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ARTICLE

Effects of Emotion on Decision-Making of Methamphetamine Users: Based on the Emotional Iowa Gambling Task

Xiaoqing Zeng[1,2,3,*], Song Tu[1,2,3] and Ting Liu[4]

[1]School of Psychology, Jiangxi Normal University, Nanchang, 330022, China

[2]Jiangxi Key Laboratory of Psychology and Cognitive Science, Nanchang, 330022, China

[3]Institute of Psychology, Jiangxi Normal University, Nanchang, 330022, China

[4]Shenzhen Daydream Network Technology Co., Ltd., Shenzhen, 518000, China

*Corresponding Author: Xiaoqing Zeng. Email: zxq3701@163.com

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ABSTRACT

The relapse of methamphetamine (meth) is associated with decision-making dysfunction. The present study aims to investigate the impact of different emotions on the decision-making behavior of meth users. We used 2 (gender: male, female) × 3 (emotion: positive, negative, neutral) × 5 (block: 1, 2, 3, 4, 5) mixed experiment design. The study involved 168 meth users who were divided into three groups: positive emotion, negative emotion and neutral emotion group, and tested by the emotional Iowa Gambling Task (IGT). The IGT performance of male users exhibited a decreasing trend from Block 1 to Block 3. Female meth users in positive emotion had the best performance in IGT than females in the other two groups. In positive emotion, the IGT performance of female meth users was significantly better than that of men. Female meth users in positive emotion had better decision-making than those in negative or neutral emotion. Female meth users in positive emotion had better decision-making performance than males in positive emotion. In negative and neutral emotions, there was no significant gender difference in decision-making.

KEYWORDS

Methamphetamine user; emotion; gender difference; Iowa gambling task; decision-making

Introduction

Drug relapse and risk decision-making

Meth using involves a risky decision-making process [1]. Meth users who exhibit a high level of impulsivity in their decision-making struggle to control their urge of using the drug, making them more prone to relapse [2,3]. According to the Incentive-Sensitization Theory, drug users are highly sensitive to drug-related cues. Drug cues may induce cravings and then disable their ability to make rational decisions [4].

However, many drug users may experience cross-sensitization. Drug users who are sensitive to one drug may also be sensitive to other drugs or even other stimuli, such as stress or negative emotions [5]. In comparison to healthy individuals, drug users exhibit poorer performance in risk decision-making [6], highlighting a decision-making disorder among drug users [7,8]. Studies demonstrate that drug users tend to prioritize immediate rewards over long-term losses [9]. Despite knowing the dangers of drugs, they still use drugs, enjoying the short-term pleasure while ignoring the long-term damage [10,11]. Hence, investigating the decision-making behavior of drug users holds great practical significance in reducing the possibility of relapse.

Emotion and risk decision-making

The Somatic Marker Hypothesis explains the connection between emotions and decision-making, suggesting that

emotions can regulate decision-making behavior in uncertain or complex situations. These emotions are termed as somatic markers [12]. According to Finucane et al., emotions are closely linked to judgment and decision-making. Individuals with mood disorders may exhibit irrational decision-making and judgment [13]. Therefore, the impact of emotions on decision-making behavior is highly significant, but it remains unclear which specific emotion can prompt individuals to engage in risky decision-making behavior.

The Mood Maintenance Hypothesis proposes that individuals experiencing positive emotions are more inclined to avoid risk in decision-making, in order to maintain the current positive state. While individuals experiencing negative emotions are more prone to risk-taking, for alleviating their negative emotion state [14]. However, some researchers argue that people experiencing positive emotions may be more inclined to seek out risks and underestimate potential negative outcomes, while people experiencing negative emotions may be more likely to overestimate risks and thus avoid taking them [15]. The Appraisal-Tendency Framework suggests that individuals experiencing positive emotions may exhibit a preference for taking risks, while individuals experiencing negative emotions may be more inclined to avoid taking risks [16]. Therefore, it is important to further investigate how emotions impact decision-making, particularly among drug users who may have impaired decision-making abilities.

Gender differences in emotional experience and risk decision-making

Previous studies on healthy people have identified significant differences between genders in both emotional experience and decision-making behavior. Specifically, women were more emotionally susceptible than men, and more strongly impacted by negative events [17–19]. Moreover, men tended to outperform women in the Iowa Gambling Task (IGT), as they were more quickly to acquire the rules of IGT than women [20]. Thus, negative emotions may have a greater impact on decision-making behavior in women compared to men. So that women may perform worse on IGT. However, it remains unclear whether these findings can be generalized to drug users.

In China, the majority of drug users were men (85.9%), though the number of female drug users is steadily increasing each year [21]. Crimes due to female drug use was gradually increasing, causing a serious negative impact on society [22]. However, there is still a lack of attention given to female drug users. Some studies have focused solely on comparing the differences in drug type, age, and educational background between male and female drug users, while neglecting to investigate potential gender differences in decision-making and emotion [23].

The current study

In summary, a wealth of research has demonstrated the close relationship between emotion and decision-making. What is not clear, however, is how different types of emotions affect the decision-making behavior of meth users. Previous studies have been insufficient, especially in whether drug use and negative emotions damages decision-making ability and whether there are gender differences in decision-making behavior among drug users. Therefore, this study integrated emotional stimuli into the IGT to investigate them. This study proposes the following hypotheses: (1) Negative emotions increase impulsive decision-making behavior among meth users, as evidenced by lower scores in the IGT. (2) Positive emotions lead to better IGT performance among meth users compared to negative or neutral emotions. (3) Regardless of emotion, male meth users outperform female users in the IGT.

Methods

Participants

168 former meth users (92 males, and 76 females), recruited in compulsory isolation and rehabilitation center, participated in the experiment. They completed a questionnaire with demographic information. In this questionnaire, they self-reported no other drug use. All participates met the following criteria: be right-handed; have normal or corrected-to-normal vision; were diagnosed by a psychiatrist to determine that they did not have other psychiatric disorders; had not taken any psychotropic drugs, and had not been exposed to any drugs during withdrawal. All participants signed informed consent. This study was approved by the ethics committee of Jiangxi Normal University. All participants signed informed consent.

The average age of men was 33.73 (SD = 6.64) and that of women is 32.00 (SD = 6.69). Among participants, 39 (23.21%) has a primary school education, 92 (54.76%) has a junior high school education, 31 (18.45%) has a senior high school education, 4 (2.38%) has a junior college education, and 2 (1.19%) has an undergraduate education. The withdrawal period of participants ranged from 7 to 16 months (M = 12.26, S.D. = 2.63). T-test was conducted on the participates' age, education level, and withdrawal time. The results showed that there was a significant gender difference in withdrawal time (t (166) = 2.71, p = 0.007, *Cohen's d* = 0.42), and the withdrawal time of female users was significantly longer than that of men. There was no significant gender difference in age or educational level ($ps > 0.05$).

Experimental design

This study employed a 2 (gender: male and female) × 3 (emotion type: positive, negative, neutral) × 5 (block: 1, 2, 3, 4, and 5) three-factor mixed experimental design, gender and emotion types as between-subject variables and the chunk as within-subject variables. Participates in neutral emotion were taken as the baseline level. The dependent variable indicators are (1) emotional valence: participants' self-rating of emotional picture valence; (2) Decision-making behavior: the net score of each block (times to choose 3 and 4 cards minus times to choose 1 and 2 cards in IGT, i.e., [3 + 4] – [1 + 2]).

TABLE 1

The valence and arousal of neutral, negative, positive pictures (N = 60)

	Neutral emotional pictures	Negative emotional pictures	Positive emotional pictures	*F*	LSD
$M_{valence}$	3.87	2.34	5.56	1003.80***	Negative < neutral < positive
$M_{arousal}$	3.29	3.91	5.04	25.58***	Neutral < negative < positive

Note: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Materials

Pictures

A total of 204 images were selected from the Chinese Affective Picture System (CAPS) [24] and the International Affective Picture System [25]. Then 80 former meth users who did not participate in the experiment were asked to view the images in two batches and rate all images on arousal (1 = very calm, 4 = neutral, 7 = very excited) and valence (1 = very unhappy, 4 = neutral, 7 = very happy). There were 120 negative emotional pictures (related to death, crime, etc.), 64 positive emotional pictures (related to family and friends, etc.), and 20 neutral emotional pictures (without emotion such as a book, dish, etc.).

After removing 20 invalid questionnaires which were filled in the same answers or did not be finished completely, 60 valid questionnaires were statistically analyzed. The results of ANOVA and multiple comparisons showed that the selected pictures could effectively induce the corresponding emotion (see Table 1). All the pictures were unified in size and pixel with the drawing software of the Windows 7 system, and the size was 800 × 600 with a resolution of 100.

The Iowa gambling task

The Iowa Gambling Task (IGT) is a computerized card selection game commonly used to measure risky decision-making tendencies (shown in Fig. 1). Participants need to choose from four decks of cards across 100 trials, to accumulate as much money as possible, and each deck may have a gain or loss. In current study, decks 3 and 4 were advantageous, providing smaller wins of ¥ 50 and lower net loss levels over time. In comparison, decks 1 and 2 were consistently disadvantageous, providing larger wins of ¥ 100 but substantially higher levels of net loss over time. Specifically, deck 1 had a 50% probability of losing ¥ 100~250, deck 2 had a 10% probability of losing ¥ 1250, deck 3 had a 50% probability of losing ¥ 25~50, and deck 4 had a 10% probability of losing ¥ 250. Research shows that compared with the healthy population, the IGT scores of drug users are generally low, and they cannot turn to advantageous decks [26].

FIGURE 1. The Iowa gambling task.

The IGT was performed on E-Prime2.0 software, and the program was designed as follows: the initial asset was ¥ 2000. First, four decks 1, 2, 3, and 4 were presented (unlimited time). Participants pressed the number keys 1, 2, 3, and 4 to select decks, and then presented feedback (the amount of money won or lost this time, 2000 ms). After that, feedback of current accumulated money was presented (2000 ms). The 100 choices in IGT were divided into 5 blocks according to the time process, so each block included 20 choices. The behavioral indicator, named net scores, was calculated by subtracting the number of disadvantageous deck choices from the number of advantageous deck choices ([3 + 4] − [1 + 2]). The changes in net scores of the five blocks reflected whether the participates' decision-making behavior became better or worse.

Procedure

The experiment was conducted in a quiet and well-lit room in the rehabilitation center. All computers used in the experiment were ASUS a5500 laptops.

Before the formal experiment, participants conducted four practice trials to confirm that they knew the experimental requirements and operations. The experimental procedure was shown in Fig. 2. First, the instruction was presented in the center of the screen (we put the instruction in the appendix), then the "+" fixation was presented (existed for 500 ms). After that, a picture appeared (2500 ms). Then, an empty screen was presented (500 ms). After each picture screening, participants needed to rate the pleasure of the picture that just appeared (1 = very unhappy, 4 = neutral, 7 = very happy), then the empty screen was presented again (500 ms). Next, four decks were presented for choice. After decks choice, the amount of money won or lost was provided as feedback (2000 ms). Then feedback of current accumulated money (2000 ms) was presented. Finally, the empty screen (500 ms) was presented. A trial was over, and the interval between two trials was 1 s.

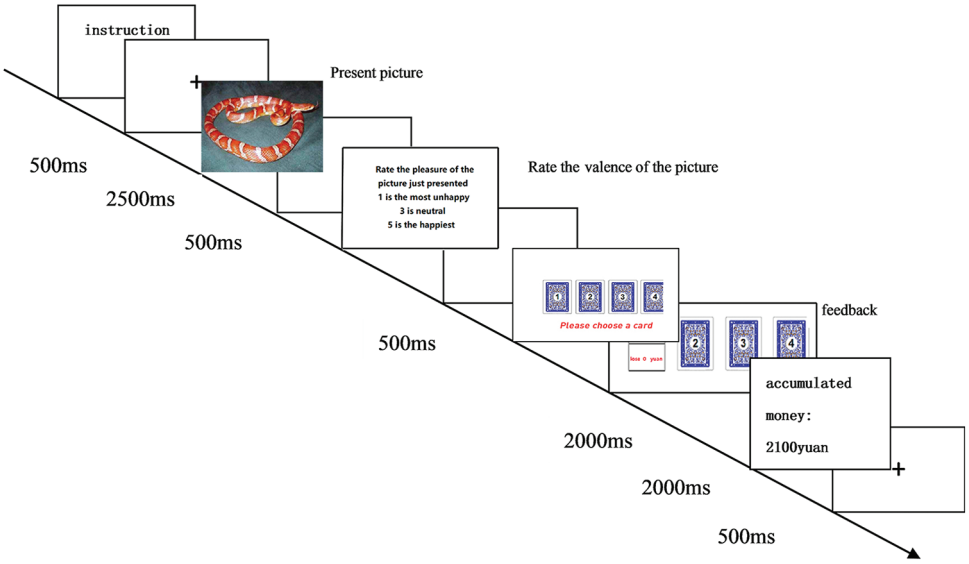

FIGURE 2. The procedure of each trial.

Results

The emotional valence ratings of pictures

The descriptive analysis of emotional pictures valence was shown in Table 2.

Taking the emotion types as the independent variable, the emotional valence of male and female participants was analyzed by one-way ANOVA. The results showed that: (1) Among the male meth users, the average valence of positive, negative, and neutral emotional pictures was significantly different (F (2, 89) = 150.45, $p < 0.001$, $\eta^2 = 0.77$), and the average valence of neutral pictures was significantly higher than that of negative pictures (MD = 1.81, $p < 0.001$), and significantly lower than that of positive pictures (MD = −1.04, $p < 0.001$); the average valence of positive pictures was significantly higher than that of negative pictures (MD = −2.85, $p < 0.001$). (2) Among the female meth users, there was also a significant difference in the average valence of three kinds of pictures (F (2, 73) = 327.52, $p < 0.001$, η^2 = 0.90), and the average valence of neutral pictures was significantly higher than that of negative pictures (MD = 2.06, $p < 0.001$), and significantly lower than that of positive pictures (MD = −1.43, $p < 0.001$); The valence of positive pictures was significantly higher than that of negative pictures (MD = −3.48, $p < 0.001$). These results showed that pictures could induce the corresponding emotions of participants.

Independent sample t-test found that: (1) In negative and neutral emotional pictures, the average valence was no significant gender difference (*ps* > 0.05); (2) In positive emotional pictures, the valence of female meth users was significantly higher than that of male users (t (56) = −3.43, p = 0.001, *Cohen's d* = 0.92).

TABLE 2

The descriptive analysis of emotional pictures valence (N = 168)

Gender	Emotions	n	M	SD	Min	Max
Male	Negative	34	2.14	0.50	1.19	3.38
	Neutral	26	3.95	0.89	2.54	5.58
	Positive	32	4.99	0.64	3.89	6.96
Female	Negative	23	2.05	0.54	1.04	2.94
	Neutral	27	4.11	0.29	3.53	4.92
	Positive	26	5.54	0.57	4.65	6.62

Effect of emotion on net scores of IGT

Participants' net scores of IGT were examined using a 3 factors repeated-measures ANOVA, with gender (male/female) and emotion (positive/neutral/negative) as between-subjects factors, and block (five blocks) as a within-subjects factor. The analysis revealed a significant main effect of block (F (4, 159) = 5.25, p = 0.001, η^2 = 0.12) and gender (F (1, 162) = 18.36, $p < 0.001$, η^2 = 0.10); the main effect of emotion was not significant (F (2, 162) = 1.69, p = 0.187, η^2 = 0.02). In addition, the interaction of block X gender was marginally significant (F (4, 159) = 2.35, p = 0.057, η^2 = 0.06), the interaction of block X emotion was significant (F (8, 320) = 1.69, p = 0.001, η^2 = 0.08), and the interaction of emotion X gender was also significant (F (2, 162) = 3.96, p = 0.021, η^2 = 0.05). The interaction of block X gender X emotion was significant (F (8, 320) = 3.57, p = 0.001, η^2 = 0.08).

Descriptive analysis was conducted on the net scores of male meth users (see Table 3). Male meth abusers' net scores were examined using a 2 factors repeated-measures ANOVA, with emotion (positive/neutral/negative) as a between-subjects factor, and block (five blocks) as a within-subjects factor. The results showed that: (1) the main effect of the block was significant (F (4, 86) = 2.77, p = 0.032, η^2 = 0.11), and the net score of block 1 was significantly higher than that of block 3 (MD = 2.25, p = 0.013); block 2 was significantly higher than block 3 (MD = 1.42, p = 0.048). (2) The main effect of emotion was not significant (F (2, 89) = 0.67, p = 0.515, η^2 = 0.01). (3) The interaction of block X

TABLE 3

Descriptive analysis of male abusers' net scores

Emotion		Block 1	Block 2	Block 3	Block 4	Block 5
Negative (n = 34)	M	−6.70	−6.65	−7.77	−8.77	−6.59
	SD	7.10	9.01	7.75	7.69	9.52
Positive (n = 32)	M	−5.75	−8.69	−10.06	−8.38	−8.63
	SD	7.56	7.71	8.46	10.22	12.60
Neutral (n = 26)	M	−6.23	−5.85	−7.62	−5.77	−5.00
	SD	7.27	9.97	9.50	11.25	13.37

emotion was also not significant (F (8, 174) = 0.72, p = 0.673, η^2 = 0.03).

Descriptive analysis was conducted on the IGT net scores of female meth users (see Table 4). Female meth users' net scores were examined using a 2 factors repeated-measures ANOVA, with emotion (positive/neutral/negative) as a between-subjects factor, and block (five blocks) as a within-subjects factor. The results showed that: (1) the main effect of block was significant (F (4, 70) = 5.58, p = 0.001, η^2 = 0.242), and the net score of block 1 was significantly lower than that of block 5 (MD = −4.24, p = 0.001); block 2 was significantly lower than block 4 (MD = −2.89, p < 0.01) and block 5 (MD = −4.86, p < 0.001); block 3 was significantly lower than block 4 (MD = −2.66, p < 0.05) and block 5 (MD = −4.62, p < 0.001). (2) The main effect of emotion was significant (F (2, 89) = 0.67, p = 0.515, η^2 = 0.01), and the net scores of the positive emotion group were significantly higher than that of the negative and neutral emotion groups (MD = 3.69, p = 0.042; MD = 5.72, p = 0.003); no significance was found between negative and neutral emotion groups (p > 0.05). (3) The interaction of block X emotion was significant (F (8, 142) = 5.93, p < 0.001, η^2 = 0.25). Simple effect analysis showed that the main effect of block existed only in the positive emotion group (F (4, 70) = 16.83, p < 0.001, η^2 = 0.49).

Gender differences in net scores of IGT

All meth users' net scores were examined using a 2 factors repeated-measures ANOVA, with gender (male/female) as a between-subjects factor, and block (five blocks) as a within-subjects factor. The results showed that: (1) In positive emotion, the main effect of the block was significant (F (4, 53) = 8.67, p < 0.001, η^2 = 0.40); the main effect of gender was significant (F (1, 56) = 28.76, p < 0.001, η^2 = 0.68); the interaction of block X gender was also significant (F (4, 53) = 8.70, p < 0.001, η^2 = 0.40). The simple effect analysis showed that the main effect of block in female users was significant (F (4, 53) = 13.69, p < 0.001, η^2 = 0.51), but in male users was not significant (F (4, 53) = 1.66, p = 0.172, η^2 = 0.11). (2) In neutral emotion, no effects were significant (ps > 0.05). (3) in negative emotion, the main effect of the block was marginally significant (F (4, 52) = 2.47, p = 0.056, η^2 = 0.16); others were not significant (ps > 0.05).

The results of the t-test showed that: (1) in negative emotion, the net scores of block 1 had a significant gender difference (t (55) = −2.28, p = 0.02, *Cohen's d* = 0.62), which showed that female users were significantly higher than male users; other blocks had no significant gender difference (ps > 0.05). (2) In neutral emotion, no blocks had significant gender difference (ps > 0.05). (3) In positive emotion, block 2 (t (56) = −2.15, p = 0.03, *Cohen's d* = 0.58), 3 (t (56) = −2.82, p = 0.006, *Cohen's d* = 0.75), 4 (t (56) = −4.88, p < 0.001, *Cohen's d* = 1.30), and 5 (t (56) = −6.81, p < 0.001, *Cohen's d* = 1.82) had a significant gender difference, which all showed that female users were significantly higher than male users.

TABLE 4

Descriptive analysis of female abusers' net scores

Emotion		Block 1	Block 2	Block 3	Block 4	Block 5
Negative (n = 23)	M	−2.26	−5.74	−6.26	−6.35	−5.39
	SD	7.44	9.23	7.78	6.65	8.26
Positive (n = 26)	M	−4.08	−4.39	−3.23	4.15	10.15
	SD	5.44	7.44	10.01	9.07	6.90
Neutral (n = 27)	M	−4.82	−2.89	−2.82	−2.15	−3.19
	SD	7.11	9.40	10.00	9.08	11.80

Discussions

Gender difference in emotional valence

We observed a significant difference in emotional valence among meth users when they were exposed to positive, negative, and neutral images. This demonstrates the efficacy of these emotional stimuli in eliciting their corresponding emotions.

Previous research indicates that women exhibit significantly higher levels of emotional responsiveness and are more emotionally expressive than men when experiencing negative emotions [27]. Nevertheless, the present study discovered that there was no significant gender difference in the emotional valence of negative images between male and female meth users. This indicates that the emotional response intensity of male and female users was similar. This finding suggests that the processing and coping styles of methamphetamine users regarding negative emotions may differ from those of the general population [28]. Furthermore, our study found that female meth users showed a significantly greater emotional valence than males when exposed to positive emotional images. This finding may be attributed to the fact that the majority of positive images used in the study were related to children, family, and interpersonal interaction. From a sociological perspective on gender role differences, women's self-identity is influenced by traditional social culture and endowed with distinct role characteristics by society. For instance, women are commonly associated with characteristics such as nurturing and caring, and often assume social roles such as nurses and preschool teachers. These roles may contribute to their heightened emotional response to positive images

involving children and family [29]. Thus, these positive emotional images related to self-identity may specifically arouse positive emotions in female meth users, resulting in a stronger priming effect on women compared to men. This heightened positive mood may facilitate better decision-making capabilities in female meth users.

The influence of emotion on decision-making

The study discovered that male meth users did not exhibit significant differences in decision-making behavior when experiencing positive, negative, or neutral emotions. Likewise, female methamphetamine users did not display significant differences in decision-making behavior when experiencing negative or neutral emotional states (Hypothesis 1 was not supported). The study showed that male meth users had a decreasing trend in IGT net scores from block 1 to block 3 (shown in Fig. 3), indicating a growing inclination to choose disadvantageous decks and a failure to make long-term decisions by switching to advantageous decks. This finding is consistent with existing research [30]. Furthermore, the study found that female meth users performed better in decision-making tasks when experiencing positive emotions compared to negative or neutral emotions (shown in Fig. 4), partially supporting Hypothesis 2. Positive emotions have been shown to broaden an individual's attention and cognition, allowing them to develop lasting personal resources and reap benefits [31]. Therefore, positive emotions have a positive impact on the decision-making behavior of female methamphetamine users.

Gender differences in decision-making

The study found that there were no significant gender differences in decision-making behaviors among meth users experiencing negative and neutral emotions. However, when exposed to positive emotions, female meth users demonstrated significantly better decision-making abilities than their male counterparts (shown in Fig. 5), contradicting Hypothesis 3. The higher net scores of female users compared to men may be attributed to their longer withdrawal time. As withdrawal time increases, the cognitive function of meth users may recover at a slower rate [32], leading to an improvement in impulsive decision-making behavior [33].

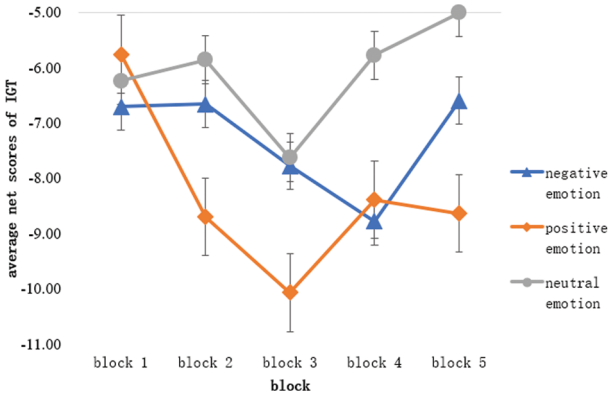

FIGURE 3. Average net scores of male meth users.

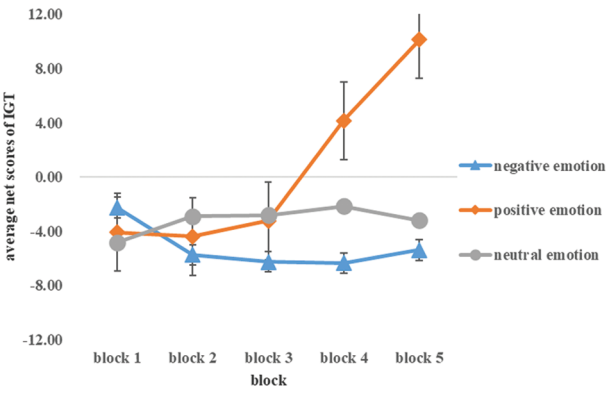

FIGURE 4. Average net scores of female meth users.

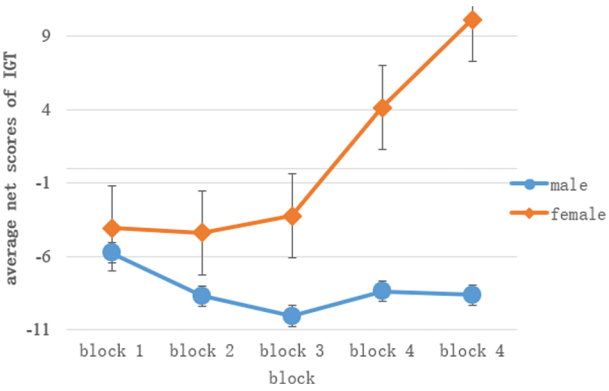

FIGURE 5. The net scores of meth users in positive emotion.

Limitations

To fully evaluate the findings of this study, it is imperative to acknowledge its limitations and suggest directions for future research. First, the study had a smaller sample size of female participants compared to male participants, and the number of positive, neutral, and negative emotional pictures was unbalanced. These factors may have potentially negative implications for the study's results. Second, while we effectively controlled for the variable of drug type, there remains a need to control or balance for other variables such as educational background, marital status, and frequency of drug abuse to ensure the validity of the study's results. Third, since this study does not include a control group of healthy participates, it is unable to make comparisons between the decision-making behaviors of meth users and healthy individuals.

Conclusions

This study examined how different emotions affect decision-making among male and female meth users. The results showed that male users did not exhibit significant differences in decision-making behavior across negative, positive, and neutral moods. In contrast, positive emotions were found to decrease impulsive decision-making behavior in female meth users. Additionally, in positive mood states, the decision-making behavior of female meth users was significantly better than that of male users. However, no significant gender

differences were observed in decision-making behavior among meth users in negative and neutral moods.

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Author Contributions: The authors confirm contribution to the paper as follows: study conception and design: Xiaoqing Zeng, Ting Liu; data collection: Ting Liu; analysis and interpretation of results: Xiaoqing Zeng, Ting Liu, Song Tu; draft manuscript preparation: Xiaoqing Zeng, Ting Liu, Song Tu. All authors reviewed the results and approved the final version of the manuscript.

Availability of Data and Materials: The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics Approval: This study was approved by the Ethics Committee of Jiangxi Normal University. All participants signed informed consent.

Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.

References

1. Stoops WW, Kearns DN. Decision-making in addiction: current knowledge, clinical implications and future directions. Pharmacol Biochem Behav. 2018;164:1–3. doi:10.1016/j.pbb.2017.12.001.
2. Ersche KD, Jones PS, Williams GB, Turton AJ, Robbins TW, Bullmore ET. Abnormal brain structure implicated in stimulant drug addiction. Science. 2012;335(6068):601–4. doi:10.1126/science.1214463.
3. Yan WS, Li YH, Xiao L, Zhu N, Bechara A, Sui N. Working memory and affective decision-making in addiction: a neurocognitive comparison between heroin addicts, pathological gamblers and healthy controls. Drug Alcohol Depend. 2014;134:194–200. doi:10.1016/j.drugalcdep.2013.09.027.
4. Berridge KC, Robinson TE. Liking, wanting, and the incentive-sensitization theory of addiction. Am Psychol. 2016;71(8):670–9. doi:10.1037/amp0000059.
5. Shaham Y, Erb S, Stewart J. Stress-induced relapse to heroin and cocaine seeking in rats: a review. Brain Res Rev. 2000;33(1):13–33. doi:10.1016/S0165-0173(00)00024-2.
6. Gorzelańczyk EJ, Walecki P, Błaszczyszyn M, Laskowska E, Kawala-Sterniuk A. Evaluation of risk behavior in gambling addicted and opioid addicted individuals. Front Neurosci. 2021;14:597524. doi:10.3389/fnins.2020.597524.
7. Yan WS, Li S, Sui N. Research paradigms and neural mechanisms for decision-making deficits in addicts. Adv Psychol Sci. 2011;19(5):652–63.
8. Yang L, Yao DW, H. CAO, Wang BQ, He YY, Su HT. The characteristics, mechanisms and interventions of drug addicts' decision-making defects. Adv Psychol Sci. 2019;27(2):329–43. doi:10.3724/SP.J.1042.2019.00329.
9. Rosenbloom MH, Schmahmann JD, Price BH. The functional neuroanatomy of decision-making. J Neuropsychiatry Clin Neurosci. 2012;24(3):266–77. doi:10.1176/appi.neuropsych.11060139.
10. Vaidya JG, Block RI, O'Leary DS, Ponto LB, Ghoneim MM, Bechara A. Effects of chronic marijuana use on brain activity during monetary decision-making. Neuropsychopharmacol. 2012;37(3):618–29. doi:10.1038/npp.2011.227.
11. Yang L, Liu WX, Zhang Y, Zhang JX, Niu LL. The external validity of delay discounting in the field of substance addiction. Adv Psychol Sci. 2021;29(1):140–9. doi:10.3724/SP.J.1042.2021.00140.
12. Bechara A, Damasio AR, Damasio H, Anderson SW. Insensitivity to future consequences following damage to human prefrontal cortex. Cognition. 1994;50(1–3):7–15. doi:10.1016/0010-0277(94)90018-3.
13. Finucane ML, Peters E, Slovic P. Judgment and decision making: the dance of affect and reason. In: Schneider S, Shanteau J, editors. Emerging perspectives on judgment and decision research (Cambridge series on judgment and decision making). Cambridge: Cambridge University Press; 2003. p. 327–64.
14. Isen AM, Patrick R. The effect of positive feelings on risk taking: when the chips are down. Organ Behav Hum Perf. 1983;31(2):194–202. doi:10.1016/0030-5073(83)90120-4.
15. Zhuang JY. Relationship of emotion and decision making. Adv Psychol Sci. 2003;(4):423–31.
16. Han S, Lerner JS, Keltner D. Feelings and consumer decision making: the appraisal-tendency framework. J Consum Psychol. 2007;17(3):158–68. doi:10.1016/S1057-7408(07)70023-2.
17. Yuan J, Zhang Q, Chen A, Li H, Wang Q, Zhuang Z, et al. Are we sensitive to valence differences in emotionally negative stimuli? Electrophysiological evidence from an ERP study. Neuropsychologia. 2007;45(12):2764–71. doi:10.1016/j.neuropsychologia.2007.04.018.
18. Codispoti M, Surcinelli P, Baldaro B. Watching emotional movies: affective reactions and gender differences. Int J Psychophysiol. 2008;69(2):90–5. doi:10.1016/j.ijpsycho.2008.03.004.
19. Hankin BL, Mermelstein R, Roesch L. Sex differences in adolescent depression: stress exposure and reactivity models. Child Dev. 2007;78(1):279–95. doi:10.1111/j.1467-8624.2007.00997.x.
20. Reavis R, Overman WH. Adult sex differences on a decision-making task previously shown to depend on the orbital prefrontal cortex. Behav Neurosci. 2001;115(1):196–206. doi:10.1037/0735-7044.115.1.196.
21. CFDA Annual report on national drug abuse monitoring (2016). World Clinic Drugs. 2017;38(9):628 (In Chinese).
22. Lai XG, Zhao XJ. Study on female crime. Beijing, China: Law Press; 2013.
23. Yang X. Negative impact of international drug control policies on women. Chinese J Drug Abuse Prev Treat. 2019;25(5):249–59.
24. Gan T, Luo YJ, Zhang ZJ. The influence of emotional time perception. J Psychol Sci. 2009;32(4):836–9+823.
25. Lang PJ, Simons RF, Balaban M. Attention and orienting: sensory and motivational processes. London: Psychology Press; 2013.

26. van Holst RJ, van den Brink W, Veltman DJ, Goudriaan AE. Why gamblers fail to win: a review of cognitive and neuroimaging findings in pathological gambling. Neurosci Biobehav Rev. 2010;34(1):87–107. doi:10.1016/j.neubiorev.2009.07.007.
27. Domes G, Schulze L, Böttger M, Grossmann A, Hauenstein K, Wirtz PH, et al. The neural correlates of sex differences in emotional reactivity and emotion regulation. Hum Brain Mapp. 2010;31(5):758–69. doi:10.1002/hbm.20903.
28. Yang L, Ma L, Zhao X, Zhang GS. Characteristics of drug addicts in emotional processing and coping style: based on negative emotions. J Psychol Sci. 2015;38(2):482–9.
29. Steiner RS, Krings F, Wiese BS. Remember the children, honey! Spouses' gender-role attitudes and working mothers' work-to-family conflict. Appl Psychology. 2019;68(2):250–75.
30. Hanson KL, Luciana M, Sullwold K. Reward-related decision-making deficits and elevated impulsivity among MDMA and other drug users. Drug Alcohol Depend. 2008;96(1–2):99–110. doi:10.1016/j.drugalcdep.2008.02.003.
31. Fredrickson BL. What good are positive emotions? Rev Gen Psychol. 1998;2(3):300–19. doi:10.1037/1089-2680.2.3.300.
32. Iudicello JE, Woods SP, Vigil O, Scott JC, Cherner M, Heaton RK, et al. HIV neurobehavioral research center (HNRC) group. Longer term improvement in neurocognitive functioning and affective distress among methamphetamine users who achieve stable abstinence. J Clin Exp Neuropsychol. 2010;32(7):704–18. doi:10.1080/13803390903512637.
33. Wang G, Shi J, Chen N, Xu L, Li J, Li P, et al. Effects of length of abstinence on decision-making and craving in methamphetamine abusers. PLoS One. 2013;8(7):e68791. doi:10.1371/journal.pone.0068791.