What causes different experimental observations of prudence and temperance? -The effect of cognitive load-

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Abstract:
Prudence and temperance are positive third-order and negative fourth-order derivatives of utility function in the expected utility framework. They can be characterized downside and outer risk aversion and play important roles in various problems like background risk and precautionary saving. It is also confirmed that they can be related to actual behavior. However, there is a stark difference in experimental observations between prudence and temperance. Existing experimental observations suggest the robust finding of prudence, but less clear evidence for temperance. This study examines the effect of difficulty as one possible cause behind the different experimental observations. We add the difficulty by memorizing eight-digit numbers during choices as a treatment variable. We observed that the difficulty does not affect choices in both prudence and temperance, but its influence in choices prudence by decision time being shortened, center choices being increasing.

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Introduction

The notion of risk aversion is a cornerstone for analyzing risky situations, but it is widely known that it is not enough for various problems like background risk, precautionary saving and others. For these problems, prudence and temperance play important roles. They are positive third-order and negative fourth-order derivatives of utility function in the expected utility framework and can be characterized downside and outer risk aversion.

Eeckhoudt and Schlesinger (2006) introduce new characterization of prudence and temperance by comparing two lotteries. Since then, they can be elicited in experimental settings. It is also confirmed that they can be related to actual behavior (Noussair et al, 2014). Existing experimental studies show stark difference in observations between prudence and temperance. We observe robust findings of prudence, but less clear evidence for temperance.[4]

An important question is emerged from the above experimental observations. These observations reflect intrinsic preferences or are affected other causes. This study examines the effect of difficulty as one possible cause behind the different experimental observations. We add the difficulty by memorizing eight-digit numbers during choices as a treatment variable. We observed that the difficulty does not affect choices in both prudence and temperance, but its influence in choices prudence by decision time being shortened, center choices being increasing.

Experimental design

The preference for the combination of good and bad can be related the signs of the derivatives of von Neumann-Morgenstern utility function within an expected utility framework. This characterization is introduced by Eeckhoudt and Schlesinger (2006). Thus, we can know the directions of higher-order risk preferences by the preference between two lotteries that have the different combinations of good and bad: combining good with bad or good with good. In this study, we measure the intensity of risk aversion, prudence and temperance by the compensation premia that make two lotteries indifferent.

We examine the effects of cognitive load on prudence and temperance by comparing the compensation premia with and without cognitive load. The elicitation method is introduced by Ebert and Wiesen (2014) and is based on the multiple price list format. Compared with the binary choice method, this method has advantage that can take the effects of cognitive load finely. Thus, we can apply this elicitation method in our experimental design for examining the effects of

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[4] See, for example, Trautmann and van de Kuilen (2018) for a review of experimental studies of higher-order risk preferences.

cognitive load. The lottery pairs are constructed by two types of bad, a sure reduction and a zero-mean risk. Participants with $u' \geq 0$ and $u'' \leq 0$, dislike them to zero.

Participants face three different choices stages that correspond to the elicitation or risk aversion, prudence, and temperance. In each stage, they compared a pair of lotteries and determined a compensation premium that is indifferent between them. We let x_i be endowment and m_i be compensation premium for stages of risk aversion (i = 2), prudence (i = 3), and temperance (i = 4). Because the interest of this study is prudence and temperance, we omit the pair of lotteries in the stage of risk aversion. In the stage of prudence, a pair of lotteries are given:

$$A_3 \coloneqq [x_3 + m_3, x_3 + \tilde{\epsilon} - k + m_3], B_3 = [x_3 - k, x_3 + \tilde{\epsilon}].$$

Here, k is a positive amount and $\tilde{\epsilon}$ is a zero-mean random variable such that the support of $x_3 - k + \tilde{\epsilon}$ is positive. In the lotteries, each outcome in the square bracket occurs with equal probabilities. A_3 is the combination of good and good, and B_3 is the combination of good and bad, and bad and good.[5] Eeckhoudt and Schlesinger (2006) show that prudence ($u''' \geq 0$) is equivalent that B_3 is preferred to A_3. In our setting, prudent participants choose the positive amount of m_3, and the value of m_3 is the intensity of prudence.

In the stage of temperance, the same idea can be applied. A pair of lotteries are given:

$$A_4 \coloneqq [x_4 + m_4, x_4 + \tilde{\epsilon}_1 + \tilde{\epsilon}_2 + m_4], B_4 = [x_4 + \tilde{\epsilon}_2, x_4 + \tilde{\epsilon}_1].$$

As in the pair of lotteries in the stage of prudence, A_4 is the combination of good and good, and B_4 is the combination of good and bad. The compensated premium of m_4 can be interpreted similarly to m_3.

Participants are randomly divided into two groups that are identified with control and treatment groups. The treatment is cognitive load that imposes to memorize eight-digit numbers. After all participants made choices, they answer eight-digit numbers. We gave an incentive to participants by paying monetary rewards depending on the number of correct answers.

We set the initial endowments as $x_2 = 2500, x_3 = 2000, x_3 = 1750$, and the list of compensation premiums as $m_i \in \{-250, -225, \ldots, 225\}$. The positive amounts are set as $k = 500$ and $l = 1000$. We introduced one symmetric zero-mean lottery (+700 by 50% and -700 by 50%) and two asymmetric zero-mean lotteries (-1400 by 20% and +350 by 80%; -350 by 80% and +1400 by 20%) in prudence stage. We introduced two symmetric zero-mean lotteries (+700 by 50% and -700 by 50%; +350 by 50% and -350 by 50%) and two asymmetric zero-mean lotteries (-1400 by 20% and +350 by 80%; -350 by 80% and +1400 by 20%) in temperance stage.

Hypotheses

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[5] To be exact, they should say that A_3 is the combination of good and good and bad and bad, and B_3 is the combination of good and bad and bad and good. Following the custom of literature, we omit the combination of bad and bad in A_2 and the combination of bad and good in B_2 for the simplicity.

Thu null hypotheses in this study are:

Hypothesis 1: Cognitive load does not affect the compensation of premium in the prudent stage.

Hypothesis 2: Cognitive load does not affect the compensation of premium in the temperate stage.

If there is no cognitive load, the compensation of premium is higher in the stage of prudence than temperance from the observation of existing studies. We are concerned what underlies this observation. One possible reason is the difference of difficulty, two zero-mean random variables are included in lotteries of the temperate stage, while only one is included in lotteries of the prudent stage. Imposing the cognitive load, making choices gets more difficult. We expect that this difficulty has a greater impact on choices in prudence than temperance by their difference of difficulty. If this guess is right, decreases of compensation premium are more in prudence than temperance,[6] and the compensation premium in prudence is closer to the one in temperance. Thus, we can conclude that the difference of difficulty is a reason why the tendency of temperance is weaker than prudence.

Results

The experiments were conducted at Center for Experimental Economics at Kansai University from March 2022 to July 2022. Participants were recruited from the main campus of Kansai University via ORSEE (Greiner, 2015), and 196 subjects participated in our experiment in total. 100 subjects were randomly assigned to Control group and 96 subjects were randomly assigned to treatment group.

The mean risk premium for risk stage is 69.271 for control group and 64.286 for treatment group, which are not significantly different between control and treatment group (the p-values are 0.748, 0.816 and 0.492 for t-test, Kromogorov-Smirnov test, and Wilcoxon rank-sum test, respectively).

The mean prudence premium is 87.088 for control group and 91.085 for treatment group, which are not significantly different between control and treatment group (the p-values are 0.779, 0.319 and 0.923 for t-test, Kromogorov-Smirnov test, and Wilcoxon rank-sum test, respectively). Therefore, Hypothesis 1 is supported by the simple statistical tests.

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[6] We apply a bias of using the price list format for this reasoning. In the price list format, participants tend to switch the middle of the price list, see, *e.g.* Abdellaoui et al. (2011). The difficulty strength this bias because it is due to heuristics.

The temperance premium is 87.088 for control group and 91.085 for treatment group, which are not significantly different between control and treatment group (the p-values are 0.300, 0.587 and 0.255 for t-test, Kromogorov-Smirnov test, and Wilcoxon rank-sum test, respectively). Therefore, Hypothesis 2 is supported by the simple statistical tests.

Cognitive load did not affect the mean risk (prudence, temperance) premium. However, there is a difference in decision making time between control and treatment group. The mean decision-making time in risk, prudence, and temperance stage is 101.3, 114.57, and 99.615 seconds for control group, respectively and those are 94. 333, 94.819, and 4.839 seconds for treatment group, respectively. The difference between control and treatment group is significant for prudence and temperance stages ($p < 0.001$ and $p=0.049$ for t-tests for prudence and temperance stages, respectively).

The finding that the increase in cognitive load made the decision faster implies that the intervention encourages subjects to use heuristics to make decisions faster and easier. To investigate this possibility, we focus on the risk, prudence and temperance neutral choice. This is because one of the simple and easy heuristics is to choose the middle of the choice list, which corresponds to a risk-neutral choice (premium 0 is located at position 11 in the list of 21 premiums).

Table 3 shows the results of logistic regression of which the explained variable is risk, prudence, and temperance neutral choice. The coefficient of treatment dummy for risk stage is not significant. The increase in cognitive load for risk stage does not affect risk neutral choice. On the other hand, the coefficient of treatment dummy is significantly positive for prudence stage and marginally significantly positive for temperance stage, implying that the increase in cognitive load promotes prudence and temperance neutral choice.

Table 2: Logistic regressions for risk, prudence, temperance neutral choices

	(1) Risk neutral	(2) Prudence neutral	(3) Temperance neutral
Treatment	0.552	2.426**	1.350*
	(0.377)	(1.203)	(0.797)
Correct answers	-0.149	-0.259	-0.0774
	(0.199)	(0.222)	(0.183)
Decision-making time	-0.00117	-0.00217	-0.00226
	(0.00246)	(0.00799)	(0.00506)
Treatment ×Decision-	-0.00684***	-0.0182	-0.0109

making time			
	(0.00265)	(0.0139)	(0.00915)
Age	-0.0981	-0.124	0.0817
	(0.108)	(0.160)	(0.120)
Female	-0.313	-0.624	-0.377
	(0.338)	(0.484)	(0.370)
Economics/Management faculty dummy	-0.457	0.183	0.233
	(0.369)	(0.492)	(0.391)
CRT	0.186*	0.154	0.147
	(0.0975)	(0.126)	(0.0928)
Overconfidence	1.205***	0.958*	0.534
	(0.387)	(0.506)	(0.401)
Constant	1.473	1.043	-2.831
	(2.434)	(3.436)	(2.677)
Observations	192	196	196

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Correct answers is the number of correct answers in the review question of which the maximum score is 6. CRT is the score of Cognitive Reflection Test of which the maximum score is 7. Overconfidence takes 1 if the expected rank of CRT score is higher than the actual rank, otherwise 0.

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