

*Experimental Evidence and an Interpretation from Regret Aversion and Zero Aversion***Sebastian Visotsky**

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Abstract

We replicate the two classic choices of the Allais paradox in a randomized survey that manipulates only the framing of the probabilities: one group saw them as percentages, the other as outcomes of a two-digit lottery draw (00–99). The paradoxical pattern appears in full force under the percentage framing but is markedly attenuated when the same probabilities are presented as identifiable numeric events. The shift in preference for the safe option between Problem 1 and Problem 2 is –39 percentage points under percentages versus –12 under numbers; the difference between the two shifts is significant (difference-in-differences $z = 2.34$, $p = 0.019$; logistic interaction $p = 0.032$). We read the result through regret theory and through the certainty-vs-zero-aversion debate: making the states of the world identifiable changes both the anticipated regret attached to each option and the salience of the zero outcome, and thereby the strength of the certainty effect that sustains the paradox. We discuss the direction of the effect, competing accounts (probability weighting, event-splitting, and aversion to zero), and a design capable of isolating the mechanism.

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Introduction

The Allais paradox Allais, is one of the best-documented violations of expected utility theory [1]. In its canonical form, the subject chooses twice:

- **Problem 1.** Option 1A: receive \$1M with probability 100%. Option 1B: receive \$1M with probability 89%, \$5M with 10%, or nothing with 1%.
- **Problem 2.** Option 2A: receive \$1M with probability of 11%, or nothing with 89%. Option 2B: receive \$5M with probability 10%, or nothing with 90%.

Expected utility implies that anyone who prefers 1A must also prefer 2A (the two pairs differ only in a common consequence of \$1M with probability 89%, which cancels out). Yet the modal observed pattern is 1A and 2B: the certainty of the million dominates in Problem 1 but loses its appeal in Problem 2, where no option is safe. This “certainty effect” is central to prospect theory Kahneman & Tversky, and to non-expected-utility theories of choice [2,3].

A feature rarely examined in the standard teaching of the problem is that it is always stated in abstract percentages. This paper asks whether the paradox is robust to the framing of uncertainty: do people respond the same way when the same probabilities are presented as concrete, identifiable events a lottery number as when they are presented as percentages? Two behavioral accounts motivate the study. First, regret aversion Loomes & Sugden; Bell: if states of the world are identifiable, the anticipated regret each option generates differs, which should modify the strength of the certainty effect [4,5]. Second, a debate about the very source of the paradox whether it stems from the appeal of certainty or from aversion to the zero outcome Incekara-Hafalir, Kim & Stecher, to which our manipulation speaks directly, since the number framing changes how concrete the “nothing” state is [6].

Hypotheses

Regret theory Loomes & Sugden ; Bell, holds that the decision-maker does not evaluate each option in isolation but anticipates, state by state, the regret (or rejoicing) of comparing the outcome obtained with the one that the rejected option would have yielded [4,5]. More intense or more vivid anticipated regret makes the option producing it less attractive.

Our conjecture is that the number framing makes states identifiable and thereby sharpens the anticipated regret tied to concrete outcomes, whereas the percentage framing dilutes it: under “1% probability of winning nothing,” a loss cannot be attributed to any particular state; especially in game 2 where that 1% is mixed into 11%. In case of losing, we don't know for sure if it was the fault of the 1% or the remaining 10%. Under “if 89 comes up you win nothing,” the loss is anchored to a single, perfectly identifiable number.

The direction of the effect on the paradox depends on which option the sharpened regret falls upon. We state the hypothesis in the form consistent with the evidence (Section 4):

H1. Under the number framing, making the small forgone prize of the safe option identifiable choosing the sure thing and seeing a number from the range that paid the large prize and making the 1% sliver feel negligible (“it’s just 89”) reduces the premium the subject pays for certainty. Consequently, the certainty effect that sustains the Allais paradox is weaker under the number framing than under the percentage framing

A note on directions. An alternative and intuitive statement of the same mechanism that the loss state of the gamble, once identifiable (“89 comes up, and it was my decision that cost me the sure million”), generates more regret would predict the opposite: greater aversion to gambling and therefore a stronger certainty effect under numbers. The data does not support that direction. We return to this tension in the Discussion.

Design and Data

An online form was administered. Participants were randomly assigned to one of two framings and answered the Allais-type choices. In the “percentage” framing, probabilities were stated numerically as percentages; in the “number” framing, they were stated as ranges of a mathematically equivalent two-digit lottery draw (00–99) e.g., “00 to 88 you win \$1M, if 89 comes up you win nothing, 90 to 99 you win \$5M” equals 89% / 1% / 10%. The design is between-subjects. Sample sizes differ across problems within each framing (Table 1), indicating that the two problems were answered by different (sub)samples; they are therefore analyzed as independent groups, and individual-level reversal rates (the paradoxical 1A $\wedge$ 2B pattern per person) cannot be

computed. In each problem, “Option A” denotes the safer alternative (lower variance): certainty in Problem 1 and the higher-probability / lower-prize lottery in Problem 2.

Table 1: Distribution of responses by problem and framing. A = safer option.

Problem	Framing	% chose A	% chose B	n
1 (safe option)	Percentage	66.3 (106)	33.8 (54)	160
1 (safe option)	Number	40.9 (18)	59.1 (26)	44
2 (no safe option)	Percentage	27.1 (29)	72.9 (78)	107
2 (no safe option)	Number	29.3 (12)	70.7 (29)	41

Results

The framing effect is localized in Problem 1. Comparing the internal A/B distribution between framings within each problem: in Problem 1 the distribution changes sharply and significantly ($\chi^2(1) = 8.26$, $p = 0.004$; Cramér's $V = 0.20$) under percentages most choose the safe option (66%), while under numbers most switch to the gamble (59%). In Problem 2 the two distributions are practically identical (27% vs. 29%; $\chi^2(1) = 0.003$, $p = 0.95$). Framing matters precisely where a safe option is at stake. The paradox is stronger under percentages. The Allais paradox is, in essence, the shift in preference for the safe option in moving from Problem 1 to Problem 2. That shift (Figure 1) is $66.3 \rightarrow 27.1$, i.e. -39 points, under percentages, and only $40.9 \rightarrow 29.3$, i.e. -12 points, under numbers. In odds-ratio terms, the shift is 5.28 under percentages versus 1.67 under numbers. The difference between the shifts is significant. The difference between the two shifts (the Problem $\times$ Framing interaction) is 27.5 percentage points. A difference-in-differences contrast over the four independent groups yields $z = 2.34$ ($p = 0.019$); a logistic regression with the interaction term confirms it ($p = 0.032$; the odds of the shift are 3.16 times larger under percentages). The certainty effect that produces the paradox is thus more than three times as strong when uncertainty is presented in percentages.

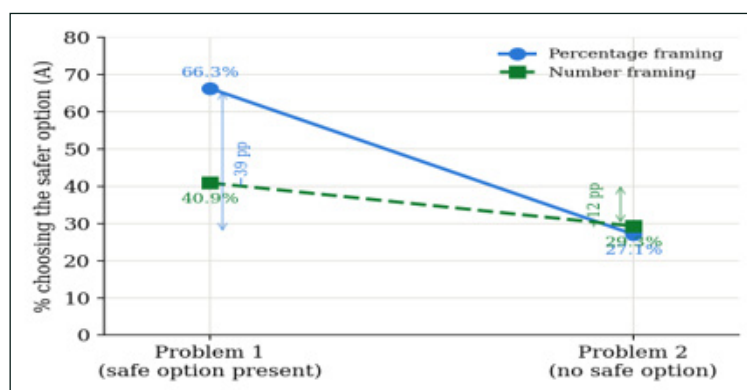


Figure 1: Preference for the safer option (A) from Problem 1 to Problem 2. The steep slope of the percentage framing is the classic certainty effect; under the number framing the drop is far smaller. The difference in slopes is the effect of interest.

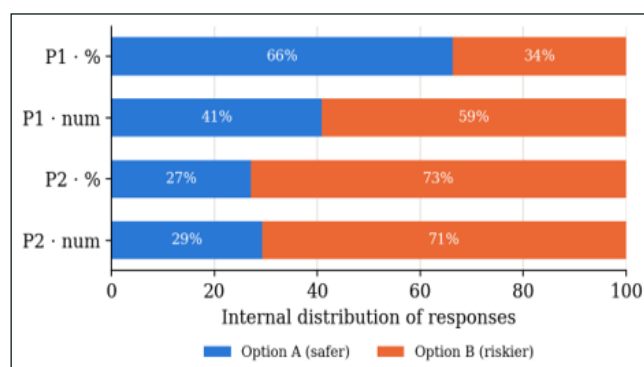


Figure 2: Internal A/B split across the four design cells. The Problem-1 bars are nearly mirror images across

framings; the Problem-2 bars are equivalent.

Discussion

The data show that the Allais paradox is not invariant to how probabilities are presented: it appears in full under percentages and is attenuated when the same numbers are translated into identifiable lottery events. The effect concentrates in Problem 1, where a safe option exists; in Problem 2, with no certainty at stake, framing is irrelevant. This is consistent with the affected channel being specifically the certainty effect.

Reading through regret. Under regret theory, the appeal of the safe option in Problem 1 can be read as avoidance of the regret of having gambled and lost the million ones had secured. Our conjecture is that making states identifiable reconfigures that regret. The evidence indicates that, under the number framing, certainty loses appeal. A coherent account is that identifying the large forgone prize under the safe choice (choosing safe and seeing a number in the 90–99 range, “I could have won \$5M”) generates vivid regret that pushes toward the gamble; and, symmetrically, that expressing the risk as “just the number 89” makes it psychologically negligible, reducing the certainty premium.

Appeal of certainty or aversion to zero? Incekara-Hafalir, Kim & Stecher argue that the Allais paradox may be driven not by the appeal of certainty per se but by aversion to the zero outcome the sheer possibility of walking away with nothing [6]. The two accounts are hard to separate in the canonical problem, because Option 1B introduces both a departure from certainty and a chance of zero that Option 1A lacks. Our manipulation is informative here: the number framing leaves the probability of zero untouched but changes how concrete that zero state is. Under numbers, the “nothing” outcome becomes a single identifiable event (“only if 89 comes up”), which appears to blunt its threat and make subjects more willing to accept the gamble in Problem 1. Read this way, our result offers indirect support for the zero-aversion account: attenuating the salience of the zero state not removing certainty is what moves choices. Regret over the forgone large prize and reduced aversion to a now-concrete zero are complementary rather than rival readings; both predict the observed weakening of the certainty effect under numbers.

The direction tension. To be explicit: the initial intuition that the gamble’s loss state, once identifiable, generates more regret predicts greater aversion to gambling and hence a stronger certainty effect under numbers. The data point the other way. Regret aversion remains a plausible frame, but the mechanism must specify that the identifiable regret operates on the forgone prize of the safe option or that concretizing the 1% sliver minimizes it rather than on the gamble’s loss. Distinguishing these channels is an open empirical question.

Other complementary accounts. Prospect theory Kahneman & Tversky, overweights small probabilities: an abstract “1%” may loom larger than “the number 89,” perceived as one case in a hundred and nearly harmless; under this reading the number framing corrects the weighting distortion rather than altering regret [2]. Separately, presenting split ranges decomposes events that appear aggregated in percentages, and the event-splitting literature documents that splitting or coalescing states systematically shifts choices even with identical probabilities. The current design cannot discriminate among these channels: all of them predict an attenuated certainty effect under the concrete framing.

Limitations

Four cautions. First, the number arms are small ($n = 44$ and 41); although the interaction contrast is significant, power is moderate and confidence intervals are wide. Second, the design is between-subjects with unequal n across problems, so individual reversal rates (the 1A $\wedge$ 2B pattern) the most direct metric of the paradox cannot be estimated. Third, counts were reconstructed from rounded percentages and should be confirmed against the raw data. Fourth, the decision is hypothetical (no real monetary incentives) and the sample comes from a single convenience population; both limit external validity.

Conclusion and Future Work

The Allais paradox depends on framing: it is robust in percentages and fragile in concrete numbers. The difference is statistically significant and localizes exactly in the choice involving a safe option, pointing to the certainty effect as the affected mechanism. Both regret aversion and aversion to zero offer coherent lenses, provided the channel is specified in the direction the data support.

To isolate the mechanism we propose: (i) a within-subject design that permits measuring individual reversals; (ii) explicitly manipulating the resolution of uncertainty (whether or not the subject is told which number came up and what would have happened under the other option), since regret requires counterfactual feedback; (iii) directly eliciting anticipated regret in each state; and (iv) independently varying the probability of zero and the concreteness of the zero state, following Incekara-Hafalir, Kim & Stecher, to separate certainty appeal from zero aversion [7]. Comparing the number framing with and without resolution would separate the regret channel from the probability-weighting channel.

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