

# Re-examination of reflection effect under Bayesian decision model

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**Abstract:** Individuals use heuristics to make decisions or solve problems when faced with complex situations, and currently known heuristics can only explain limited human decision-making behaviors. Anchoring strategy is a decision-making strategy proposed by Kahneman and Tversky. It is a strategy used by decision-makers when the decision-making target is beyond the decision-maker's judgment distance. It can be used to explain the reflection effect and loss aversion effect. On the basis of this hypothesis, this study attempts to further test this hypothesis with a Bayesian model. In order to examine whether people use anchoring strategies in reflex effect and loss aversion situations, this study, based on Bayesian decision model, treats anchoring strategies that follow the principle of mean reversion as the world state  $S$  related to the decision maker's action  $A$ , in the case of excluding the conditional probability of this state, observe whether the reflex effect and loss aversion effect are still contrary to the expected utility under the rational person hypothesis, so as to test whether people use the anchoring strategy. For this reason, in Experiment 1, we use rationality and profit and loss scenarios (loss/gain) as independent variables of the study to test that the subjective probability of the participants is different from the objective probability. The results show that the main effect of rationality is significant, the main effect of profit and loss situation is significant, and there is a significant interaction between the two. In experiment 2, we re-examined the reflection effect using a Bayesian model. By introducing the calculation method of subjective probability, the research results confirm that mean reversion as an explanation for the reflection effect has utility.

**Keywords:** Anchoring strategy; Bayesian model; Reflect effect; Decision-making; Mean reversion

## 1. Instruction

In descriptive decision-making, will decision-makers be influenced by default decision-making information other than prior knowledge that previous studies have not focused on when faced with risky decisions in situations where options are far away from themselves? This study assumes that decision makers will be affected by decision information other than prior knowledge, and by controlling the presence or absence of default decision information<sup>[1]</sup>, a Bayesian model is established to examine whether the optimal decision result changes. By confirming that decision makers rely on the default decision prospect theory and information to make decisions under the Bayesian model<sup>[2]</sup>, it provides support for the existence of anchoring strategies, and further corrects the defects in the description of reflection effects and loss aversion in prospect theory.

### 1.1. Anchoring Strategy and Prospect Theory

Two of the most famous phenomena proposed by prospect theory, namely reflection effect and loss aversion, Kahneman established a value function and a weight function, trying to describe these two phenomena in terms of gain and loss relative to a reference point<sup>[3][4]</sup>. Numerous studies have attempted to explore the causes of reflex effects and loss aversion, and the anchoring hypothesis provides an explanation from a particular perspective. The hypothesis holds that in descriptive decision-making, when the decision maker decides that the information he knows is not enough to make a decision, a heuristic of social adaptation will be used, and such a decision-making method is called anchoring strategy<sup>[5]</sup>. The study pointed out that in the two scenarios of loss and gain outlined by prospect theory, people used anchoring strategies, which led to the occurrence of reflex effects. as follows:

a) You would prefer to choose:

Must get 3000 yuan

80% chance to get 4000 yuan

b) You would prefer to choose:

3000 yuan must be lost

80% chance of losing 4,000 yuan

Gigerenzer believes that probability is not a form that can be smoothly understood by people in life, so it is not suitable for most people as a reliable clue [6].

When this cue is ambiguous, decision makers employ anchoring strategies. In the face of the above situation, decision makers will be based on the principle of mean reversion: that is, when changes beyond the subject's understanding occur, the subject will tend to falsify the propensity for such changes to occur<sup>[7]</sup>.

This study uses a Bayesian decision model to test the existence of mean reversion, and examines the influence of anchor effects on decision-making results by separating the descriptive information (prior probability) and anchor effect (posterior probability) in the traditional paradigm<sup>[8][9]</sup>. The experimental method is to add an experiment based on the classical paradigm, in which the subjects are guided to use the anchoring strategy, and report the probability of guessing, observe whether the subjective probability is significantly different from the described probability, and observe the selection risk in the decision result. Proportion of decision makers for options and safety options.

The research hypothesizes that the proportion of decision makers who choose the risky option and the safe option can be explained by the expected utility under subjective probability, that is, the expected utility of the safe option under the subjective probability is greater than the expected utility value of the risky option.

Study 1 assumes that the biased information  $P(B)$  of the anchor effect exists, that is, the probability  $P(A)$  in the descriptive information is significantly different from the subjective probability  $P(A|B)$ .

Study 2 assumes that the expected utility values ( $E(P)$ ,  $E(Q)$ ) of risk options and safety options under subjective probability match the decision-making results of the subjects, that is,  $E(P) < E(Q)$ ,  $N(P) < N(Q)$ .

## 2. Method

### 2.1. Experiment 1: the effect of descriptive reasonableness on mean reversion

#### 2.1.1. Purpose of experiment

Test the hypothesis of mean reversion and explore how descriptive plausibility affects its effect size.

#### 2.1.2. Participants

We recruit 100 college students from Tianjin Normal University, include 52 men and 48 women. They have normal or corrected-to-normal vision, are native Chinese speakers, and receive a small payment for participating in the experiment.

#### 2.1.3. Experimental design and procedure

The experiment uses a self-made scale to answer the test online. The test adopts a 2X3 within-subject design, in which the situational factor 1 has two levels: loss and gain, and the situational factor 2 has three levels: very reasonable, a bit reasonable, and unreasonable.

The experiment requires the subjects to complete the test online. Each completed subject will test the validity of the corresponding numbered scale returned, and will be rewarded accordingly after passing the test to ensure the quality of the answers to the scale.

#### 2.1.4. Experimental materials

The self-compiled scale "Confidence and Bias Scale for Descriptive Decision-Making" has a total of 20 items. In the pre-compiled scale, a small number of subjects are used to score the reasonableness of the descriptive information on five points. The three levels of "somewhat reasonable" and "unreasonable" contain 8, 7, and 5 items respectively, and their Cronbach's alpha value exceeds 0.8. Among the 20 items, 10 items are loss scenarios, and 10 items are gain scenarios. . At the same time, in order to balance the bias of choice, the scale contains 10 positive question items and 10 reverse

question items.

Examples are as follows:

"When you are a guest at your neighbor's house, you break the blue-and-white porcelain of your neighbor's house, and you have a 50% probability of compensation for 4,100 yuan." You guess that the probability of your actual compensation is higher than 50%/equal to 50%/lower than 50%."

Experimental expectations:

First, we assume that the disbelief effect exists, that is, the degree of inconsistency between the guesses and the objective description probabilities exceeds the misselect rate. Second, the confidence we want to measure is biased confidence, that is, we expect that in the gain scenario X positive question and the loss scenario X positive question, the number of people who guessed the result "below 50%" was significantly higher than the guess The result is "above 50%"; and in the reverse question, the number of guessing results "above 50%" is significantly higher than that of guessing results "below 50%". With biased confidence, the calculated subjective probability is less than 50%.

**2.1.5. Experimental results**

In terms of overall selection, the degree of guessing "above" is significantly higher than the degree of guessing "below". Due to the pre-balancing, this bias cannot be reasonably explained here.

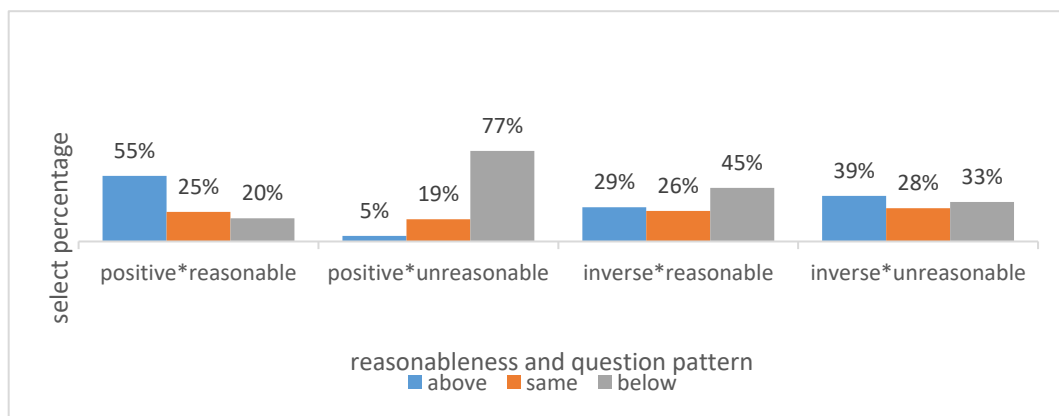
The result analysis shows that the main effect of rationality is significant  $F(2,5)=3.029$ , and the main effect of profit and loss is significant  $F(1,5)=8.633$ .

We can see from the table that if we combine forward questioning and reverse questioning (reverse questioning and reverse scoring), in a reasonable situation in the acquisition situation, the number of people who guess "above" is significantly more than "above" In the unreasonable situation in the obtained situation, the number of people who guessed below is significantly more than the number of "above", that is, there is a biased belief  $H>1$ . In all situations in the loss situation, the number of people who guessed "above" was significantly more than the number of people who guessed "below", that is, the biased belief  $H<1$ ; in the loss situation, the rationality effect was not significant.

In the case of introducing the covariate "questioning style" and ignoring the profit and loss, we can see that the interaction between the questioning style and the rationality is significant, that is, in the positive questioning, the subjects' biased belief  $H>1$  under reasonable circumstances; unreasonable case  $H < 1$ . In the reverse question, although a reversal occurred, the confidence bias was not significant.

*Table 1: Guess results of gain and loss under different reasonableness in Experiment 1.*

		Gain situation			Loss situation		
		above	same	below	above	same	below
Reasonableness	reasonable	37	33	26	92	32	36
	general reasonable	41	23	64	42	32	22
	unreasonable	7	22	67	28	17	19



*Figure 1: The effect of reasonableness and questioning style on confidence bias.*

### 2.1.6. Discussion of Experiment 1

This experiment uses biased trust to measure decision makers' selective trust in descriptive information. The experimental results support the hypothesis that unreasonable descriptive information will lead decision makers to believe that the subjective probability of an event occurrence is lower than the descriptive probability, that is, mean reversion occurs. Reasonable information does not lead to mean reversion.

In the gain situation, the experiment was as expected, but in the loss situation, the experimental results were not as expected, possibly because the question statement in the loss situation was not clear enough<sup>[10]</sup>.

## 2.2. Experiment 2: Re-examination of reflection effect under subjective probability

### 2.2.1. Experimental purpose

Test whether the reflection effect exists in the context of Chinese culture, and explore whether the reflection effect can be explained by the expected utility theory under the subjective probability.

### 2.2.2. Participants

The subjects were the same as in Experiment 1.

### 2.2.3. Experimental design and procedure

This experiment is the same as the classic paradigm of reflection effects, describing expectations and probability changes

"You prefer to choose:

Must get 2,000 yuan.

50% probability of getting 4,100 yuan, 50% probability of not getting it".

Participants were asked to make decisions through an online quiz.

### 2.2.4. Experimental results

Question 1:

A. Certainly get 2,000 yuan, B. 50% chance of getting 4,100 yuan, 50% chance of not getting

N=35 [71]\*\* [29]

Question 2:

C. A certain loss of 2,000 yuan, D. 50% chance of losing 4,100 yuan, 50% chance of not losing

N=35[41][59]\*

According to the chi-square test, the effect was significant in the gain context ( $\chi^2=61.70$ ,  $p<0.01$ ), and the effect in the loss context was also significant ( $\chi^2=9.21$ ,  $p=0.03$ ).

According to the results of Experiment 1, for the biased belief in the unreasonable situation, H is 0.375 in the acquisition situation, that is, the probability of mean reversion is  $P(B)=1-0.375=0.625$ . According to the Bayesian formula, we can first find that when people face the acquisition situation in the unreasonable situation, the probability of the individual's estimated acquisition occurrence is  $0.68*0.5=0.34$ .

$$P(A|B)=0.311$$

Therefore, the utility value of the risk option under subjective probability can be calculated  $E(Q)=P(A|B)*4100=1275$

It can be known that  $E(Q)<E(P)$

According to the results of experiment 2, in the acquisition context,  $N(P)>N(Q)$ , which does not match the utility.

In the loss scenario, the biased belief  $H=1.141$  in the unreasonable scenario,

$$P(C|D)=0.571$$

Calculate the risk option utility in the loss scenario  $E(Q2)=P(C|D)*4100=2340$

That is,  $E(Q2)<E(P2)$ ,

According to the results of Experiment 2, in the loss scenario,  $N(P2) < N(Q2)$ , which matches the utility.

### 2.2.5. Discussion of Experiment 2

Experiment 2 is to confirm that people's risk decisions are in line with expected utility theory in the case of subjective probability decision-making. However, the experimental results support this theory only in the gain domain, with no results consistent with expected utility in the loss domain. And the reflection effect in experiment 2 is also not significant in the loss field. Combined with the fact that the main effect was not significant in the loss scenario in Experiment 1, it can be speculated that it is possible that under a 50% probability decision, the reflex effect itself is not significant - which is also consistent with the results of earlier studies.

The effects that emerge in the gain context suggest that mean-reversion models can provide an explanation for the phenomenon of reflex effects that differs from "people tend to overestimate certain options in the face of gains and underestimate options in the face of losses.<sup>[5]</sup>" Certain options." The study demonstrated that this tendency is actually caused by the inconsistency of subjective and objective probabilities.

## 3. General discussion

By establishing a Bayesian model, this study confirms that in the acquisition context, people do not believe in the probability in the descriptive information in the descriptive decision-making process with insufficient description, but deviate from the rules of the game, and establish a subjective probability through adaptability. , to make a decision - using mean-reversion anchoring strategies. This is different from the explanation of the same phenomenon by prospect theory, which emphasizes that individuals give probabilities different weights, while this hypothesis takes into account the difference between the subjective and objective probabilities of a problem. This study believes that people will not still follow the rules of the game under uncertain conditions, but will consider solutions outside the rules in such cases and use more comprehensive strategies to solve the problem. This also proves to a certain extent that the game system is not independent from the outside world, but is closely related to ecological rationality<sup>[11]</sup>. At the same time, this study also interprets the cognitive mechanism of mean reversion to a certain extent<sup>[12]</sup>. The anchoring strategy establishes a unique subjective probability model for descriptive decision-making, abandons the weighted model, and analyzes the reasons for the reflection effect and loss avoidance from the perspective of ecological rationality.

## 4. Conclusions

The value of this research lies in the use of subjective probabilities under the Bayesian model to explain abnormal phenomena in people's decision-making process. Viewing human decision-making behavior from this perspective will broaden our understanding of the diversity of thinking strategies that individuals use to solve problems. It is widely used in real life. Future research can focus on the application of anchoring strategies in real life, and further explore different forms of heuristic strategies. There is a need to conduct further research on the phenomenon of anchoring strategies in order to thoroughly investigate its diverse mechanisms, as well as complicated influencing factors, and take into account the potential effects of factors inclusive of individual differences, cognitive schemas, and text structure.

## References

- [1] Chen Fan. (2013). *A comparative study of risk decision-making under the descriptive and empirical paradigms. (Doctoral dissertation, Fudan University).*
- [2] Xiong Liwen. (2005). *Bayesian Decision Theory and Inductive Logic. Journal of Beijing Normal University: Social Sciences Edition (02), 109-114.*
- [3] Zhang Changwen, & Xu Guo. (2003). *Economic Thinking of Expected Utility Theory. Journal of Shandong Normal University: Natural Science Edition, 018(001), 102-103.*
- [4] Li Haijun, Xu Fuming, Xiang Peng, Kong Shixiao, & Meng Zhenzhen. (2013). *Dependence Based*

on *Expectation Theory*. *Advances in Psychological Science*, 21(2), 317-325.

[5] Amos Tversky, & Daniel Kahneman. (1979). *Prospect theory: an analysis of decision under risk*. *econometrica*, 47(2), 263-291.

[6] Gigerenzer, G. , Todd, P. M. , & Group, A. (2000). *Simple heuristics that make us smart*. *OUP Catalogue*, 23(5), 727-41; discussion 742-80.

[7] Sun, Y. T. , & Hong, G. U. (2009). *Review on the evolutionary paradigm of decision making*. *Journal of Tangshan Teachers College*.

[8] Xiang Ling, & Zhang Qinglin. (2006). *Supporting Theory of Subjective Probabilistic Judgments*. *Advances in Psychological Science* (05), 51-58.

[9] Li Zhanglu. (2013). *On the basic probability fallacy in subjective probability judgment*. *Theory and Modernization* (01), 12-17.

[10] Li Xiaoping, Ge Minggui, Cui Lizhong, Sang Qingsong, & Xuan Bin. (2009). *Re-exploration of the occurrence conditions and mechanism of the effect of profit and loss in decision-making: a kind of perspective and some discussions on the perspective itself*. *Acta Psychologica Sinica*( 3), 196-207.

[11] He Guibing, Li Shu, & Liang Zhuyuan. (2018). *Small to large: Behavioral decision-making boosts social development*. *Acta Psychologica Sinica*, 50(8).

[12] Jones, C. S. . (2015). *Nonlinear mean reversion in the short-term interest rate*. *The Review of Financial Studies*(3), 3.