Better Is Worse, Worse Is Better: Violations of Dominance in Intertemporal Choice

Marc Scholten
Universidade Europeia

Daniel Read
Warwick Business School

We examine violations of dominance in intertemporal choice. Adding an immediate receipt to a delayed payment, or adding a delayed receipt to an immediate one, makes the prospect objectively better, and yet decreases the likelihood it will be chosen (better is worse). Conversely, adding an immediate payment to a delayed receipt, or adding a delayed payment to an immediate one, makes the prospect objectively worse, and yet increases the likelihood it will be chosen (worse is better). Results are consistent across between-participant and within-participant comparisons and across hypothetical and real choices. Prior expectations about the 4 violations of dominance draw on Loewenstein and Prelec’s (1993) sequences model and the implied preference for improvement over deterioration. Detailed results suggest that there is a role for loss aversion and debt aversion in people’s reaction to individual losses.

Keywords: intertemporal choice, dominance, sequences, discounting, gestalt

Intertemporal choices are those in which the outcomes of available options are distributed over time. Just as with risky choices, intertemporal choices are often at variance with economic principles of rationality. Two cornerstones of any normative theory are descriptive invariance and dominance (Tversky & Kahneman, 1986), both of which have seen violations in intertemporal choice (Loewenstein & Sicherman, 1991; Magen, Dweck, & Gross, 2008). We report new violations of dominance, in which an intertemporal prospect fares better by making it worse, and fares worse by making it better.

In intertemporal choice, dominance means that if the cumulative outcome of one option in successive time periods is never worse than that of another option, and better at least in one time period, then the first option is a dominant option, and should therefore be preferred. Formally, to detect dominance between X and Y, we must compare \( \sum_{j=1}^{n} x_j \) with \( \sum_{j=1}^{n} y_j \) for each time period \( i = 1 \ldots n \). If there is no time period in which the cumulative outcome of \( X \) is worse than that of \( Y \), and at least one time period in which it is better, then \( X \) dominates \( Y \). When the outcomes are monetary, dominance relies only on the assumptions that more money is better than less money (monotonicity), and that money sooner is better than money later (i.e., positive time preference; Fisher, 1930).

In intertemporal choice, dominance has been violated in preferences for sequences: People often prefer an improving sequence over a deteriorating sequence yielding the same total payoff, when, in terms of cumulative outcomes, the former is dominated by the latter. To account for this, Loewenstein and Prelec (1993) developed the sequences model. This model assigns a role to the gestalt features of a sequence, where “gestalt” means that the whole (the sequence) is different from its parts (the outcomes in the sequence). More specifically, a sequence derives utility not only from the discounted utilities of its outcomes, but also from how it deviates from a uniform distribution. Deviating from a uniform distribution is bad (the spread-
ing motive), but deviating from it in the positive direction is good (the improvement motive). If the improvement motive outweighs the spreading motive, and if gestalt value outweighs discounting, people will exhibit a preference for improvement tempered by a desire for spreading.

Formally, the gestalt value of a sequence derives from comparing, for each time period $i = 1 \ldots n$, the cumulative outcome $\sum_{j=1}^{i} x_j$, which indicates how the sequence develops over time, with the uniformly cumulative outcome $(i/n) \sum_{j=1}^{i} x_j$, which indicates how the sequence, given its total payoff, would be uniformly developing over time. Like dominance detection, therefore, the computation of gestalt value involves cumulative outcomes. The difference is that, in dominance detection, cumulative outcomes are, for each time period, compared between options, whereas, in the computation of gestalt value, cumulative outcomes are compared, for each time period and within each option, with uniformly cumulative outcomes.

Given a preference for improvement over deterioration, it should be possible to increase the likelihood that an option is chosen by making it objectively worse, when a bad outcome turns the option into an improving sequence, and decrease the likelihood that an option is chosen by making it objectively better, when a good outcome turns the option into a deteriorating sequence. We show that this is indeed the case.

We will report four comparisons between pairs of binary choices. In each choice pair, there is a common referent option $R$. In one choice, $R$ is compared with target option $T^+$, and, in the other choice, it is compared with target option $T^-$, where $T^+$ dominates $T^-$, but neither dominates, or is dominated by, $R$. We will show that choice of $T^+$ over $R$ is less likely than choice of $T^-$ over $R$.

Preliminaries

In this section, we explain how discounting, one component of the sequences model, acts as a constraint on violations of dominance implied by gestalt value, and we discuss the violations of dominance that we expect, and those that we do not expect.

Discounting as a Constraint on Violations of Dominance

Preference for improvement over deterioration is an indication that gestalt value outweighs discounting. This does not mean, however, that discounting is inoperative, and discounting will impose constraints on whether violations of dominance occur. Some preliminary evidence on this comes from two option triples, each having the following form:

- $T^+$ receive $G_S$ today and pay $L_L$ in 1 year.
- $T^-$ pay $L_L$ in 1 year.
- $R$ pay $L_S$ today.

By gestalt value, choice of $T^+$ over $R$ would be less likely than choice of $T^-$ over $R$, because $T^+$ is a decreasing sequence. By discounting, the reverse would be true, because, when one sequence dominates the other, the discounted value of the dominating sequence is always greater than the discounted value of the dominated one, for any positive discount rate. Whether discounting outweighs gestalt value depends on the interest rate that has to be paid over the 1-year interval. For the choice between $T^-$ and $R$, the interest rate is $L_L/L_S - 1$, where $L_L < L_S < 0$, and, for the choice between $T^+$ and $R$, it is $L_L/(L_S - G_S) - 1$, where $G_S > 0$. Thus, $G_S$ decreases the interest paid over the interval. If the decrease in interest is too steep, gestalt value may be outweighed by discounting, and we would see a “rational” change in choice behavior. In one option triplet, the outcome set $\{L_L, L_S, G_S\}$ was $\{-600, -450, 50\}$, where $G_S$ decreases the interest rate from 33.33% to 20%. In violation of dominance, we found that choice of $T^+$ over $R$ was significantly less likely than choice of $T^-$ over $R$, a difference of 6%. In the other option triplet, the outcome set $\{L_L, L_S, G_S\}$ was $\{-400, -300, 50\}$, where $G_S$ decreases the interest rate from 33.33% to 14.29%. Although choice of $T^+$ over $R$ was still less likely than choice of $T^-$ over $R$, the difference was only 3%, and no longer significant. This suggests that discounting imposes constraints on whether violations of dominance occur, and we took this into account in the construction of the choice pairs to be tested.

Violations of Dominance

The choice pairs presented to our participants are displayed in Table 1. In the comparison
between the Gains pair and the Unmixed-deteriorating pair, the referent option \((R)\) is £100 in 1 year, the dominated option \((T^-)\) is £75 today, and the dominating option \((T^+)\) is £75 today and £5 in 1 year (an unmixed sequence of only gains, or a good). In the comparison between the Losses pair and the Mixed-deteriorating pair, \(R\) is –£75 today, \(T^-\) is –£100 in 1 year, and \(T^+\) is £5 today and –£100 in 1 year (a mixed sequence that exchanges a sooner gain for a larger-later loss, or a schedule of debt). In each comparison, the interest rate implied by \(R\) and \(T^-\) (33.33%) is higher than that implied by \(R\) and \(T^+\) (26.67% and 25%, respectively), so that, by discounting, choice of \(T^+\) over \(R\) would be more likely than choice of \(T^-\) over \(R\). However, because \(T^-\) is an improving sequence, gestalt value has the reverse implication. When gestalt value outweighs discounting, we would see violations of dominance in which an option fares better by making it objectively worse.

Nonviolation of Dominance

It has been shown that people choose a dominant option when dominance is detected, but that they may choose a dominated option when it is not (Tversky & Kahneman, 1986). In our case, we expect that, in a direct choice between £75 today \((T^-)\) and £75 today and £5 in 1 year \((T^+)\), few will choose \(T^-\). Rather, most people will cancel the common consequence, and treat the choice as a decision of whether to accept or decline £5 in 1 year. In our first study, we only ask our participants to compare, in two separate choices, \(R\) with \(T^-\) and \(T^+\). In our second study, we also ask them to compare, in a direct choice, \(T^-\) with \(T^+\).

Study 1

Method

Design. The stimuli are presented in Table 1. There were two choices between single dated outcomes, one for receipts (between £75 today and £100 in 1 year), one for payments (between –£75 today and –£100 in 1 year). The options in these choices were then changed into sequences, according to a 2 (mixed – unmixed sequence) x 2 (improving – deteriorating sequence) design.
Participants. We recruited a sample of British residents through Maximiles, an Internet service in which members earn points for completing questionnaires (see Reimers, 2009, for additional details). In this study, £1 worth of Maximiles points. The sample included 982 participants, 40% men, 55% having an A level or less and 45% having a bachelor’s degree or more, 83% being employed and 17% either unemployed or students. Age ranged from 17 to 64 years, with a mean of 43 and a median of 45. Among the 87% of the participants who agreed to answer, 33% earned less than 20k in gross yearly household income, 56% earned between 20k and 60k, and 12% more than 60k.

Procedure. The sample was recruited in three waves over the course of 1 week. Each wave was presented with two of three groups of questions. In one group (S), the two choices involved only single dated outcomes; in the second group (M), the two choices involved a mixed sequence; in the third group (U), the two choices involved an unmixed sequence. One group of questions appeared in the beginning of the questionnaire and was separated from the other group by a set of distractor items (standard intertemporal tradeoffs between a smaller-sooner and a larger-later gain; intertemporal tradeoffs between length and duration of outcome streams, both in the social and in the professional sphere, and risky tradeoffs between high- or low-risk gains or losses and their certainty equivalents). The order of the groups was counterbalanced across participants, as was the order of the questions within each group. The first wave (N = 317) was presented with S and M, the second wave (N = 301) with the S and U, and the third wave (N = 364) with M and U. No participant was invited for more than one wave.

Comparisons. To sidestep any controversy concerning whether within-participant or between-participant designs are more appropriate for testing theories of individual decision making (e.g., Hershey & Schoemaker, 1980; Kahneman & Tversky, 1979; Keren & Raaijmakers, 1988; Tversky & Kahneman, 1992), we use both. Only the first group of questions answered by each wave served for the between-participants comparisons. In all, 325 participants responded first to S, 347 to M, and 310 to U. The first two waves, who responded to S and either M or U, served for the within-participant comparisons.

Results

Table 2 reports choice proportions, effect sizes, and significance tests. Across between-participants and within-participant comparisons, the four violations of dominance are generally confirmed. We highlight three results:

1. The strongest effects are observed for the unmixed deteriorating sequence, obtained by adding a delayed gain to an immediate one. These involve ordinal changes in choice probability. In the between-participants comparison, a majority (73%) chose £75 today, $218 \chi^2(1) = 68.31, p < .005, \chi^2(M)(1) = 4.66, p = .03$. Similarly, in the within-participant comparison, a majority (65%) chose £75 today, $\chi^2(M)(1) = 27.51, p < .005, \chi^2(M)(1) = 1.20, p = .27$.

These ordinal (majority-minority) changes in choice probability rule out an alternative explanation of our results, according to which adding a small amount (–£5 or £5) to one of the options changes the error rate in the choice function. First consider the choices involving net losses. In comparison to –£75 today, a majority rejected –£100 in 1 year, and an even larger majority rejected £5 today and –£100 in 1 year. Furthermore, in comparison –£100 in 1 year, a majority chose –£75 today, and an even larger majority chose –£75 today and –£5 in 1 year.

One might argue, therefore, that adding a small amount (–£5 or £5) to one of the options decreases the error rate in the choice function. For this interpretation, things become more complicated with the choices involving net gains. In comparison to £75 today, a majority rejected £100 in 1 year, but a smaller majority rejected –£5 today and £100 in 1 year. Now, the error-rate interpretation would have to assume that adding a small amount (–£5) to one of the options increases the error rate in the choice function. Moreover, in comparison to £100 in 1 year, a majority chose £75 today, but a minority chose £75 today and £5 in 1 year, which rules out the error-rate interpretation altogether.

2. No ordinal changes are observed for the mixed improving sequence, obtained by adding an immediate loss to a delayed gain. This result becomes meaningful when compared with Result 1: The pain of an immediate loss (in the mixed improving sequence) is larger than the
### Table 2

**Study 1: Stimuli, Choice Proportions, Effect Sizes, and Significance Tests**

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Referent option</th>
<th>Target option</th>
<th>Between-participant</th>
<th>With-in-participant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>$P_{\text{NS}}$</td>
<td>$P_{S}$</td>
</tr>
<tr>
<td>Mixed</td>
<td>Improving</td>
<td>Receive £75</td>
<td>.27</td>
<td>.36</td>
</tr>
<tr>
<td></td>
<td></td>
<td>today</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Receive £100</td>
<td>Pay £5 today and</td>
<td>.40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>in 1 year</td>
<td>receive £100 in 1 year</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Receive £75</td>
<td>Receive £5 today</td>
<td>.60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>today</td>
<td>and pay £100 in 1 year</td>
<td></td>
</tr>
<tr>
<td>Unmixed</td>
<td>Improving</td>
<td>Pay £100 in</td>
<td>.73</td>
<td>.44</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 year</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Receive £75</td>
<td>Receive £75 today</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>today</td>
<td>and receive £5 in 1 year</td>
<td></td>
</tr>
</tbody>
</table>

*The effect size is $\text{Logit } d' = \text{Log(}\Omega_{S}\) − \text{Log(}\Omega_{\text{NS}}\)$, where $\Omega = P(1 − P)$. For instance, the difference between proportions $.9 − .6 = .3$ would show the same size as the difference between proportions $.6 − .2 = .4$, because the former is closer to the upper bound of 1 than the latter is to the lower bound of 0. The test statistics are Pearson’s $\chi^2$ for independent samples ($\chi^2$), and McNemar’s $\chi^2$ for dependent samples ($\chi^2_{d}$).*
pleasure of a delayed gain (in the unmixed deteriorating sequence). Thus, although the immediate loss boosts the popularity of the mixed improving sequence, the decision maker has literally mixed feelings about this option.

3. The weakest effects are observed for the unmixed improving sequence, obtained by adding a delayed loss to an immediate one. This result becomes meaningful when compared with Results 1 and 2: In comparison to Result 2, we observe that adding a delayed loss, or a debt, is more painful than adding an immediate loss, which confirms that people are debt averse; in comparison to Result 1, we observe that the pain of adding a delayed loss is larger than the pleasure of adding a delayed gain, which follows from both loss aversion and debt aversion.

We next report a second study, in which we incentivize choice. We use only the unmixed deteriorating sequence, which is a good; thus, a sequence of gains only, thus avoiding the problem of engineering incentivized choice involving losses, which may not even differ from hypothetical choice (Etchart-Vincent & l’Haridon, 2011). In intertemporal choice, the problem is compounded by the fact that participants would have to pay their dues over time.

Study 2

Method

Participants. We recruited a sample of American residents through MTurk, and we offered a show-up fee of £0.60. The sample included 68 participants, 62% men, 32% having some college or less and 68% having an associate’s degree or more, 82% being employed and 18% either unemployed or students. Age ranged from 18 to 70 years, with a mean of 30 and a median of 27.

Procedure. Participants were informed that their first task would be to choose between payments in Amazon gift cards. They were told that their chosen option might be paid out for real, based on the result of a prize draw, and so they were asked to fill in their preferred email address, in case their name was drawn. Participants then proceeded to the choice task, which read: “Please choose between the following two payments in Amazon gift cards, where the payments will be made at different times in the future. Two participants will receive their chosen payment, at the time specified, in Amazon gift cards. The cards will be sent by email.”

Choice sets. There were three choices. One group of participants (N = 27) chose between receiving $75 in 1 week (T<sup>-</sup>) and receiving $100 in 9 weeks (R). Another group (N = 16) chose between receiving $75 in 1 week and receiving $5 in 9 weeks (T<sup>+</sup>), and receiving $100 in 9 weeks (R). A final group (N = 25) chose between receiving $75 in 1 week (T<sup>-</sup>) and receiving $75 in 1 week and receiving $5 in 9 weeks (T<sup>+</sup>).

Results

A majority (67%) chose T<sup>-</sup> over R, χ<sup>2</sup><sub>p(1) = 3.00, p = .08</sub>, and a minority (25%) chose T<sup>+</sup> over R, χ<sup>2</sup><sub>p(1) = 4.00, p = .05</sub>. Thus, R was less likely to be chosen than T<sup>-</sup>, but more likely to be chosen than T<sup>+</sup>, χ<sup>2</sup><sub>p(1) = 6.98, p = .01</sub>. Finally, an overwhelming majority (88%) chose T<sup>-</sup> over T<sup>+</sup>, χ<sup>2</sup><sub>p(1) = 14.44, p < .005</sub>. We thus observe that P(T<sup>-</sup>; R) > 1/2, P(R; T<sup>+</sup>) > 1/2, but P(T<sup>-</sup>; T<sup>+</sup>) < 1/2, in violation of weak stochastic transitivity (Tversky, 1969), and P(T<sup>-</sup>; R) + P(R; T<sup>+</sup>) - P(T<sup>-</sup>; T<sup>+</sup>) > 1, or .67 + .75 − .12 = 1.30 > 1, in violation of triangle inequality (Regenwetter, Dana, & Davis-Stober, 2011).

Discussion

Drawing on Loewenstein and Prelec’s (1993) sequences model, we identified four violations of dominance in intertemporal choice, and we obtained all four of them, in both between-participant and within-participant comparisons. We also obtained, in between-participant comparisons, a violation of weak stochastic transitivity and triangle inequality. Violations of weak stochastic transitivity in within-participant comparisons are commonly interpreted as the result of intra-attribute comparisons between the options (for risky choice, see Leland, 1994; Tversky, 1969; for intertemporal choice, see Roelofsma & Read, 2000; Scholten & Read, 2006, 2010). To produce the current violation, the sequences model must assume that, in the choice between the dominating option T<sup>+</sup> and the dominated option T<sup>-</sup>, cancellation of the common consequence has priority over computation of gestalt value, thus favoring T<sup>-</sup> over T<sup>+</sup>. Definitely, choice probabilities in between-
participants comparisons can violate weak stochastic transitivity even when each participant has transitive preferences (Birnbaum & Gutierrez, 2007), but our violations of dominance occurred in both between-participants and within-participant comparisons.

Our violations of dominance are similar to those seen previously in risky choice. Mellers, Weiss, and Birnbaum (1992) showed that a gamble could be assigned a lower price when it was made objectively better. For instance, the average participant assigned a lower price to a 95% chance of winning $83.50 and a 5% chance of winning $31.50 than to a 95% chance of winning $83.50 and a 5% chance of winning nothing. Bateman et al. (2007) showed that a gamble could be chosen more often when it was made objectively worse. For instance, a minority chose a 7 in 36 chance of winning $9 and nothing otherwise over a sure gain of $2, whereas a majority chose a 7 in 36 chance of winning $9 and losing 5¢ otherwise over a sure gain of $2. This is the format that we followed as well: The dominant options fares worse, and the dominated option fares better, in comparison to a referent option.

There also violations of stochastic dominance. Birnbaum (2005; Birnbaum & Navarrete, 1998) reports violations in which, for instance, $T^− = ($99, .92; $91, .03, $6, .05) is preferred to $T^+ = ($99, .95; $8, .03; $6, .02), while ($99, .95), the first branch of $T^+$, dominates ($99, .92; $91, .03), the first two branches of $T^−$, and ($8, .03; $6, .02), the last two branches of $T^+$, dominates ($6, .05), the last branch of $T^−$. To examine whether an intertemporal equivalent of this choice would also violate dominance, we changed each outcome according to the formula $t = h(1 − p)p$ (Rachlin, Raineri, & Cross, 1991), where $h = 1/7$ (changing “days” into weeks). Because, in risky choice, only one outcome occurs, whereas, in intertemporal choice, all outcomes occur, we changed each outcome according to the formula $x'_i = 100x_i / \sum_{n=1}^N x_n$, where the summation is over the three outcomes of each option. To achieve dominance, we allowed a small dollar change in the largest outcome of each option, and, upon rounding all quantities to the nearest integer, we arrived at the following choice:

$T^+$ Receive $90 today, $7 in 5 weeks, and $5 in 7 weeks.

$T^−$ Receive $48 today, $3 in 3 weeks and $46 in 5 weeks.

Choice between $T^+$ and $T^−$ depends, according to the sequences model, on the balance between discounted utility (favoring $T^+$ by discounting, favoring $T^−$ by concave utility) and gestalt value (favoring $T^−$, because $T^+$ is steeply deteriorating, and $T^−$ exhibits a better spreading). However, one might suggest that heuristics, or editing operations, come into play (see Birnbaum, 2005; Tversky & Kahneman, 1986): In this case, people might ignore the “peanuts” in both sequences, compare $90 today (T^+)$ with “roughly” $90 spread out over time (T^−), and choose $T^+$. A more systematic analysis of candidate algorithms governing choice involving sequences is left for future research. Our modest aim was to show that an intertemporal prospect may fare better by making it worse, and fare worse by making it better.

References


Hershey, J. C., & Schoemaker, P. J. H. (1980). Prospect theory’s reflection hypothesis: A critical ex-


Received October 23, 2013
Revision received March 24, 2014
Accepted May 19, 2014