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Research Methods, Influencing Factors and Brain Mechanism of Risk Decision Making

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Abstract

Risk decision refers to the process in which an individual makes an optimal choice by comparing the probability and value of the result brought by each choice from two or more options. At present, questionnaire and experiment methods are used to measure subjects' preference for risk decision making. It is found that risk decision is mainly affected by decision object, external environment and decision maker. Event-related potentials and functional congratulatory resonance imaging are commonly used to study the brain mechanisms associated with risk decision making.

Keywords

Risky decision making, domain-specific risk taking, Individual differences, ERPs.

1. Overview

Decision-making is what people must face in their life. Whether it is the choice of daily life or the choice of marriage and career, people make decisions all the time. Decision making has always been the focus of many disciplines. In previous studies, different scholars have different definitions of decision making. For example, Simon et al. (1987) [1]argue that decision-making is a cognitive process in which individuals choose and evaluate among multiple options. Yetes (1990) believes that decision-making is the choice behavior made by individuals in order to obtain satisfactory results[2].

According to whether the decision has a definite outcome, researchers divide the decision into deterministic decision and uncertain decision. In deterministic decision-making, the results of different choices are determined, and individuals can make choices by weighing different results. In the uncertain decision making, the result brought by each alternative plan is unknown. Individuals need to make a choice after weighing the advantages and disadvantages by analyzing the possibility of alternative plan and the consequences. For example, in economic life, whether to choose the time deposit with low risk and low return or the stock with both risk and return; In choosing a career, the decision to choose a sure thing or to take a chance and interview with a better company is a matter of uncertainty. Uncertain decision making can be divided into risk decision making and fuzzy decision making according to whether the probability of the result is determined. The probability of risk decision making is known while the probability of each result of fuzzy decision making is unknown. Risk decision refers to the process in which an individual makes an optimal choice by comprehensively comparing the value and probability of each result from two or more options. Kahneman (1991) believed that decisions with uncertain results and risks are risky decisions[3]. Yates and Stone (1992) believe that risk decision making is a cognitive process in which decision makers consider and analyze influencing factors such as the probability of outcome occurrence, the size of income and loss, and individual subjective expectations in order to make the optimal choice[4].

Based on researchers' views on risk decision making, it can be seen that risk decision making has the following characteristics: firstly, risk decision making is made between two or more choices; secondly, the probability of results brought by each choice in risk decision making is

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estimable, and decision makers have clear goals in the decision-making process. In general, risk decision refers to the process in which an individual makes optimal choice by comparing the probability and value of the result brought by each choice from two or more options.

2. Research Paradigm

In the relevant studies on risk decision making, researchers mainly use questionnaire and experiment methods to measure individual risk decision making preference. Common questionnaires to measure Risk decisions include Domain Specific Risk taking Scale (DOSPERT), Risk Preference Index (RPI), Sensation Seeking Scale, SSS). The subjects set different risk options by the way of text questions, and measured the risk preference of the subjects according to their choices. The risk Domain Specificity Scale (DOSPERT) has been validated in several countries[5-7] is a relatively commonly used scale in risk decision making research, and also a relatively widely used domain-specific scale for risk decision making. The scale requires subjects to answer the possibility of participating in risk activities in five specific risk areas of finance, health, entertainment, morality and society to measure their risk appetite. The higher the scale score, the higher the level of risk appetite of the subjects.

Questionnaire method cannot reflect the real decision-making process, has low ecological validity, and is easily affected by factors such as the attitude of the subjects. Therefore, researchers designed some risk decision tasks by simulating real risk decision scenarios under laboratory conditions. For example, Balloon Analogue Risk Task (BART) [8], wheels of fortune [9], lowa gambling task (IGT) [10].

One of the more common is the 'Wheel of fortune' task [9]. As shown in Figure 1-1, this paradigm includes a select interface, a wait interface, and a result rendering interface. In the selection screen, the experimenter presented the subjects with two options, each consisting of a ring with a different proportion of blue and red. The blue part represents the gain, the red part represents the loss, and the proportion of the two colors in the wheel represents the possibility of gain or loss. For example, in the selection screen shown in Figure 1, the left wheel indicates a 50% chance of winning 200 tokens and a 50% chance of losing 200 tokens, while the right wheel indicates a 75% chance of winning 50 tokens and a 25% chance of losing 50 tokens. After the subjects made the choice, they entered the waiting interface, and the pointer on the turntable began to rotate and stopped at a certain position on the turntable randomly. After entering the result feedback interface, the subject can observe the result of the current round of decision making and the comparison result if another choice is made, and then the decision regret of the subject is measured [11]. Of the two turntables, one represents the high-risk, high-return option (e.g., 50 percent chance of winning 200 tokens, 50 percent chance of losing 200 tokens), and the other represents the low-risk, low-return option (e.g., 75 percent chance of winning 50 tokens, 25 percent chance of losing 50 tokens). The experimenters measured the subjects' propensity to make risky decisions by recording the number of times they chose high-risk and high-reward options.

Figure 1. Schematic diagram of "Wheel of Fortune" task

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The second common type is the balloon simulated risk decision task [8]. As shown in Figure 2, two buttons and an uninflated balloon are displayed during the balloon simulation task. One button said "press this button to pump up the balloon" and the other said "press to collect $$$." On the right side of the balloon, "total eamed $" and" last balloon $" are displayed. During the experiment, the task of the subjects was to inflate the balloon. After each time the balloon was inflated, the subjects could obtain a certain cumulative income, but each balloon was preset with an "explosion point". The balloon would explode when the number of inflate reached the "explosion point", and the income of the current round of the subjects would be cleared if the balloon exploded. The subjects could voluntarily stop inflating the balloon before it exploded, at which time the income of the current round would be included in the total income. After the balloon explodes or the subject voluntarily stops inflating, it automatically enters the next round. In this task, the experimenter measured the risk decision-making preference of the subjects by the number of balloon explosions in the task. The more the number of balloon explosions, the more risky the subjects were, and the less conservative the subjects were. At present, balloon simulation task is widely used in the assessment of risk decision-making preference [8].

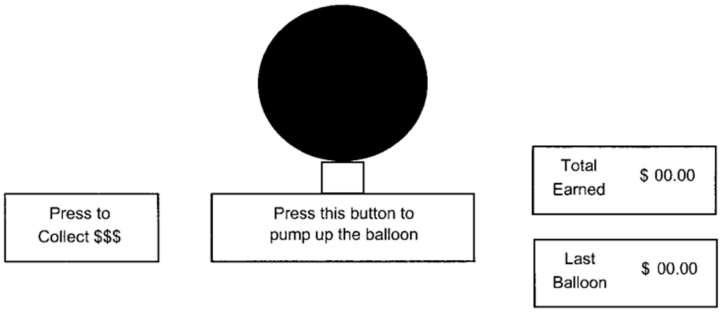

Figure 2. Schematic diagram of balloon simulation task

3. Influencing Factors

As a decision that is closely related to individual life, researchers at home and abroad have found that risk decision is affected by many factors. In summary, the influencing factors mainly include three parts: decision object factor, external environment factor and decision subject factor.

3.1. Decision object

The effect of reward type on risk decision making. Xu Sihua et al.[12]used the balloon simulation task to explore and compare the influence of real and virtual monetary reward types on risk decision making, and found that compared with virtual reward, subjects in the real monetary reward situation were more likely to be affected by the result of the last decision, and failure of the last decision result would significantly reduce the risk decision making behavior of the subjects in this decision making. At the same time, in the real monetary reward situation, the reward range can significantly affect the risk decision-making behavior of the subjects, the larger the reward range, the less willing the subjects to make risk decision-making behavior. However, in the virtual monetary reward situation, the change of reward range had no effect on the risk decision-making behavior of the subjects.

The influence of domain specificity on risk decision making. Domain specificity of risk decision making refers to a specificity of an individual's risk decision making in a specific domain that may be influenced by specific risk factors in a specific domain.Under the traditional theoretical framework of risk decision making, researchers regard risk decision preference as a personality trait with cross-domain and cross-context consistency. For example, the expected

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value theory [13] holds that an individual's risk decision preference can be explained by means of mathematical expression. In this model, an individual's risk attitude is a stable personality trait. On the continuum from risk aversion to risk seeking.

With the further research in this field, the view of risk decision preference as a stable personality trait has been questioned. Slovic's study found that whether individuals were classified as risk preference or risk aversion was affected by measurement methods[14]. The study of Reynaud and Couture also found that individuals' risk decision-making preferences were not stable in different situations and fields[15]. In view of the above problems, Sarin and Weber argued that individuals' risk decision-making preferences should be considered in specific situations and domains. Individual risk decision preference is not consistent across domains, but domain specific. For example, individuals may prefer to be conservative when it comes to economic decisions and to take risks in areas of daily life[16].

3.2. External environmental

The influence of others' behavior on risk decisions. Donley et al. , in a study of 60 male adolescents, found that, compared with peers, negative evaluations of adolescents by adults can affect adolescents' emotional and physiological indicators and thus their risk decisions[17]. In addition, the decision-making behaviors of others also affect individuals' risk decision-making preferences. When individuals see that others are more willing to take risks in decision-making, they are more willing to take risks in decision-making themselves.

The influence of time pressure on risk decision making. Time pressure can affect individual risk decision-making behavior. For example, by setting different time pressure conditions, Zur and Breznitz found that individuals prefer to be conservative rather than risk-taking under high time pressure conditions[18].

The effect of income or profit or loss scenarios on risk decisions. When individuals make risk decisions, they face not only benefit scenarios (for example, 50 percent gains $100, or 100 percent gains $50), but also profit and loss scenarios (for example, 50 percent loses $100, or 100 percent loses $50). Previous studies have found that individuals are more willing to take risks in the income scenario and more conservative in the profit and loss scenario[19].

3.3. Individual factors

The Influence of gender on risk decision-making. Previous studies have found that boys and girls are significantly different in risk-making behaviors due to their different growth and education environments, risk perception and risk attitude. Specifically, men have more risk decision-making behaviors; Moreover, men have lower risk assessment and are more willing to take risks.

The Influence of self-esteem on risk decision making. Previous studies have found that individuals with high self-esteem have an equal amount of risk decision-making preference to seek self-improvement, whereas individuals with low self-esteem avoid taking risks to protect themselves [20]. For example, Duan Jing et al.[21] studied 130 college students and found that individuals with high self-esteem were more inclined to take risks than those with low self-esteem. Individuals with low implicit self-esteem take more risks when making decisions for others than when making decisions for themselves.

The influence of personality Traits on risk decision-making. From the perspective of personality traits, individuals with different personality traits have different behaviors in risk decision-making. For example, Wang et al. (2017), based on a study of 130 college students, found that extraversion and openness in personality traits were positively correlated with risk preference, while agreeableness and conscientiousness were negatively correlated with risk preference [22].

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The effect of addictive behaviors on risk decision-making. As the study progressed, researchers found differences in risk decisions between people with addiction and those without. For example, a study found that smokers showed more risk appetite in risk decision-making tasks compared to non-smokers[8]. Wei et al. (2017), based on a study of 21 nicotine addicts, also found that individuals with nicotine addiction had more risk-taking behaviors in balloon simulation tasks than normal individuals. Online game addiction can also affect individual risk decision-making behavior[23]. Compared with the normal group, individuals with online game addiction show more risk preference [24].

The influence of childhood experiences on risk decision-making. An individual's early life environment will affect the risk decision-making behavior in adulthood. For example, Griskevicius et al. found that low socioeconomic status in childhood would lead individuals to have a higher risk decision-making preference[25]. Lu 's research on left-behind children in China found that the unpredictability of the early environment would lead children to form fast life history strategies and have more risk-taking behaviors in balloon simulated risk tasks. However, other studies have found the opposite conclusion. For example, Amir et al. found that individuals with low socioeconomic status in childhood would be more averse to taking risks in order to control uncertainties in life[26].

4. Research on the Brain Mechanism

The extensive application of brain imaging technology also promotes the exploration of the brain mechanism of risk decision making. event-related potential (ERP) and functional magnetic resonance imaging (fMRI) are most commonly used in the study of brain mechanisms related to risk decision making.

fMRI is widely used in the research of cognitive neuroscience. When the activity of neurons in the brain increases, oxygen consumption will also increase. When hemoglobin combines with oxygen molecules or releases oxygen molecules, magnetic changes will be caused. It has high spatial resolution. Previous studies have found that multiple brain regions are involved in making risk decisions. For example, previous studies have found that the medial prefrontal cortex is closely related to individuals' risk decision-making [27], and studies on patients with brain injury have also found that the damage of the prefrontal cortex will make individuals more inclined to take risks[28]. Engelmann and Tamir also found that the interaction between the ventral striatum and the ventral medial prefrontal cortex was associated with risk-taking behavior in adults[29]. The anterior cingulate gyrus -- thalamic functional connection is a complete mediator between nicotine addiction and risk decision-making behavior[23].

ERP technology evoked potentials (EP) in human brain (evoked potentials) and computer average stack technology evoked evoked potentials (EP) can evoke the firing conditions of neurons related to specific events in the brain, and it has higher time resolution compared with fMRI technology. Previous studies have found that the ERP components involved in risk decision-making mainly include N2, P2 and P3. The induction of the N2 component was usually around 200ms after the presentation of the stimulus and returned to baseline around 350ms, which was a negative wave mainly distributed in the frontal region. The N2 component is associated with cognitive conflict. In risk decision-making, the greater the cognitive conflict an individual produces, the greater the amplitude of N2 component. P2 components are positive waves within the range of 150ms to 300ms after the presentation of stimulation, mainly distributed in the frontal and central regions of the cerebral cortex[30]. Compared with deterministic decision-making, P2 amplitude is larger in uncertain decision-making, indicating that P2 may be related to the processing of uncertainty in risk decision-making[31]. Kait et al. (2016) studied 31 college students through balloon simulation task and found that when the risk and reward increased, the amplitude of P2 component located around the left caudate

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nucleus increased[32]. P3 component refers to the positive wave appearing after 300m stimulation, which is mainly distributed in the center-top region, and the amplitude of P3 component is the largest near the center line. Previous studies have found that P3 components are associated with the probability of risk decisions, uncertainty of stimuli, and importance. In addition, P3 is also associated with cognitive resource allocation. When subjects invest more cognitive resources in the decision-making process, P3 fluctuates more.

In addition to fMRI and ERP techniques, Sacre et al. studied the electrophysiological evidence of risk decision making by implanting intracranial electrodes in the cortex and subcortex of 10 subjects, and found that the electrical signals in the right hemisphere of the brain increased when participants had risk preference and the electrical signals in the left hemisphere of the brain increased when participants had risk aversion[33].

References

[1] Simon H A, Dantzig G B, Hogarth R, et al. Decision making and problem solving [J]. 1987, 17(5): 11-31.

[2] Yates J. Risk-taking behavior [M]. John Wiley & Sons, 1992.

[3] Kahneman D J P S. Article commentary: Judgment and decision making: A personal view [J]. 1991, 2(3): 142-5.

[4] Yates J F, Stone E R. The risk construct [J]. 1992.

[5] Johnson J, Wilke A, Weber E U J P P B. Beyond a trait view of risk taking: A domain-specific scale measuring risk perceptions, expected benefits, and perceived-risk attitudes in German-speaking populations [J]. 2004, 35: 153-72.

[6] Schwartz A, Yamagishi K, Hirahara N, et al. Risk perception and risk attitudes in Tokyo: A report of the first administration of DOSPERT+ M in Japan [J]. 2013, 8(6): 691-9.

[7] Wu J, Cheung H Y J P R. Confirmatory factor analysis of DOSPERT scale with Chinese university students [J]. 2014, 114(1): 185-97.

[8] Lejuez C W, Read J P, Kahler C W, et al. Evaluation of a behavioral measure of risk taking: the Balloon Analogue Risk Task (BART) [J]. 2002, 8(2): 75.

[9] Mellers B, Schwartz A, Ritov I J J O E P G. Emotion-based choice [J]. 1999, 128(3): 332.

[10] Bechara A, Damasio A R, Damasio H, et al. Insensitivity to future consequences following damage to human prefrontal cortex [J]. 1994, 50(1-3): 7-15.

[11] Coricelli G, Critchley H D, Joffily M, et al. Regret and its avoidance: a neuroimaging study of choice behavior [J]. 2005, 8(9): 1255-62.

[12] Xu Sihua, Fang Zhuo, RAO Hengyi. Effects of real and virtual monetary rewards on risk decision-making behavior [J] Psychology. 2013, 45(08): 874-86.

[13] Von Neumann J, Morgenstern O. Theory of games and economic behavior, 2nd rev [J]. 1947.

[14] Slovic P J P B. Assessment of risk taking behavior [J]. 1964, 61(3): 220.

[15] Reynaud A, Couture S J T, Decision. Stability of risk preference measures: results from a field experiment on French farmers [J]. 2012, 73: 203-21.

[16] Sarin R K, Weber M J E J O O R. Risk-value models [J]. 1993, 70(2): 135-49.

[17] Donley S. You're Stressing Me Out: Adolescent Stress Response to Social Evaluation and its Effect on Risky Decision-Making [D]; UC Irvine, 2017.

[18] Zur H B, Breznitz S J J a P. The effect of time pressure on risky choice behavior [J]. 1981, 47(2): 89-104.

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[19] Wang X T, Simons F, Brédart S J J O B D M. Social cues and verbal framing in risky choice [J]. 2001, 14(1): 1-15.

[20] Brockner J, Grover S, O'malley M N, et al. Threat of future layoffs, self-esteem, and survivors' reactions: Evidence from the laboratory and the field [J]. 1993, 14(S1): 153-66.

[21] Duan Jing, Liu Yongfang, He Qi.[J]. Journal of Psychology, 2012, 44(03): 369-76.

[22] Wang X, Pan Y, Zhang K, et al. Emotional experience and personality traits influence individual and joint risk-based decision making [J]. 2017, 45(6): 881-92.

[23] Wei Z, Yang N, Liu Y, et al. Resting-state functional connectivity between the dorsal anterior cingulate cortex and thalamus is associated with risky decision-making in nicotine addicts [J]. 2016, 6(1): 1-9.

[24] Pawlikowski M, Brand M J P R. Excessive Internet gaming and decision making: do excessive World of Warcraft players have problems in decision making under risky conditions? [J]. 2011, 188(3): 428-33.

[25] Griskevicius V, Tybur J M, Delton A W, et al. The influence of mortality and socioeconomic status on risk and delayed rewards: a life history theory approach [J]. J Pers Soc Psychol, 2011, 100(6): 1015-26.

[26] Amir D, Jordan M R, Rand D G. An uncertainty management perspective on long-run impacts of adversity: The influence of childhood socioeconomic status on risk, time, and social preferences [J]. Journal of Experimental Social Psychology, 2018, 79: 217-26.

[27] Van Leijenhorst L, Moor B G, De Macks Z a O, et al. Adolescent risky decision-making: neurocognitive development of reward and control regions [J]. 2010, 51(1): 345-55.

[28] Rogers R D, Everitt B, Baldacchino A, et al. Dissociable deficits in the decision-making cognition of chronic amphetamine abusers, opiate abusers, patients with focal damage to prefrontal cortex, and tryptophan-depleted normal volunteers: evidence for monoaminergic mechanisms [J]. 1999, 20(4): 322-39.

[29] Engelmann J B, Tamir D J B R. Individual differences in risk preference predict neural responses during financial decision-making [J]. 2009, 1290: 28-51.

[30] Schuermann B, Endrass T, Kathmann N J F I H N. Neural correlates of feedback processing in decision-making under risk [J]. 2012, 6: 204.

[31] Polezzi D, Lotto L, Daum I, et al. Predicting outcomes of decisions in the brain [J]. 2008, 187(1): 116-22.

[32] Kiat J, Straley E, Cheadle J E J S C, et al. Escalating risk and the moderating effect of resistance to peer influence on the P200 and feedback-related negativity [J]. 2016, 11(3): 377-86.

[33] Sacré P, Kerr M S, Subramanian S, et al. Risk-taking bias in human decision-making is encoded via a right–left brain push–pull system [J]. 2019, 116(4): 1404-13.