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ABSTRACT

Three common anomalies of intertemporal choice (Gain/Loss Asymmetry, Short/Long Asymmetry, and the Absolute Magnitude Effect) are investigated using both sequences and matching in a within-subjects experiment. In both procedures, it appears that the participants in this study evaluate monetary outcomes over time differently than the traditional discounting model predicts. Patterns consistent with two of the anomalies (Gain/Loss and Absolute Magnitude Effect) surface and interact in both elicitation techniques. Finally, a systematic inconsistency exists between the two methods. We observe significantly more consistency between the two elicitation techniques when the outcome is a gain in the relatively far future than when it is an equitable future loss.

Keywords: Time preference, discounting, anomalies, procedure invariance

1. Introduction

Many decisions involve monetary outcomes that are experienced over time, such as the reception of wages or the payment of debts. To incorporate the time element into decision making, the concept of discounting monetary outcomes has become a well-accepted cornerstone of financial decision analysis (Clemen and Reilly 2001). Most of the previous research on how individuals implicitly discount future outcomes uses a model that incorporates a constant positive discount rate, which has appealing normative properties associated with it, as well as an axiomatic foundation (Fishburn and Rubenstein 1982, Koopmans 1960, Samuelson 1937). Descriptive studies have been carried out to investigate whether or not individuals behaviorally adhere to this normative model. Two types of elicitation procedures have been predominantly utilized when empirically testing the traditional model; matching of quantity-timing pairs (which we can call *Pairwise Matching*) and rating (or ranking) of sequences (known here as *Relative Valuation of Sequences*). This paper attempts to understand the relationship between the results from these two different elicitation procedures and to reveal any interactions which have been previously unexplored.

The equivalence of the two elicitation methods above has been assumed when empirically testing the traditional discounting model. However, the conclusions from the two streams of research are quite dependent on the elicitation method used.

Pairwise Matching has revealed three particular phenomena: *Gain/Loss Asymmetry, Short/Long Term Asymmetry,* and the *Absolute Magnitude Effect*. Gain/Loss Asymmetry is the finding that individuals use different discount rates for monetary gains than for losses. In general, gains are discounted more heavily than losses (Ahlbrecht and Weber 1997, Loewenstein and Prelec 1991, Shelley 1993, Thaler 1981). Short/Long Term Asymmetry occurs when the

time delay of future outcomes affects the subjective discount rate: Long term outcomes tend to be associated with lower discount rates. (Ahlbrecht and Weber 1997, Benzion, Rapoport, and Yagil 1989, Chapman 1996, Kirby and Marakovic 1995, Stevenson 1992, Thaler 1981). This anomaly is also known as the *immediacy effect* (Read, Loewenstein, and Kalyanaraman 1999, Weber and Chapman 2005) or *present-biased preference* (O'Donoghue & Rabin 1999). The Absolute Magnitude Effect refers to the finding that large monetary amounts are discounted less (proportionally) than smaller amounts (Benzion *et al. 1*989, Chapman and Elstein 1995, Kirby and Marakovic 1996, Loewenstein and Prelec 1992, Thaler 1981). Frederick, Loewenstein, and O'Donoghue (2002) provide a comprehensive review of the significant findings in this area regarding these anomalies.

In contrast, the relevant research that incorporated the Relative Valuation of Sequences procedure has shown that individuals may use characteristics of the sequence (such as peak, trend, endpoint and uniformity) when making value judgments, and that these judgments seldom follow the predictions of the traditional discounting model. The main deviations from the normative model include *negative time discounting* and *preference for spreading*. Negative time discounting occurs when a person prefers a positive net monetary outcome being delayed, or a negative net monetary outcome occurring sooner rather than later. One prevalent example of this is that people often prefer an increasing sequence of positive outcomes to a decreasing one with an equal mean (Loewenstein and Sicherman 1991, Schmitt and Kemper 1996, Read and Powell 2002). Preference for spreading involves preferring a moderate sequence to a more extreme sequence with an equal mean. That is, people may prefer to spread outcomes over time rather than concentrate them (Chapman 1996, Guyse, Keller, and Eppel 2002, Loewenstein and Prelec

1993). The phenomena associated with the findings regarding sequences are discussed in detail by Frederick and Loewenstein (2008).

Even though research using Pairwise Matching and Relative Valuation of Sequences has shown deviations from the traditional discounting model, the *relationship* between the two sets of findings has yet to be investigated in the monetary domain. Frederick (2003) performed a thorough investigation of seven different elicitation techniques on intergenerational time preference (discounting of lives), but money was not included in that study. Frederick found a great deal of variation among the results obtained with the seven different techniques. The matching technique resulted in significantly less discounting of future lives than observed in a binary choice technique, but greater discounting than observed in several others. The sequence technique resulted in negative discounting, a preference for increasing sequences. This work did not include sequences that consolidated all of the outcomes into either the first or last period though, which *normatively* would be optimal for gains and losses respectively. In addition, in some techniques gains were used, in others losses, but never both in a within context.

Frederick and Loewenstein (2008) did investigate inconsistencies also, but only within the sequence framework, the conflicting results stemming from either choice or pricing tasks. In general choice tasks and pricing tasks can lead to different results when asked between-subjects. Only one of the experiments used a within-subjects design (Study 2b) and interestingly the *inconsistency disappeared*, with choice dependent on pricing in manner which showed a preference for decreasing sequences. The three anomalies described above were not investigated in that work.

Hardisty *et al.* (2010) compared three different elicitation methods, and also found that resulting discount rates were influenced significantly by the choice of technique. They suggested

that to obtain predictive value, an elicitation technique should match the behavior to be predicted as closely as possible. Both Albrecht and Weber (1997) and Read and Roelofsma (2003) found differences between observed discount rates when using matching and choice techniques. Olivola and Wang (2010) used a novel auction-based approach to demonstrate that theoretically equivalent elicitation methods yield different discount rates. The results of all of these papers suggest that judgments made with regard to discounting are influenced greatly by the choice of elicitation technique.

Scholten and Read (2010) proposed resolving previously-observed anomalies with an "attribute-based" model of intertemporal preferences, relying on direct comparisons of delays and magnitudes between the possible outcomes, while incorporating reference-dependence. This method relies on a binary choice elicitation technique, though its observations and conclusions seem to apply to Pairwise Matching as well. It is not clear to what extent the insights gained from Scholten and Read's approach are applicable to comparisons between more than two outcomes, or comparisons between sequences with more complex outcomes since they were not incorporated into their experiments and model. In addition, that study only elicited preference for absolute gains with different values. Losses were not included and even though the time frame was manipulated, it was not systematically done so to investigate the Short/Long Asymmetry. Finally, the experiments were all between-subjects.

We focus in this paper on the relationship between the three discounting anomalies discussed and the choice of elicitation technique in the monetary domain. If the anomalies surface only for Pairwise Matching, this would suggest that the attribute-based model applies primarily to the types of elicitation procedures described by Scholten and Read. But this would also question the robustness of the anomalies, since they would be context dependent. One may argue that this

would be a violation of procedure invariance (Tversky, Sattath, and Slovic 1988). If they surface in Relative Valuation of Sequences as well, it would suggest the insights from the attribute-based model may generalize to intertemporal preferences more broadly.

Explicit attention has been given to these anomalies, since they have surfaced using Pairwise Matching. Patterns that are consistent with them can be explored using the Relative Valuation of Sequences elicitation procedure. Findings respective to the Relative Valuation of Sequences cannot be explored using Pairwise Matching, since "configural" aspects (*e.g.*, the uniformity of sequence patterns) cannot be displayed when presenting information in a pairwise fashion. In addition, the within-subjects interactions between the hypothesized sources of the anomalies as well as the within-subjects consistency between the two elicitation procedures are investigated. The only evidence in this area that previously incorporated a within-subjects design (Frederick and Loewenstein 2008, Study 2b) found the inconsistency between pricing and choice to disappear when evaluating sequences. That study did not compare sequences to matching, nor investigate the difference between gains and losses, short and long time frame, and small vs. large dollar values. We hope that this paper begins to address these areas.

To summarize, if findings consistent with the anomalies found in Pairwise Choice also occur when using the Relative Valuation of Sequences elicitation procedure, especially in a within-subjects design, then they may be considered pervasive and alternate models to traditional discounting are warranted (Ainslie and Haslam 1992, Chung and Herrnstein 1967, Herrnstein 1997, Keller and Stratzzera 2002, Loewenstein and Elster 1992, Loewenstein and Prelec 1992). However, if findings consistent with the same anomalies *do not* exist using the Relative Valuation of Sequences elicitation procedure, then a violation of procedure invariance (Tversky,

Sattath, and Slovic 1988) may be present that must be taken into account when eliciting value judgments for outcomes over time.

The next section presents an experiment designed to explore the interactions of the factors which have been shown to create the anomalies, as well as the consistency between these two types of procedures. We analyze the results, and conclude with a general discussion and directions for further research.

2. Methods, Results and Discussions

The experiment elicited and compared preferences for sequences of monetary outcomes (*Relative Valuation of Sequences*) along with the elicitations of separate timing/magnitude matching judgments (*Pairwise Matching*). One research question addressed is whether or not the anomalies of discounted utility theory revealed in previous literature (Gain/Loss Asymmetry, Short/Long Term Asymmetry, and the Absolute Magnitude Effect) will surface in some form with this alternative elicitation technique. *i.e.,* is there a pattern in the ranking data that is consistent with the findings associated with the anomalies. In addition, this work will investigate the interactions between the factors associated with the anomalies, expanding on the notion of inseparability discussed by Scholten and Read (2010). Finally, this work will also investigate the within-subjects consistency *between* these two particular methods, which has not been previously explored.

2.1. Method

Participants. The participants were 78 undergraduate students at California State University who volunteered to participate in the study. Their ages ranged from 19 to 50, with a mean of

about 25.5 (median age of 24). Participants were recruited through an advertisement presented in one of their classes. They were compensated with five extra credit points for the class for voluntary participation in the experiment that lasted 20 minutes on average.

Procedure. Participants were asked to complete a paper-and-pencil questionnaire that consisted of two parts. One part consisted of five triples (with the same mean) that differed only in the distribution of the outcomes over the time horizon. An example task is presented below:[1]

Please rank order (according to personal preference) these sequences on different ways that you could **receive $60** for sure over **the next 3 years**?

Sequence Shape	**This Year**	**Next Year**	**2 Years from Now**	**Rank (fill in the blank) 1=best, 5=worst**
Sharp Increase	**$0**	**$0**	**$60**	
Increase	**$10**	**$20**	**$30**	
Constant	**$20**	**$20**	**$20**	
Decrease	**$30**	**$20**	**$10**	
Sharp Decrease	**$60**	**$0**	**$0**	

Given the initial sequence set above, the Gain/Loss effect was investigated by multiplying all outcomes in both magnitudes of sequences and both time frames by negative one and changing the instructions to read "pay" instead of "receive." By multiplying the outcomes in the matrix by negative one, the coding of the sequence shapes reverses. Below is an example task:

Please rank order (according to personal preference) these sequences on different ways that you could **pay $60** for sure over **the next 3 years**?

Sequence Shape	**This Year**	**Next Year**	**2 Years from Now**	**Rank (fill in the blank) 1=best, 5=worst**
Sharp Decrease	**$0**	**$0**	**-$60**	
Decrease	**-$10**	**-$20**	**-$30**	
Constant	**-$20**	**-$20**	**-$20**	
Increase	**-$30**	**-$20**	**-$10**	
Sharp Increase	**-$60**	**$0**	**$0**	

The Short/Long Term effect was investigated by adding a constant 15 years to all outcome timings and changing the wording to "Please rank order (according to personal preference) these sequences on different ways that you could **receive $60** for sure for 3 consecutive years, **starting 15 years from now**?" In addition, the fill-in-the-blank lines were moved to the left of the consequence matrix to help the participants realize the difference in time horizons.

Finally, the Absolute Magnitude Effect was investigated by multiplying all the outcomes in the matrix above by 50.

The design incorporated a 2 (Short/Long) x 2 (Small/Large Magnitude) x 2 (Gain/Loss) factorial design, creating eight possible combinations. All of the participants in the study saw all eight combinations. The order of the eight combinations was randomized for each participant.

The other part of the experiment required the participants to make a matching judgment to find the indifference point between the two extreme sequences taken from the five triples presented in the first section, for example (0, 0, x) and (x, 0, 0). This task is similar to the *Pairwise Matching* procedure used in previous research, with the exception of explicitly

identifying a middle time period where no money is received.[2] The extreme monetary outcomes from the first part (-$3,000, -$60, $60, $3,000) were used with the two timing options to yield a 2 (Short/Long) x 2 (Small/Large Magnitude) x 2 (Gain/Loss) factorial design, again leading to eight different scenarios, which were also randomized across the participants. An example is as follows:

I am indifferent between *receiving* $60 2 years from now and receiving (Fill in the Blank Amount) this year.

This Year	Next Year	2 Years from Now
$0	$0	$60
$	$0	$0

Fill in the blank

The two tasks (Relative Valuation of Sequences and Pairwise Matching) were randomly counterbalanced and randomly assigned to participants to minimize any order effects.

2.2. Results and Discussions

Analysis of Relative Valuations of Sequences. The first part of the experiment incorporated a 2 (Short/Long) x 2 (Small/Large Magnitude) x 2 (Gain/Loss) factorial design which created eight possible combinations. The percentage of participants ranking each sequence shape first is exhibited in Table 1. The traditional discounting model would predict that the Sharp Decrease sequence shape be ranked first by all participants in all scenarios. Quick inspection of Table 1

reveals that even though the Sharp Decrease shape is the modal 1st ranked, it was not the 1st ranked with all our participants in all 8 scenarios. There could be an association between the way the participants ranked all of the other shapes and the factors pertaining to the anomalies investigated.

INSERT TABLE 1 ABOUT HERE

To further investigate and see if the factors that predict the presence of the anomalies in Pairwise Matching indeed had a corresponding predictable effect on the mean rankings, a repeated measures ANOVA was performed. This ANOVA included the dependent variable Ranking, the dichotomous independent variables Gain/Loss, Short/Long, Magnitude, and the ordinal independent variable Shape (five levels ordered by slope of the sequence)[3]. Results from the ANOVA are in Table 2.

INSERT TABLE 2 ABOUT HERE

The "Analysis 1" portion of Table 2 included all of the variables listed above, along with appropriate interactions. The Analysis 1 portion reveals a main effect for Shape, two-way interactions between Gain/Loss*Shape and Magnitude*Shape, and a three-way interactions between Gain/Loss, Magnitude and Shape as well as between Gain/Loss, Short/Long, and Shape. All other main effects and interactions were insignificant ($p > .10$). The main effect of Shape indicates that the five different sequence shapes (from Sharp Decrease to Sharp Increase) received different mean ranks, which are displayed graphically in Figure 1.

INSERT FIGURE 1 ABOUT HERE

Since the instructions read that a rank of 1 is the best and a rank of 5 is the worst, lower numbered ranks are better than higher ranks. On average across all conditions, the participants in this study ranked the sequences as the discounting model would predict, with the Sharp Decrease sequence shape[4] receiving the best ranking on average. This is consistent with their modal choices displayed in Table 1. In the monetary domain, this result is consistent with Frederick and Loewenstein (2008), Read and Powell's (2002) "Maximization", and Guyse, Keller and Eppel (2002). Frederick's (2003) study which compared the different elicitation methods found a preference for increasing sequences, but his study investigated lives and not money and did not include the Sharp Decrease sequence shape that was both ranked highest and more often ranked 1st by the participants in this study.

Arguably more interesting may be the four significant interactions displayed in Analysis 1 of Table 2. These will be explained one at a time.

The Gain/Loss by Shape interaction is displayed graphically in Figure 2. The statistical significance of this interaction is an important result, since it reveals that there is a pattern consistent with the Gain/Loss Asymmetry present in the Relative Valuations of Sequences task. This anomaly unveiled in previous literature showed that participants discounted gains at a higher rate than losses. A higher discount rate would imply that the discounted value (or utility) would be higher for the Sharp Decrease sequence shape in gains than in losses: So utility *ratings* would show a steeper decline from Sharp Decrease to Sharp Increase. Although the *rankings* associated with any particular sequence shape would be the same as the ratings ordinally, we can

reasonably expect that if discount rates are relatively lower (closer to zero), then ratings of discounted utility are less different and there may be more "rank reversals" reported between the participants in this Relative Valuation of Sequences task. Thus we could expect in general that there should be a better ranking of the Sharp Decrease sequence shape in the domain of gains than in the domain of losses. Likewise, the ranking of the Sharp Increase sequence shape should be ranked worse in the gains domain than in the losses domain. Inspection of Figure 2 is consistent with previous findings. As shown in Figure 2, the mean ranks of the Sharp Decrease sequence shapes in gains and losses are 1.9 and 2.9 respectively. Likewise the mean ranks of the Sharp Increase sequence shapes for gains and losses are 3.7 and 4.4 respectively, both of which are consistent with the direction predicted by the anomaly. Looking back at Table 1, once can see that the percentages ranking the Sharp Decrease sequences shape as 1st is descriptively around 25% higher for gains than for losses, which is also in accordance with Gain/Loss Asymmetry.

INSERT FIGURE 2 ABOUT HERE

In the gains domain, the mean rankings are strictly monotonic with respect to the slope of the sequence shape, in accordance with the traditional discounting model. In the domain of losses though, the pattern of ranking reflects more of an upside down "U" shape, which goes against the discounting model that would predict that individuals faced with equal losses should put them off as far away in the future as possible (with the Sharp Decrease sequence shape). The relatively favorable mean rank to the constant sequence shape among the other shapes in the domain of losses indicates that many individuals rank this shape highly, maybe to spread out payments rather than pay them all now (Sharp Increase shape) or all later (Sharp Decrease

shape). This could be related to the suggestion of Gigliotti and Sopher (1997) that individuals often cannot fully distinguish between patterns of income and consumption. Frederick and Loewenstein (2008) suggest that "allocating consumption among multiple periods would evoke the idea of distributional equity, and favor flat sequences" (p. 226). Read and Powell (2002) also discussed this idea while examining a wide range of factors which can influence preferences over sequences.

Since our data is within-subjects, we could also investigate choice patterns within the individual using the logic presented earlier, *i.e.*, higher discount rates would predict a stronger preference for a decreasing sequence, that is, either of the Sharp Decrease or Decrease shapes should be chosen as 1st ranked. Therefore, we can define a *propensity for the Gain/Loss Asymmetry* to be:

$$P_{GL} = \begin{cases} 1 & \text{if the individual participant more often ranked a decreasing sequence shape as 1st for gains than they did for losses} \\ 0 & \text{otherwise} \end{cases}$$

With this definition, descriptively 45% of our participants displayed such an effect. This information (along with the other propensities) is contained in Table 3.

INSERT TABLE 3 ABOUT HERE

To summarize, a pattern consistent with the Gain/Loss Asymmetry descriptively appears in the participants' modal choices, and is further supported by the statistical analysis of the mean

rankings data. Therefore, predictable patterns consistent with this anomaly appear to be present in the Relative Valuation of Sequences task even in a within-subjects design.

When the money involved is in the loss domain, a pattern consistent with the Absolute Magnitude Effect also appears to be present in the Relative Valuation of Sequences task. It is exhibited by the significant interaction of magnitude with sequence shape and with whether the outcomes are gains or losses in Table 2. In order to better understand how a form of this anomaly could be surfacing, the data was partitioned into gains and losses and two additional ANOVAs were performed on these two data sets (Analysis 2a and 2b of Table 2 respectively). Notice that the interaction between Shape and Magnitude is not present in the gains data, but is still significant in the losses data displayed in Table 2.

The two graphs in Figure 3 display these results visually. The Absolute Magnitude Effect predicts that small magnitudes will be discounted at a higher rate than larger magnitudes, that is, Sharp Decrease sequence shape should have a better mean rank when the magnitude is small than when it is large. The interaction between Magnitude, Shape and Gain/Loss decomposed in Figure 3 displays a more complex relationship between these factors. It appears that in the context of valuing sequences within-subjects with our parameters, magnitude only affects the responses when in the loss domain. It can be seen that in the gains domain the magnitude of the money involved has no effect on the mean rankings, the mean ranks are the same for both small and large amounts. The magnitude *does* have an effect in the domain of losses though, as displayed by the differences in their respective lines in the middle of Figure 3. It appears that the participants in this study have a stronger preference for delaying the loss (ranking more highly on average the Sharp Decrease shape) of the small magnitude of money than the large magnitude ($\bar{x}_{small} = 2.7$, $\bar{x}_{large} = 3.0$). Likewise, the participants also seem to on average rank more highly the

immediate loss (ranking more highly on average the Sharp Increase shape) of the large magnitude loss relative to the small loss ($\bar{x}_{small} = 3.5$, $\bar{x}_{large} = 3.1$). Both of these results are consistent with small magnitudes being discounted at a higher rate than large magnitudes, *i.e.*, in accordance with the Absolute Magnitude Effect.

INSERT FIGURE 3 ABOUT HERE

In the past studies using the Pairwise Matching technique, spreading could not be observed because of the experimental design. The preference to spread losses was stronger with the larger magnitude of money (displayed in the middle of Figure 3). The preference to spread losses could be a result of self-control issues with the individuals. Even though it is optimal to delay the payment of $3000 as far into the future as possible, participants may fear that they would not be able to save the $3000 for payment in the last period, so they may prefer to opt to spread the payments out over time by highly ranking the constant sequence shape on average. This is similar to the preference individuals have in paying taxes incrementally instead of all at once on April 15th. Saving for a $60 payment takes much less self-control, and therefore they would prefer to pay it in the last period. However, the difference in mean rankings for the small loss do not appear to be significant unless the sequence is increasing, which indicates a dislike for paying all $60 early.

The contents of Table 1 provide additional (point estimate) support to the result above. In the domain of losses, we see that a higher percentage prefer delaying (ranking Sharp Decrease 1st) the loss of the small magnitude of money than the large magnitude (45% vs. 41% in the short-run case, 47% vs. 45% in the long-run case). Table 3 shows that 17% of our participants displayed a

propensity for the Absolute Magnitude Effect. Therefore, in the *domain of losses*, our results indicate that there appears to be a pattern consistent with literature detailing The Absolute Magnitude Effect, even while utilizing a within-subjects design.

Addressing the Gain/Loss by Short/Long by Shape interaction that appears in Table 2 Analysis 1, when the data was partitioned into gains and losses (Table 2, Analysis 2a and 2b), the Short/Long by Shape interaction becomes *insignificant* ($p > .10$) in both of these domains. Inspections of the appropriate interaction plots support this conclusion. So it appears that this three way interaction may be no more than a product of the leverage of the Gain/Loss by Shape interaction ($p < .001$) and therefore does not reveal any additional insights. Note though that 13% of our participants displayed the propensity for the Short/Long Asymmetry as seen in Table 3.

More generally, forty of our seventy eight participants (51%) displayed a propensity (as defined above) for at least one of the anomalies. The average number of propensities per participant was 0.75.

As mentioned, no previous research has investigated these anomalies within the Relative Valuation of Sequences task. Our findings suggest that when analyzing the mean ranks, patterns consistent with the Gain/Loss Asymmetry and the Absolute Magnitude Effect (when dealing with losses specifically) surfaced in the Relative Valuation of Sequences task. These results were confirmed when looking at the sample percentage of participants ranking the Sharp Decrease sequence shape 1st. Patterns associated with the Short/Long Asymmetry failed to surface in our study. It could be that this anomaly does not appear when using the Relative Valuation of Sequences task, does not appear in a within-subjects design, or that our dollar values and timing parameters does not evoke such a pattern in the elicited rankings. More research would be needed to make a substantive claim regarding this null result.

These results do show though that the factors pertaining to Gain/Loss Asymmetry and the Absolute Magnitude Effect (for losses) may be more pervasive than previously documented. The two factors pertaining to these anomalies that influence discount rates in Pairwise Matching appear to also have a predictable effect on the way individuals rank sequences of monetary outcomes, even while utilizing a within-subjects design.

Analysis of the Pairwise Matching Data: The data collected in the second part of the experiment consisted of Judged Indifference Points, or "*JIP*"s, expressed in dollars, between receiving (or paying) a certain (large or small) amount at two different (short or long) time periods. The *JIP*s reported by the participants are their elicited net present values of the outcome/timing options. Using the traditional discounting formula for finding the net present value of the monetary amount ($\$x \in$ [-\$3000, -\$60, \$60, or \$3000]) received (or paid) two years in the future, $NPV = JIP = x/(1+r)^2$, and solving for r results in Eq. 1. The judged indifference points reported by the participants of the study were then substituted into Equation (1) to calculate a set of implicit (subjective) discount rates.

$$r = \left(\sqrt{\frac{x}{JIP}}\right) - 1 \qquad (1)$$

The implicit discount rates then were used in a repeated measures multifactor ANOVA as the dependent variable, with the dichotomous independent variables Gain/Loss, Short/Long, and Magnitude[5]. The results of the ANOVA appear in Table 4.

INSERT TABLE 4 ABOUT HERE

The only effect that was significantly related to the calculated implicit discount rates was the interaction between whether the money was a gain or a loss and the magnitude of the money. Figure 4 graphically displays this interaction. On average the participants in this study did not discount the *small* magnitude of money differently across gains and losses ($\bar{x}_{(r \text{ small gain} - r \text{ small loss})} < 1\%$, Paired $t_{73} = 0.26$), but did when the magnitudes were *large* ($\bar{x}_{(r \text{ large gain} - r \text{ large loss})} = 13\%$, Paired $t_{73} = 2.21$, $p < .05$). Participants discounted gains at a higher rate than equivalent losses (as depicted in Figure 4 by the dashed (gains) line always being above the solid (loss) line), which is expected from previous research regarding the Gain/Loss Asymmetry. The within-subjects design incorporated allowed us to reveal though, that this anomaly was only (significantly) present with our participants when the magnitude of the money was large and not small. This is an interesting result, since previous research has not investigated Gain/Loss Asymmetry and the Absolute Magnitude Effect simultaneously. In addition, when partitioning once more into sets of gains and losses, large gains were discounted significantly higher than small gains ($\bar{x}_{(r \text{ large gains} - r \text{ small gains})} = 9\%$, Paired $t_{73} = 1.83$, $p < .05$). This finding is opposite in direction from the Absolute Magnitude Effect previously discussed. The dollar values chosen for small and large gains ($60 and $3000 respectively) may be influencing the outcomes with respect to the participants' psychological accounting of the outcomes. One may argue that if money is in need, one may be very impatient to receive it, especially large values. We did not elicit income or current wealth from undergraduate student participants, so to help explain this, we looked at the point estimates for the correlation between our demographic variable of age (a possible weak proxy for income or current wealth) and the implied discount rate. Interestingly, age was *negatively* correlated with the implied discount rate for *large* gains, which indicates that as age increases, the discount rate decreases for large gains. Conversely, age was *positively*

correlated with the discount rate for *small* gains. One could postulate that the participants' displayed impatience (by way of an increase in the implied discount rate) to receive the larger ($3000) amount may be the result of a mental accounting heuristic (Loewenstein and Thaler 1989) slating it for immediate consumption[6]. Finally, the difference in implied discount rate for losses was insignificant ($\bar{x}_{(r\ \text{small loss} - r\ \text{large loss})} = 3\%$, Paired $t_{73} = 1.45$).

INSERT FIGURE 4 ABOUT HERE

Therefore, under certain conditions revealed through the interactions, both the Gain/Loss Asymmetry and the Absolute Magnitude Effect surfaced in the Pairwise Matching task just as patterns consistent with them both appeared in the Relative Valuation of Sequences task. The within-subjects design did not alleviate the presence of these two anomalies. The Short/Long Asymmetry failed to surface once more. This is surprising, since the results of Roelofsma and Read (2000) and Scholten and Read (2006), when considered together, seem to reveal at the very least an interaction between the Absolute Magnitude Effect and the Short/Long Asymmetry in choice techniques. [7] But their experiments were between-subjects in design. More research is warranted in this area to see if the Short/Long Asymmetry materializes when utilizing a within-subjects design.

Analysis of Consistency between the Relative Valuations of Sequences Data and the Pairwise Matching Data. In order to check the consistency between the rankings data and the implicit discount rates, the sign of the implicit discount rate used was inferred for each participant scenario by scenario. The two sequences from the Relative Valuation task used to make this

inference were the Sharp Increase and the Sharp Decrease scenarios, since these are what appeared in the Pairwise Matching task. For example, if an individual ranked the Sharp Decrease sequence better than the Sharp Increase sequence in the gains domain, then the inferred sign of the implicit discount rate was positive.[8] The appropriate sign of the discount rate calculated from the indifference points reported by the individuals in the Pairwise Matching task for *the same scenario* was also recorded. If these signs were the same, for a given scenario, we say that the participant is "consistent" on that scenario. An indicator variable, I_C was created such that:

$$I_C = \begin{cases} 1 & \text{if the implied sign of the discount rate is the same in both tasks for the same scenario} \\ 0 & \text{otherwise} \end{cases}$$

Note that this is a very conservative measure of consistency, since the magnitude of the implied discount rate is not considered, only its sign. This is the strongest measure we can use here though, since once cannot estimate the magnitude of the implied discount rates for the relative valuation of sequences task, since sequences within a task have the same mean. If we in fact find an influence of the factors discussed (which have led to the anomalies presented) on this relatively weak measure of consistency, one would expect an even greater violation of procedure invariance with a stronger measure.

For an expeditious description of the results by assuming independence, there were 299 cases of consistency (as defined) out of the 576 trials (8 tasks for 72 participants)[9]. The 95% confidence interval (corrected) indicates that consistency between the two tasks range from 48%

to 56%. So on average, the likelihood of consistency could be a "coin flip." To relax the assumption of independence and also to investigate whether or not the factors which have been shown to promote the anomalies discussed may also influence consistency between these tasks, we used I_C as the dependent variable in a repeated measures multifactor ANOVA[10]. The independent variables included the dichotomous variables for Gain/Loss, Short/Long, and Magnitude, along with all appropriate interactions. The results of the ANOVA model appear in Table 5.

INSERT TABLE 5 ABOUT HERE

As displayed in Table 5, whether the task involved gains and losses and when these occurred appear to significantly affect the consistency between these two elicitation procedures. On average, participants were 57% consistent for gains, and 47% consistent for losses. A plot of the marginal means appears as Figure 5.

INSERT FIGURE 5 ABOUT HERE

Referring to Figure 5, it appears that participants were on average more consistent with the sign of their implicit discount rates for gains than for losses in both the short and long time frames, indicated by the gains line being above the loss line for both time frames. The difference between consistency in the short time frame is insignificant ($\bar{x}_{(\text{Short Gain} - \text{Short Loss})} = 5\%$, Paired $t_{71} = 0.93$), but the difference between gains and losses in the long time frame (3 years starting 15 years from now) is highly significant ($\bar{x}_{(\text{Large Gain} - \text{Large Loss})} = 17\%$, Paired $t_{71} = 3.37$, $p < .001$). It

appears that our participants were significantly more consistent between the two tasks when working with future gains than future losses. It may be "harder" for the individuals to discount losses correctly, since they in fact might prefer to spread them out based on the same participants' responses to losses in the Relative Valuation of Sequences task. Since they cannot display a preference for spreading losses in a Pairwise Matching task, we would expect less consistency between the two methods.

Finally, these participants provided no evidence that the magnitude of the money influences consistency (or inconsistency) between the two methods.

The domain (gains versus losses) and the time frame (short versus long) appear to *simultaneously* influence consistency between these two tasks. Previous worked cited utilized between-subjects designs to provoke (to some extent) the presence of inconsistencies. Frederick and Loewenstein (2008, Study 2b) found that a within-subjects design alleviated the inconsistency between choice and preference for a sequence of outcomes. This work adds additional insights about inconsistencies between the Relative Valuation of Sequences and the Pairwise Matching tasks utilized in intertemporal choice.

4. Conclusion

We have investigated a number of issues involved with eliciting time preference in this study. We have been able to show that a pattern consistent with the Gain/Loss Asymmetry does appear in the Relative Valuation of Sequences task, not only by itself, but also as a dependent condition for a pattern consistent with the Absolute Magnitude Effect. Because these patterns exist in a within-subjects design, one may contemplate that they may indeed be pervasive.

Some may find it interesting that also in this within-subjects study, Pairwise Matching anomalies were not entirely mitigated. Small gains and losses were discounted the same (no Absolute Magnitude Effect and no Gain/Loss Asymmetry) but large losses were discounted much less (implicit $r = 14\%$) than equivalent gains (implicit $r = 27\%$). It was known that in between-subjects Pairwise Matching studies, losses are discounted less than gains, and (independently) large gains are discounted less than small gains. Our results confirm this Gain/Loss Asymmetry for large values and our sample evidence also pointed in this direction for small gains and losses. In this context though, when participants were faced with all scenarios in a randomized fashion, we found our participants to be more impatient for the large gain than for the small gain, and no difference in displayed impatience for losses. We postulated that this could be dependent on the current income or wealth of the participants, but it could also be an unexpected result of the randomized factorial design used. More research is warranted to investigate this finding.

It is interesting to observe that Short/Long Asymmetry did not surface in our within-subjects design for either elicitation technique. Therefore, this anomaly may be unique to the Pairwise Matching task in a between-subjects design only, and therefore a violation of procedure invariance may exist. More research is needed investigating this violation of invariance to solidify its significance. It could be that with different dollar amounts and different time periods, a Short/Long Asymmetry could arise in the Relative Valuation of Sequences task or in a within-subjects Pairwise Matching context.

The Short/Long Asymmetry is not completely absent from this study, though. *When* the sequence started (now or in 15 years) did interact with whether the sequence was a gain or a loss when we investigated the *consistency* between the two techniques, with participants being

statistically more consistent between the two tasks when working with future gains than future losses.

Since patterns of choice consistent with the Gain/Loss Asymmetry and the Absolute Magnitude Effect were revealed in the Relative Valuation of Sequences task *and* the Pairwise Matching task in a within-subjects construct, the two respective anomalies investigated in previous research using only the Pairwise Matching task in between-subjects designs have additional empirical support. More research is needed to investigate whether the insignificant findings here are due to the parameters chosen, context effects, or due to the inherent difference between within- and between-subjects designs. In addition, a creative research design may be able to investigate whether the anomalies associated with the aspects of sequence shape could also be present in a matching task.

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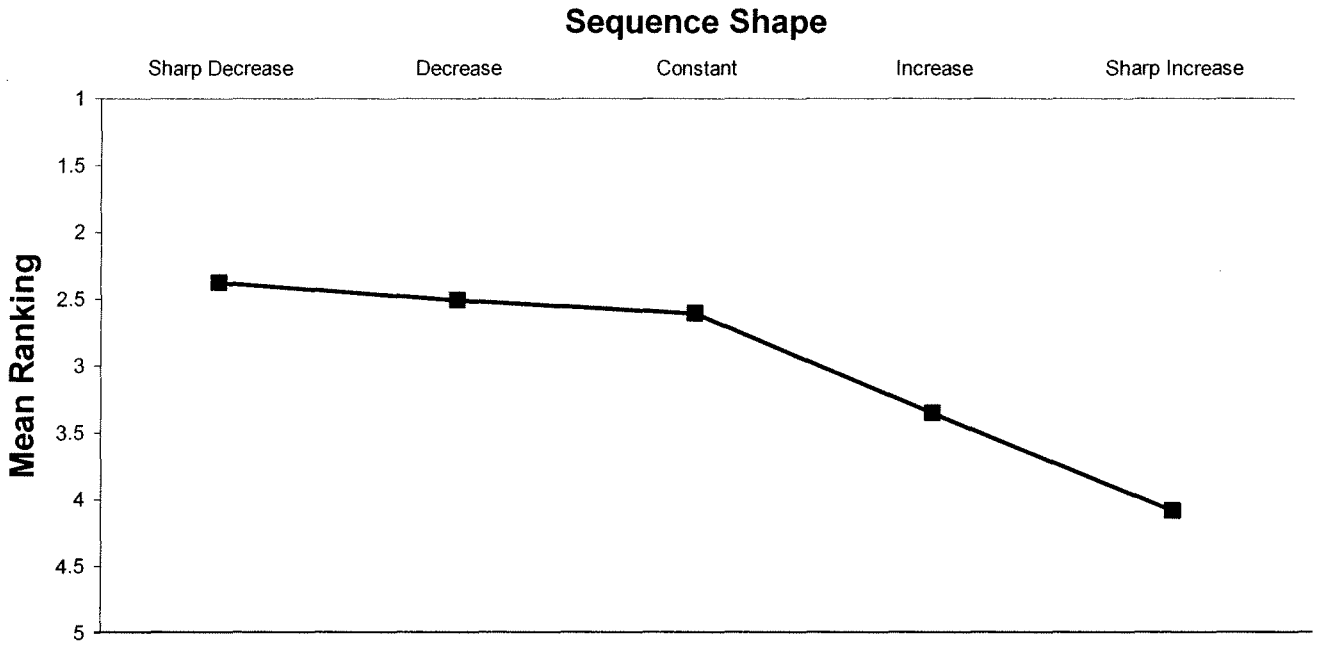
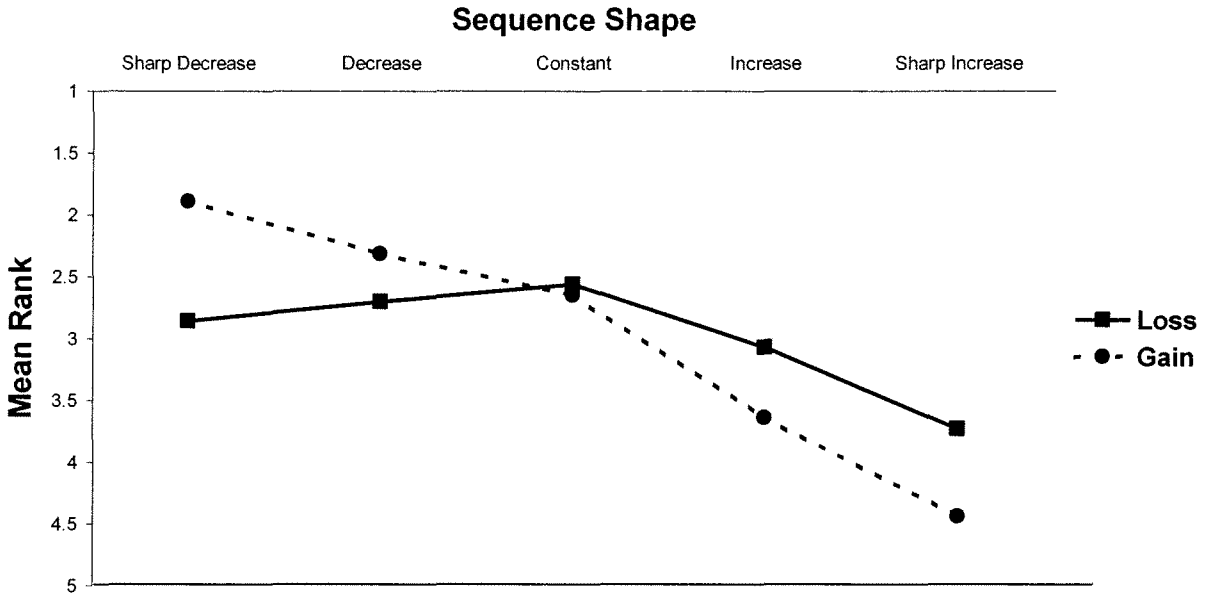
Figure 1. Mean Rankings by Sequence Shape



Mean Ranks				
Sharp Decrease	Decrease	Constant	Increase	Sharp Increase
2.4	2.5	2.6	3.4	4.1

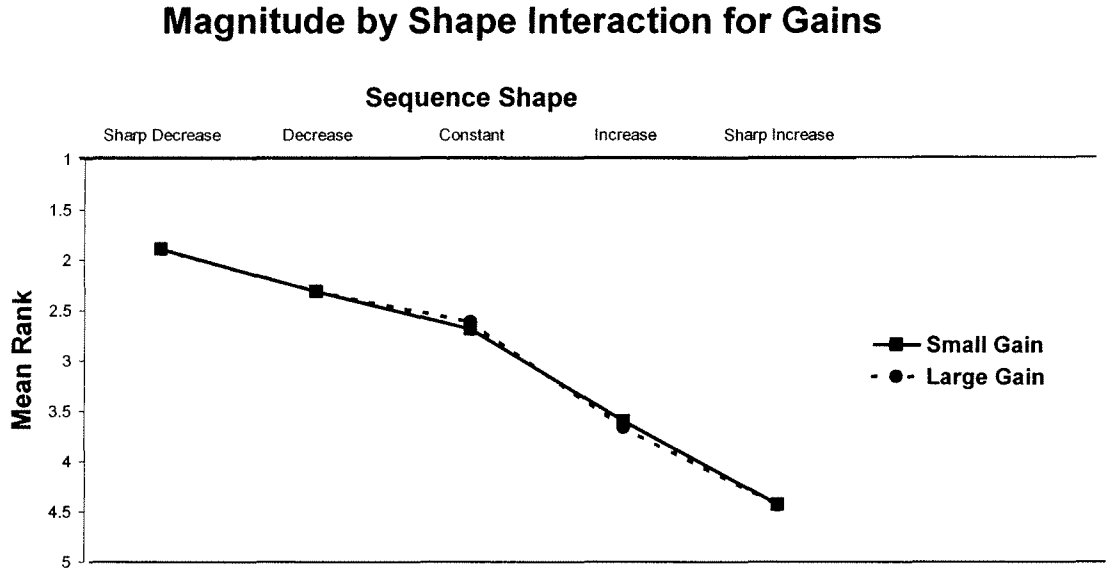
Figure 2. Gain/Loss by Sequence Shape Interaction

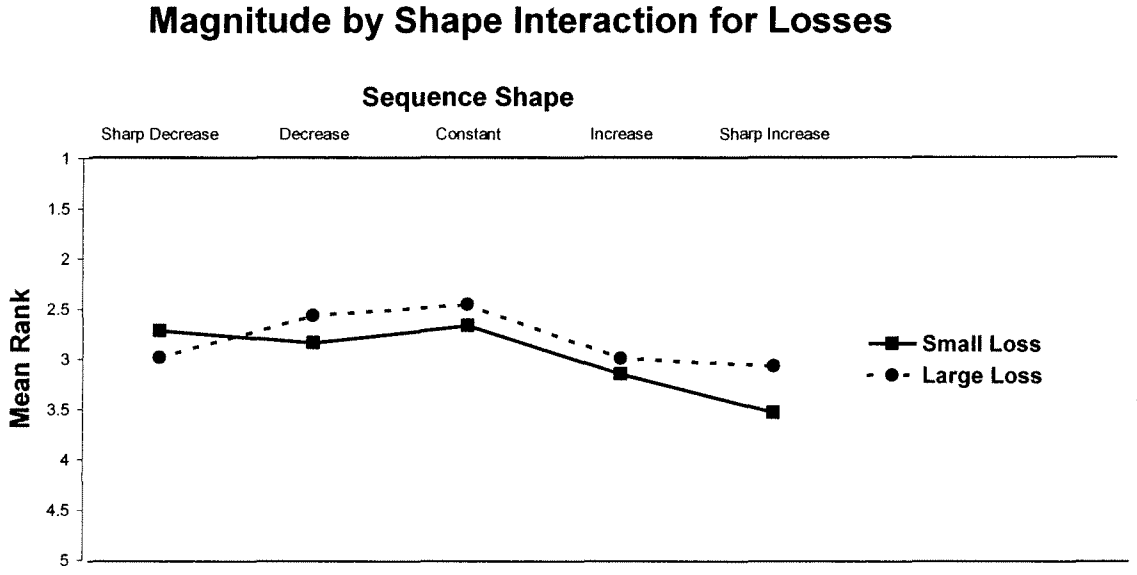


Mean Ranks

	Sharp Decrease	Decrease	Constant	Increase	Sharp Increase
Loss	2.9	2.7	2.6	3.1	3.7
Gain	1.9	2.3	2.7	3.6	4.4

Figure 3. Disentanglement of the Significant Three-Way Interaction Between Gain/Loss, Magnitude, and Sequence Shape

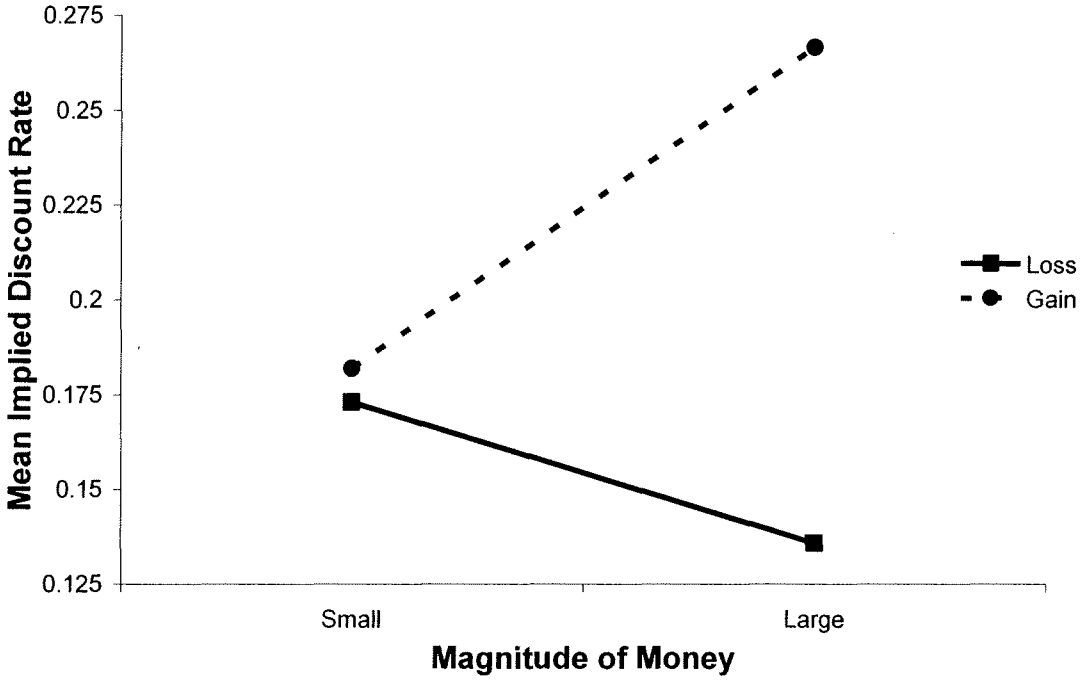




Mean Ranks

	Sharp Decrease	Decrease	Constant	Increase	Sharp Increase
Small Loss	2.7	2.8	2.7	3.2	3.5
Large Loss	3.0	2.6	2.5	3.0	3.1
Small Gain	1.9	2.3	2.7	3.6	4.4
Large Gain	1.9	2.3	2.6	3.7	4.4

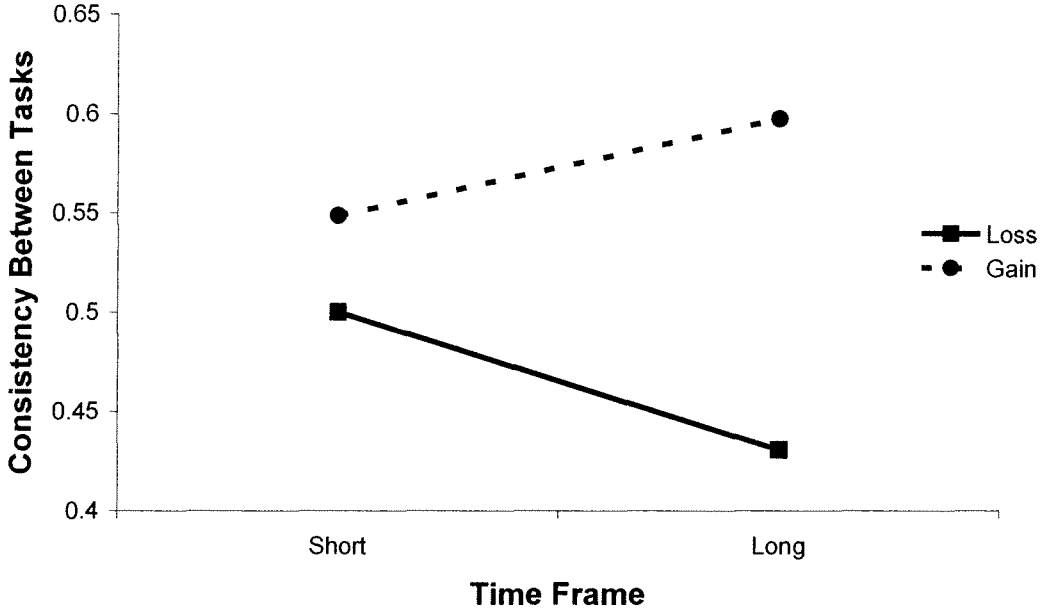
Figure 4. Interaction Between Gain/Loss and Magnitude of Implicit Discount Rates for Matching Data



Mean Discount Rate

	Small	Large
Gain	18%	27%
Loss	17%	14%

Figure 5. Interaction Between Gain/Loss and Short/Long on the Consistency Between Tasks



	Percentage Consistent	
	Short	Long
Loss	50%	43%
Gain	55%	60%

Table 1.

Percentage of Participants Ranking Each Sequence Shape as First for the Eight Scenarios

	Gain				Loss			
	Small		Large		Small		Large	
Sequence Shape	Short	Long	Short	Long	Short	Long	Short	Long
Sharp Decrease	71	76	67	71	45	47	41	45
Decrease	1	8	7	7	7	5	9	11
Constant	14	5	14	13	16	8	24	16
Increase	3	3	4	4	1	4	8	7
Sharp Increase	11	8	8	5	32	36	18	22

Table 2.
ANOVA Results on Relative Valuation of Sequences

Factor	*df*	*F*	MS_e
Analysis 1 (Both Gains and Losses)			
Gain/Loss	1	0.69	0.00
Short/Long	1	1.00	0.00
Magnitude	1	2.85	0.01
Shape	1.499†	44.93***	853.67
Gain/Loss*Short/Long	1	0.20	0.00
Gain/Loss*Magnitude	1	1.82	0.00
Gain/Loss* Shape	1.720†	23.32***	181.18
Short/Long*Magnitude	1	1.00	0.00
Short/Long *Shape	2.147†	1.14	2.25
Magnitude*Shape	2.642†	4.23**	5.57
Gain/Loss*Short/Long*Magnitude	1	0.08	0.00
Gain/Loss*Short/Long*Shape	2.591†	3.40*	3.54
Gain/Loss*Magnitude*Shape	2.479†	4.16*	5.22
Short/Long*Magnitude*Shape	2.981†	0.11	0.08
Shape*Gain/Loss*Short/Long*Magnitude	3.100†	1.51	0.80
Analysis 2a (Gains Only)			
Short/Long	1	1.00	0.00
Magnitude	1	1.00	0.00
Shape	1.628†	88.35***	827.38
Short/Long*Magnitude	1	0.20	0.00
Short/Long*Shape	2.512†	2.17	2.53
Magnitude*Shape	2.380†	0.25	0.26
Short/Long*Magnitude*Shape	3.004†	1.06	1.06
Analysis 2b (Losses Only)			
Short/Long	1	0.66	0.00
Magnitude	1	2.73	0.01
Shape	1.540†	9.18**	158.56
Short/Long*Magnitude	1	0.66	0.00
Short/Long*Shape	2.123†	1.90	3.60
Magnitude*Shape	2.255†	6.65**	11.98
Short/Long*Magnitude*Shape	2.996†	0.44	0.30

Note: * $p < 0.05$, ** $p < .01$, *** $p < .001$. *Sphericity assumed via results of Mauchly's Test unless indicated by* † *in which df are corected via Greenhouse-Geisser estimate.*

Table 3.

Displayed Propensity for the Three Anomaly in the Relative Valuation of Sequences Elicitation Procedure

Propensity for Anomaly	Percent Displaying	Margin of Error (95%)
Gain Loss Asymmetry	44.7	11.2
Magnitude Effect	17.1	8.5
Short/Long Asymmetry	13.2	7.6

Note: "Propensity" for the anomaly is defined to occur when the individual participant's 1st Ranked choice was for Gain/Loss Asymmetry: More often a decreasing shape for gains than for losses. For Absolute Magnitude Effect: More often a decreasing shape for the small dollar value than for the large dollar value. For Short/Long Asymmetry: More often a decreasing shape for the short time frame than the long time frame.

Table 4.
ANOVA Results on Pairwise Matching

Factor	*df*	*F*	MS_e
Gain/Loss	1	3.03	0.72
Short/Long	1	1.65	0.10
Magnitude	1	0.82	0.08
Gain/Loss*Short/Long	1	0.05	0.00
Gain/Loss*Magnitude	1	5.22*	0.55
Short/Long*Magnitude	1	2.25	0.20
Gain/Loss*Short/Long*Magnitude	1	0.42	0.01

Note: $^{*}p < 0.05$, $^{**}p < .01$, $^{***}p < .001$. *Sphericity assumed via results of Mauchly's Test , every W = 1.000*

Table 5.
ANOVA Results on Consistency between the Sign of the Implicit Discount Rate for the Relative Valuation of Sequences and the Pairwise Matching task

Factor	*df*	*F*	MS_e
Gain/Loss	1	5.46*	1.69
Short/Long	1	0.21	0.02
Magnitude	1	1.72	0.21
Gain/Loss*Short/Long	1	7.31**	0.50
Gain/Loss*Magnitude	1	2.11	0.14
Short/Long*Magnitude	1	3.651	0.14
Gain/Loss*Short/Long*Magnitude	1	0.80	0.04

Note: $^{*}p < 0.05$, $^{**}p < .01$, $^{***}p < .001$. *Sphericity assumed via results of Mauchly's Test , every W = 1.000*

[1] Note that the "Sequence Shape" column (which is italicized) was not present when the participants performed the task. It is included here to indicate how the sequences are coded with respect to their shape throughout this work.

[2] This design is incorporated so that the two techniques used are as similar as possible, to promote consistency, as well as not biasing the respondents by focusing on particular characteristics (relevant considerations) of the techniques (Frederick 2003). As we will see, consistency between the methods is not a given, even when similarities between the methods are strong.

[3] Two participants (numbers 54 and 74) were excluded from the analysis because some of their responses (rankings) did not conform with the survey directions. The remaining participants responses were both complete and in accordance with the survey instructions, therefore $n = 76$.

[4] The Sharp Decrease sequence shape gives all the money up front ($x, 0, 0) and also delays the entire payment the furthest in the future (0, 0, -$x).

[5] Four Participants (numbers 15, 36, 39, and 72) were excluded from this analysis due to leaving at least one matching judgment blank. They were included in the previous analysis since they left no ranking assignment blank. The subsequent sample size for the matching judgments is therefore $n = 74$.

[6] We did not have enough evidence that these correlations were significantly different from zero, though. We are considering future work to investigate this finding explicitly, given the results of the study presented here.

[7] Scholten and Read (2010) discuss this in more detail, in terms of subadditivity, superadditivity, and inseparability.

[8] Likewise, if the Sharp Decrease sequence was ranked more highly than the Sharp Increase sequence in the losses domain, the inferred discount rate would also be positive.

[9] The six participants who were excluded from *either* of the two previous analyses were excluded here, since both tasks had to be successfully completed in order to investigate consistency ($n = 72$).

[10] Given the nature of dependency that most certainly exists in this variable per participant, we feel this to be the most appropriate method, even though I_C is dichotomous in nature.