Gain-Loss Asymmetry in Delay and Effort Discounting of Different Amounts

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Abstract

Loss aversion entails the attribution of greater weight to losses than to equivalent gains. In terms of discounting, it is reflected in a higher rate for gains than for losses. Research on delay discounting indicates that such gain-loss asymmetry may depend on the amount of the outcome. In the current study, we address the question of how gains and losses are discounted in delay or effort conditions (physical or cognitive) across four outcome amounts. Our results replicate previous findings for intertemporal choices by showing that losses are discounted more slowly than gains, but only for smaller amounts, while there is no evidence of asymmetry in the evaluation for larger amounts. For physical effort discounting, we found an inverse asymmetry for the smallest amount tested (gains are discounted less steeply than losses), while such an effect is absent for larger amounts. Our results provide no support for the asymmetric evaluation of gains and losses for cognitive effort. Overall, our findings indicate that loss aversion may not be as pervasive as one might expect, at least when decisions are effort-based.

Keywords

delay discounting; effort discounting; choice behavior; loss aversion; magnitude effect

1 Introduction

Discounting refers to the subjective devaluation of outcomes as a function of the costs associated with obtaining them. It has been shown that the way people discount outcomes is related to the sign of the outcome and its amount. In our study, we focus on delay and effort as discounting factors. Furthermore, we investigate how the sign of an outcome and its amount interact from the perspective of the discounting rate.

Two prominent effects have emerged in research on delay discounting. The first is the sign effect in the delay, which refers to the finding that losses are discounted in delay less steeply than gains of the same amount (Estle et al., 2006; Myerson et al., 2017). The second is the magnitude effect, which refers to the finding that larger gains are discounted less steeply than smaller gains (Białaszek et al., 2019; Green et al., 2013). Although appealing, these general statements are only partially true due to the interaction between the sign and the amount of an outcome. Loss aversion in intertemporal choices (as seen in the sign effect) is usually observed for smaller amounts. This is related to the fact that the magnitude effect is present for gains (Green et al., 2013) but not for losses (Green et al., 2014). Therefore, the rate of delay discounting of small gains is higher than the rate of small losses; however, with larger rewards the rate of discounting is lower and usually not different from the rate of discounting of losses of the same (large) amounts.

The state of knowledge is less clear in the domain of effort discounting. Studies on this topic have resulted in mixed findings, with some studies finding gain-loss asymmetry for physical (Chen et al., 2020) and cognitive (Massar et al., 2020) effort-based decisions, and others finding gain-loss asymmetry for cognitive effort only in certain groups (Byrne and Ghaiumy Anaraky, 2020); in some cases, there was insufficient support to show such asymmetry (Lockwood et al., 2017; Nishiyama, 2016). One study suggested the presence of

an asymmetry of the opposite direction, in which gains loomed larger than losses for physical effort (O'Brien and Ahmed, 2019).

The findings are much clearer for the magnitude effect in effort-based decisions. Studies have consistently reported slower discounting of larger amounts compared to smaller amounts for both physical and cognitive effort (Białaszek et al., 2017; Nishiyama, 2014; Ostaszewski et al., 2013). However, to the best of our knowledge, no study has examined directly how the magnitude and sign effects interact in effort discounting.

The main aim of the current study was to investigate whether a gain-loss asymmetry exists in delay and effort discounting, and if the sign of an outcome interacts with its magnitude. We hope to demonstrate that people would engage in more work (physical or cognitive) where this could lead to the avoidance of losses of different magnitudes rather than leading to equivalent gains.

2 Materials and methods

2.1 Participants

A total of 699 participants were recruited for the study (598 females, 96 males, and 5 nonbinary), aged between 18 and 60 years ($M = 26.28$, $SD = 8.58$). The participants were recruited from the SWPS University subject pool and received course credit for participation. All experimental procedures were approved by the local ethics committee, and informed consent was obtained prior to participation.

2.2 Procedure

Discounting was measured using a dynamic staircase procedure (Du et al., 2002; Hardisty et al., 2013) that was implemented and administered through Qualtrics (<https://www.qualtrics.com/>). Participants were assigned randomly to different amount conditions: 100 PLN, 300 PLN, 1800 PLN, and 11000 PLN (hereafter respectively referred to

as amount magnitudes 1, 2, 3, and 4; 1 PLN was equivalent to approximately USD 0.26 at the time of the study). Outcome sign (gain or loss) and type of discounting (delay, physical effort, and cognitive effort) were within-subject factors and presented in random order. Three different delays were used: 3 months, 10 months, and 48 months. Physical effort was operationalized as the length of the sidewalk to be cleared of snow (7 meters, 30 meters, and 100 meters). Cognitive effort was operationalized as the number of official form pages to be filled-in (10 pages, 40 pages, and 150 pages). Participants chose between an adjusting payoff, immediate or effortless, and a fixed delayed or effortful payoff (the effortful payoff was adjusted from trial to trial for losses). Indifference points were obtained for each delay and effort level (for details, see Du et al., 2002; Hardisty et al., 2013). The procedures were part of a larger study that included psychometric scales.

2.3 Data Analysis

The area under the curve (AUC) was used as the primary dependent variable (Myerson et al., 2001). Analyses were performed by Bayesian ANOVA using multivariate Cauchy priors for the standardized effects with an r value of 0.5 for fixed effects and 1 for random effects (Rouder et al., 2012). *Post-hoc* comparisons were performed using Bayesian *t*-tests with Cauchy priors (scale set to $1/\sqrt{2}$; location set to 0). Log-transformed ($\log_{10}$) Bayes Factors (BF) were corrected for multiplicity, as suggested by Westfall et al. (1997) and interpreted as suggested by Lee and Wagenmakers (2013). The results are reported in keeping with the outlines given in van den Bergh et al. (2019) and were performed in JASP (JASP team, 2020). Effects analyses for the matched models were conducted (see van den Bergh et al. 2019 for details) to interpret the Bayesian ANOVA results.

3 Results

The ANOVA results indicate that all the data were best represented by models including both main effects and interaction terms (Table 1), which means that the sign and amount interacted for all types of discounting. Post-hoc analyses were conducted to gain a deeper understanding of the simple and interaction effects of each model. Ten comparisons were performed for each model: 4 comparing discounting rates in gains and losses across each amount level, and 6 comparing the dependent variable in subsequent amount conditions separately for gains and losses (3 for gains and 3 for losses, i.e., *amount 1* vs. 2, 2 vs. 3, and 3 vs. 4).

Table 1. Effects analyses across matched models for three discounting conditions.

Effects	P(incl)	P(incl D)	log ₁₀ (BF)
Delay			
Sign	0.4	5.08×10^{-17}	43.37
Amount	0.4	8.12×10^{-18}	-1.66
Interaction	0.2	1	39.35
Physical effort			
Sign	0.4	4.06×10^{-5}	3.66
Amount	0.4	4.17×10^{-5}	136.6
Interaction	0.2	1	10.11
Cognitive effort			
Sign	0.4	0.02	-2.27
Amount	0.4	0.18	197.08
Interaction	0.2	0.82	3.89

Note. P(incl) = prior probability of including the term in the model; P(incl|D) = probability of including the term given the data; log₁₀(BF) = logged posterior odds of including the term in the model. The inclusion Bayes Factors of an interaction term also reflects evidence for the main effects of the interacting terms.

Analyses of the delay conditions reveal extreme evidence for differences in discounting of gains and losses for the first ($\log_{10}(\text{BF}) = 17.79$) and second ($\log_{10}(\text{BF}) = 11.96$) amount conditions. The Bayes factor for the third amount indicates anecdotal evidence for the null hypothesis ($\log_{10}(\text{BF}) = -0.44$) and strong evidence in favor of the null hypothesis for the largest amount ($\log_{10}(\text{BF}) = -1.46$), confirming that losses are discounted less steeply than gains, but only for smaller outcome magnitudes. The within-sign comparisons reveal extreme evidence for differences between the second and third amounts of gain ($\log_{10}(\text{BF}) = 2.10$). All other comparisons provide evidence for the null hypotheses, whose strength ranges from anecdotal to very strong (*gains* – 1-2: $\log_{10}(\text{BF}) = -1.32$; and 3-4: $\log_{10}(\text{BF}) = -0.23$; *losses* – 1-2: $\log_{10}(\text{BF}) = -1.50$, 2-3: $\log_{10}(\text{BF}) = -0.86$; and 3-4: $\log_{10}(\text{BF}) = -1.48$), which shows that the magnitude effect only occurred for gains for delay discounting. The comparisons between gains and losses for discounting in physical effort revealed differences only for the smallest amount ($\log_{10}(\text{BF}) = 6.13$), with gains being discounted less steeply than losses. All other comparisons showed at least strong evidence for the null hypothesis (*amount* 2: $\log_{10}(\text{BF}) = -1.60$; *amount* 3: $\log_{10}(\text{BF}) = -1.45$; and *amount* 4: $\log_{10}(\text{BF}) = -1.53$). Comparisons within the gains condition provide anecdotal evidence of no differences between *amounts* 1 and 2 ($\log_{10}(\text{BF}) = -0.34$), extremely strong evidence for differences between *amounts* 2 and 3 ($\log_{10}(\text{BF}) = 7.71$), and anecdotal evidence for differences between *amounts* 3 and 4 ($\log_{10}(\text{BF}) = 0.37$). All comparisons for losses indicate very strong evidence of differences between pairs 1-2 ($\log_{10}(\text{BF}) = 7.19$), 2-3 ($\log_{10}(\text{BF}) = 6.11$), and 3-4 ($\log_{10}(\text{BF}) = 2.28$), reflecting the presence of magnitude effects for both gains and losses. Discounting comparisons of cognitive effort across signs indicates evidence for the null hypotheses in all cases (1: $\log_{10}(\text{BF}) = -0.07$; 2: $\log_{10}(\text{BF}) = -1.57$; and 3: $\log_{10}(\text{BF}) = -0.56$, 4: $\log_{10}(\text{BF}) = -0.10$), with their weights ranging from anecdotal to very strong. Comparisons within sign conditions indicate extremely strong evidence for differences between *amounts* 1 and 2, and 2

and 3, and moderate evidence for differences between *amounts* 3 and 4 in both gains ($I-2$: $\log_{10}(\text{BF}) = 3.03$; $2-3$: $\log_{10}(\text{BF}) = 9.35$; and $3-4$: $\log_{10}(\text{BF}) = 0.89$) and losses ($I-2$: $\log_{10}(\text{BF})=8.08$; $2-3$: $\log_{10}(\text{BF}) = 13.92$; and $3-4$: $\log_{10}(\text{BF}) = 0.98$). This suggests that there was a magnitude effect across gains and losses in this condition, while the sign effect did not result in any substantial differences.

Fig. 1. Mean areas under the curve (AUC) for each amount condition in gains and losses from posterior distributions. Error bars represent 95% credible intervals. AUCs were arcsine transformed due to a departure from normality.

4 Discussion

Loss aversion ranks as one of the fundamental effects that shape human choice behavior (Camerer, 2005; Novemsky and Kahneman, 2005; Ruggeri et al., 2020). We have put this claim to the test in the current study by examining how delay and effort affect the devaluation of gains and losses of different magnitudes. Our findings indicate that loss aversion is not as pervasive as one might expect, and it may be present only under specific circumstances when decisions are intertemporal, and may even be absent or reversed in specific cases of effort-based decisions.

Our results replicate previous findings showing that an asymmetric evaluation of gains and losses for intertemporal decisions is present only for smaller amounts (Estle et al., 2006; Green et al., 2014, 2013). This process is most likely driven by a relatively constant discounting of losses of various amounts and an increase in its rate for smaller gains compared to larger ones.

When choices involve physical effort, the interaction of sign and amount manifests itself in slower discounting of gains compared to losses for the smallest amount studied. Though this effect may be surprising given the well-established existence of the loss aversion phenomenon, our results are by no means unique, and previous studies have provided similar findings for effort (O'Brien and Ahmed, 2019), and riskless or risky decisions (Harinck et al., 2007), where the reversed loss aversion is also present for small amounts.

Despite the results indicating that there is an interaction between sign and amount for cognitive effort decisions, its shape does not indicate any apparent asymmetries in the discounting of gains and losses, and the interaction may stem from the larger difference between the two smallest amounts in the domain of losses compared to the domain of gains. Such an effect has no direct and meaningful interpretation. What is clear, however, is the evidence for (a) the lack of loss aversion and (b) the presence of the magnitude effect in

cognitive effort. The pattern of results, in which gains were discounted less steeply than losses of the same magnitude for the smallest amount in the physical effort condition, but such an effect was absent in the cognitive effort condition, might be due to the fact that the two types of effort were not calibrated with each other. It would be worthwhile for further studies to use equal or calibrated values of effort across domains (see for example: Białaszek and Marcowski, 2019).

The results also stand in contrast to those of some studies that have investigated loss aversion in effort-based choice. However, we would like to emphasize that our study employed a different methodology and theoretical basis from previous research. For example, O'Brien and Ahmed (2019a) applied a framework based on prospect theory (Tversky and Kahneman, 1992), with gains and losses operationalized as changes in effort level relative to a point of equilibrium, and choice outcomes as lotteries. Massar et al. (2020) used a task in which losses to an endowed sum of money could be reduced by exerting effort.

5 Conclusions

Our main results suggest that unlike in intertemporal decisions, loss aversion for physical effort discounting is reversed in the smallest amount studied, and absent in cognitive effort discounting. The magnitude effect, however, is present for both delay and effort discounting; however, unlike the results for the delay domain, it is also present for losses in the effort domain.

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7 Research data

The data sets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

8 Declarations of interest

None

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