# Re-examination of the "Asymmetric Function"Explanatory Mechanism for Loss Aversion

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## Abstract

The "uneven route" explanatory mechanism, first proposed by Liu Huan et al. in 2009, explains and predicts how and why loss aversion occurs. This explanatory mechanism posits that loss aversion occurs when the route of loss (the number of transformations of the same ownership) is greater than the route of gain. The present study manipulates the uneven route proposed by Liu Huan et al. (2009) and tests the uneven route explanatory mechanism under different experimental conditions. The results of the four experiments in this study, as well as the results of a mini-meta-analysis of these four experiments, support the uneven route explanatory mechanism. This result was validated across between-subjects and within-subjects experimental designs, different amounts, and different measurement indicators, indicating that the finding is robust. In this paper, loss aversion disappears in the tax payment/refund scenario compared to the winning/losing money scenario.

## Full Text

## Preamble

**Reexamination of the "Uneven Route" Account of Loss Aversion**

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## Abstract

The "uneven route"account is an explanatory mechanism first proposed by Liu et al. in 2019 to explain and predict how and why loss aversion occurs. This mechanism posits that loss aversion emerges when the number of routes (transfers of ownership) for a loss exceeds that for a gain. The present study manipulates the uneven route variable proposed by Liu et al. (2019) and tests this account across different experimental conditions. Results from four experiments, along with a mini meta-analysis of these studies, support the uneven route explanation. These findings are robust across between-subjects and within-subjects designs, different monetary amounts, and different measurement indices. Notably, compared with win/lose scenarios, loss aversion disappears in tax/refund scenarios.

**Keywords:** loss aversion, uneven route, reexamination

[1]We thank Richard Gonzalez, who was responsible for experiments and data analysis in the 1992 version of prospect theory (Advances in prospect theory: Cumulative representation of uncertainty), for suggesting the term "route" to express the concept of "程数."

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## 1. Introduction

### 1.1 Loss Aversion

Imagine you have the opportunity to play a game with equal probabilities of winning or losing the same amount of money: a coin toss game where you win 50 yuan if it lands on heads and lose 50 yuan if it lands on tails. People typically reject such games (Gal, 2006), indicating that the utility derived from losing a given amount is greater than the utility from gaining the same amount (Ariely, Huber, & Wertenbroch, 2005; Camerer, 2005; Fox & Poldrack, 2014; Harinck, Van Dijk, Van Beest, & Mersmann, 2007). Loss aversion constitutes a key component of the value function $v$ in prospect theory (PT) (Kahneman & Tversky, 1979), where the slope of the loss portion is steeper than that of the gain portion. Previous research suggests that the psychological utility of a loss is approximately 1.5–2.5 times that of an equivalent gain (Glöckner & Pachur, 2012; Rick, 2010; Sokol-Hessner, Hsu, Curley, Delgado, Camerer, & Phelps, 2009; Tversky & Kahneman, 1992).

In economics and finance literature, loss aversion is regarded as a universal behavioral bias (Boyce, Wood, & Ferguson, 2016; Gaechter, Johnson, & Herrmann, 2007) and has received widespread attention in economic analysis (Schmidt &

Zank, 2005). Applications of loss aversion to real-world problems have achieved remarkable success. For example, Thaler' s "Save More Tomorrow" (SMarT) program leverages loss aversion to effectively increase retirement savings rates (Liu et al., 2019; Thaler & Benartzi, 2004). Given its substantial influence across social sciences, numerous studies have sought to explore the underlying mechanisms of loss aversion.

### 1.2 Possible Explanatory Mechanisms for Loss Aversion

Previous research has proposed various mechanisms to explain loss aversion, which can be categorized into two types: (1) direct factors that trigger loss aversion, and (2) indirect factors that contribute to it.

**1.2.1 Direct Factors** Direct factors refer to processes or emotions directly triggered by losses. Building on the expected utility model ($\Sigma w(p)v(x)$), the utility of gains and losses comprises both the subjective value and subjective probability of outcomes. Consequently, asymmetries based on subjective value (Kahneman & Tversky, 1979) or subjective probability (Bilgin, 2012) may lead to loss aversion.

From the perspective of subjective value asymmetry, the value function for losses is steeper than that for gains (Liberman, Idson, & Higgins, 2005). Thus, the subjective values of gains and losses are unequal—equivalent losses produce greater psychological impact than equivalent gains (Kahneman & Tversky, 1979; Tversky & Kahneman, 1992), rendering the expected value (EV) of the coin toss game ($+x$, 50%; $-x$, 50%) less than zero. This represents the classic explanation of loss aversion in prospect theory (Kahneman & Tversky, 1979).

From the perspective of subjective probability asymmetry, the expected value of an option depends on the subjective probabilities of gains and losses. Bilgin (2012) proposed that loss aversion stems not from value asymmetry between gains and losses but from probability asymmetry. In the coin toss game, the subjective probability of losing exceeds that of winning, making the expected value of playing the game negative.

**1.2.2 Indirect Factors: A New Uneven Route Account** Indirect factors arise from processes or emotions associated with losses. Overgeneralization represents one such indirect factor, reflecting how past experiences can trigger loss aversion (Skinner, 1985; Ert & Erev, 2013). Liu et al. (2009) proposed a novel mechanism: the uneven route account. "Route" refers to the number of transfers of the same ownership. This account assumes that loss aversion occurs when the number of routes for a loss exceeds that for a gain, with more routes producing stronger psychological impact. The uneven route account offers a new perspective for understanding loss aversion.

Reconsidering the coin toss game reveals an asymmetry in route processes despite its mathematical fairness (+¥50, 50%; -¥50, 50%). The gain scenario rep-

resents a "one-route" process [FIGURE:1, left]: 50 yuan transfers directly from another' s pocket (account) to the player' s pocket (account) without requiring time, effort, or energy. Conversely, the loss scenario constitutes a "two-route" process [FIGURE:1, right]: first, the player must expend time, effort, and energy to obtain 50 yuan (Route 1: 0 yuan transfers from another' s pocket to the player' s pocket), then lose that 50 yuan (Route 2: 50 yuan transfers from the player' s pocket to another' s pocket). Completing this process requires careful consideration of one' s ability and willingness to fulfill the commitment.

Liu et al. (2009) hypothesized that this asymmetry in gain and loss processes causes loss aversion. If the typical asymmetry (i.e., "one-route gain" vs. "two-route loss" ) is altered, loss aversion should disappear.

An example illustrates this core assumption [Figure 2: see original paper]. Thaler and Benartzi (2004) successfully eliminated loss aversion in the SMarT program by reframing retirement savings as deductions from future salary increases rather than current wages. The unarticulated reason for this effect, Liu et al. (2009) argued, was their manipulation of "two-route loss" into "one-route loss."

To test this hypothesis, Liu et al. (2009) designed several manipulations, including "one-route gain vs. one-route loss," "two-route gain vs. one-route loss," and "one-route gain vs. two-route loss" / "three-route gain vs. two-route loss." Notably, in their Experiment 3, the classic win/lose scenario (one-route gain vs. two-route loss) was modified into a tax/refund scenario (three-route gain vs. two-route loss). The two scenarios are as follows:

**Win/Lose Scenario (One-Route Gain vs. Two-Route Loss):**
*Imagine a coin toss game:*
*- If heads, you win x yuan*
*- If tails, you lose 50 yuan*
*What is the minimum x for which you would play?*

**Tax/Refund Scenario (Three-Route Gain vs. Two-Route Loss):**
*Imagine a coin toss game:*
*- If heads, the government refunds you x yuan*
*- If tails, you pay 50 yuan in taxes*
*What is the minimum x for which you would play?*

In the tax/refund scenario, "government refunds you x yuan" replaces "you win x yuan," and "you pay 50 yuan in taxes" replaces "you lose 50 yuan." While both scenarios involve equal chances of gaining or losing the same monetary amount, the gain and loss processes differ. The loss process remains two-route in both scenarios [Figure 3: see original paper]. However, the gain process is one-route in the win/lose scenario but three-route in the tax/refund scenario: first, you earn salary (Route 1), then pay taxes (Route 2), and finally receive a tax refund (Route 3).

Interestingly, participants' minimum acceptable $x$ was approximately 100 yuan

in the win/lose scenario but only 50 yuan in the tax/refund scenario (Liu, Liang, & Li, 2009), indicating loss aversion in the former but its disappearance in the latter.

### 1.3 Reexamination of the Uneven Route Account

Liu et al. (2009) hypothesized that loss aversion arises because loss routes exceed gain routes. They constructed scenarios involving lifespan, freedom, and win/lose/tax/refund situations to manipulate "one-route gain vs. one-route loss," "two-route gain vs. one-route loss," and "one-route gain vs. two-route loss" / "three-route gain vs. two-route loss." Results showed that altering the asymmetrical "one-route gain vs. two-route loss" eliminated loss aversion.

Despite its novelty, the uneven route account has received limited attention, though some researchers have cited it (e.g., Wang, Ong, & Tan, 2015). Potential reasons include: (1) the original publication was in Chinese, limiting accessibility; (2) the single study contained too many manipulation categories across different scenarios; and (3) the lifespan and freedom scenarios were described unnaturally, potentially causing interpretive disagreements among participants (Li, 2015).

Therefore, a critical question remains: Is the uneven route account robust? To address this, the present study reexamines Liu et al.' s (2009) key findings, focusing on one manipulation category—three-route gain vs. two-route loss—using "universal currency" (monetary value) to represent all possible outcomes.

### 1.4 Overview of the Present Study

We selected Liu et al.' s (2009) Experiment 3 as our experimental material, including both win/lose (one-route gain vs. two-route loss) and tax/refund (three-route gain vs. two-route loss) scenarios because both manipulate monetary gains and losses (unlike lifespan, freedom, or health). If monetary outcomes consistently serve as universal currency or proxies for various possible outcomes $x$ in prospect theory's value function $v(x)$, the results should have broad applicability (Kahneman & Tversky, 1979; Tversky & Kahneman, 1992).

Accordingly, we designed and conducted four related experiments with progressively stricter conditions. Experiment 1 used a between-subjects design to directly replicate the original study, including identical recruitment materials, consent forms, experimental instructions, and choice questions. Experiment 2 employed a within-subjects design, where participants completed both scenarios, as this makes it easier to detect that the two situations are essentially identical. Given that loss aversion magnitude increases with amount (the magnitude effect), Experiment 3 increased the amount from 50 yuan to 500 yuan. To measure loss aversion more diversely, Experiment 4 used a rating scale method rather than the fill-in-the-blank approach, asking participants to report their willingness to participate (WTP). Finally, we conducted a mini meta-analysis across all four experiments to summarize evidence for the uneven route account.

## Experiment 1

Experiment 1 directly replicated Liu et al.' s (2009) Experiment 3 using a between-subjects design. In both scenarios, the loss amount was fixed at 50 yuan, matched by a gain of $x$ yuan. The independent variable was the experimental condition (scenario), and the dependent variable was the loss aversion coefficient ($l$; the ratio of loss to gain sensitivity). Following Liu et al. (2019), we defined $l$ as the ratio of $x$ to 50. We hypothesized that $l$ would differ between the win/lose (one-route gain vs. two-route loss) and tax/refund (three-route gain vs. two-route loss) scenarios. We used the Mann–Whitney $U$ test to examine differences in loss aversion coefficients between scenarios. If the coefficient in the win/lose scenario significantly exceeded that in the tax/refund scenario, the replication would confirm Liu et al.' s (2009) findings.

Additionally, because the loss aversion coefficient was non-normally distributed, we conducted mixed-effects logistic regression using the *lme4* and *lmerTest* packages in R (Bates, Mächler, Bolker, & Walker, 2015; Kuznetsova, Brockhoff, & Christensen, 2017). Treating participants as random effects allowed us to generalize our results (Baayen, Davidson, & Bates, 2008; Judd, Westfall, & Kenny, 2012). Participants' reported gain amounts $x$ that would match a 50-yuan loss were coded as a binary variable: $x \leq 50$ indicated no loss aversion, while $x > 50$ indicated loss aversion.

### 2.1.1 Participants

We planned to recruit 300 participants—approximately 2.5 times the original sample size (Simonsohn, 2015). We ultimately recruited 334 participants from Nanchang University. Eight were excluded for not providing numerical responses, and 14 were excluded for $l > 100$ (consistent with Liu et al., 2009). The final valid sample comprised 312 participants ($N$male = 197; $M$age = 18.57 $\pm$ 1.42 years), with 160 randomly assigned to the win/lose scenario and 152 to the tax/refund scenario.

### 2.1.2 Procedure

All participants signed informed consent forms before beginning the experiment and were randomly assigned to one of two conditions: win/lose or tax/refund.

### 2.1.3 Results and Discussion

Kolmogorov–Smirnov tests indicated that loss aversion coefficients were non-normally distributed in both scenarios (win/lose: $Z = 0.352$, $p < 0.001$; tax/refund: $Z = 0.370$, $p < 0.001$). An independent-samples Mann–Whitney $U$ test revealed a significant difference between conditions ($U$ = 10,099.50, $Z$ = 2.687, $p = 0.007$). Specifically, the median loss aversion coefficient was 2.00 in the win/lose scenario (indicating loss aversion) and 1.00 in the tax/refund scenario (indicating no loss aversion) .

**TABLE:1** Mann–Whitney $U$ Test for Loss Aversion Coefficients in Experiment 1

| Routes | Scenario | Gain | Loss | $M$ (SD) | Mean Rank | Mann–Whitney $U$ |
|---|---|---|---|---|---|---|
| One | Money | | Two | 3.52 (6.28) | | 10,099.50 |
| Three | Tax | | Two | 2.38 (3.18) | | |

Note: **p* < 0.01, two-tailed. $M$ = mean, SD = standard deviation, Mdn = median.

Due to the non-normal distribution, we used mixed-effects logistic regression to test for loss aversion occurrence, with scenario as a fixed effect (1 = win/lose; 0 = tax/refund) and participant as a random effect. The model failed to converge, so we conducted a logistic regression with scenario as the predictor. Results revealed a significant scenario effect ($b$ = 0.64, SE = 0.23, $z$ = 2.79, $p$ = .005, OR = 1.90), indicating that loss aversion was 1.90 times more likely in the win/lose scenario than in the tax/refund scenario.

Consistent with Liu et al. (2009), Experiment 1 found loss aversion in the win/lose scenario but not in the tax/refund scenario.

## Experiment 2

Experiment 2 mirrored Experiment 1 but used a within-subjects design instead of between-subjects. In within-subjects designs, participants can more easily recognize that the two scenarios (win/lose and tax/refund) involve identical gains and losses in monetary terms—that "you win $x$ yuan" is financially equivalent to "the government refunds you $x$ yuan," and "you lose 50 yuan" is equivalent to "you pay 50 yuan in taxes." Moreover, within-subjects designs control for individual-specific factors, better isolating experimental effects. Consequently, some studies have used within-subjects designs to test the robustness of framing effects (Frisch, 1993; Levin, Johnson, & Davis, 1987; Stanovich & West, 1998).

We anticipated that loss aversion coefficients might be more similar across scenarios in a within-subjects design. Therefore, Experiment 2 employed this more stringent condition to test the uneven route account. If the difference in loss aversion coefficients observed in Experiment 1 replicated under these conditions, it would provide stronger support for the account.

### 2.2.1 Participants

Using G*Power (Faul et al., 2007) with 80% power, an effect size of 0.36 (common in psychology), and Wilcoxon signed-rank test as the analysis method, we

*calculated a required sample of 66 participants. We recruited 117 participants from Nankai University; 35 were excluded for incomplete responses, yielding a final sample of 82 (*N*male = 34,* M*age = 21.09 ± 2.34 years).

### 2.2.2 Procedure

Each participant visited the laboratory twice, with sessions separated by more than one day. Participants completed questions for both scenarios in random order and signed informed consent forms.

### 2.2.3 Results and Discussion

Due to non-normal distribution of loss aversion coefficients (K-S test, $Z = 0.341$, $p < .0001$), we used Wilcoxon signed-rank tests. Results showed significantly higher coefficients in the win/lose scenario than in the tax/refund scenario ($Z = 4.470$, $p < 0.001$). The median coefficient was 1.55 in the win/lose scenario (indicating loss aversion) and 1.00 in the tax/refund scenario (indicating no loss aversion) .

**TABLE:2** Wilcoxon Signed-Rank Test for Loss Aversion Coefficients in Experiment 2

| Routes | Scenario | Gain | Loss | *M* (SD) | Positive Ranks |
|---|---|---|---|---|---|
| One | Money | | Two | 2.51 (3.06) | 4.470*** |
| Three | Tax | | Two | 1.24 (0.55) | |

Note: $^{**}p < 0.001$, two-tailed. $M$ = mean, SD = standard deviation, Mdn = median.

We conducted mixed-effects logistic regression on loss aversion occurrence (1 = loss aversion; 0 = no loss aversion), with scenario as a fixed effect (1 = win/lose; 0 = tax/refund) and participant as a random effect. Results revealed a significant scenario effect ($b = 0.73$, SE = 0.35, $z = 2.09$, $p = 0.037$, OR = 2.07), indicating that loss aversion was 2.07 times more likely in the win/lose scenario than in the tax/refund scenario.

Consistent with Liu et al. (2009) and Experiment 1, Experiment 2 found loss aversion in the win/lose scenario (median coefficient = 1.55) but not in the tax/refund scenario (median coefficient = 1.00).

## Experiment 3: Reexamining the Uneven Route Account by Manipulating Amount Size

In Experiments 1 and 2, the loss aversion coefficient in the tax/refund scenario was approximately 1, indicating no loss aversion. Previous research has demonstrated a magnitude effect in loss aversion: when asked to state amounts, people

become willing to risk larger hypothetical losses (Harinck et al., 2007), suggesting that loss aversion increases with amount size. One possible explanation for the absence of loss aversion in the tax/refund scenario could be the relatively small monetary amount. To rule out this alternative explanation, we conducted Experiment 3 with a larger amount (500 yuan instead of 50 yuan). Additionally, to ensure participants could better understand the tax/refund scenario, we recruited working adults with tax experience rather than undergraduate students without such experience.

### 2.3.1 Participants

The target sample size was 66, identical to Experiment 2. We recruited 80 working adults with tax experience; 10 were excluded for incomplete responses, yielding a final sample of 70 ($N$male = 37, $M$age = 30.63 $\pm$ 6.00 years).

### 2.3.2 Procedure

Participants completed questions for both scenarios in random order, with sessions separated by more than one day. All participants signed informed consent forms.

### 2.3.3 Results and Discussion

Due to non-normal distribution of loss aversion coefficients (K–S test, $Z = 0.418$, $p < 0.001$), we used Wilcoxon signed-rank tests. Results showed significantly higher coefficients in the win/lose scenario than in the tax/refund scenario ($Z = 3.190$, $p = 0.001$). The median coefficient was 2.00 in the win/lose scenario (indicating loss aversion) and 1.40 in the tax/refund scenario (indicating significantly reduced loss aversion) .

**TABLE:3** Wilcoxon Signed-Rank Test for Loss Aversion Coefficients in Experiment 3

| Routes | Scenario | Gain | Loss | $M$ (SD) | Positive Ranks |
|---|---|---|---|---|---|
| One | Money | | Two | 6.52 (16.95) | 3.190** |
| Three | Tax | | Two | 2.64 (3.36) | |

Note: **p* < 0.01, two-tailed. $M$ = mean, SD = standard deviation, Mdn = median.

The gain amount $x$ matching a 500-yuan loss was coded as a binary variable: $x \leq 500$ indicated no loss aversion, while $x > 500$ indicated loss aversion. Mixed-effects logistic regression on loss aversion occurrence (1 = loss aversion; 0 = no loss aversion), with scenario as a fixed effect (1 = win/lose; 0 = tax/refund) and participant as a random effect, revealed a significant scenario effect ($b = 1.44$, SE = 0.62, $z = 2.35$, $p = 0.019$, OR = 4.24), indicating that loss aversion was 4.24 times more likely in the win/lose scenario than in the tax/refund scenario.

## Experiment 4: Measuring Willingness to Participate

Experiments 1–3 measured loss aversion coefficients through fill-in-the-blank responses. Experiment 4 instead used a rating scale method, asking participants to report their willingness to participate (WTP) in the game. Lower WTP indicates stronger loss aversion. Participants rated their WTP on a 0–100 scale (0 = very unlikely, 100 = very likely), with responses constrained to this range to avoid extreme values. To ensure comprehension of the tax/refund scenario, we recruited working adults with tax experience rather than inexperienced undergraduates. To make the scenario more realistic and meaningful, we conducted a pilot survey of participants'annual tax payments and, based on results, increased the amount to 5000 yuan. Consistent with Experiments 2 and 3, Experiment 4 used a within-subjects design.

### 2.4.1 Participants

The target sample size matched Experiments 2 and 3. We recruited 77 working adults with tax experience through Wenjuanxing ($N$male = 33, $M$age = 29.77 $\pm$ 5.41 years).

### 2.4.2 Procedure

Experimental materials were adapted from previous experiments. Participants were presented with two hypothetical scenarios:

**Win/Lose Scenario (One-Route Gain vs. Two-Route Loss):**
*Imagine a coin toss game:*
*- If heads, you win 5000 yuan*
*- If tails, you lose 5000 yuan*
*Please indicate your willingness to participate:*
*Very unwilling (0) ———————— Very willing (100)*

**Tax/Refund Scenario (Three-Route Gain vs. Two-Route Loss):**
*Imagine a coin toss game:*
*- If heads, the government refunds you 5000 yuan*
*- If tails, you pay 5000 yuan in taxes*
*Please indicate your willingness to participate:*
*Very unwilling (0) ———————— Very willing (100)*

Participants were recruited and responded through Wenjuanxing' s sample service, completing the win/lose scenario first, followed by the tax/refund scenario. All participants signed electronic informed consent forms.

### 2.4.3 Results and Discussion

K–S tests indicated that WTP differences between scenarios were non-normally distributed ($Z$ = 0.137, $p$ = 0.001), so we used Wilcoxon signed-rank tests. Results showed significantly higher WTP in the tax/refund scenario than in the

win/lose scenario ($Z = 3.327$, $p = 0.001$). Mean WTP was approximately 50 in the tax/refund scenario, at the midpoint of the scale, indicating ambivalence about participation .

**TABLE:4** Wilcoxon Signed-Rank Test for Willingness to Participate in Experiment 4

| Routes | Scenario | Gain | Loss | *M* (SD) | Positive Ranks | Mean Rank |
|---|---|---|---|---|---|---|
| One | Money | | Two | 39.92 (26.77) | 40.00 | |
| Three | Tax | | Two | 50.55 (29.75) | 59.00 | |

Note: **p* < 0.01, two-tailed. *M* = mean, SD = standard deviation, Mdn = median. *Z* = 3.327**

WTP values were converted to a binary variable: values $< 50$ indicated loss aversion, values $> 50$ indicated no loss aversion, and values $= 50$ were excluded from analysis. Mixed-effects logistic regression on loss aversion occurrence (1 = loss aversion; 0 = no loss aversion), with scenario as a fixed effect (1 = win/lose; 0 = tax/refund) and participant as a random effect, revealed a significant scenario effect ($b = 1.29$, SE = 0.50, $z = 2.56$, $p = 0.011$, OR = 3.62), indicating that loss aversion was 3.62 times more likely in the win/lose scenario than in the tax/refund scenario.

Consistent with Liu et al. (2009) and Experiments 1-3, Experiment 4 found loss aversion in the win/lose scenario but not in the tax/refund scenario.

## 3. Mini Meta-Analysis

Given that the experiments used different samples (tax-inexperienced undergraduates vs. tax-experienced working adults), different measures (loss aversion coefficient vs. WTP), and different designs (between- vs. within-subjects), we conducted a mini meta-analysis to provide stronger evidence for the uneven route account. To combine effect sizes across designs, we converted within-subjects sample sizes to between-subjects equivalents using the formula:

$$d_{\mathrm{B}} = d_{\mathrm{W}} \sqrt{2(1 - r)}$$

where $r$ is the correlation between the two dependent variables across tax/refund and win/lose scenarios, $d$ is the effect size, B denotes between-subjects design, and W denotes within-subjects design (Morris & DeShon, 2002). Transformed sample sizes are shown in .

**TABLE:5** Original and Transformed Effect Sizes Across Four Experiments

| Experiment | Original $d$ | Transformed $d$ |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |

We used an Excel template to calculate meta-analytic effect sizes (Goh, Hall, & Rosenthal, 2016). Overall, the meta-analysis yielded a significant effect (mean $d = 0.33$, $Z = 4.555$, $p < 0.001$, two-tailed), indicating that loss aversion was more likely in the win/lose scenario than in the tax/refund scenario. Thus, the meta-analysis provides stronger evidence for the uneven route account.

## 4. General Discussion

The meta-analysis and four experiments consistently support Liu et al.' s (2009) uneven route explanation of loss aversion, demonstrating robust findings across progressively stricter conditions. The results are stable across different experimental designs (between- vs. within-subjects), samples (undergraduates vs. working adults), monetary magnitudes (small vs. large amounts), and measurement indices (loss aversion coefficient vs. WTP). These findings collectively demonstrate that manipulating the routes of monetary gains and losses can alter loss aversion behavior.

Through four experiments, we confirmed the reliability of the uneven route account. Experiment 1 directly replicated Liu et al. (2009) with supporting results. Experiment 2 replicated Experiment 1 using a within-subjects design, yielding consistent results. Experiment 3 introduced a more stringent condition by testing the magnitude effect, increasing the amount from 50 to 500 yuan, with results again aligning with previous experiments. Finally, Experiment 4 employed a more diverse measure, replicating the pattern observed in Experiments 1–3.

Loss aversion is considered a universal behavioral influence on individual decision-making. Our findings challenge the common assumption that equivalent losses consistently outweigh equivalent gains across contexts. Many studies have explored loss aversion' s underlying mechanisms, which can be categorized as (1) direct factors and (2) indirect factors.

Direct factors involve processes or emotions triggered by losses. Prospect theory exemplifies this approach, where gain and loss utility comprises subjective value and probability. Because prospect theory' s value function parameters vary across individuals, transformed values reflect subjective psychological rather than objective monetary value. Thus, loss aversion in prospect theory partly reflects affective properties, with parameter $l$ capturing both cognitive and emotional processes.

Indirect factors are caused by loss-related processes or emotions, which can be termed "overgeneralization," reflecting how past valuable experiences trigger loss aversion (Skinner, 1985; Ert & Erev, 2013). For example, the "lemon avoidance" hypothesis suggests people reject attractive mixed gambles due to aversion to problematic offers (Ert & Erev, 2008). Another perspective suggests loss aversion may reflect generalization of effective negotiation strategies that benefit from emphasizing losses and minimizing gains (Yechiam, Telpaz, & Hochman, 2014). The higher median loss aversion coefficient in win/lose scenarios could be explained by lemon avoidance and complaint bias, while the disappearance of loss aversion among tax-experienced participants in tax/refund scenarios may reflect overgeneralization. Future research should distinguish between overgeneralization and uneven route explanations.

We propose classifying the uneven route as another indirect factor. "Route" is defined as the number of transfers of the same ownership. In traditional scenarios, gains are typically one-route (from not having to having), while losses are two-route (adding a "from having to not having" process). Thus, loss aversion occurs because loss routes exceed gain routes, with more routes producing stronger psychological impact. In short, asymmetrical routes between gains and losses produce loss aversion. Although our experimental design was guided by the uneven route account, whether this mechanism represents a cognitive explanation or overgeneralization remains an open question. We hope this replication will attract more researchers to investigate which perspective better explains these data.

Why is loss aversion so robust and widely studied? We speculate that in models of risky and uncertain decision-making, "monetary value" has long served as a proxy for various possible outcomes $x$ (defining the basic utility function as value $v(x)$). This treatment of $x$ traces back to the concept of mathematical expectation (

$$EV = \sum p_i x_i$$

), first appearing in the work of Blaise Pascal and Christian Huygens, who applied it to Pascal' s wager on God' s existence (Jiang, Yang, Chen, & Li, 2018; Lopes, 1995). Since most real-world outcomes can be represented or measured monetarily, money appears to be an ideal proxy for possible outcomes. However, an essential feature of this universal currency is that people must first expend time, effort, and energy to acquire money before they can lose it. In other words, losing money is inherently a two-route process. This property of money provides the foundation for loss aversion and the shape of prospect theory's value function $v$ (Kahneman & Tversky, 1979; Tversky & Kahneman, 1992), where losses are steeper than gains. If certain outcomes (e.g., life, freedom, health) lack this asymmetry (i.e., one-route loss and two-route gain), loss aversion may not occur (Liu et al., 2009; Wilson, Arvai, & Arkes, 2008). For such outcomes, acquisition is innate rather than prerequisite for loss, making gain and loss processes symmetrical (one-route each). We therefore propose that if prospect theory' s outcomes $x$ were personal outcomes (e.g., life, freedom, health) rather

than monetary proxies, the value function $v$ would not be an asymmetrical S-shaped curve (steeper for losses), but rather a symmetrical curve. Recognizing this inherent property of money—its asymmetrical routes for gains and losses—may open an alternative pathway to demystifying loss aversion.

Indirect evidence supports our hypothesis that money' s asymmetrical routes cause loss aversion. Consumer behavior research shows that monetary pathways (cash vs. tokens) and income timing (before vs. after experiments) significantly influence money-splitting decisions (Li, 2002).

This paper offers a novel approach to explaining loss aversion. The uneven route account provides fresh perspective for loss aversion research, and we hope our findings will inform future investigations and guide further research on uneven routes.

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## References

Ariely, D., Huber, J., & Wertenbroch, K. (2005). When do losses loom larger than gains? *Journal of Marketing Research, 42*(2), 134–138.

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language, 59*(4), 390–412.

Bates, D., Mächler, M., Bolker, B. M., & Walker, S. C. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software, 67*(1), 1–48.

Bilgin, B. (2012). Losses loom more likely than gains: Propensity to imagine losses increases their subjective probability. *Organizational Behavior and Human Decision Processes, 118*(2), 203–215.

Boyce, C. J., Wood, A. M., & Ferguson, E. (2016). Individual differences in loss aversion: Conscientiousness predicts how life satisfaction responds to losses versus gains in income. *Personality and Social Psychology Bulletin, 42*(4), 471–484.

Camerer, C. F. (2005). Three cheers—psychological, theoretical, empirical—for loss aversion. *Journal of Marketing Research, 42*, 129–133.

Ert, E., & Erev, I. (2008). The rejection of attractive gambles, loss aversion, and the lemon avoidance heuristic. *Journal of Economic Psychology, 29*(5), 715–723.

Ert, E., & Erev, I. (2013). On the descriptive value of loss aversion in decisions under risk: Six clarifications. *Judgment and Decision Making, 8*(3), 214–235.

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences.* Behavior Research Methods, 39*(2), 175–191.

Fox, C. R., & Poldrack, R. A. (2014). Prospect theory and the brain. In P. Glimcher & E. Fehr (Eds.), *Neuroeconomics: Decision making and the brain* (2nd ed., pp. 533–568). London, UK: Elsevier.

Frisch, D. (1993). Reasons for framing effects. *Organizational Behavior and Human Decision Processes, 54*(3), 399–429.

Harinck, F., Van Dijk, E., Van Beest, I., & Mersmann, P. (2007). When gains loom larger than losses: Reversed loss aversion for small amounts of money. *Psychological Science, 18*, 1099–1105.

Jiang, C.-M., Yang, S.-W., Chen, J.-F., & Li, S. (2018). Believing in God or not: The explanations from analytic and heuristic decision models. *Journal of Dialectics of Nature, 40*(10), 23–31.

Judd, C. M., Westfall, J., & Kenny, D. A. (2012). Treating stimuli as a random factor in social psychology: A new and comprehensive solution to a pervasive but largely ignored problem. *Journal of Personality and Social Psychology, 103*(1), 54–69.

Gaechter, S., Johnson, E. J., & Herrmann, A. (2007). Individual-level loss aversion in riskless and risky choices. *Social Science Electronic Publishing, 1*(2), 37–39.

Gal, D. (2006). A psychological law of inertia and the illusion of loss aversion. *Judgment and Decision Making, 1*(1), 23–32.

Glass, G. V., McGaw, B., & Smith, M. L. (1981). *Meta-analysis in social research.* Beverly Hills, CA: Sage.

Glöckner, A., & Pachur, T. (2012). Cognitive models of risky choice: Parameter stability and predictive accuracy of prospect theory. *Cognition, 123*(1), 21–32.

Goh, J. X., Hall, J. A., & Rosenthal, R. (2016). Mini meta-analysis of your own studies: Some arguments on why and a primer on how. *Social and Personality Psychology Compass, 10*(10), 535–549.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision making under risk. *Econometrica, 47*(2), 140–170.

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2017). lmerTest package: Tests in linear mixed effects models. *Journal of Statistical Software,*

*82*(13), 1-26.

Levin, I. P., Johnson, R. D., & Davis, M. L. (1987). How information frame influences risky decisions: Between-subjects and within-subject comparisons. *Journal of Economic Psychology, 8*(1), 43-54.

Li, S. (2002). Do money-earning time and money-exchanging route matter? *Psychology and Marketing, 19*(9), 777-782.

Li, X. (2015). Is loss aversion due to the routes of loss more than gain? *Journal of Psychological Science, 38*(2), 394-399.

Liberman, N., Idson, L. C., & Higgins, E. T. (2005). Predicting the intensity of losses vs. non-gains and non-losses vs. gains in judging fairness and value: A test of the loss aversion explanation. *Journal of Experimental Social Psychology, 41*(5), 527-534.

Liu, H., Liang, Z.-Y., & Li, S. (2009). Is loss aversion a robust effect? An uneven route of seeing that losses loom larger than the same amount of gains. *Acta Psychologica Sinica, 41*(12), 1123-1132.

Liu, H., Sui, X.-Y., Huang, Y.-N., Lin, R.-P., & Xu, M.-X. (2019). The nudging role of behavioral economics in retirement savings decisions: Current situation and future prospects. *Advances in Psychological Science, 27*(3), 418-428.

Lopes, L. L. (1995). Algebra and process in the modeling of risky choice. *Psychology of Learning and Motivation, 32*, 177-220.

Morris, S. B., & DeShon, R. P. (2002). Combining effect size estimates in meta-analysis with repeated measures and independent-groups designs. *Psychological Methods, 7*(1), 105-125.

Rick, S. (2010). Losses, gains, and brains: Neuroeconomics can help to answer open questions about loss aversion. *Journal of Consumer Psychology, 21*(4), 453-463.

Schmidt, U., & Zank, H. (2005). What is loss aversion? *Journal of Risk and Uncertainty, 30*(2), 157-167.

Simonsohn, U. (2015). Small telescopes: Detectability and the evaluation of replication results. *Psychological Science, 26*(5), 559-569.

Skinner, B. F. (1985). Cognitive science and behaviourism. *British Journal of Psychology, 76*(3), 291-301.

Sokol-Hessner, P., Lackovic, S. F., Tobe, R. H., Camerer, C. F., Leventhal, B. L., & Phelps, E. A. (2015). Determinants of propranolol' s selective effect on loss aversion. *Psychological Science, 26*(7), 1123-1130.

Stanovich, K. E., & West, R. F. (1998). Individual differences in framing and conjunction effects. *Thinking & Reasoning, 4*(4), 289-317.

Thaler, R. H., & Benartzi, S. (2004). Save More Tomorrow™: Using behavioral economics to increase employee saving. *Journal of Political Economy, 112*(S1), S154–S187.

Tversky, A., & Kahneman, D. (1992). Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and Uncertainty, 5*(4), 297–323.

Wang, X. T., Ong, L. S., & Tan, J. H. (2015). Sense and sensibility of ownership: Effects of ownership experience on valuation of goods. *Journal of Behavioral and Experimental Economics, 58*, 171–177.

Wilson, R. S., Arvai, J. L., & Arkes, H. R. (2008). My loss is your loss··· sometimes: Loss aversion and the effect of motivational biases. *Risk Analysis: An International Journal, 28*(4), 929–938.

Yechiam, E., Telpaz, A., & Hochman, G. (2014). The complaint bias in subjective evaluations of incentives. *Decision, 1*(2), 147–160.

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