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Change of Decision-Making Processes in Repeated Risk-Taking Behavior in Complex Dynamic Situations

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The purpose of this study is to examine how decision-making processes change in repeated risk-taking behavior in complex dynamic situations. Repeated risk-taking behavior is defined as behavior in which people repeat risk-taking behavior in a complex dynamic situation. For example, in a gambling game people make a bet according to the amount of money they have, and win or loss in a game influences the complex dynamic situation (e.g., total money), and affects the next bet. We limit the discussion to personal decision-making processes. Therefore, we are not concerned here with decision-making processes in a group (e.g., a company and a government) or in an emergency (the scene of a fire or an earthquake).

There are three approaches to explaining individual differences in risk-taking behaviors. The first is the "personality factors approach". For instance, Zuckerman (1994) indicated that sensation seekers prefer physical risk-taking behaviors (e.g., skydiving, smoking, and drugs). The second is the "situational factors approach". Tversky & Kahneman (1986) indicated that in gain situations people prefer risk-averse options, but on the contrary, in loss situations people prefer risk-taking options. The third is the interaction approach explained by personality, situational, and cognitive factors. Bromiley & Curley (1992) divided the kinds of risk-situation into physical sensation, gambling and lotteries, everyday life experiences, and business and finance. They examined which personality and cognitive factors influenced risk-taking behaviors. To make the decision-making processes clear, Ueichi & Kusumi (1998a, b) examined the relationship between personality factors (e.g., Five Factor Model, sensation seeking, and optimism), cognitive factors (risk perception, own perceived competence, and perceive a cost and benefit), and risk-taking behaviors in four situations: personal, social, gain-loss, and loss situations. Covariance structure analysis showed two processes: firstly, neuroticism (Five Factor Model) affected risk significance, risk significance affected perceived benefit, and perceived benefit affected risk-taking behavior; secondly, openness affected own perceived competence, own perceived competence affected risk perception, risk perception affected risk-taking behavior. Schunn & Reder (1997) used the Kanfer-Ackerman Air Traffic Controller Task as a complex dynamic situation. They examined the relationship between general intelligence, adaptivity of strategy, and performance. The results indicated that general intelligence affected adaptivity of strategy and performance.

The previous researches, however, have not clearly shown the relationship between personality factors, cognitive factors, and risk-taking behavior in repeated risk-taking behavior. In other words, it is not obvious how the decision-making processes of people change in repeated risk-taking behavior in complex dynamic situations.

Therefore, the present study uses TV games as a device for reproducing personal, gain-loss, and complex dynamic situations (skiing and gambling) and measures the cognitive factors and preferences of people regarding the level of risk-taking behavior in repeated risk-taking behavior. To make clear the change in decision-making processes, we examine the change of relationship between (1) personality factors and cognitive factors, (2) cognitive factors, and (3) cognitive factors and risk-taking behavior in repeated risk-taking behavior.

EXPERIMENT

METHOD

Subjects. Subjects were 25 graduate students (10 males, 15 females).

Apparatus. We used a skiing game (SONY PlayStation software: DOWNHILL SNOW, PACK-IN-SOFT Victor Interactive software Inc.) as a physical risk-taking situation and a pachinko game (SANKYO FEVER real machines' simulation Vol.2, T･E･N laboratory) as a gambling situation to measure the preference of subjects regarding the level of risk-taking behavior.

Task. *Physical risk-taking situation (ski game)* Subjects had to reach a goal as fast as possible within a time limit and without falling down. There were two options: the high-risk and high-return course for experts (high-risk course) and the low-risk and low-return course for beginners (low-risk course). Subjects chose one of the courses in each trial. The trial was repeated three times. We instructed subjects that they should think that they were really skiing.

Gambling situation (pachinko game) A pachinko game is much the same as a slot machine. Subjects had to get as much money as possible. There were two options: high-risk and high-return machine (high-risk machine) and low-risk and low-return machine (low-risk machine).

Subjects chose one of the machines in every trial. The trial was repeated three times. We instructed subjects that they should think they were really getting some money. The rate was 1 yen per ball (about 2300 yen per hit).

Measurement scales. *Five Factor Model* A part of the Japanese language Five Factor Model (Wada, 1996) was used as a scale of personality factors. The scale of each factor (neuroticism: anxious, uneasy; openness: penetrating, versatile; extroversion: cheerful, talkative; conscientiousness: diligent, punctual; agreeableness: generous, gentle) was composed of six items. Each item was assessed on an 11-point scale. The score of each factor was summed up in six items.

Own perceived competence Own perceived competence was a scale to measure how far the subject has risk knowledge and skill for each situation. The scale was composed of four items (internal-stable: skill; internal-unstable: assessment of the situation; external-stable: knowledge of the object; external-unstable: luck). Each item was assessed on an 11-point scale.

Risk controllability Risk controllability was a scale to measure to what degree the subject thinks about a need of risk knowledge and skill to avoid risk in each situation. The scale was composed of four items in the same way as the own perceived competence scale.

Risk significance Risk significance was a scale to measure to what degree the subject wants something in each situation (e.g., a feeling of satisfaction and achievement). The scale was composed of three items. Each item was assessed on an 11-point scale.

Risk perception Risk perception was a scale to measure what probability of risk the subject feels for each risk-taking behavior. In skiing, the probability was the subjects' estimation that he could reach the goal within a limit time for the high-risk course and the low-risk course. In pachinko, the probability was the subjects' estimation that he could make money on a high-risk and low-risk machine. Each item was assessed on an 11-point scale that ranged from 0% to 100%.

Perceived benefit Perceived benefit was a scale to measure what degree of benefit (e.g., pleasure and delight) the subject feels for each risk-taking behavior. Each item was assessed on an 11-point scale.

Self-confidence Self-confidence was a scale to measure to what degree the subject thinks of making good (e.g., confidence to reach the goal within a limit time, make money) for each risk-taking behavior. Each item was assessed on an 11-point scale.

Risk-taking behavior Risk-taking behavior was a scale to measure to what degree the subject takes a risk for each risk-taking behavior. Risk-taking behavior was measured by whether the subject prefers the high-risk or low-risk option (course and machine).

Experimental procedure. *Practice trial* Before the practice trial the Five Factor Model was measured, then tasks and operations were explained to subjects. In skiing, the subjects practiced until they reached the goal for each course within a time limit and without falling down (practice time was about 20-60 minutes). In pachinko, subjects played each pachinko machine for five minutes.

First trial Firstly, subjects completed a questionnaire of their own perceived competence, risk controllability, risk significance, risk perception, perceived benefit, and self-confidence. Secondly, the subjects played the game either high-risk or low-risk option.

Second and third trial The procedure of the second and third trial was the same as the first trial. The total of the trial time was about 90 minutes (30 minutes in skiing, 60 minutes in pachinko).

RESULTS

1. Effects of Five Factor Model on cognitive factors

To assess the effect of personality factors (neuroticism, openness, extroversion, conscientiousness, and agreeableness) on cognitive factors (own perceived competence, risk controllability, and risk significance), the data was analyzed with analysis of variance (ANOVA). Subjects were divided into a high, middle, and low group depending on each score of the Five Factor Model (e.g., neuroticism and openness). In the physical risk-taking situation (skiing), there were no significant effects between the Five Factor Model and cognitive factors. In the gambling situation (pachinko), only on the first trial, the main group effect of neuroticism was significant on the score of preference for a win in game in the scale of risk significance, $F(2,25) = 5.32$, $p < .05$ (Low group (M =8.29) > Middle (M=5.36), High (M=6.14): Tukey-Kramer's multiple comparison). This means that it is more likely for the subjects of low neuroticism to prefer surely winning a game even at low allotments to getting much money at high-risk option. The others were not significant.

Ueichi & Kusumi (1998a, b) showed the effect of neuroticism on risk significance and the effect of openness on own perceived competence. In repeated behavior, it was found that on the first trial personality factors were related to cognitive factors, but on the second and third trials personality factors did not clearly relate to cognitive factors. This fact suggests that in repeated behavior cognitive factors are affected by assessment of the result of risk-taking behavior rather than by personality factors.

2. Effects of cognitive factors on risk-taking behavior

First, to examine the relationship between risk significance and perceived benefit and between own perceived competence and risk perception, the data was analyzed with t-test. Subjects were divided into a high and low group using the mean score of each factor and

Table 1 Effects of cognitive factors on each trial in physical risk-taking and gambling situation

	First trial				Second trial				Third trial			
	n	*M*	*SD*	*t*	*n*	*M*	*SD*	*t*	*n*	*M*	*SD*	*t*
	Perceived Benefit in Physical Risk-Taking Situation (ski game)											
Risk Significance												
High Group	15	7.33	2.14		13	8.38	2.18		16	8.63	1.99	
Low Group	10	6.40	2.95	0.87	14	5.83	2.72	2.59*	9	6.33	1.73	2.88**
	Perceived Benefit in Gambling Situation (pachinko game)											
Risk Significance												
High Group	14	6.85	2.07		14	7.28	1.81		13	7.38	.02	
Low Group	11	5.00	3.13	1.78+	11	3.64	2.69	4.04***	12	3.83	3.15	3.37**
	Risk Perception in Physical Risk-Taking Situation (ski game)											
Own Competence												
High Group	7	65.7	22.9		11	62.7	24.53		11	69.1	19.7	
Low Group	18	47.2	26.5	1.61	14	49.3	32.69	1.13	14	45.0	32.7	2.15*
	Risk Perception in Gambling Situation (pachinko game)											
Own Competence												
High Group	8	40.0	20.0		9	40.0	18.0		10	53.0	22.6	
Low Group	17	32.9	16.4	0.93	16	33.1	20.8	0.82	15	32.6	21.5	2.27*

+ $p < .10$ * $p < .05$ ** $p < .01$ *** $p < .001$

each trial as a cut point.

Table 1 shows that there were significant effects of risk significance on perceived benefit in each situation and on each trial. This means that people seeking pleasure tend to be interested in the high-risk option. There were no significant effects of own perceived competence on risk perception on the first and second trials. On the third trial, there were significant effects of own perceived competence on risk perception in each situation. This means that people with risk knowledge and skill tend to think that the high-risk option is not dangerous.

Secondly, to examine the effects that perceived benefit, risk perception, and self-confidence have on the risk-taking behavior, the data was analyzed with *t*-test.

There were significant effects of perceived benefit on risk-taking behavior in each situation and on each trial. This means that those who feel much pleasure in the high-risk option tend to choose the high-risk option. There were no significant effects of risk perception on risk-taking behavior on the first and second trials. On the third trial, there were significant effects of risk perception on risk-taking behavior in each situation. This means that those who assess the risk of high-risk option as not so serious tend to choose the high-risk option. There were no significant effects of self-confidence on risk-taking behavior.

Thus, the fact suggested that risk significance affects risk-taking behavior mediated by perceived benefit from the beginning and own perceived competence affects risk-taking behavior mediated by risk perception by learning and development.

DISCUSSION

It is concluded that there are two decision-making processes which have an effect on risk-taking behavior: (a) neuroticism affects risk-significance, risk significance affects perceived benefit, and perceived benefit affects risk-taking behavior and (b) openness affects own perceived competence, own perceived competence affects risk perception, and risk perception affects risk-taking behavior (Figure 1). This fact is the same as in previous research (e.g., Ueichi & Kusumi, 1998a, b).

Moreover, in repeated behavior, there are two important findings. The first finding is the change of effects of own perceived competence on risk-taking behavior mediated by risk perception. Risk significance affects risk-taking behavior mediated by perceived benefit constantly and strongly. In contrast, own perceived competence affects risk-taking behavior mediated by risk perception only on the third trial. Thus, it suggests that process (a) is acquired at an early stage and is stable, but process (b) is acquired by learning and development. The second finding is the change of effects of personality factors on cognitive factors. The previous researches showed that personality factors affect cognitive factors and risk-taking behavior (e.g., Bromiley & Curley, 1992; Seligman, 1991; Ueichi & Kusumi, 1998a, b; Zuckerman, 1994). The present study indicates, however, that personality factors do not affect risk-taking behavior mediated by cognitive factors in repeated risk-taking behavior except on the first trial. It suggests that in repeated risk-taking behavior the effects of personality factors on both cognitive factors and risk-taking behavior is weaker than the effects of other factors (e.g., assessments of results).

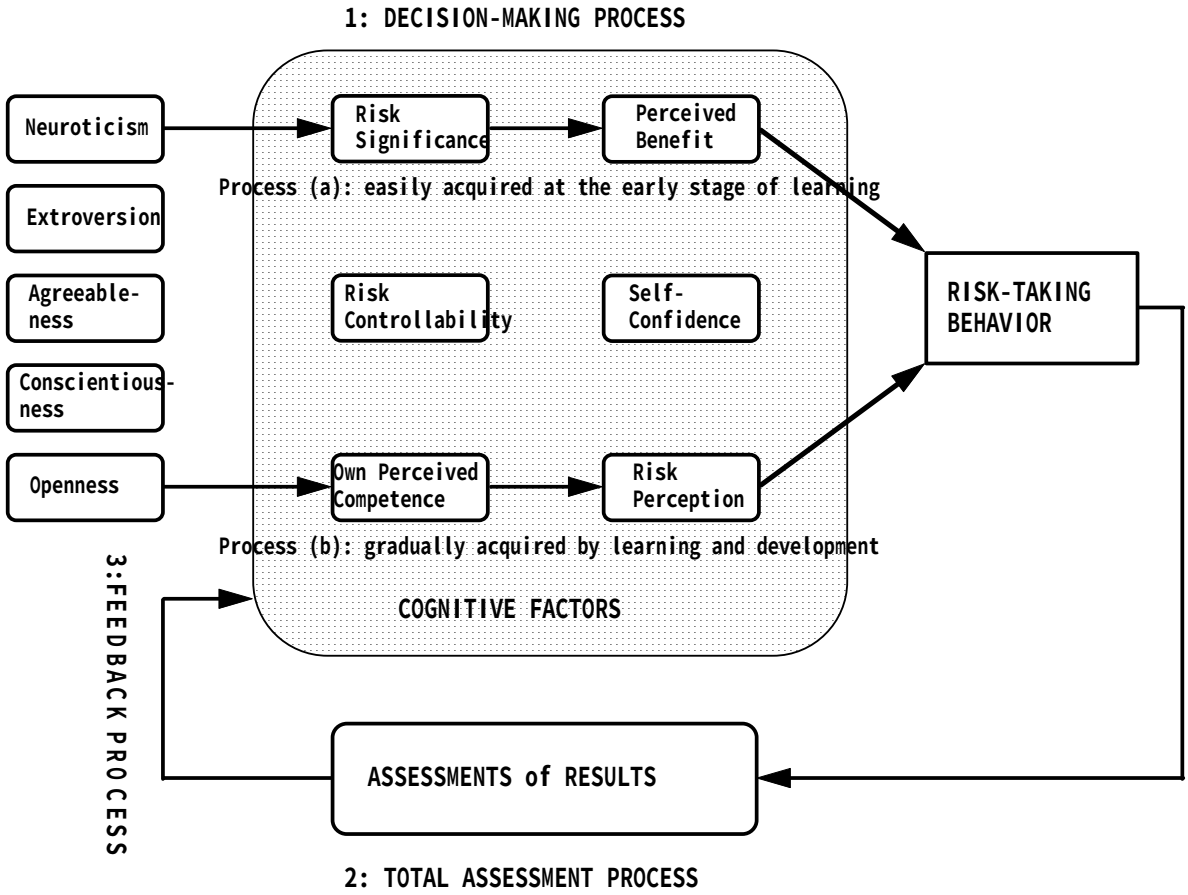

Figure 1 Dynamic Risk-Taking Model

Finally, we would like to propose a dynamic risk-taking model in order to explain individual differences in risk-taking behavior (Figure 1). In the dynamic risk-taking model, individual differences are expressed not only as the differences of a level of a score on a scale representing each factor (e.g., personality factors, cognitive factors, and risk-taking behavior) but also as the differences in strength of relation among the factors. Moreover, the dynamic risk-taking model incorporates the process in which assessments of results are fed back to cognitive factors. The dynamic risk-taking model is composed of three processes: (1) a decision-making process, (2) a total assessment process where people assess results of risk-taking behavior, and (3) a feedback process by which assessments of results have an impact on cognitive factors. Their processes are looped back as 1-2-3-1... The future direction of this study will be to examine this model in other situations.

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