# Exploring the Fourfold Pattern Through the Lens of Fuzzy Trace Theory

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## ABSTRACT

**The fourfold pattern of risk attitudes is a phenomenon which addresses individuals' decisions with respect to probabilities of losses and gains. According to Cumulative Prospect Theory (CPT) [1], individuals become more risk seeking in decisions involving losses and risk averse in decisions involving gains when the respective probabilities are moderate/high. These risk attitudes are reversed when the probabilities are low: risk aversion in losses, risk seeking in gains. CPT explains this effect by arguing that individuals distort probability estimates by overweighting low probabilities while underweighting moderate to high probabilities. Fuzzy Trace Theory (FTT) [2] offers an alternative account, predicting that the fourfold pattern of risk attitudes is mediated by individuals' mental representations. We run the first critical test between CPT and FTT on the stimuli hypothesized to cause the fourfold pattern of risk attitudes. The present work provides evidence that risky choices are mediated by reliance on gist mental representations, metacognitive intercession, and reward sensitivity, supporting FTT's account of decision under risk.**

## BACKGROUND

- **Cumulative Prospect Theory [1]**
  - Moderate and high probabilities (p>=.5) are underweighted. This leads to the framing effect—a risk aversion in gains and a risk seeking in losses [3,4].
  - Low probabilities (p<.1) are overweighted. This leads to the reversal in the framing effect—a risk seeking in gains and risk aversion in losses.

**The Fourfold Pattern of Risk Attitudes [1,5]**

| | GAIN | LOSS |
|---|---|---|
| **HIGH PROBABILITY** | **95% chance to win 10,000 RISK AVERSE** | **95% chance to lose 10,000 RISK SEEKING** |
| **LOW PROBABILITY** | **5% chance to win 10,000 RISK SEEKING** | **5% chance to lose 10,000 RISK AVERSE** |

- **Fuzzy Trace Theory [2]**

**An example of FTT's mental representations for the standard risky choice problem (preferred outcome is underlined)**

| Option | Categorical gist | Ordinal gist | Interval gist |
|---|---|---|---|
| **Sure option:** 500 people saved for sure. | Some chance that some are saved. | More chance that fewer saved. | 500 are saved. |
| **Risky option:** 5% probability 10,000 people saved and 95% probability no one saved. | Some chance that some are saved and some chance that none are saved. | Less chance that more are saved and some chance that none are saved. | 500 are saved. |

## METHOD AND MATERIAL

**CRITICAL TEST**
- CPT: Probabilities weighted regardless of mental representations.
- FTT: Risk attitudes are meditated by mental representations.

**Truncation: manipulating mental representations [6,7]**
- Zero or nonzero components are truncated.
- Ex: 5% probability that 10,000 people are saved (nonzero component) and 95% probability that no one is saved (zero component).

| Truncation condition | Decision options with their corresponding gist representations* | Predicted change in risk attitudes |
|---|---|---|
| Zero truncated | A) 9500 people saved for sure. **(Some chance that some are saved).** B) 95% probability 10,000 people saved. **(Some chance that some are saved).** | ↑ Increase in risky choice** |
| Nonzero truncated | A) 9500 people saved for sure. **(Some chance that some are saved).** B) 95% probability no one saved. **(Some chance that none are saved).** | ↓ Decrease in risky choice** |

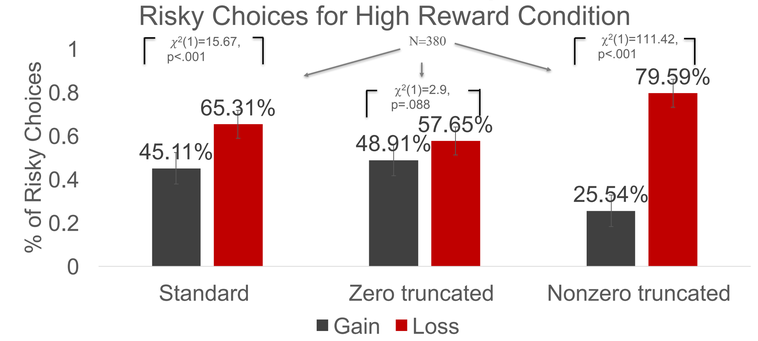
*Figure.* An example of the changes in mental representations with respect to the truncation conditions
*In this column, underlined text shows the predicted choice by FTT and the text in bold shows corresponding gist representations.
** Compared to the standard condition baseline.

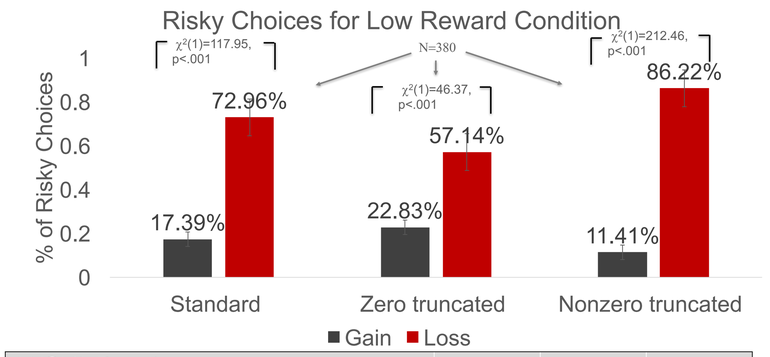
- **EXPERIMENTAL MANIPULATIONS:**
  - **Between subject:** 2 Frames (Gain/Loss) x
  - **Within subjects**: 2 Reward conditions✧ (9500/500) x 3 Truncation conditions (standard/zero-truncated/nonzero-truncated)
    - 4 replications (different risky choice framing scenarios) selected at random without replacement for a set of 24 ✧✧
- **RESPONSE VARIABLE:** Average number of risky choices of 4 replications✧✧✧
- **COVARIATES:** Risk perception items, and individual differences
  - 4 items measuring gist with binary choice options (Yes/No).
    - "*In the questions that you saw in this survey did you consider …*"
      Gist #1*: "… 5% to be nil (basically nothing)"*
      Gist #2: *"… 95% to be virtually certain?"*
      Gist #3: *"… 9500 and 10,000 to be essentially the same?"*
      Gist #4: *"... 500 to be essentially nil, compared to 10,000?"*
  - Individual differences that affect risk attitudes: Scales for Numeracy [8][a] ,Need For Cognition [9] [b], and Reward Sensitivity [10] (Sensation Seeking [11])[c]
- **SAMPLE:** 95 subjects recruited with Amazon Mechanical Turk, and given a survey designed on Qualtrics. ✧✧✧✧

✧ Reward and probability vary systematically with one another and are therefore interchangeable -- a gain of 10,000 with 5% probability is an expected reward of 500, a gain of 10,000 with a 95% probability is an expected reward of 9,500, etc. Therefore, high reward is the high probability of gains or low probability of losses, and low reward is the low probability of gains or high probability of losses.
✧✧ Replications were counterbalanced.
✧✧✧ Risky choice is coded as 1 and certain choice is coded as 0.
✧✧✧✧✧ 46 subjects were randomly assigned to the gain frame, and 49 subjects were randomly assigned to the loss frame.
[a] Numeracy attenuates the framing effect [12].
[b] Need For Cognition attenuates the framing effect within subjects [13].
[c] Sensation Seeking increases risk taking for high rewards [14].

## RESULTS

**Observed Choice Frequencies**




| *ANOVA Results* | | | |
|---|---|---|---|
| Main experimental conditions | df | Sum Sq | F value |
| Truncation | 2 | 0.006 | 1.01 |
| Reward | 1 | 0.070 | 21.42*** |
| Frame | 1 | 0.673 | 205.07*** |
| Truncation x Reward | 2 | 0.003 | 0.535 |
| Truncation x Frame | 2 | 0.124 | 18.81*** |
| Reward x Frame | 1 | 0.032 | 9.81** |
| Truncation x Reward x Frame | 2 | 0.006 | 0.95 |
| Residuals | 558 | 1.833 | |
| *Note.* ** p<.01, *** p<.001 | | | |

- Second ANOVA conducted with interactions of all covariates.
- Significant results are all replicated.
- Additionally found significant effects of gist of low probability (F=22.19,p<.001), gist of high probability (F=127.91, p<.001), gist of high reward interacting with reward level (F=55.96, p<.001), reward and frame (F=25.25, p<.001), gist of high reward with frame (F=17.58, p<.001), and gist of low reward with frame (F= 20.93, p<.001).
- Also observed effects of Numeracy (F=15.17, p<.001), NFC interacting with Numeracy (F=10.06, p<.01), and SS interacting with reward (F=12.65, p<.001). These p values are not significant after controlling for multiple comparisons using the Holm-Bonferroni procedure.

## DISCUSSION

- **Results support FTT over CPT.**
- **Manipulating gist (truncation) changes risk attitudes.**
  - **Verified by self-reported gist.**
- **Future work will test a wider range of probability and reward levels with truncation conditions.**

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