Visual Search Attentional Bias Modification Decreases the Attentional Bias for Facial Expression of Sadness and the Relapse Tendency in Abstinent Methamphetamine Drug Users

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Abstract. Abstinent drug users were hypothesized to harbor attentional bias towards stimuli relevant to negative facial expressions. This study investigated the attentional bias hypothesis for abstinent methamphetamine users, as well as the effects of attentional bias modification on the attentional bias for facial expressions and its effects on relapse tendency in abstinent drug users. These possibilities were investigated by using the dot-probe paradigm and “find-the-smile” visual search paradigm in two different behavioral experiments. The results of Experiment 1 showed that abstinent methamphetamine users displayed significant attentional bias for the facial expression of sadness. The results of Experiment 2 showed that the visual search attentional bias training significantly increased the attentional bias for happy faces and decreased the attentional bias for sad faces in abstinent methamphetamine users. The research has also found that such a training program decreased the relapse tendency. These results indicate that the visual search attentional bias modification may be an effective behavioral intervention for methamphetamine users.

1. Introduction

Accurate perception of other people's emotions is the psychological basis for individuals to normally perform their social functions. Studies showed that abstinent drug users had significant deficits in processing emotional faces [1]. For example, abstinent opioid abusers have significant deficits in facial expression processing [2]. They usually harbor an obvious attentional bias towards negative emotions [3-5] and are more likely to experience negative emotions, which play an important role in relapsing [6,7]. The enhancement of negative emotional experience among abstinent drug users is also closely related to the attentional bias for external negative emotional stimuli including negative facial expressions [6].

The visual search training is an effective training program to change the attentional bias for negative emotional stimuli, which has been widely used in different populations and achieved good therapeutic effect. For instance, it was found to significantly decrease social anxiety and attentional bias towards negative emotional stimuli for depressive patients. It could significantly change their physiological status and activity patterns of their brains, and even significantly reduce their anxiety and depressive symptoms [8-10]. These findings suggest that, the visual search attentional bias modification for abstinent drug users can significantly improve their attentional bias for negative emotional stimuli, improve their social function and reduce their relapse tendency.

At present, the current drug using situation all over the world shows a trend of increasing utilization rate of methamphetamine drug and decreasing utilization of traditional drug (such as heroin). Compared with traditional drug, methamphetamine drug is a class of psychotropic substances artificially synthesized in the laboratory, its mechanism of addiction and its impact on brain and mind are significantly different from traditional drug [11-13]. However, previous studies on the attentional bias of abstinent drug users just focused on abstinent traditional drug users. No study has ever examined the attentional bias for emotional faces in abstinent methamphetamine drug users. We investigated the attentional bias hypothesis for negative facial expressions in
abstinent methamphetamine users, and we also investigated the effects of visual search training on the attentional bias and its effects on relapse tendency among these abstinent methamphetamine users.

2. Experiment 1

Based on the dot-probe paradigm, Experiment 1 investigated whether there is an attentional bias for negative facial expressions in abstinent methamphetamine users.

**Participants.** Fifty-one Chinese males from a mandatory drug rehabilitation center who had only used methamphetamine (age 19-47; abstinent time: $M = 6.57$ months, $SD = 6.67$; drug using time: $M = 30.7$ months, $SD = 17.55$; educational level: $M = 1.92$, $SD = 0.69$) and had no history of mental illness participated and constituted the abstinent group. In the current study, the educational level of participants was coded as: "primary school" = 1, "middle school" = 2, "high school" =3, "undergraduate" = 4. In addition, 30 Chinese undergraduate students (male, age 20-25, self-reported no history of drug addiction or mental illness) participated in the experiment, forming the control group. The mean age of the participants in the abstinent group was significantly higher than that in the control group ($t (58.38) = 9.48$, $p < 0.001$, $d = 1.91$). The experiment was reviewed and approved by the school ethics committee and all participants gave informed consent.

**Design.** A 2 (group: abstinent, control) × 4 (facial expression: happiness, sadness, disgust, neutral) mixed-model experimental design was used, with group being the between-subjects factor while facial expression being the within-subjects factor.

**Materials and Procedure.** The stimuli were presented by the dot-probe paradigm. In each trial, a fixation point was presented for 1000ms, then a pair of facial expression images was displayed for 500ms, one image appeared at the top of the screen, another one appeared at the bottom of the screen. When the faces disappeared, a probe of up arrow was displayed at the top of the screen or a probe of down arrow was displayed at the bottom of the screen, the corresponding key for the probe was the upper key or the lower key. The probe was randomly displayed on both sides of the screen, and the participants were asked to quickly and accurately press the corresponding keys to identify the probe.

The facial expression images were chosen from the BU-3DFE database, including the facial expressions of happiness, sadness, disgust, neutral [14]. These images included eight Asian models’ faces (4 males, 4 females), each model’s face generated four different expression pairs, including happiness-neutral, disgust-neutral, sad-neutral and neutral-neutral. Each pair of expressions came from the same model, therefore there were 32 pair of expressions. A total of 160 trials were presented, thus each pair of expressions was repeatedly presented for five times. All the stimuli were presented in a completely random order. The accuracies and reaction times of participants were recorded in this task.

**Data Analysis.** The trials with incorrect responses, and the trials on which the reaction time was less than or equal to 200ms and greater than or equal to 2000ms, as well as the trials that were three standard deviations away from the mean were excluded [15]. On average, 5% of trials were excluded. The attentional bias score was calculated according to the following formula:

$$\text{Ab} = \frac{\text{RT (Opposite side)} - \text{RT (Same side)}}{\text{RT (Same side)}}.$$  \hspace{1cm} (1)

“RT (Opposite side)” indicated the reaction time when the probe point was located on the opposite side of the emotional stimuli. “RT (Same side)” indicated the reaction time when the probe point was on the same side of the emotional stimuli (In the calculation of neutral - neutral attentional bias, the neutral expression on the left of the concatenation "-" is defined as emotional stimulus). A positive score indicated that the participant had an attentional bias towards the emotional face. We carried out a mixed – model analysis of covariance (ANCOVA) on attentional bias, in which age and educational level were entered as the covariates. The Greenhouse-Geisser correction was used when the spherical distribution hypothesis was not satisfied.

**Results and Discussion.** The results showed that the interaction between group and facial expression was significant ($F (2.52, 193.63) = 4.53$, $p = 0.007$, $\eta_p^2 = 0.06$). However, the main
effects of group and facial expression were not significant ($F_s < 2.5, ps > 0.07$). We also found that compared with the control group, abstinent methamphetamine users showed a significant attentional bias for the facial expression of sadness ($F(1, 78) = 9.37, p = 0.003, \eta^2_p = 0.11$), but there was no significant attentional bias for other facial expressions ($F_s < 1.01, ps > 0.32$) (see Fig. 1). In addition, we observed a significant difference in attentional bias among different expressions among abstinent methamphetamine users ($F(3, 75) = 3.36, p = 0.02, \eta^2_p = 0.12$). Subsequent Bonferroni post-hoc test had shown that, the attentional bias for the expression of sadness was significantly higher than that of neutral faces in abstinent methamphetamine users ($p = 0.02$). However, there was no significant difference in attentional bias between different expressions in the control group ($F(3, 75) = 1.99, p = 0.12, \eta^2_p = 0.07$).

![Figure 1](image_url)

Figure 1. The Attentional Bias of the Abstinent Drug Users Group and the Control Group to Different Facial Expressions in Experiment 1 ($M \pm SE$).

The results of Experiment 1 showed that compared with the control group, abstinent methamphetamine users showed a significant attentional bias for the facial expression of sadness. This result was consistent with previous studies on abstinent traditional drug users. For example, abstinent traditional drug users are reported to have an attentional bias for negative emotional faces and overestimate the emotional intensity of the expressions of sadness and anger [3-5]. Abstinent heroin drug users are also more sensitive to negative emotions than normal people [16]. In addition, previous studies also showed that heroin addicts respond more strongly to negative emotional stimuli than positive emotional stimuli [17]. These results suggest that both traditional drug abusers and methamphetamine users have preferential processing and high sensitivity for negative emotions.

3. Experiment 2

Following previous study [18], we used the find-the-smile visual search training to investigate the effects of attentional bias modification on the attentional bias for facial expressions and its effects on relapse tendency among these abstinent methamphetamine drug users.

Participants. Thirty participants (age 19-48) of Experiment 1 participated in this experiment. But eventually five of them dropped out before the end of experiment. A total of 25 participants were randomly assigned to the training or control group. Twelve of them (abstinent time: $M = 12$ months, $SD = 6.58$; drug using time: $M = 24.33$ months, $SD = 9.8$; educational level: $M = 2.08, SD = 0.79$) were assigned to the training group and the other 13 participants (abstinent time: $M = 9.46$ months, $SD = 3.82$; drug using time: $M = 28.38$ months, $SD = 8.98$; educational level: $M = 1.69, SD = 0.63$) formed the control group. There were no significant differences in the age, abstinent time, drug using time, and educational level between the two groups ($ts < 1.37, ps > 0.18$). This experiment was reviewed and approved by the school ethics committee and all participants gave informed consent.

Materials and Procedure. Participants were asked to complete three experimental tasks in a sequence of pre-test, training and post-test. In the pre-test, firstly, participants were asked to finish
the 18-item Re-addiction Tendency Questionnaire [19], a 5-point scale (0 “very slight”, 5 “very severe”) that measures the relapse tendency. The higher the total score, the higher the tendency to relapse (α = 0.8). Then they were asked to finish the dot-probe task as described in Experiment 1.

After the pre-test, participants in the training group were asked to finish an eight-week attentional bias training (once a week; each training consisted of 120 trials) in which the task of the participants were to search a happy face in a crowd of 15 non-happy faces (4×4 matrix arrangement) on a computer screen by clicking the mouse. When participants succeeded in finding the face, the screen gave the correct response: “You're great!” Participants in the control group were asked to search for the only neutral face with a mole in a crowd of 15 distractor faces (4×4 matrix arrangement). The face materials were all from the Chinese Facial Affective Picture System [20] and came from different models.

Target faces of the training group consisted of 16 happy faces (8 males and 8 females; randomly presented one of them for each trial). In each trial, the 15 distractor faces consisted of 8 sad faces (5 males and 3 females) and 7 disgusted faces (4 males and 3 females). Target faces of the control group consisted of 10 neutral faces with a mole (created by using the Adobe Photoshop software; 5 males and 5 females; randomly presented one of them for each trial). The remaining distractor faces consisted of 11 neutral faces (8 males and 3 females), 2 sad faces (female) and 2 disgusted faces (female), and all distractor faces had no moles. In the training task, the position of the face was completely random.

After the training stage, participants were asked to finish the post-test which was identical to the pre-test.

**Data Analysis.** The data processing method was identical to those of Experiment 1. In Experiment 2, on average 1% of trials were eliminated. We conducted a 4 (facial expression: happiness, sadness, disgust, neutral) × 2 (group: training, control) × 2 (time: pre-test, post-test) mixed-model analysis of variance (ANOVA) on attentional bias and a 2 (group: training, control) × 2 (time: pre-test, post-test) mixed—model analysis of variance (ANOVA) on relapse tendency.

**Results and Discussion.** As for the attentional bias, the results showed that the interaction between facial expression and time was significant ($F(3, 69) = 5.77, p = 0.001, \eta^2_p = 0.20$), and there was a trend of interaction between facial expression, group and time ($F(3, 69) = 2.38, p = 0.08, \eta^2_p = 0.09$). The results of simple effect analysis showed that, in the pre-test, there was no significant difference in the attentional bias for the four different facial expressions (i.e., happiness, sadness, disgust, neutral) between the training group and the control group ($Fs < 1.28, ps > 0.27$). Compared with the pre-test, the participants in the training group significantly increased the attentional bias for the expression of happiness after 8 weeks of the find-the-smile visual search training ($F(1, 23) = 5.41, p = 0.03, \eta^2_p = 0.19$) and reduced the attentional bias for the expression of sadness ($F(1, 23) = 5.19, p = 0.03, \eta^2_p = 0.18$) (see Fig. 2), but there was no significant change in the attentional bias for the expressions of disgust and neutral ($Fs < 0.67, ps > 0.42$). Furthermore, for the control group, there was no significant change in the attentional bias for all facial expressions (i.e., happiness, sadness, disgust, neutral) after the post-test ($Fs < 1.09, ps > 0.31$).

**Figure 2.** The Attentional Bias of the Training Group and the Control Group to Different Facial Expressions in Experiment 2 ($M \pm SE$).
As for the relapse tendency, the results showed that the main effect of time ($F(1, 23) = 2.52, p = 0.13, \eta^2_p = 0.1$) and the main effect of group ($F(1, 23) = 0.47, p = 0.5, \eta^2_p = 0.02$) were both not significant, but there was a trend of interaction between time and group ($F(1, 23) = 3.28, p = 0.08, \eta^2_p = 0.13$) (see Fig. 3). Compared with the pre-test, the participants in the training group significantly reduced their relapse tendency after 8 weeks of training ($F(1, 23) = 5.55, p = 0.03, \eta^2_p = 0.19$). But there was no significant change in the relapse tendency in the control group after the post-test ($F(1, 23) = 0.03, p = 0.88, \eta^2_p = 0.001$).

![Figure 3. The Relapse Tendency of the Training Group and the Control Group in Experiment 2 ($M \pm SE$).](image)

The results of Experiment 2 showed that after 8 weeks of visual search training, abstinent methamphetamine users in training group significantly improved their attentional bias for the facial expressions of happiness and sadness and decreased their relapse tendency, but these changes were not observed in the control group. Therefore, these results suggest that the visual search attentional bias modification may be an effective behavioral intervention for methamphetamine users.

4. General Discussion

To sum up, the present study investigated the attentional bias of abstinent methamphetamine users, the effects of visual search training on the attentional bias of facial expressions and relapse tendency among them for the first time. We found that abstinent methamphetamine users displayed a significant attentional bias for the facial expression of sadness. In addition, the visual search attentional bias training significantly decreased the attentional bias for the facial expression of sadness and decreased the relapse tendency for abstinent methamphetamine users. These results indicate that the visual search attentional bias modification may be an effective behavioral intervention for methamphetamine drug users in drug rehabilitation.

Previous studies have not reached a consensus on the effect of visual search attentional bias modification training. For instance, visual search training can significantly decrease the attentional bias for rejective social signals in low self-esteem individuals and increase their self-esteem level [18]. It can also decrease the attentional bias for negative emotions in depressive patients and therefore reduce their depressive symptoms [10]. However, other studies found that visual search training cannot improve the attentional bias towards negative emotional face for Dysthymia patients [21]. The visual search training used in our study required the participants to find the expression of happiness among the expressions of sadness and disgust, which actually involved both the processing of positive emotions and negative emotions. In Experiment 1, we found that participants focused more on the facial expression of sadness. And in Experiment 2, we found that the visual search training program, which was not aimed at the expression of sadness, significantly increased the attentional bias for the facial expression of happiness and decreased the attentional bias for the expression of sadness and relapse tendency. However, the underlying mechanisms behind this phenomenon—such as how the visual search training decrease the attentional bias for the expression of sadness and relapse tendency—have not been identified. Since the emotional state and eye movement pattern of the participants were not measured, this study could not clarify this issue.
In addition, our participants were all males, so future research should take female participants into account. Finally, the effect of training intensity and frequency, and the maintenance of training effect, should be considered in the future study.

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References


