the next two experiments, we attempt to demonstrate the special vulnerability of the time dimension

with two additional manipulations. In Experiment 3, we explicitly instruct subjects to pay careful attention to either the date (i.e., future time) or the money amount; as in Experiment 2, subjects are faced with a conjoint rating task. By comparing the impact of this manipulation with a control group—which saw no such attention instructions—we can see which of the two dimensions is attended to “by default,” even when no attention instructions are given. Experiment 4 has the same logic, except that now a visual cue is used to facilitate comparison of either future times or money amounts in the conjoint task.

We expect to replicate the results of Experiments 1 and 2 for the time-sensitivity parameter and to observe greater time-sensitivity, with less discounting of the near future and more discounting of the far future, under attention bolstering or facilitated comparison. Comparing the attention or visual cue conditions with the control group, we expect the manipulation to have an effect on discounting, but not to have an effect on money utility. In other words, we expect that computation of money utility proceeds “by default,” and is not affected by attention or facilitated comparison. In contrast, we expect to find that time discounting is affected by these manipulations.

### 5.1. The Effects of Attention to Monetary Value and Future Time on Valuation (Experiment 3)

In this study, subjects were instructed to attend to monetary value, to future time, or were given no attention instructions (the control group), and we examined the effects of these conditions on their valuations of rewards that varied on monetary value, future time, and a third attribute.

### 5.2. Experiment 3: Method

One hundred and twenty-one students (48 female, 59 male, 14 failed to indicate their gender; mean age 22.2 years,  $SD = 4.4$  years) each rated their preferences for hypothetical prizes of gift certificates for an online store and were compensated \$3. To ensure that subjects read all 15 gift certificate options before assigning ratings, they first had to indicate a “rough-cut” preference of all the prizes by dividing the list into a more and less preferred “top” and “bottom half.” Next, they put 100 next to their favorite, and rated the remaining options in proportion to their favorite.<sup>7</sup> The 15 options varied on three attributes (whose order

<sup>7</sup> The specific instructions read: “Put a 100 next to your favorite prize. Then rate all the remaining prizes in proportion to your favorite, i.e., if you like a prize half as much as your favorite rate it ‘50’; if you like it a quarter as much rate it ‘25,’ and so on. (Another way to think of this rating method is this: If you like a prize exactly as much as a 50% chance of winning your favorite prize, then rate that prize ‘50’; if you like a prize exactly as much as a 25% chance of winning your favorite prize, then rate that prize ‘25.’)”

of presentation was randomized across subjects): the *Product* (music CDs, videos, books), the *Future time* when the certificate would arrive (1 day, 1 week, 1 month, 3 months, or 1 year), and the *Face value* of the certificate (\$1, \$10, \$30, \$70, \$100). As in Experiment 1, the combination of *attribute levels* was determined using a *D-optimal* designer. Subjects were randomly assigned to one of three conditions (No focus, Time-focus, Value-focus). All subjects were told to make sure their ratings accurately reflected their own preferences. In addition, subjects in the Time-focus [Value-focus] conditions were told to “make sure that the impact of arrival time [face value] on your ratings is consistent across all certificates.” The 15 options were presented on one page, in one of two random orders counterbalanced across experimental conditions.

**5.3. Experiment 3: Results**

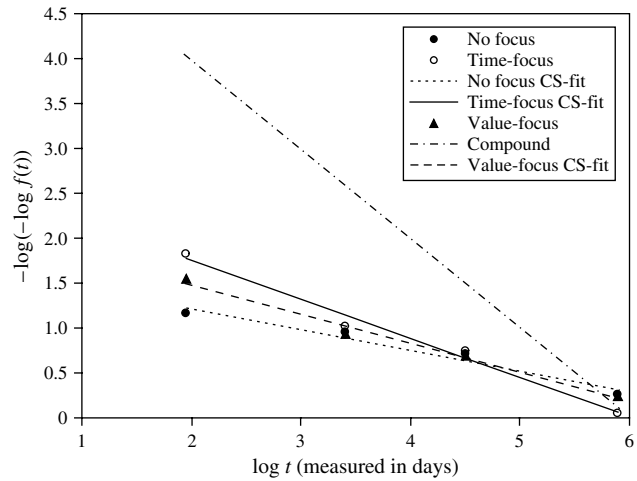
We expected the results for time-focus and no focus subjects to replicate those of within and between subjects, respectively, in Experiment 1, and of unlimited and restricted time subjects, respectively, in Experiment 2, so we begin by comparing these two groups. The analytical approach was identical to that used for Experiment 2.

*Excluded data.* Two subjects who did not rate all certificates were excluded from analysis. We also identified 22 subjects who exhibited a negative time preference, and conducted the analyses both with and without these subjects.<sup>8</sup>

*Comparison of time-focus and no focus groups on attributes.* Similar to Experiments 1 and 2, a 4 (Future time: 1 week, 1 month, 3 months, 1 year) × 2 (Focus: Time-focus, No focus) ANOVA on subjects’ time log-utility estimates revealed the predicted Future time × Focus interaction (see Table 1), with relatively higher discounting for the near future and lower discounting in the far future for subjects in the no focus condition (Figure 5). So, time-focus subjects were more time-sensitive than controls, where the overall influence of the future time attribute, i.e., the mean (max. log-utility – min. log-utility), increased from 0.77 for controls to 0.95 for time-focus subjects.

Figure 5 also shows the close fit of the constant-sensitivity function to the average discount factors and provides a visual comparison with compound discounting. Consistent with results in the previous experiments, the time-sensitivity estimates are lower in the no focus condition than in the time-focus condition (Table 1), both for the estimates at the aggregate and individual levels. For the individual-level

**Figure 5 Experiment 3: Log-Log Discount Factor Against Log Future Times, Fitted CS Functions and Compound Discounting Benchmark**



estimates, this difference between conditions can be tested (and supported) statistically:  $t(61) = 2.12, p = 0.04, r = 0.26$ ; Kruskal-Wallis,  $p = 0.03$ . As before, estimates of the  $b$  coefficient were considerably smaller than 1 (all  $ps < 0.001$ ), confirming that the discount function is not exponential. Again, the impatience parameter,  $a$ , did not change significantly with time-focus (by  $t$ -test or Kruskal-Wallis,  $ps > 0.28$ ), and was uncorrelated with  $b$  ( $r_s = -0.003$ ).

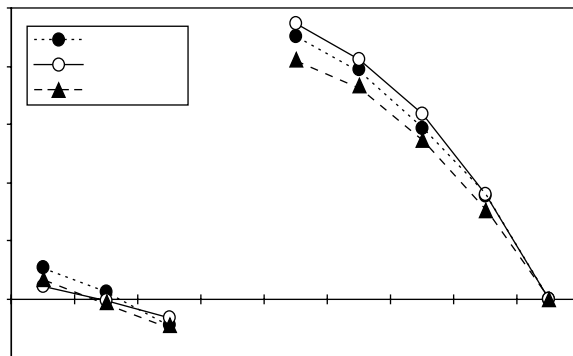
The same ANOVA analysis for each of the product and value attributes suggested that, in focusing attention on future time, time-focus subjects paid less attention to product type<sup>9</sup>: Product × Focus interaction,  $F(2, 122) = 4.76, p = 0.01, \eta^2 = 0.27$ , where time-focus subjects showed less overall influence of product type than did controls, i.e., mean (max. log-utility – min. log-utility) was 0.27 and 0.49, respectively (shown in Figure 6 as the difference between the log-utilities for first and third favorite products). There was no effect of the time-focus manipulation on the face value of the gift certificates ( $Fs < 1$ ).

*Comparison of value-focus and no focus groups on attributes.* In contrast to the effects of attention to future time on discount factors, paying attention to the face value of the gift certificates did not change subjects’ utilities for face value significantly ( $Fs < 1$ ). Although the effect was not significant, its direction was consistent for all face values (all utilities for subjects in the value-focus condition were lower than those for the controls) and the overall influence of face value, i.e., mean (max. log-utility – min. log-utility), was slightly reduced for value-focus subjects (2.05) compared to controls (2.26). The face-value manipulation had no

<sup>8</sup> As in Experiment 2, it was not possible to calculate individual  $b$  estimates for negative discounters. However, all analyses we completed including the negative discounters gave very similar results and identical conclusions to those excluding them.

<sup>9</sup> Because subjects’ preferences for the three products varied, we organized the utilities for each subject into descending order and labeled them as first, second, and third favorite product.

**Figure 6** Experiment 3: Mean Utilities for Product and Face Value Attributes



significant effect either on subjects' discount factors or on their product utilities ( $ps > 0.31$ ).

*Internal consistency.* As in Experiment 2, measures of internal consistency, calculated for each subject as the correlation between the predicted preference ratings for the 15 certificates (i.e., the estimated utilities) and their actual preference ratings, did not differ across conditions (by  $t$ -test,  $ps > 0.45$ ). Hence, subjects appeared to perform the valuation task with similar care in the three conditions.

#### 5.4. Experiment 3: Conclusion

These results replicated those of Experiments 1 and 2 in that subjects who were instructed to attend to arrival time of certificates had larger time-sensitivity parameter estimates, i.e., they were more time-sensitive such that they showed relatively lower discounting of the near future and relatively higher discounting of the far future, than controls. Subjects' impatience again appeared to be independent of their time-sensitivity: The  $a$  parameter was not changed significantly by the attention manipulation (unlike the time-sensitivity parameter), and it was uncorrelated with the time-sensitivity parameter across subjects.

In addition, Experiment 3 examined the impact of an identical attention manipulation on the face-value attribute. The value-focus manipulation caused no significant change on the utilities of different face-value certificates, though, directionally, the attention manipulation decreased all utilities and produced a lower relative influence of face value on ratings. These directional effects are very different from the effects of the time-focus manipulation on future time valuations, where time-sensitivity increased the relative importance of future time and decreased the relative importance of other attributes, presumably reflecting the redirection of attention resources to the future time attribute. These results suggest that people are naturally relatively time-insensitive, and that increasing time-sensitivity may require additional

attention resources, consistent with findings for insensitivity to time duration (Zakay 1998). People do not show the same insensitivity for monetary value, because an equivalent manipulation for face value had very little effect.

In this study, face value was the most important attribute and had the largest influence on value for subjects in the control group, so it is possible that a ceiling effect prevented any significant effect of the attention manipulation for this attribute. While the directional decrease in relative importance of face value with increased attention suggests that a ceiling effect may be unlikely, this directional difference might be due to chance. In addition, by using explicit instructions to direct subjects' attention to particular attributes, our manipulation could cause a demand effect. In our next study, to rule out the possibilities of both a ceiling effect for the face-value attribute and a demand effect of our manipulation, we attempt to replicate our results: First, changing the levels of the attributes so that face value is no longer the most important attribute, and second, using a new, and more subtle, visual cue manipulation.

#### 5.5. The Effects of Visual Cues for Monetary Value and Future Time on Valuation (Experiment 4)

In this study, subjects were provided with visual cues for monetary value, for future time, or were not given visual cues (the control group), and we examined the effects of these conditions on their valuations of rewards similar to those used in Experiment 3.

#### 5.6. Experiment 4: Method

Two hundred and eighteen students (111 female, 107 male; mean age 21.1 years,  $SD = 2.4$  years) each rated their preferences for 15 hypothetical prizes of gift certificates for an online store in return for candy or partial course credit. This experiment was very similar to Experiment 3: The instructions for rating each prize, i.e., "Put 100 next to your favorite prize, etc." were identical, and the 15 options varied on the same three attributes. However, the levels of each attribute, their presentation, and the experimental manipulation were changed from Experiment 3. The levels of each attribute were: *Product* (music CDs, DVDs, books), *Future time* when the certificate would arrive (1 day, 2 weeks, 1 month, 6 months, or 18 months), and the *Face value* of the certificate (\$36, \$44, \$50, \$58, \$72). The combination of attribute levels was determined using a  $D$ -optimal designer. Subjects were randomly assigned to one of three visual cue conditions (No cue, Time-cue, Value-cue). For no cue (i.e., control) subjects, each prize was presented in three columns containing the information of the three attributes presented in words and numbers (e.g., \$50; 1 month;

books). For subjects in the time-cue [value-cue] conditions, the future time [face value] attributes were instead presented using slash marks to represent the amount of time [dollars]. For future time, each slash mark represented two weeks' delay, while, for face value, each slash mark represented \$2; so, for example, six months was represented by //////////////// and \$36 by ////////////////. This explanation, together with an example, was provided for subjects at the top of the relevant attribute column. The prizes were presented on a single page, with the slash marks presented on one line and left-justified in their respective columns, to ensure that comparison of the attribute levels presented in this way across the 15 prizes was extremely easy. Thus, this manipulation should facilitate the comparison of the future time levels or the face-value levels for subjects in the time-cue and value-cue conditions, respectively.

**5.7. Experiment 4: Results**

We used the same analytical approach that we used in Experiment 3. Just as in Experiment 3, we expected an interaction between the time-cue and control conditions and future time.

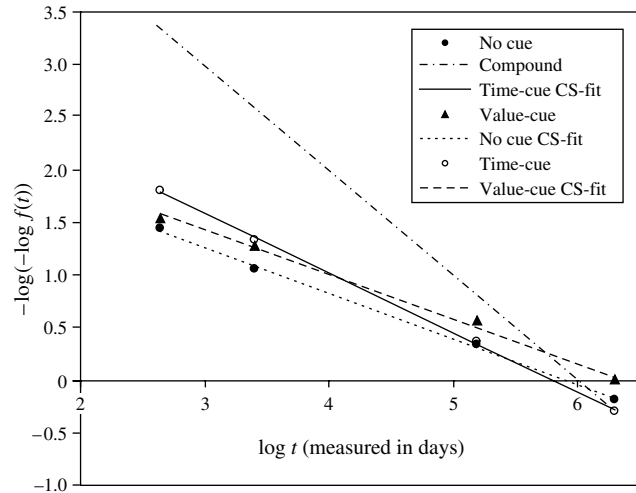
*Excluded data.* We excluded 30 subjects who exhibited a negative time preference.<sup>10</sup>

*Comparison of time-cue and control groups on attributes.* A 4 (Future time: 2 weeks, 1 month, 6 months, 18 months) × 2 (Visual cue: Time-cue, Control) ANOVA on subjects' time log-utility estimates revealed the predicted Future time × Visual cue interaction (see Table 1), with relatively higher discounting for the near future and lower discounting in the far future for subjects in the control condition. The overall influence, i.e., mean (max. log-utility – min. log-utility), of the future time attribute increased from 1.21 for controls to 1.35 for subjects in the time-cue condition. (The future time attribute had the greatest overall influence for all three conditions in this experiment.)

Figure 7 shows the constant-sensitivity function for the average discount factors and provides a visual comparison with compound discounting. Consistent with the previous experiments, the time-sensitivity *b* estimates are lower in the control condition than in the time-cue condition (Table 1) at both the aggregate level, and at the individual level. This difference can be tested statistically for the individual-level estimates:  $t(121) = 2.85, p = 0.005, r = 0.25$ ; Kruskal-Wallis,  $p = 0.004$ . The impatience parameter, *a*, did not change significantly with the time-cue (by *t*-test or Kruskal-Wallis,  $ps > 0.33$ ), and was relatively uncorrelated with *b* ( $r_s = -0.11, p = 0.15$ ).

<sup>10</sup> Just as in previous experiments, for robustness, the analyses were conducted both with and without the negative discounters (with the exception of the individual analysis of *b* estimates). The results were very similar in both cases.

**Figure 7 Experiment 4: Log-Log Discount Factor Against Log Future Times, Fitted CS Functions and Compound Discounting Benchmark**



A similar ANOVA analysis for each of the product and value attributes found no effect of the time-cue manipulation ( $Fs < 1$ ) (also see Figure 8, which shows little change in the log-utilities for the product and face-value attribute levels with our manipulation).

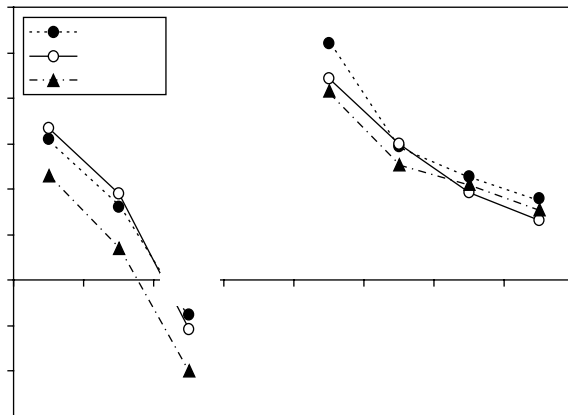
*Comparison of value-cue and control groups on attributes.* Providing a visual value cue did not change the subjects' utilities significantly ( $Fs < 1$ ), though, as in Experiment 3, directionally the manipulation decreased utilities slightly. An ANOVA analysis for each of the future time and product attributes found that the value-cue condition did have some effect on valuations. There was a main effect of the manipulation for both product and future time utilities, where subjects in the value-cue condition placed relatively less value on products and showed less discounting overall ( $Fs > 3.54, ps < 0.06, etas > 0.17$ ), suggesting perhaps a slight decrease in attention to these attributes with the presence of the value cue.

*Internal consistency.* As in Experiments 2 and 3, the internal consistency of the subjects' ratings, calculated for each subject as the correlation between the predicted preference ratings for the 15 certificates (i.e., the estimated utilities) and their actual preference ratings, did not differ from the control group in either of the experimental conditions (by *t*-test,  $ps > 0.23$ ) suggesting that subjects in all three conditions took similar care in performing this valuation task.

**5.8. Experiment 4: Conclusion**

We replicated the effects of increased time-sensitivity, seen in Experiments 1, 2, and 3, where subjects who were provided with visual cues for future time had larger time-sensitivity parameter estimates, i.e., they were more time-sensitive where they showed relatively lower discounting for the near future

**Figure 8** Experiment 4: Mean Utilities for Product and Face Value Attributes



and relatively more discounting for the far future, than controls without visual cues. An equivalent manipulation for face value replicated the results of Experiment 3, with no significant effect on face-value utilities, and the same directional effects when compared to controls without visual cues. Once again, the subjects' impatience was relatively independent of their time-sensitivity: The  $a$  parameter did not change significantly with the visual cue manipulation and was not significantly correlated with the time-sensitivity parameter.

The results replicated those in Experiment 3 even though a very different manipulation of attention was used, i.e., a visual cue rather than direct instruction, and even though face value was now not the most important attribute (unlike in Experiment 3). Furthermore, the visual cue enhanced the relative importance of future time, even though future time was already the most important attribute. That is, even when future time is the attribute that people are most influenced by, and so presumably paying the most attention to, they are still somewhat insensitive to the temporal dimension.

## 6. Summary and Conclusion

We examined the idea that the temporal dimension has a special fragility in terms of its impact on overall preference, contributing both theoretically and empirically to the literature on temporal discounting, a field with important implications for policy and decision making. Specifically, unlike the impact of other dimensions such as money, we suggest that people are insufficiently insensitive to future time, and what sensitivity they have is easily influenced. We provide empirical support for this. In addition, our theoretical contribution is the derivation of a discounting function that separates time-sensitivity from impatience, which

enables examination of the effects of our manipulations on both constructs, and provides an easy comparison with the normative compound function, for which the time-sensitivity  $b$  estimate is equal to 1. In our four experiments, the subjects were considerably less sensitive than required by compound discounting ( $b$  estimates were considerably smaller than 1), and we successfully changed subjects' sensitivity to the temporal dimension: In Studies 1, 3, and 4, we increased subjects' time-sensitivity using a comparative within-subject presentation (Experiment 1), direct instruction (Experiment 3), or provision of a visual cue for the time dimension (Experiment 4), while in Experiment 2, we compromised subjects' time-sensitivity using time pressure.

The effects on the subjects' valuations were consistent: A significant interaction between the primary experimental manipulation (e.g., time pressure or attention instructions) and future time, where subjects in more time-sensitive conditions showed less discounting of near-future rewards and more discounting of far-future rewards compared to subjects in less time-sensitive conditions. More time-sensitive conditions are arguably more ideal for valuation: Subjects had more information (Experiment 1), more time (Experiment 2), paid more attention (Experiment 3), and were provided with a visual aid (Experiment 4). And their valuations were "better," in that they were somewhat closer to the normative compound form (the  $b$  estimates were closer to 1). They showed relatively less discounting of the near future, but relatively more discounting of the far future, suggesting that people are insensitive to the temporal dimension such that there is too much discounting of the near future but not enough discounting of the far future.

Changes in time-sensitivity occurred independent of impatience, with no significant effects on impatience in our four studies, and correlations between the time-sensitivity and impatience parameters were very low, suggesting that these may be separable constructs in discounting. The idea that temporal discounting may include multiple constructs is not new (see Frederick et al. 2002), though time-insensitivity has not previously been a candidate construct.

Our success in manipulating time-sensitivity supports our proposal that the temporal dimension is relatively fragile, easily altered, unlike some other quantities that are unaffected by the same manipulations. In Experiment 2, restricting subjects' valuation time caused subjects to transfer attention from the time attribute to the restaurant attribute, even though future time was the most influential attribute for subjects with no pressure to make a quick valuation. A priori, one might expect increased attention to the most important (i.e., most influential) attribute to emerge as the simplest strategy when decision

time is scarce. Rather, the temporal dimension seems unusually vulnerable, neglected when decisions had to be taken quickly. Similarly, in Experiments 3 and 4, increasing attention to the future time attribute using verbal instructions or a visual cue increased sensitivity leading to greater influence of future time in the subjects' valuations. In contrast, equivalent manipulations on the face-value attribute caused no increase in influence of face value, independent of whether future time or face value was the more important (influential) attribute. Monetary value was attended even when it was relatively unimportant, while the temporal dimension was neglected even when it was the most important attribute present.

That people may be naturally insensitive to the temporal dimension is consistent with previous research, which shows that people commonly neglect the duration of events in their evaluations of those events (Frederickson and Kahneman 1993), due in part to a lack of attentional focus (Zakay 1998). And the idea of natural time-insensitivity may provide a point of integration for quite different theories about the valuation of future events, for example, those based on temporal construal theory (Liberman and Trope 1998) and subadditivity (Read 2001).

Liberman and Trope (1998) have shown that people cognitively construe events in the distant future quite differently from events in the very near future: as abstract and pallid relative to a more concrete and vivid present. This may help explain the type of time-insensitivity people show. People are not completely insensitive to the temporal dimension (i.e., they do not show zero discounting). Rather, time-insensitivity resembles an approach in which people put full weight on the present and similar smaller weight on all future times. This difference in weight may reflect a difference in perception in which events in the present or immediate future are perceived in one way (concrete and vivid) and valued similarly, while later events are perceived in another way (abstract and pallid) and also valued similarly. This is consistent with Ebert (2001) where, even with severely limited cognitive resources, people's valuations of the immediate and far future were quite different. With additional cognitive resources, effort, or motivation, people may correct these initial valuations—e.g., using an anchoring-an-adjustment process (Gilbert 2002, Tversky and Kahneman 1974)—or use another form of systematic processing to produce the results we see in Ebert (2001), where far-future valuations decrease with more cognitive resources, and in the current research, where near-future valuations increase and far-future valuations decrease with unlimited valuation time and greater attention to the temporal dimension.

In his account of the valuation of future events, Read (2001) has proposed that in many contexts—though probably not all—the hyperbolic shape of the discounting function can be explained by subadditive discounting: i.e., the discounting shown over a particular delay (e.g., over a year) will be greater when that delay is subdivided (e.g., into months). Read proposes an attentional explanation for subadditivity (alongside another alternative explanation), in which subdivision increases the overall attention assigned to the temporal dimension. The current research demonstrates a similar effect on discounting for the far future, using direct manipulations of attention, supporting his attentional explanation.

So, people might show the form of time-insensitivity we observe because of similarity in how they construe and then value events beyond the present, and the resulting insensitivity and inattention to variation in times beyond the present may help to explain why subadditivity occurs. In this way, natural time-insensitivity serves as a causal *explanation* of hyperbolic discounting, not simply an alternative description of the shape of the discounting function. And the manipulations we use to moderate time-sensitivity, which change the structure of the discounting function to make it more or less hyperbolic, are among the first moderators of this fundamental psychological function to be demonstrated. To our knowledge, only one other study (currently unpublished) has done this (Zauberman et al. 2007). Similar to Ainslie (2001), who argues that the hyperbolic form of the temporal discounting function is fundamental, we suggest that people's time-insensitivity is a natural tendency that is not readily corrected. Certainly, subjects' discounting remains far from exponential even with increased time-sensitivity in all four studies.

While people in our studies were not insensitive to dimensions like money, for other dimensions we might observe insensitivity similar to that for time. In particular, there are intriguing parallels between the time dimension and probability, as some have noted (Prelec and Loewenstein 1991, Rachlin et al. 1991, Keren and Roelofsma 1995). The form of insensitivity shown for the temporal dimension (full weight on immediate future events, with similar smaller weight on all future times) has a counterpart in the probability domain where people put great weight on outcomes that are certain (100% chance) (Prelec and Loewenstein 1991), while the weight put on outcomes of intermediate probabilities is smaller and relatively similar (Kahneman and Tversky 1979).

Although we increased sensitivity with certain manipulations (giving people more time to think or focus their attention on the arrival date of an item), our respondents' valuations of future events did not come

close to the compound norm. This raises the question of whether the personally ideal level of temporal sensitivity is possibly different from, and indeed lower than one ( $b < 1$ ). Our sensitivity-promoting manipulations invariably had the effect of increasing discounting of the far future. This highlights an old dilemma, namely, that intertemporal rationality ( $b = 1$ ) plus a nontrivial discount factor, licenses the decision maker to ignore distant future outcomes, whose impact is erased by the surprising power of compounding. Although temporal insensitivity does lead to preference reversals, this may be a small price to pay for the protection provided to one's long-term goals.

So, time-insensitivity may lead managers to be inappropriately indifferent between medium-term and longer-term consequences of similar merit. However, it may also promote extended vision, as they more heavily weight their long-term strategic goals.

Finally, our results suggest that preference reversals resulting from time-insensitivity relative to the compound norm are likely to be fairly robust to change. In the short-run (i.e., for decisions in the nearer future) managers will continue to desire instant results that may be inferior, and consumers will prefer rapid delivery of goods that may not be ideal. Those same managers and consumers will display relative patience in similar decisions when outcomes will occur in the distant future. Those managers with insight into these tendencies can try to prevent short-sighted behavior by committing to strategic plans when outcomes are still distant in time.

### Acknowledgments

The authors gratefully acknowledge the support of Research Grant SES0079138 from the National Science Foundation. The authors also thank Elizabeth Brown, Kristi Fasteson, Elina Groberman, Noelle Nelson, Diana Ng, Swapna Panuganti, and Neelima Teerdhala for their assistance in the execution of these experiments.

### Appendix

**PROPOSITION.** Assume that preferences ( $\geq$ ) over simple temporal prospects have a discounted utility representation:  $(x, t) \geq (y, s)$  iff  $u(x)f(t) \geq u(y)f(s)$ , with a continuous, strictly increasing utility function  $u(x)$ ,  $u(0) = 0$ , and a continuous, strictly decreasing discount function  $f(t)$ , with  $f(0) = 1$ ,  $\lim_{t \rightarrow +\infty} f(t) = 0$ . Then the following two conditions are equivalent:

Temporal Scale Invariance (TSI). For any outcomes  $x, y, z \geq 0$ , dates  $t, s, r, q \geq 0$ , and scale factor  $\lambda > 0$ , the indifference pair  $(x, t) \sim (y, s)$  and  $(x, r) \sim (y, q)$  implies:  $(x, \lambda t) \sim (z, \lambda s)$  if and only if  $(x, \lambda r) \sim (z, \lambda q)$ .

*Constant sensitivity discounting.* The discount function has the form,  $f(t) = \exp(-at^b)$ , with  $a, b > 0$ .

**PROOF.** The proposition is equivalent, modulo a log transformation, to Prelec (1998, Proposition 1C), which uses

a “compound invariance” (CI) axiom to derive the compound invariant probability weighting function,  $w(p) = \exp(-\alpha(-\ln p)^\beta)$ , where  $p$  is probability, and  $\alpha, \beta$  are positive constants.

To prove that TSI implies constant sensitivity discounting, we induce preferences  $\geq^*$  over risky prospects  $(x, p)$  via the transformation,  $p = \exp(-t)$ , so that the temporal prospect  $(x, t)$  may be interpreted as a simple gamble, giving an  $e^{-t}$  chance at outcome  $x$ , and a  $1 - e^{-t}$  chance at outcome 0. In that case, if risky preferences  $\geq^*$  can be represented by  $u(x)w(p)$ , where  $w(p)$  is a probability weighting function, then temporal preferences can be represented by  $u(x)f(t)$ , where  $f(t) = w(e^{-t})$ , i.e.,  $w(p) = f(-\ln p)$ .

If TSI holds for preferences  $\geq$  over  $(x, t)$ , then the induced preferences  $\geq^*$  over risky prospects satisfy

$$(x, e^{-t}) \sim^* (y, e^{-s}) \text{ and } (x, e^{-s}) \sim^* (y, e^{-q}) \text{ implies:}$$

$$(x, e^{-\lambda t}) \sim^* (z, e^{-\lambda s}) \text{ iff } (x, e^{-\lambda r}) \sim^* (z, e^{-\lambda q})$$

or

$$(x, e^{-t}) \sim^* (y, e^{-s}) \text{ and } (x, e^{-s}) \sim^* (y, e^{-q}) \text{ implies:}$$

$$(x, (e^{-t})^N) \sim^* (z, (e^{-s})^N) \text{ iff } (x, (e^{-r})^N) \sim^* (z, (e^{-q})^N).$$

The second line is the CI axiom in Prelec (1998), where  $N = \lambda$  is the compounding factor, applied to “probabilities”  $e^{-t}, e^{-s}, e^{-r}, e^{-q}$ . TSI therefore implies CI for probabilities in the half-open interval  $(0, 1]$ , which by Proposition 1C implies that there exists constants  $\alpha > 0, \beta > 0$ , such that the probability weighting function has the form,  $w(p) = \exp(-\alpha(-\ln p)^\beta)$ , for:  $0 < p \leq 1$  (Proposition 1C actually assumes CI on the closed interval  $[0, 1]$ , but the proof (p. 517) only requires the half-closed interval  $(0, 1]$ ). However, if risky preferences are represented by  $u(x)w(p)$ , then temporal preferences  $\geq$  are represented by  $u(x)f(t) = u(x)w(e^{-t})$ , where  $f(t) = w(e^{-t}) = \exp(-\alpha(-\ln(e^{-t}))^\beta) = f(-\ln p) = \exp(-at^\beta) = \exp(-(at)^b)$  (with  $a = \alpha^{1/\beta}, b = \beta$ ). This proves that TSI implies constant sensitivity. The converse was proved by direct calculation in the text.

**REMARK 1.** If TSI is restricted to strictly positive times then CI only holds for probabilities in the open interval  $(0, 1)$ , in which case, Prelec (1998, Proposition 1D), there exists constants  $\alpha > 0, \beta > 0, 0 < \gamma \leq 1$ , such that the probability weighting function has the form,  $w(p) = \gamma \exp(-\alpha(-\ln p)^\beta)$ , for:  $0 < p < 1$ , and  $w(1) = 1$ . This function is not continuous at  $p = 1$  unless  $\gamma = 1$ . The associated discount function,  $f(t) = \gamma \exp(-(at)^b), t > 0, f(0) = 1$ , includes the continuous-time version of the  $\beta - \delta$  “quasi-hyperbolic” model (Laibson 1997),  $f(t) = \beta \delta^t, t > 0, f(0) = 1$ .

**REMARK 2.** TSI is sufficient for constant sensitivity, but the same functional form (and certain generalizations) can be derived from substantially weaker conditions, using the strong results developed by Luce (2001). Luce also shows that the original proof (in Prelec 2004) holds even if CI, and hence TSI, hold only at  $\lambda = 2, 3$ , and only for prospects where one outcome is immediate ( $t = 0$ ).

### References

- Abele, A. E., P. Petzwold. 1998. Pragmatic use of categorical information in impression formation. *J. Personality Soc. Psych.* 75: 347–358.

- Ainslie, G. 2001. *Breakdown of Will*. Cambridge University Press, New York.
- Ainslie, G., V. Haendel. 1983. The motives of the will. E. Gottheil, K. Druley, T. Skodola, H. Waxman, eds. *Etiology Aspects of Alcohol and Drug Abuse*. Charles C. Thomas, Springfield, IL, 119–140.
- Ainslie, G., N. Haslam. 1992. Hyperbolic discounting. G. F. Loewenstein, J. Elster, eds. *Choice Over Time*. Russell Sage, New York, 57–92.
- Alessi, S. M., N. M. Petry. 2003. Pathological gambling severity is associated with impulsivity in a delay discounting procedure. *Behav. Processes* **64** 345–354.
- Ariely, D., G. F. Loewenstein. 2000. When does duration matter in judgment and decision making? *J. Experiment. Psych.: General* **129**(4) 508–523.
- Block, R. A., D. Zakay. 1997. Prospective and retrospective duration judgments: A meta-analytic review. *Psychonomic Bull. Rev.* **4**(June) 184–197.
- Chaiken, S., Y. Trope, eds. 1999. *Dual Process Theories in Social Psychology*. The Guilford Press, New York.
- Chapman, G. B., E. J. Coups. 1999. Time preferences and preventive health behavior: Acceptance of the influenza vaccine. *Medical Decision Making* **19** 307–314.
- Coller, M., M. B. Williams. 1999. Eliciting individual discount rates. *Experiment. Econom.* **2** 107–127.
- Ebert, J. E. J. 2001. The role of cognitive resources in the valuation of near and far future events. *Acta Psychologica* **108**(September) 155–171.
- Fishburn, P. C., A. Rubinstein. 1982. Time preference. *Internat. Econom. Rev.* **23**(3) 677–694.
- Frederick, S., G. F. Loewenstein, T. O'Donoghue. 2002. Time discounting and time preference: A critical review. *J. Econom. Literature* **40** 351–374.
- Frederickson, B. L., D. Kahneman. 1993. Duration neglect in retrospective evaluations of affective episodes. *J. Personality Soc. Psych.* **65** 44–55.
- Gilbert, D. T. 2002. Inferential correction. T. Gilovich, D. W. Griffin, D. Kahneman, eds. *Heuristics and Biases: The Psychology of Intuitive Judgment*. Cambridge University Press, Cambridge, UK, 167–184.
- Gilovich, T., D. W. Griffin, D. Kahneman, eds. 2002. *Heuristics and Biases: The Psychology of Intuitive Judgment*. Cambridge University Press, Cambridge, UK.
- Green, L., N. Fristoe, J. Myerson. 1994. Temporal discounting and preference reversals in choice between delayed outcomes. *Psychonomic Bull. Rev.* **1**(3) 383–389.
- Green, L., J. Myerson, E. McFadden. 1997. Rate of temporal discounting decreases with amount of reward. *Memory Cognition* **25**(5) 715–723.
- Green, P. E., V. Srinivasan. 1978. Conjoint analysis in consumer research: Issues and outlook. *J. Consumer Res.* **5** 103–123.
- Green, P. E., Y. Wind. 1975. New way to measure consumers' judgments. *Harvard Bus. Rev.* 107–117.
- Griffin, D. W., D. Dunning, L. Ross. 1990. The role of construal processes in overconfident predictions about the self and others. *J. Personality Soc. Psych.* **59** 1128–1139.
- Gyrd-Hansen, D., J. Sogaard. 1998. Discounting life-years: Whither time preference? *Health Econom.* **7** 121–127.
- Hsee, C. K. 1996. The evaluability hypothesis: An explanation of preference reversals between joint and separate evaluations of alternatives. *Organ. Behav. Human Decision Processes* **46** 247–257.
- Kahneman, D., A. Tversky. 1979. Prospect theory: An analysis of decision under risk. *Econometrica* **47**(2) 363–391.
- Kenny, D. A., C. M. Judd. 1986. Consequences of violating the independence assumption in analysis of variance. *Psych. Bull.* **99** 422–431.
- Keren, G., P. Roelefsma. 1995. Immediacy and certainty in intertemporal choice. *Organ. Behav. Human Decision Processes* **63** 287–297.
- Kirby, K. 1997. Bidding on the future: Evidence against normative discounting of delayed rewards. *J. Experiment. Psych. General* **126**(1) 54–70.
- Kirby, K., N. N. Marakovic. 1995. Modeling myopic decisions: Evidence for hyperbolic delay-discounting within subjects and amounts. *Organ. Behav. Human Decision Processes* **64** 22–30.
- Laibson, D. 1997. Golden eggs and hyperbolic discounting. *Quart. J. Econom.* **112**(2) 443–477.
- Liberman, N., Y. Trope. 1998. The role of feasibility and desirability considerations in near and distant future decisions: A test of temporal construal theory. *J. Personality Soc. Psych.* **75**(July) 5–18.
- Loewenstein, G. F. 1987. Anticipation and the valuation of delayed consumption. *Econom. J.* **97**(387) 666–684.
- Loewenstein, G. F. 1988. Frames of mind in intertemporal choice. *Management Sci.* **34** 200–214.
- Loewenstein, G. F. 1992. The fall and rise of psychological explanations in the economics of intertemporal choice. G. F. Loewenstein, J. Elster, eds. *Choice Over Time*. Russell Sage, New York, 3–34.
- Loewenstein, G. F., D. Prelec. 1991. Negative time preference. *Amer. Econom. Rev.* **81**(2) 347–352.
- Luce, R. D. 2001. Reduction invariance and Prelec's weighting functions. *J. Math. Psych.* **45** 167–179.
- Prelec, D. 1998. The probability weighting function. *Econometrica* **66** 497–527.
- Prelec, D. 2004. Decreasing impatience: A criterion for non-stationary time preference and hyperbolic discounting. *Scandinavian J. Econom.* **106**(3) 511–532.
- Prelec, D., G. F. Loewenstein. 1991. Decision making over time and under uncertainty: A common approach. *Management Sci.* **37** 770–786.
- Rachlin, H., A. Raineri, D. Cross. 1991. Subjective probability and delay. *J. Experiment. Anal. Behav.* **55** 233–244.
- Read, D. 2001. Is time-discounting hyperbolic or subadditive? *J. Risk Uncertainty* **23** 5–32.
- Redelmeier, D. A., D. Kahneman. 1996. Patient's memories of painful medical treatments—Real-time and retrospective evaluations of two minimally invasive procedures. *Pain* **66** 3–8.
- Rosenthal, R., R. L. Rosnow. 1991. *Essentials of Behavioral Research: Methods and Data Analysis*, 2nd ed. McGraw-Hill, New York.
- Senior, N. W. 1836. *An Outline of the Science of Political Economy*. Clowes and Sons, London, UK.
- Shelley, M. K. 1993. Outcome signs, question frames and discount rates. *Management Sci.* **39** 806–815.
- Soman, D. 2001. The mental accounting of sunk time costs: Why time is not like money. *J. Behav. Decision Making* **14** 169–185.
- Sultan, F., R. S. Winer. 1993. Time preferences for products and attributes and the adoption of technology-driven consumer durable innovations. *J. Econom. Psych.* **14** 587–613.
- Thaler, R. H. 1981. Some empirical evidence on dynamic inconsistency. *Econom. Lett.* **8** 201–207.
- Tversky, A., D. Kahneman. 1974. Judgment under uncertainty: Heuristics and biases. *Science* **185**(4157) 1124–1131.
- Varey, C. A., D. Kahneman. 1992. Experiences extended across time: Evaluation of moments and episodes. *J. Behav. Decision Making* **5** 169–185.
- Zakay, D. 1998. Attention allocation policy influences prospective timing. *Psychonomic Bull. Rev.* **5**(1) 114–118.
- Zauberman, G., J. R. Bettman, S. A. Malkoc, B. K. Kim. 2007. Time horizon neglect: Prospective duration insensitivity in consumer preference. Working paper, Wharton School, University of Pennsylvania, Philadelphia, PA.