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The Influence of Cognitive Load on the Framing Effect of

Risk Decision-making of Basketball Players

BY

CHANG Shuzhi and SUN Yanlin

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BY

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Abstract

This study set up number strings of different lengths as memory tasks to form high and low cognitive loads, which simulated real stress situations. And the study explored the regularity and differences of framing effect of basketball players under different situations of high cognitive load and low cognitive load. 51 basketball players participated in this study, and the subjects completed three groups of experiments. In the experiments, the subjects were asked to complete the basketball decision-making tasks. The study showed that there was framing effect of risk decision-making in basketball. And the type of framework affected the risk preference of basketball players. Cognitive load affected the framing effect of risk decision-making of basketball players. Under the low cognitive load condition, framing effect was significant, while under the high cognitive load condition, framing effect was weakened. The framing effect in basketball weakened as the players' cognitive effort increased. Besides, the framing effect was not only the result of heuristic system, but also the analytical system played an important role in the processing of framework information.

Keywords: cognitive load, risk decision-making, framing effect, basketball players

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BY

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Introduction

When Kahneman and Tversky (1981) studied the "Asian Disease Problem", they found that people are affected by alternative verbal descriptions when making decisions. They called this phenomenon of preference reversal caused by different descriptions as framing effect. And they pointed out that the framing effect is due to different reference points, people have different attitudes towards risks and different ways of decisions-making. Faced with gains, people tend to avoid risks cautiously, while faced with losses, people are willing to take risks and tend to seek risks. At present, a large number of studies(Druekman & Mc Dermott, 2008；Huang & Liu 2012; Liu & Yang, 2012；Yang & Zhang, 2015) show that there is a framing effect in sports context. The other studies(Wang, Zhang, & Wang, 2011；Shao, 2016；Han, 2017) found that framing effect has an important impact on the behavior of athletes in the sports context. In addition, more researchers have begun to pay attention to the research on the influencing factors of the athlete's framing effect, for example the decision-making task context(Liu & Yang, 2012), neurological traits(Jörg Rieskamp, 2009) and psychological resilience(Yang, Zhang, & Li, 2015), cognition, emotion, personality and self-esteem level of athletes themselves(Li, Yuan, 2016) and other factors influence on the framing effect of sports risk decision-making. It is of great practical significance for coaches and athletes to reduce the negative impact of framing effect in training and competition by looking for effective factors affecting framing effect.

During the game, basketball players not only have to face the pressure of time, but also face various complex information on the court. How to deal with the information and cognitive load, and whether the cognitive load received by basketball players influences the framing effect of their risk decision-making, which are worthy questions to study. At present, in the researches on the relationship between cognitive load and the framing effect of risk decision-making, Yan (2017) found that the framing effect is significant when there is no cognitive load. The moderate cognitive load increases the subjects' rational thinking and weaken the framing effect. Igou and Bless (2010), He and Jin (2010) have shown that cognitive load affects the speed of decision-making, and the framing effect tends to weaken with the occurrence of cognitive

The Influence of Cognitive Load on the Framing Effect of Risk Decision-making of Basketball Players

BY

CHANG Shuzhi and SUN Yanlin

www.guildaa.org

load. They indicated also that framing effect is not only the result of heuristic system but that analytical system plays an important role. These findings confirm that analytical cognitive processing is used to increase cognitive load, which takes up cognitive resources and weakens framing effect. However, the study by Igou and Bless (2007) drew different conclusions., while investigating the influence of cognitive efforts on framing effect , they found that when situational information requires decision-makers to conduct deeper cognitive processing, longer thinking time leads to more obvious framing effect; increasing the decision maker's processing motivation and processing capacity (increasing the decision-making time) also makes the framing effect more obvious. Based on this, they believe that the framing effect will enhance as decision-makers' cognitive effort increases.

However, When Whitney, Rinehart and Hinson (2008) investigated the impact of cognitive effort on framing effect, they deployed cognitive load to control participants' cognitive effort in the decision-making process, and found that cognitive load does not affect the strength of framing effect. It is believed that this is caused by individuals' use of heuristic system to process framework information. It can be seen that the conclusions reached by researchers on the relationship between cognitive load and the framing effect of risk decision-making are inconsistent. Some studies believe that cognitive load enhances the framing effect, some think that cognitive load weakens the framing effect, and some other studies consider that there is no functional relationship between the two variables.

So, for basketball players, during the game, will cognitive load affect their
framing effect of risk decision-making? When basketball players receive different levels of cognitive load, is there any difference in the effect of high cognitive load and low cognitive load on their risk decision-making framing effect? Under high cognitive load, whether the framing effect of risk decision of basketball players is enhanced or weakened, and what characteristics the framing effect presents under high and low cognitive load conditions are issues worthy of further discussion. Therefore, this study set up number strings of different lengths as memory tasks to form high and low cognitive loads, which simulated real stress situation. And the study will explore the regularity and differences of framing effect of basketball

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BY

CHANG Shuzhi and SUN Yanlin

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players under different situations of high cognitive load and low cognitive load.

Methods

With the method of random sampling, a total of 51 basketball players were selected from Tianjin University of Sport, comprising of 37 male and 14 female players. They were all national level two or above athletes, with an average age of 20.23±1.72 years old. They have participated in national competitions and won the top 8 in the team. The training period was more than 10 years. All study participants reported that the naked eye vision was normal or normal after correction, no color weakness or color blindness, and all were right-handed. They have not participated in such kind of decision-making experiment before.

All subjects were paid a certain amount of money.

Experimental materials for basketball players' risk decision-making

According to the "Sports Situation Risk Decision Questionnaire" compiled by Huang Zhijian, the experimental materials of basketball players' risk decision-making framing effect were compiled. Examples of the contents of the experimental materials are as follows:

1. Suppose a basketball team has 60 chances to attack in an important game. Now there are two attack schemes A and B to choose from. The coach predicted that the results of the two schemes might be as follows:

Positive framework

Scheme A: 20 attacks successful with scoring.

Scheme B: 1/3 chance of the 60 attacks may be successful; 2/3 of chance are likely to fail in 60 attacks without scoring.

Negative framework

Scheme A: 40 attacks failure without scoring

The Influence of Cognitive Load on the Framing Effect of Risk Decision-making of Basketball Players

BY

CHANG Shuzhi and SUN Yanlin

www.guildaa.org

Scheme B: 2/3 chances of the 60 attacks all fail without scoring; 1/3 of chances, 60 attacks are successful.

The experiments showed the decision-making tasks and alternatives of framing effect to the subjects through stimulus images. All images were produced by the software. All images were stimulated into a gray (RGB: 192,192,192) background. The images were processed in a unified way of 15×15cm with a resolution of 480 pixels per inch and a uniform brightness and contrast. In as much as the decision-making tasks in the study needed to be presented to the subjects with two frameworks, positive and negative, two types of stimulus materials were formed. The materials are shown in figure 1 and figure 2:

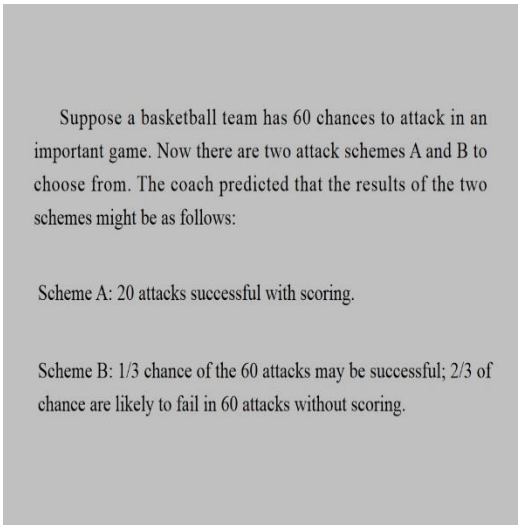

Figure 1 Decision-making task—positive framework (stimulus picture)

The Influence of Cognitive Load on the Framing Effect of Risk Decision-making of Basketball Players

BY

CHANG Shuzhi and SUN Yanlin

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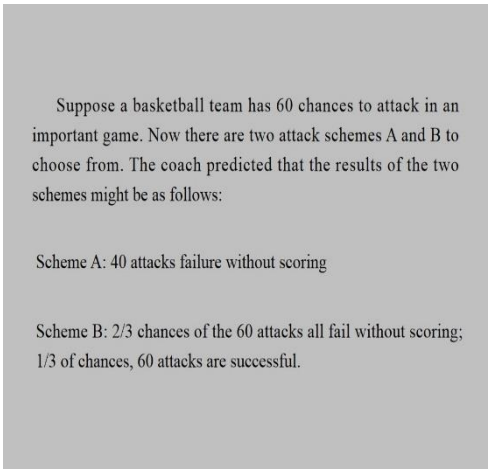

Figure 2 Decision-making task—negative framework (stimulus picture)

Cognitive load materials

According to the dual-task experimental method used by Cheng Jiaping and Luo Yuejia (2017) cognitive load was divided into two levels: high cognitive load and low cognitive load. The two levels were distinguished by the length of the number string that needed to be memorized. Under high cognitive load conditions, the number length was 6; under low cognitive load conditions, the number length was 2. The number strings used in the experiment were random 2 digits and random 6 digits generated by a random number generator.

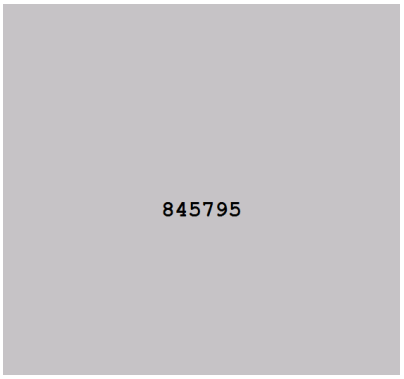

Figure 3 High cognitive load (example of stimulating pictures)

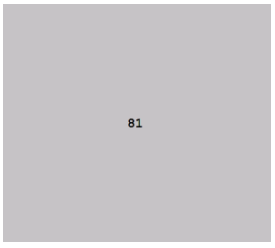

Figure 4 Low cognitive load (example of stimulating pictures)

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Pp.66-85, © JULY 2020

The Influence of Cognitive Load on the Framing Effect of Risk Decision-making of Basketball Players

BY

CHANG Shuzhi and SUN Yanlin

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Experimental Procedures

Test was individually administered in the computer room of the sports psychology laboratory. Participants were instructed to open the program, input the number (subject number is given by the experimenter) and personal information (including name, gender, age, grade, sports level). And then entered the experimental program, subjects read the instruction, and pressed any key to enter the practice and formal experiment after reading the instruction. Subjects stared at the center of the screen with both eyes, and the eyes were about 70cm away from the screen. First, a black outline box was displayed in the center of the screen for 500 milliseconds, and the gaze point "+" was located in the center of the box, which was used to remind subjects to concentrate and did not require any response from the subjects; After the "+" image disappeared, a blank interval of 500 to 800 milliseconds appeared at random, and then what followed was a 1500 millisecond basketball decision task and options, and subjects used the corresponding key on the keyboard to make a choice.

The experiment 1 procedure is shown in figure 5.

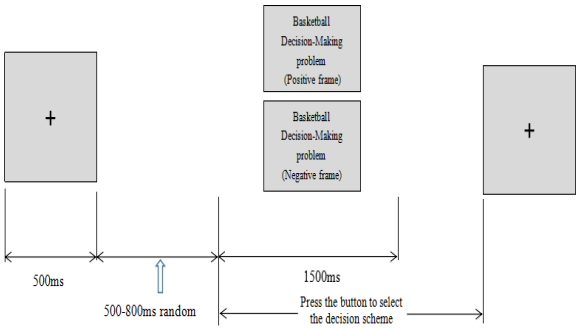

Figure 5 Flow chart of no cognitive load experiment (Experiment 1)

Experiment 2 and 3 Procedures:

Subjects stared at the center of the screen with both eyes, and the eyes were about 70cm away from the screen. First, the gaze point "+" was presented for 500ms; and then a string of black numbers that needed to be memorized appears on the gray background for 4000 ms; And then another string of black numbers that did not need to be memorized appears randomly on the gray background for 500 to 800 ms; Next, a 1500ms basketball decision-making task and alternatives appeared on the screen. After making a choice, subjects were asked to select the string of numbers they had just memorized on the screen after an empty screen with interval of 500-800ms. After the subjects selected the string of numbers, e-prime automatically transited the experiment to the next trial. The experiment 2 and 3 procedure are shown in figure 6 and figure 7.

The only difference between experimental procedure 2 and 3 was that the number string in the high cognitive load experiment of experiment 2 was a set of 6 numbers, while the number string in the low cognitive load experiment of experiment 3 was 2 numbers.

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Pp.66-85, © JULY 2020

The Influence of Cognitive Load on the Framing Effect of Risk Decision-making of Basketball Players

BY

CHANG Shuzhi and SUN Yanlin

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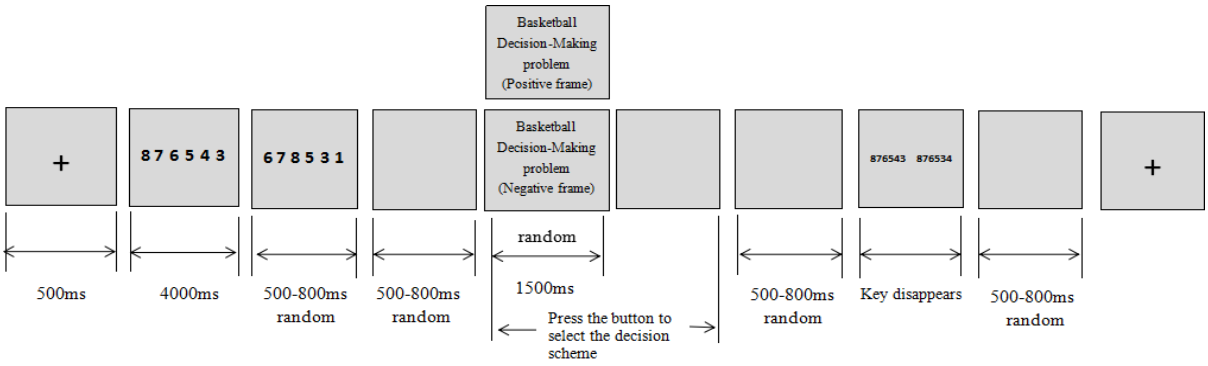

Figure 6 Flow chart of high cognitive load experiment (experiment 2)

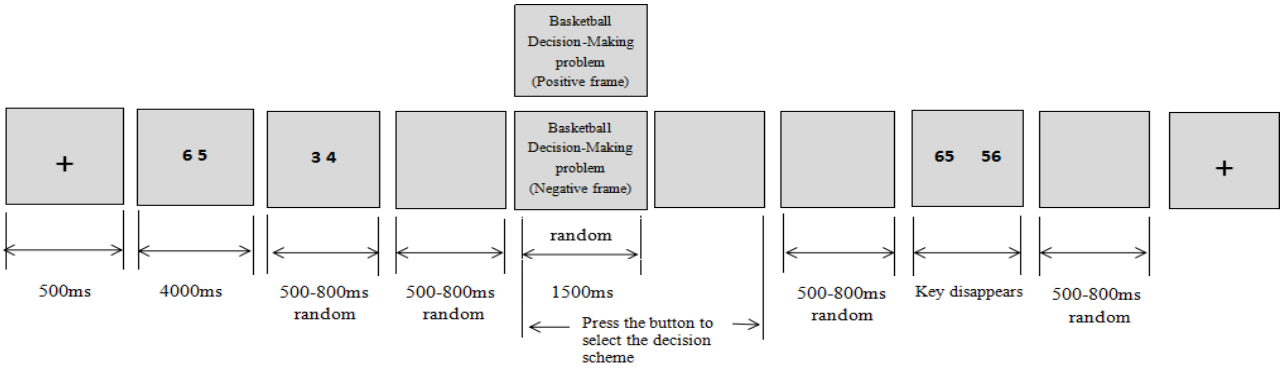

Figure 7 Flow chart of low cognitive load experiment (experiment 3)

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The Influence of Cognitive Load on the Framing Effect of Risk Decision-making of Basketball Players

BY

CHANG Shuzhi and SUN Yanlin

www.guildaa.org

Experimental variables

The dependent variables included the frequency of the subjects choosing two schemes and the reaction time of the risk decision-making. The frequency of choosing a scheme referred to the frequency with which subjects chose conservative scheme and risky scheme under different positive and negative framework types. Reaction time referred to the time interval from the presentation of the stimulus picture of the decision-making task to the time the subjects pressed the key.

All data were processed by SPSS 21.0 for Windows.

Results

In this study, a total of 51 subjects participated in the experiments. The details are as follows (See table 1):

Table 1 Distribution of Subjects

	gender		Sports Level		age	Name of sports
	Boy	Girl	Level 1	Level 2		
Total	37	14	28	23	20.23±1.72	Basketball

The Influence of Cognitive Load on the Framing Effect of Risk Decision-making of Basketball Players

BY

CHANG Shuzhi and SUN Yanlin

www.guildaa.org

Note：*p<.05, **p<.01, ***p<.001

Under the condition of no cognitive load, the framing effect of basketball players' risk decision-making

Table 2 Test results of framing effect of basketball players' risk decision-making without cognitive load

cognitive load	framework type	M	SD	*N*
No cognitive load	Positive framework	0.493	0.256	51
	negative framework	0.685	0.275	51

Note：*p<.05, **p<.01, ***p<.001

It can be seen from table 2 that when there was no cognitive load pressure, the average score of risk-taking tendency was 0.493(M=0.493) and the standard deviation was 0.256(SD=0.256) when basketball players were in positive framework of risk decision-making; Under the negative framework, the average score was 0.685(M=0.685), and the standard deviation was 0.275(SD=0.275). The results showed that there was a framing effect phenomenon in basketball players.

Validity test of cognitive load setting

First, by analyzing and comparing the correct rate of recalling numbers in the high memory load group and the low cognitive load group, the t test found that the recall accuracy rate of the high cognitive load group (M= 90.99%) was lower than the recall accuracy rate of the low cognitive load group (M= 92.43%), t=-1.110, p>0.05, but the result was not significant (see table 3). The validity of cognitive load setting was not obvious from the correct

rate of number recall. Therefore, the validity of cognitive load setting was investigated by analyzing and comparing the reaction time of high and low cognitive load groups.

Table 3 Descriptive statistics and tests of cognitive load induction (accuracy rate)

	N	M	SD	t	p
correct rate of high cognitive load group	51	90.99%	13.02%	-1.11	.272
correct rate of low cognitive load group	51	92.43%	11.48%		

Note：*p<.05, **p<.01, ***p<.001

Table 4 Descriptive statistics and tests of cognitive load induction (reaction time)

	N	M	SD	t	p
reaction time of high cognitive load group	51	2516.150	920.380	7.751	.000
reaction time of low cognitive load group	51	1441.246	623.46185		

Note：*p<.05, **p<.01, ***p<.001

By analyzing and comparing the reaction time of the high cognitive load group and the low cognitive load group, the t-test found that the reaction time of the high cognitive load group (M=2516.150) was higher than that of the low cognitive load group (M=1441.246) , t=7.751, p<0.001, indicating that the cognitive load setting was valid. (See table 4)

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The Influence of Cognitive Load on the Framing Effect of Risk Decision-making of Basketball Players

BY

CHANG Shuzhi and SUN Yanlin

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Analysis of the framework effect of basketball players' risk decision under different cognitive loads

Table 5 Test results of the framing effect of basketball players' risk decision-making under different cognitive loads

cognitive load	framework type	M	SD	*N*
high cognitive load	Positive framework	42.860%	27.718%	51
	negative framework	68.611%	28.523%	51
low cognitive load	Positive framework	46.651%	31.387%	51
	negative framework	74.063%	26.494%	51

Note：*p<.05, **p<.01, ***p<.001

From table 5, it can be seen that under the condition of high cognitive load, the average score of basketball players' risky behaviors under the positive framework was 42.860%（M=42.860%）and the standard deviation was 27.718% (SD=27.718%)；While under the negative framework, the average score was 68.611% (M=68.611%) and the standard deviation was 28.523% (SD=28.523%). Under the condition of low cognitive load, the average score of basketball players' risky behaviors under the positive framework was 46.651%（M=46.651%）and the standard deviation was 31.387% (SD=31.387%)；While under the negative framework, the average score was 74.063% (M=74.063%) and the standard deviation was 26.494% (SD=26.494%). It can be seen that there was a framing effect in basketball players under both high and low cognitive load. Analysis of the influence of cognitive load on the framing effect of risk decision-making

The Influence of Cognitive Load on the Framing Effect of Risk Decision-making of Basketball Players

BY

CHANG Shuzhi and SUN Yanlin

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Table 6 Results of ANOVA of cognitive load on the framing effect of risk decision-making

Sources of variation	SS	df	MS	F	*p*	Partial Eta Squared
cognitive load	1090.098	1	1090.098	4.827	.033	.088
framework type	36029.604	1	36029.604	33.376	.000	.400
cognitive load*framework type	11554.836	1	35.009	.151	.699	.003

Note：$^{*}p<.05$, $^{**}p<.01$, $^{***}p<.001$

From the table 6, it can be seen that the main effect of cognitive load F=4.827, p =.0335< 0.05, indicating that the main effect of cognitive load was significant. The main effect of framing effect F=33.376, p=0.000<0.001, indicating that the main effect of framing effect was very significant. The interaction effect between cognitive load and framing effect F=.151, p=.699>0.05, the interaction effect was not significant. In addition, it can be seen from the results that the effect value of cognitive load was η^2=.0880>0.06, and the effect size was large; the effect size of the main effect of the framework type η^2=0.400>0.16, the effect size was large; while the effect value of the interaction between framework type and cognitive load was η^2=.003<0.06, the effect size was very small, indicating that the relationship between the two variables was weak.

It can be seen from table 6 that the main effect of the framework effect F=33.376, p=0.000<0.001, the independent variable had a statistically significant influence on the dependent variable, and the main effect of the framework type variable was significant, so a pairwise comparison was made. The difference between the risk decision tendency under the negative framework and the risk decision tendency under the positive framework was

The Influence of Cognitive Load on the Framing Effect of Risk Decision-making of Basketball Players

BY

CHANG Shuzhi and SUN Yanlin

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statistically significant (p=0.000), and the difference was 26.579 (95% confidence interval:17.339-35.820). Therefore, there was a framing effect in basketball players under cognitive load. Under the negative framework, basketball players were more inclined to risk-taking behavior than under the positive framework.

It can also be seen from table 6 that the main effect of cognitive load F=4.827, p=0.033<0.05, the influence of independent variables on dependent variables was statistically significant, and the main effect of cognitive load was significant, so a pairwise comparison was made. The difference between therisk decision tendency under high cognitive load and that under low cognitive load was statistically significant (p=0.000), and the difference was 4.623 (95% confidence interval: 0.397-8.850). Therefore, there was a framing effect in basketball players under cognitive load. Under the negative framework, basketball players were more inclined to risk-taking behavior than under the positive framework. In addition, cognitive load had an impact on basketball players' risk decision-making preference, and basketball players were more inclined to avoid risks and choose conservative behaviors under high cognitive load than under low cognitive load. The above results are shown in figure 8.

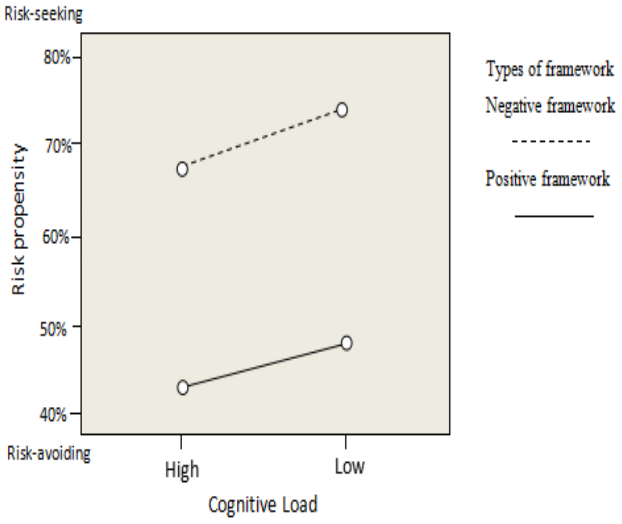

Figure 8 Risk decision scores under cognitive load

Discussion

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The Influence of Cognitive Load on the Framing Effect of Risk Decision-making of Basketball Players

BY

CHANG Shuzhi and SUN Yanlin

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This study found that under different framework conditions, basketball players' decision-making preferences for substantially the same problem will change with the change of the positive and negative framework; This study found that under different framework, basketball players' decision-making preferences for substantially the same problem will change with the change of the positive and negative framework; In other words, basketball players tended to avoid risks when the decision-making scheme was described with a positive framework, while basketball players tended to seek risks when the decision-making scheme was described with a negative framework, showing a significant framing effect, which indicated that there was a phenomenon of risk decision-making framing effect in basketball. At the same time, the research results showed that basketball players had a framing effect under the condition of imposing cognitive load, whether it was under high cognitive load or low cognitive load. And under the negative framework, the risk decision tendency of basketball players was more inclined to take risks than under the positive framework. At the same time, cognitive load had an impact on basketball players' risk decision-making preferences. Compared with the low cognitive load condition, basketball players under high cognitive load tended to avoid risks, chose conservative behaviors and made rational decisions. And cognitive load weakened the framing effect of basketball players.

Investigating the reasons, there may be the following reasons: First, the cognitive load theory proposed by Sweller J and Merrienboer J (1998) believes that the capacity of human brain working memory is limited. When an individual is processing information stimuli, the information stored in the memory system interacts with other external information, all of which need to occupy the space of the system. So the information that the brain can process simultaneously is limited. Therefore, the more complex the information that needs to be processed, the more difficult it is for the brain to allocate cognitive resources, and the work efficiency will decrease. However, Kahneman(1981) believes that the brain is very flexible in processing information, and the individual's cognitive system will allocate certain resources to analyze the stimulus. The brain can flexibly control and adjust this process, and adjust and transfer the limited resources to the more important information. Studies have found that when individuals perform a certain cognitive task, they store "weighted

The Influence of Cognitive Load on the Framing Effect of Risk Decision-making of Basketball Players

BY

CHANG Shuzhi and SUN Yanlin

www.guildaa.org

information" in their working memory. This weighted information is the cognitive control of information processing, and its main function is to improve the processing authority of task-related stimuli, while inhibiting the processing of distracting stimuli irrelevant to the task. Load theory proposes that excessive cognitive load will reduce the cognitive resources used to store "weighted information", so that the processing of distracting stimuli cannot be effectively suppressed. Therefore, compared with low cognitive load conditions, under high cognitive load conditions, distracting stimuli will get more attention and be better processed (Lavie, 2011; Lavie, Hirst, de Fockert, & Viding, 2004). That is to say, high cognitive load will increase the degree of processing of distracting stimuli. This view is also supported by the results of multiple studies ((Holmes, Mogg, de Fockert, Nielsen, & Bradley, 2014; Konstantinou, Beal, King, & Lavie, 2014).

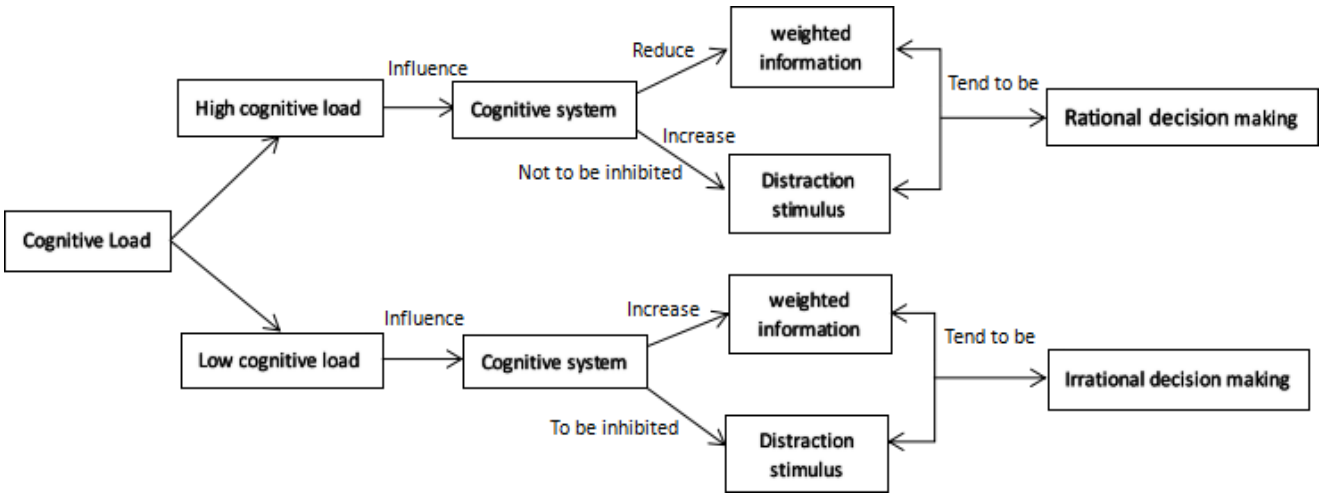

Figure 9 Mechanism of cognitive load

The Influence of Cognitive Load on the Framing Effect of Risk Decision-making of Basketball Players

BY

CHANG Shuzhi and SUN Yanlin

www.guildaa.org

This theory can also explain the framing effect of basketball players. Basketball players in the basketball game field, when it came to the critical moment of winning or losing, the "weighted information" in the brain was the shooting and score, while other key information (such as tactics, coordination, etc.) was suppressed as distracted stimulus unrelated to the shooting task, which made basketball players prone to framework effect. According to the cognitive load theory, the framing effect can be reduced by adding distractor. How to increase basketball players' cognitive processing of distraction stimulation (such as tactics, coordination, etc.)? We can improve the cognitive load of basketball players, such as making the basketball players pay more attention to the position changes of the players on the court or the offensive strategies of rival opponents, so that the distracted stimuli can be better analyzed and processed. At this time, the cognitive resources were occupied by the distracted stimuli, and the cognitive resources allocated to the framing effect were reduced less, and framing effect weakened, so that basketball players can make more rational and correct decisions.

Second, according to the view of information processing theory, under certain circumstances, cognitive load often has little influence on heuristic processing, while cognitive load has a greater impact on analytical processing. If framing effect is only the result of heuristic system, and then the strength of framing effect is not affected by cognitive load. Because the heuristic system processes information in parallel and reacts automatically, it does not occupy or occupy little psychological resources; If the framing effect is the result of the combined action of the heuristic system and the analytical system, then when making risk decision with cognitive load, subjects need to allocate resources in the two systems, so the intensity of framing effect will be different under different cognitive load conditions. It is found that analytical processing plays a major role in the risk decision-making process (Pei Yang, 2018)). Therefore, basketball players used the analytical system to process the framework information in the

The Influence of Cognitive Load on the Framing Effect of Risk Decision-making of Basketball Players

BY

CHANG Shuzhi and SUN Yanlin

www.guildaa.org

game, and part of the cognitive resources were separated. At this time, the cognitive resources focusing on the framing effect were reduced, and the framing effect was weakened. Therefore, basketball players tended to make rational decisions.

Conclusion

1. In summary, there is framing effect of risk decision-making in basketball. And the type of framework affects the risk preference of basketball players,that is, the subjects show risk avoidance under the positive framework, and risk seeking under the negative framework.

2. Cognitive load affects the framing effect of risk decision-making of basketball players. Under the low cognitive load condition, framing effect is significant, while under the high cognitive load condition, framing effect is weakened, that is, with the increase of cognitive load, framing effect tends to weaken.

3. The framing effect in basketball will weaken as the players' cognitive effort increases. Besides, the framing effect is not only the result of heuristic system, but also the analytical system plays an important role in the processing of framework information.

Recommendations

To summarize the results of this study and existing research results and theories, future research can focus on:

First of all, there are many factors that influence the framing effect of basketball players. This study preliminarily discusses the influence of cognitive load on the framing effect of basketball players' risk decision-making, and the research on other influencing factors remains to be further explored.

Secondly, the research object of this paper is basketball players. Due to practical factors, only college basketball players are selected, and they are all in the same school. In the future, higher level athletes can be included, and the sports level is divided in detail, and a more detailed comparative

analysis is made. And the research conclusion is richer and more convincing.

In addition, the selection of experimental materials should be consistent with the actual situation of basketball players. In the future, we can try to observe and study the subjects in the real decision-making situation, so as to strengthen the ecological validity of such research.

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The Influence of Cognitive Load on the Framing Effect of Risk Decision-making of Basketball Players

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