Effect of Loss Probability on Loss Aversion Behavior

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Abstract

[Objective] To examine how the probability of loss influences individuals' subjective experience of loss and their loss-avoidance behavior. [Methods] Across three experiments, loss probability was manipulated using a wheel-of-fortune lottery task, a bean paradigm, and a simulated lottery scenario, in order to assess participants' subjective experience, reaction time, recognition performance, and degree of loss aversion. Results Under low loss-probability conditions, individuals exhibited stronger subjective negative experiences of loss, faster responses to negative stimuli, and lower recognition accuracy; under high loss-probability conditions, individuals were less sensitive to losses and showed reduced loss aversion. [Limitations] The sample consisted primarily of college students, limiting the generalizability of the findings; moreover, the monetary stakes in the experiments were relatively small, and the interaction mechanisms between probability and outcome value require further in-depth investigation. [Conclusion] The probability of loss occurrence moderates loss sensitivity: low-probability losses enhance loss aversion, whereas high-probability losses attenuate loss aversion.

Full Text

The Effect of Loss Probability on Loss Aversion

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Abstract:
[**Objective**] To examine the effect of loss probability on individuals' subjective evaluation of losses and loss aversion. [**Methods**] Three experiments manipulated loss probability using a wheel-of-fortune task, a bean paradigm, and a simulated lottery scenario to assess subjective affective responses, reaction

times, recognition accuracy, and the magnitude of loss aversion. **Results** Low-probability loss conditions were associated with stronger negative subjective experiences, faster responses to negative stimuli, and lower recognition accuracy, whereas high-probability loss conditions were associated with reduced loss sensitivity and attenuated loss aversion. [**Limitations**] The sample primarily comprised university students, which may limit the generalizability of the findings; additionally, the loss magnitudes were relatively small, and the interaction between probability and outcome value warrants further investigation. [**Conclusions**] Loss probability systematically modulates loss sensitivity, with low-probability losses amplifying loss aversion and high-probability losses diminishing it.

Keywords: loss aversion; prospect theory; probability; negativity bias

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The phenomenon where equal losses produce stronger psychological utility than equal gains is known as loss aversion. This bias is ubiquitous in economic behavior and is modulated by multiple factors, exhibiting domain and individual specificity. For instance, men do not display loss aversion in mate selection contexts, and loss aversion diminishes or disappears after repeated decisions with feedback. Regarding individual differences, women exhibit greater sensitivity to losses, while older adults or individuals with high power show lower degrees of loss aversion.

Kahneman and Tversky introduced loss aversion as an established fact within prospect theory. In early research, loss aversion described behavioral regularities, while subsequent studies used it to explain phenomena such as the endowment effect and status quo bias. However, treating loss aversion as an axiomatic fact may constrain exploration of its underlying psychological mechanisms. Researchers have attempted to investigate the causes of loss aversion through "hot" and "cold" pathways. The hot pathway emphasizes the dominant role of emotion, proposing that the asymmetric intensity of positive and negative emotions elicited by losses and gains explains loss aversion. The cold pathway, conversely, focuses on cognitive evaluation and rational deliberation, suggesting that the total expected value of options determines whether loss aversion occurs. The asymmetry of subjective utility between losses and gains represents a prominent theory exploring loss aversion from the cold pathway. Kahneman and Tversky proposed that the subjective value of losses exceeds that of equivalent gains, manifesting in the value function as a steeper curve for losses than for gains. This asymmetry has received support from neuroscientific evidence.

When investigating the subjective utility of losses and gains, researchers typically set their probabilities as equal and assume equal subjective perception of probability, yet this assumption does not hold. People' s perception of probability is complex, and they often assign greater weight to loss probabilities. Bilgin found that even when objective probabilities are equal, probabilities attached to losses are subjectively perceived as larger. Moreover, probability and outcome influence each other, an interaction that has not received adequate attention in loss aversion research.

Loss aversion can be viewed as a manifestation of negativity bias in the decision-making domain. Negativity bias refers to the general tendency for individuals to attend to, learn from, and utilize negative stimuli more than positive ones. In decision-making, this bias manifests as stronger reactions to losses. The frequency-based explanation of negativity bias posits that the low frequency of negative stimuli makes them more perceptually salient. Figure-ground perception plays a crucial role in environmental perception; whether stimuli are perceived as figure or ground relates to their frequency of occurrence. High-frequency positive events are more likely to be perceived as ground, whereas low-frequency negative events are more likely to be perceived as figure. By this logic, artificially increasing the frequency of negative events may cause them to recede into the "ground," while low-frequency positive events become more salient, potentially even producing a positivity bias.

Loss aversion can also be explained through frequency theory: people exhibit loss aversion because losses occur relatively infrequently in daily life, making them more likely to be perceived as "figure" and attract greater attention. Yechiam and Hochman similarly found that losses induce transient physiological arousal, directing attention to task-relevant events. Based on the frequency-based account of negativity bias, this study hypothesizes that loss aversion may arise because the low probability of losses in everyday life leads to heightened sensitivity. In typical contexts where losses are low-probability, people are more sensitive to losses, react more strongly, and are more prone to loss aversion. If the probability of losses is artificially increased, sensitivity to losses decreases, reactions weaken, and loss aversion becomes less likely. This study tested this hypothesis through three experiments examining affective, cognitive, and behavioral domains to obtain convergent evidence. Experiment 1 directly compared the intensity of psychological feelings elicited by losses and gains under high versus low loss probability conditions. Experiment 2 employed an adapted bean paradigm to investigate memory differences for losses and gains under varying loss probability contexts. Experiment 3 used a lottery scenario to explore how loss probability influences loss aversion behavior.

Experiment 1: The Effect of Probability on Subjective Feelings

Participants

Using G*Power 3.1, we calculated that a minimum sample size of 32 participants was required for Cohen' s $f = 0.25$, $\alpha = 0.05$, and Power = 0.8. We recruited 150 university students from a central Chinese province, all with normal or corrected-to-normal vision. The average completion time was 158.31 seconds, with a positively skewed distribution. Participants completing under 45 seconds were considered non-serious and excluded ($n = 5$). Additionally, participants who rated losses as causing positive feelings or gains as causing negative feelings –contrary to common sense–were deemed invalid and excluded ($n = 25$). The final sample comprised 120 valid responses (77 females, 43 males) with a mean age of 19.43 ± 1.40 years, yielding an 80% validity rate.

Experimental Design and Procedure

This experiment employed a 2 (loss probability: high vs. low) × 2 (outcome: loss vs. gain) within-subjects design.

The experiment used a wheel-of-fortune game where probabilities were represented by the proportion of areas on the wheel. The high loss probability condition (i.e., low gain probability) featured an 80% chance of losing ¥50 and a 20% chance of gaining ¥50. The low loss probability condition (i.e., high gain probability) featured a 20% chance of losing ¥50 and an 80% chance of gaining ¥50. The dependent variable was the intensity of psychological feelings toward anticipated losses and gains.

The experimental program was developed using jsPsych and deployed on an online platform. Participants first viewed a wheel displaying the loss/gain amounts and probabilities, then rated the psychological feelings of anticipated losses and gains on a bipolar scale (1 = very unhappy, 5 = neutral, 9 = very happy). Subsequently, participants viewed the other wheel and completed corresponding ratings. The order of wheel presentation and rating scales was counterbalanced.

Results

Psychological feeling intensity was operationalized as the distance between ratings and the midpoint value of 5. For anticipated losses, this represented unhappiness intensity; for anticipated gains, happiness intensity.

A repeated-measures ANOVA on psychological feeling intensity revealed significant main effects of loss probability, $F(1, 119) = 17.05$, $p < 0.001$, $\eta_p^2 = 0.13$, $BF_{10} = 3.07$, and outcome valence, $F(1, 119) = 48.21$, $p < 0.001$, $\eta_p^2 = 0.29$, $BF_{10} = 1.81 \times 10^8$. The interaction between loss probability and outcome valence was also significant, $F(1, 119) = 102.12$, $p < 0.001$, $\eta_p^2 = 0.46$, $BF_{10} = 2.26 \times 10^{22}$. Simple effects analysis showed that unhappiness intensity for anticipated losses was significantly lower in the high loss probability condition ($M = 1.38$, $SD = 1.32$) than in the low loss probability condition ($M = 2.82$, $SD = 1.23$), $t(119) = 9.90$, $p < 0.001$, Cohen' s $d = 1.13$, $BF_{10} = 1.77 \times 10^{14}$. Happiness intensity for anticipated gains was significantly higher in the high loss probability condition ($M = 3.28$, $SD = 0.91$) than in the low loss probability condition ($M = 2.48$, $SD = 1.24$), $t(119) = 6.49$, $p < 0.001$, Cohen' s $d = 0.74$, $BF_{10} = 4.71 \times 10^6$.

These results demonstrate that probability influences the intensity of psychological feelings elicited by outcomes. Both losses and gains produce stronger psychological feelings when their occurrence probability is low.

[Figure 1: see original paper]

Experiment 2: The Effect of Probability on Memory for Losses and Gains

Negative stimuli not only elicit stronger emotional experiences but also consume more cognitive resources. Experiment 2 used an adapted bean paradigm to investigate how probability affects memory for negative stimuli. Unlike Experiment 1, which explicitly described probabilities, Experiment 2 implemented experiential probabilities to examine whether they similarly influence cognitive processing of negative stimuli.

Participants

Using G*Power 3.1, we calculated that a minimum sample size of 34 participants was required for Cohen' s $f = 0.25$, $\alpha = 0.05$, and Power = 0.8. We recruited 64 university students (19 males, 45 females) from a central Chinese province.

Experimental Design and Materials

This study adapted the bean paradigm, which presents virtual beans of different shapes and quantities on a computer screen, with each bean corresponding to either positive value (gain points) or negative value (lose points). Participants could choose to "select" or "not select" individual beans; selecting a bean yielded immediate feedback about point changes, while not selecting left points unchanged. The experiment comprised a memory phase and a recognition phase. During the memory phase, participants needed to remember each bean' s features and associated valence; during the recognition phase, they judged whether presented beans had appeared in the memory phase.

Bean "valence" was operationalized through losses and gains. Loss probability was manipulated by controlling the frequency of negative-valence beans during the memory phase. In the high loss probability group (i.e., low gain probability), the memory phase included 10 negative-valence beans and 5 positive-valence beans. In the low loss probability group (i.e., high gain probability), the memory phase included 5 negative-valence beans and 10 positive-valence beans.

The experiment used a 2 (loss probability: high vs. low) × 2 (bean valence: positive vs. negative) mixed design. Loss probability was a between-subjects variable, and bean valence was a within-subjects variable. Participants were randomly assigned to high or low loss probability groups ($n = 32$ each). Dependent variables were reaction time, recognition accuracy, and decision criterion during the recognition phase.

The experiment consisted of practice, memory, and recognition phases, lasting approximately 15 minutes. After reading instructions, participants completed the practice phase. In the memory phase, a black fixation cross "+" appeared for 200 ms, followed by a bean. Participants pressed "J" for positive valence and "F" for negative valence, after which feedback appeared. Each bean was presented randomly three times, giving participants three opportunities to learn its valence. Beans disappeared after a keypress or after 1000 ms without response, followed by a 1000 ms blank screen. Forty-five bean trials were presented randomly. Subsequently, participants entered the recognition phase, where 5 positive-valence and 5 negative-valence beans from the memory phase appeared in random order for valence judgment.

Results

A repeated-measures ANOVA on reaction time revealed non-significant main effects of loss probability and bean valence, but a significant interaction, $F(1,62) = 8.66$, $p = 0.005$, $\eta^2 = 0.12$, $BF_{10} = 9.21$ [Figure 2: see original paper]. Simple effects showed that negative bean reaction time was significantly lower in the low loss probability group ($M = 3.26$, $SD = 0.15$) than in the high loss probability group ($M = 3.34$, $SD = 0.13$), $t(62) = 2.38$, $p = 0.020$, Cohen' s $d = 0.59$, $BF_{10} = 3.82$. Positive bean reaction time did not differ significantly between low ($M = 3.31$, $SD = 0.14$) and high ($M = 3.29$, $SD = 0.14$) loss probability groups, $t(62) = 0.53$, $p = 0.59$, Cohen' s $d = 0.13$.

A repeated-measures ANOVA on recognition accuracy revealed non-significant main effects but a significant interaction, $F(1,62) = 13.48$, $p = 0.001$, $\eta_p^2 = 0.18$, $BF_{10} = 60.90$ [Figure 2: see original paper]. Simple effects showed that negative bean recognition accuracy was significantly lower in the low loss probability group ($M = 0.61$, $SD = 0.18$) than in the high loss probability group ($M = 0.75$, $SD = 0.22$), $t(62) = 2.87$, $p = 0.006$, Cohen' s $d = 0.71$, $BF_{10} = 12.35$. Positive bean recognition accuracy was significantly higher in the low loss probability group ($M = 0.73$, $SD = 0.22$) than in the high loss probability group ($M = 0.61$, $SD = 0.26$), $t(62) = 2.15$, $p = 0.036$, Cohen' s $d = 0.54$, $BF_{10} = 2.98$.

A repeated-measures ANOVA on decision criterion revealed non-significant main effects but a significant interaction, $F(1,63) = 7.47$, $p = 0.008$, $\eta^2 = 0.11$, $BF_{10} = 11.66$ [Figure 2: see original paper]. Simple effects showed a marginal difference for negative beans between low ($M = 4.08$, $SD = 5.03$) and high ($M = 2.19$, $SD = 4.04$) loss probability groups, $t(62) = 1.78$, $p = 0.08$, Cohen' s $d = 0.44$, $BF_{10} = 1.85$. The decision criterion for positive beans was significantly lower in the low loss probability group ($M = 1.12$, $SD = 2.47$) than in the high loss probability group ($M = 4.06$, $SD = 5.32$), $t(62) = 2.68$, $p = 0.01$, Cohen' s $d = 0.67$, $BF_{10} = 8.92$.

These results indicate that when loss probability is low during the memory phase, individuals respond faster to negative beans but show lower recognition accuracy, partially supporting our hypothesis. This pattern may arise because, in signal detection theory, the frequency of prior signals influences subsequent judgments. When negative beans appear infrequently during encoding, participants adopt stricter decision criteria for negative beans, leading them to under-report negative beans during recognition. Since no distractor beans were included in the recognition phase, this tendency to under-report negative beans ultimately resulted in lower recognition rates for negative-valence beans.

[Figure 2: see original paper]

Experiment 3: The Effect of Probability on Loss Aversion Behavior

Experiments 1 and 2 demonstrated probability' s influence on affective experience and memory for losses, but did not directly address loss aversion behavior. Experiment 3 simulated a scratch-card lottery game to investigate how loss probability affects loss aversion behavior.

Participants

Using G*Power 3.1, we calculated that a minimum sample size of 52 participants was required for Cohen' s $d = 0.80$, $\alpha = 0.05$, and Power = 0.8. We recruited 100 university students (31 males, 69 females) from a central Chinese province, with a mean age of 20.31 ± 1.50 years.

Experimental Design and Procedure

This experiment used a single-factor between-subjects design with loss probability as the independent variable. Participants were randomly assigned to high or low loss probability groups ($n = 50$ each). In the high loss probability scratch-cards, the loss-to-gain outcome ratio was 7:3; in the low loss probability condition, the ratio was 3:7 . Both lottery sets had equal maximum gain and loss values, with total gains amounting to ¥5.

Participants selected a set of lottery tickets, scratched all tickets, and recorded each outcome and total earnings, which would be used in subsequent game steps. We then measured loss aversion behavior using two methods. First, a fill-in-the-blank method asked: "A 50% probability of gaining ¥100 and a 50% probability of losing ¥__x, please write the maximum amount you would accept." The gain/loss ratio (Gain/Loss) represents the loss aversion coefficient θ, where larger θ values indicate greater loss aversion. Second, participants evaluated a fair coin toss game: "If heads, gain ¥10; if tails, lose ¥10,"rating their willingness to participate and the degree of willingness (1-5 scale). The procedure lasted approximately 7 minutes.

Results

Independent samples t-tests revealed that the loss aversion coefficient θ was significantly lower in the high loss probability condition ($M = 1.43$, $SD = 0.54$) than in the low loss probability condition ($M = 1.67$, $SD = 0.53$), $t(98) = 2.23$, $p = 0.03$, Cohen' s $d = 0.45$, $BF_{10} = 1.88$.

In the high and low loss probability groups, 33 (64%) and 37 (72%) participants, respectively, were unwilling to play the game. Chi-square analysis revealed no significant difference in proportions. Although willingness to participate did not reach statistical significance, unwillingness to participate was significantly lower in the high loss probability condition ($M = 3.42$, $SD = 1.71$) than in the low loss probability condition ($M = 4.59$, $SD = 0.80$), $t(68) = 3.73$, $p < 0.001$, Cohen' s $d = 0.90$, $BF_{10} = 67.36$.

Compared to low loss probability conditions, participants in high loss probability conditions exhibited smaller loss aversion coefficients and weaker unwillingness to participate in the fair coin toss game.

General Discussion

The three experiments consistently demonstrated that the subjective utility of loss outcomes is influenced by their probability. In typical contexts, low-probability losses produce stronger negative experiences, whereas artificially increasing loss probability attenuates the negative experience. Kahneman and Tversky noted that perceptions of loss and gain outcomes are not absolute but depend on specific contexts. Walasek and Stewart similarly found that individuals' perceptions of loss and gain magnitudes are influenced by their range. This study further proposes that perceptions of loss and gain outcomes also depend on the probability of their occurrence.

In research on the psychological mechanisms of loss aversion, the hot pathway emphasizes emotion-dominated response processes, while the cold pathway focuses on cognitive system-dominated rational analysis, with the core being the trade-off of subjective utility between losses and gains. This study explores loss aversion mechanisms from a probability perspective, expanding the explanatory boundaries of the cold pathway. On one hand, it highlights the interaction between probability and outcomes in loss aversion. On the other hand, unlike "subjective probability asymmetry" where Bilgin argued that objective probabilities are subjectively weighted differently when attached to losses versus gains, this study emphasizes that the perception of outcome value is influenced by its occurrence probability.

Previous research on negativity bias has primarily focused on cognition, emotion, and information dissemination. This study provides supporting evidence for the frequency-based explanation of negativity bias in behavioral decision-making. Prior studies show that people allocate stronger attention to loss stimuli and exhibit stronger emotional reactions, consistent with Experiment 2' s finding that individuals are more sensitive to loss signals under low loss probability conditions—likely stemming from the salience caused by the low frequency of losses. By artificially increasing loss probability, this study found that low-frequency gains are perceived as figure, thereby reversing loss aversion behavior, which partially supports the context-dependent plasticity of loss aversion.

Negativity bias is driven by multiple mechanisms, and different domains may require different theoretical explanations. Beyond frequency theory, the adaptive value theory adopts an evolutionary perspective, proposing that high sensitivity to negative stimuli enhances survival and gene transmission probabilities. The key to determining which theory provides better explanatory power in a specific domain lies in whether people' s response intensity to negative stimuli depends on their frequency. This study found that for low-threat losses, response intensity depends on loss frequency, supporting the frequency-based explanation.

Liu et al. proposed a third pathway explaining loss aversion—the "route number theory"—which suggests that losses involve a dual-route experience ("from nothing to having" and "from having to nothing"), whereas gains typically involve only a single route ("from nothing to having"). The present findings may intersect with this theory. The reason losses trigger stronger experiences may be attributed to their low frequency; similarly, in the route number theory, low-probability three-route gains such as tax refunds, due to their rarity, may produce stronger psychological feelings than conventional two-route losses.

Understanding loss aversion through the lens of loss frequency can explain common phenomena. For example, the gambler' s fallacy may arise because after experiencing high-frequency losses, sensitivity to losses decreases while attention shifts toward gains. Practically, this perspective helps calibrate excessive avoidance of low-probability negative events, such as refusing to fly due to overestimated concerns about plane crashes.

This study has several limitations. First, the sample consisted entirely of university students; future research should expand to broader age groups and occupational populations, such as older adults who rely more on personal experience than contextual information. Second, the interaction mechanism between probability and outcome—for instance, whether a compensatory relationship exists—requires further investigation. Third, the monetary losses in the experiments were relatively small and easily adapted to; future studies should employ larger loss magnitudes to test whether loss aversion remains probability-dependent when adaptation is impossible.

Loss probability systematically influences the degree of loss aversion. Under high loss probability conditions, people are less sensitive to losses and exhibit lower loss aversion; under low loss probability conditions, people are more sensitive to losses and show higher loss aversion.

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Author Contributions:
Liu Huan, Yang Xinyao, Wang Jiangdong: Conceptualized the research proposition and design, developed the research protocol;
Wang Jiangdong: Conducted the experiments;
Yang Xinyao: Collected, cleaned, and analyzed the data;
Liu Huan, Yang Xinyao, Wang Jiangdong: Drafted the manuscript;
Liu Huan, Yang Xinyao: Revised the final manuscript.

Note: Figure translations are in progress. See original paper for figures.