



Negative implicit in-group stereotypes of Chinese male drug abusers: evidence from ERP

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Accepted: 27 June 2022

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Abstract

Psychological dependence is the most important factor leading to relapse, few studies have examined whether in-group stereotypes exist in drug abusers, while it's helpful for drug abusers in getting rid of psychological dependence. To investigate the presence of in-group stereotypes and the neural mechanisms in drug abusers, two experiments were designed in this study. Experiment 1 used a classification–verification paradigm and Experiment 2 used The Extrinsic Affect Simon Task (EAST), simultaneous collection of EEG data from China. 18 and 17 males were analyzed respectively in Experiment 1 and 2. The results in Experiment 1 showed that (1) there was no significant difference in reaction times or N400 amplitude between the condition "Drug abusers-Negative words" and the condition "Drug abusers-Positive words". In Experiment 2, we found that (2) participants in the condition "Drug abusers-Negative words" scored higher in accuracy rates than in the condition "Drug abusers-Positive words". (3) Participants in the condition "Drug abusers-Negative words" were shorter than "Drug abusers-Positive words" in reaction times (RTs). (4) Participants in the condition "Drug abusers-Negative words" were lower than "Drug abusers-Positive words" in the peak of N400. The conclusion is that there are significant negative implicit in-group stereotypes among Chinese male drug abusers. The experimental results and the uniqueness of Chinese male drug abusers in this study were discussed.

Keywords Drug abuser · Implicit in-group stereotypes · Reaction time · ERP · N400

Introduction

The World Health Organization defines drug addiction as a long-term, recurrent disease. Globally, about 270 million people abuse drugs each year, health care services in many countries are poorly equipped to deal with Corona Virus Disease(COVID-19), restrictions imposed on drugs are hampered, and drug markets are likely to further expand and become more complex (United Nations Office on Drugs and Crime, 2021). In addition, to prevent the spread of COVID-19, various regions may implement closed-off management, which leads to a decrease in social connections, this may

increase the risk of relapse (Aki et al., 2020). The situation of drug trade and use remains grim in China. There are 2,148 million drug users, including 223,000 new drug users, by the end of 2019. The enormous number of drug abusers, the aggravating concealment of drug use and the rise of new types of drugs result in the increasing difficulty in governance (Office of the China National Narcotic Control Committee, 2021). The number of relapses even exceeds the number of new drug abusers in the same year period (Zeng et al., 2019), and the probability of relapse is extremely high (Tanguay et al., 2015), and how to reduce the relapse rate effectively has become a key challenge that urgently needs to be broken in drug addiction intervention and treatment (Office of the China National Narcotic Control Committee, 2021).

Clinicians have found that psychological dependence is the most important factor in relapse (Zeng & Chen, 2020). In previous studies have explored the effects of variables such as family functioning (Zeng & Tan, 2021), self-concept (Chung & Maisto, 2016), negative motions (Cavicchioli et al., 2019; Zeng et al., 2018), social support (Zeng & Chen,

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2020), personality traits, and self-efficacy (Chung & Maisto, 2016; Zhang & Zeng, 2021) on relapse in drug abusers, but little is still known about the psycho-social processes that lead to the cessation of addictive behaviors (Fiorentine & Hillhouse, 2003; Zeng & Chen, 2020). So far, there has been no detailed study on the in-group stereotype of drug abusers from the perspective of them, and it has not been confirmed whether the in-group stereotype exists in them. The current study combines advanced Electroencephalogram (EEG) technology to exam the in-group stereotype of drug abusers.

In-group stereotypes

Stereotypes are cognitive structures of knowledge, perceptions, and expectation about a group (Fiske, 2014; Hamilton & Trolier, 1986; Wang, 2001), there are two types, positive and negative (Greenwald & Banaji, 1995; Seibt & Förster, 2004; Zhu, 2012), they may appear in the same target group at the same time. For example, women are perceived as gentle, empathetic and can also be seen as weak (Xu, 2003). Stereotypes can change out-group's perceptions to the target group and make inferences accordingly (Ferrari et al., 2017; Tsukiura & Cabeza, 2011), and it plays an important role in guiding people's social perceptions and behaviors (Fiske, 2004; Li, et al., 2020).

Numerous studies have demonstrated the existence of negative stereotypes of drug abusers among the public (Brener et al., 2010; Brown, 2015; Keyes et al., 2010), for example, they believe that drug abusers, an extremely marginalized group that lacks capacity just like criminals (Fiske, 1998), are dangerous, irresponsible (Conrad et al., 2006; Herek et al., 2003; Tindal et al., 2010), self-destructive, without work potential (Nieweglowski et al., 2018), dirty and with poor self-control (Peretti-Watel et al., 2003).

In addition, stereotypes are also involved in some studies related to stigma, since stigma includes three components: cognition (negative stereotype), attitude (prejudice) and behavior (discrimination) (Corrigan & Watson, 2002). Cognitive (Negative stereotype) is the antecedent of stigma. In the study of Matthews et al. (2017) indicate that stigma is a part of the dynamic process of addiction formation. They compared the social context of addiction, and find that in the context of negative stereotypes, the affected addicts will internalized the negative stereotypes and became more addicted.

According to Social identity theory, individuals tend to gain self-esteem by comparing the group they belong to with other groups, however, negative in-group stereotypes may cause individuals to evaluate themselves more negatively. Yang et al., (2019) said that negative stereotypes of the target group by the out-group may be internalized as in-group stereotypes of the target group after being perceived by the target group, thereby changing the target group's cognition

and behavior. Therefore, The target group may form negative in-group stereotypes, reduce their self-esteem and the likelihood of seeking treatment, and increase the likelihood of depression. On this basis, we hypothesized that drug abusers have negative in-group stereotypes.

EEG indicators of stereotype activation: N400

With the development of science and technology, Event-Related Potential (ERP) and Functional magnetic resonance imaging (fMRI) have been widely applied in the field of psychology. Research on the neural mechanism of the mental process of drug abusers can not only reflect the difference between drug abusers and normal people, but also reveal the root cause of the difference. Scholars at home and abroad mainly studied the brain mechanisms of mental processes of drug abusers, such as cognitive processing (Luo et al., 2006), attention bias (Zhou et al., 2012), attention control (Zhou et al., 2017) and impulsivity increase (Wang et al., 2017a, 2017b). ERP is thought to be the electrical expression of brain activity in response to or preparation for a particular event (Fabiani et al., 2007). And it has been widely used to measure brain mechanisms of stereotype due to its high temporal resolution (Hajcak et al., 2010; Yoder & Decety, 2014). According to previous ERP studies on gender stereotypes, N400 is a negative going component occurring about 400 ms after the onset of the stimulus, generally representing a significant difference between stereotyped consistent processing and stereotyped inconsistent processing (Wang et al., 2017a, 2017b; Wang et al., 2010, 2016; Jia et al., 2010), this is to say, the time when subjects acquire information that is different from their own beliefs would elicit larger N400 amplitude. The second component concerning stereotypes is P600. P600 is a positive component occurring about 600 ms after the onset of the stimulus. In previous studies, the discussion on the activation of P600 by stereotype is still under fierce debate, and whether it can be used as an indicator of stereotype activation remains to be investigated (Wang et al., 2017a, 2017b; Chen and Wang, 2015). Therefore, the N400 component was selected as the indicator of stereotype activation in the current study.

Current study

As mentioned above, in previous studies, there is been a lot of research on stereotypes and drug abusers, however, they all focus on the influence of other factors on the relapse of drug abusers and the stereotype of drug abusers from out-groups, there is few studies about in-group stereotypes among drug abusers. In addition, the application of ERP technology can not only profoundly understand the self-stereotype of drug abusers, but also enrich the groups of stereotype and guide rehabilitation psychotherapy. The innovations

of this study are as follows: 1) As for the objects: the subjects of this study are drug abusers. Drug abusers in China are both offenders and victims, which is unique. 2) Innovation of research perspective: this study aims to explore whether drug abusers have negative in-group stereotypes of themselves from their own perspective. 3) As for the methods: the present study implemented ideas and methods from cognitive neuroscience to explore in group stereotypes of drug abusers.

Previous research has found that men have higher rates of substance use and are more likely to be stigmatized for substance abuse (Greenfield et al., 2010; Weeks & Stenstrom, 2020). Men account for 85.9% of the substance abuse population in China and are a high-risk group for substance abuse (National Medical Products Administration, 2017). Therefore, it has wider application value to study the in-group stereotype of male drug abusers. Meanwhile, for the convenience of sampling, this study was conducted for male drug abusers.

Therefore, this study designed two experiments to measure the presence of negative in-group stereotypes and the cognitive neural mechanisms when in-group stereotypes were activated in drug abusers. Experiment 1 we used the classification–verification paradigm, due to drug abusers are troubled by negative emotions for a long time (Zeng et al., 2018), and that such diffuse negative emotions have a debilitating effect on their stereotype expression (Wang et al., 2015). In order to overcome the influence of negative emotions, we designed Experiment 2, the Extrinsic Affect Simon Task (EAST), a variant of IAT (Dang et al., 2003). All experiments were to test two hypotheses: (1) Participants had significantly longer reaction times (RTs) in the "Drug abusers-Positive words" task condition than in the "Drug abusers-Negative vocabulary" condition. (2) Participants evoked greater N400 amplitude in the "Drug abusers-Positive words" task than in the "Drug abusers-Negative vocabulary" condition.

Methods

For Experiment 1, we used a classification–verification paradigm and Experiment 2 used the EAST, simultaneous collection of EEG data from subjects. In all experiments, we compared the difference of participants' RTs, accuracy rates and N400 amplitude of ERP to examine the existence of in-group stereotypes in drug abusers.

Design

For Experiment 1, a 2 (group category words: Drug abusers, ordinary people) \times 2 (characteristic words: positive words, negative words) within-group experimental design

was used, in which the group category words were the initiating stimuli and the characteristic words were the target stimuli, and 60 trials were set in each of the four conditions, for a total of 240 trials. The formal experiment was preceded by a 16-trial practice session. The experimental program was compiled with E-prime 2.0, and EEG data were acquired with the Neuro Scan Nuamps EEG system. For Experiment 2, a 2 (group category words: Drug abusers, ordinary people) \times 2 (characteristic words: positive words, negative words) within-group experimental design was used, in which the group category words were the target stimuli and the characteristic words were the interfering stimuli, and 60 trials were set in each of the four conditions, for a total of 240 trials. The formal experiment was preceded by a 16-trial practice session. The experimental program was compiled with E-prime 2.0, and EEG data were acquired with the Neuro Scan Nuamps EEG system.

Participants

All participants were males and diagnosed as free of mental illness by the drug rehab hospital using DSM-IV, with ordinary visual or corrected visual acuity, and right-handed. Table 1 shows the basic information of all subjects.

Material and measures

Based on the 6 virtues and 24 positive forces of positive psychology (Peterson & Seligman, 2004), six graduate psychology students from the Drug Addiction Research Group wrote as many positive and negative words as possible, resulting in 51 words for each of the two traits. Then, 62 psychology graduate students were asked to rate the lexical characteristics of these words (1–7 = very positive, 2 = relatively positive, 3 = slightly positive, 4 = neutral, 5 = slightly negative, 6 = relatively negative, 7 = very negative). After eliminating questionnaires with too much missing data and consecutive identical reactions, 55 valid questionnaires remained, and the results of the different test showed significant differences between the two groups of characteristic words ($F_{(1,54)} = 1550.23$, $P < 0.001$,

Table 1 Participant characteristics

Experiment	number of participants	Age (years)	Duration of drug use (years)	Duration of detoxification (months)
Experiment 1	20	35(8.73)	8(6.80)	12(8.09)
Experiment 2	20	37(9.28)	11(7.53)	15(6.40)

Displaying mean (M) and standard deviations (SD) for age, number of participants, and their duration of drug use and detoxification

$\eta^2 = 0.94$). Finally, 30 characteristic words each for positive and negative attributes were identified ($M_{\text{positive words}} = 1.81$ and $M_{\text{negative words}} = 5.97$).

Procedure

For Experiment 1, at first, show participants documents approved by the ethics committee of Jiangxi Normal University. And then, started the experiment procedure, a gaze point “+” was presented in the center of the screen, the gaze point disappeared after 500 ms, after an interval of 150–250 ms the group category words (“Drug abusers” or “Ordinary people”) would be presented for 500 ms, after the disappearance of group category words, the interval was 200 ms, then, the characteristic words would be presented for 3000 ms. The participants were asked to judge whether the presented words could describe the previously presented words and to press the key “J”, if not, press the key “F”, and to move to the next trial at an interval of 1000 ms. To balance the order of key presses, the other half of the participants were asked to press the opposite key. The RTs and the number of correct reactions were recorded automatically by E-Prime 2.0, and the brain waves were recorded by Neuroscan 4.5 in real-time (Fig. 1).

In this experiment, the judgments that “Positive words” can describe “Ordinary people” and “Negative words” can describe “Drug abusers” were set as correct reactions. The judgments that “Positive words” can describe “Drug abusers” and “Negative words” can describe “Ordinary people” were set as incorrect reactions. “The participants were not given feedback on the results of their keystrokes. To ensure that the participants accurately grasped the requirements of the experiment, each participant was asked to answer two verbal questions at the end of the experiment: (1) what do you think “Ordinary people” mean in the experiment. and (2) under what circumstances do you press the key “J” and the key “F”. Thus, the data of the two participants who did not define “Ordinary people” as people who do not use drugs or who were not clear about the keystroke requirements were excluded, and the data of the final 18 participants were used for behavioral and ERPs statistical analysis.

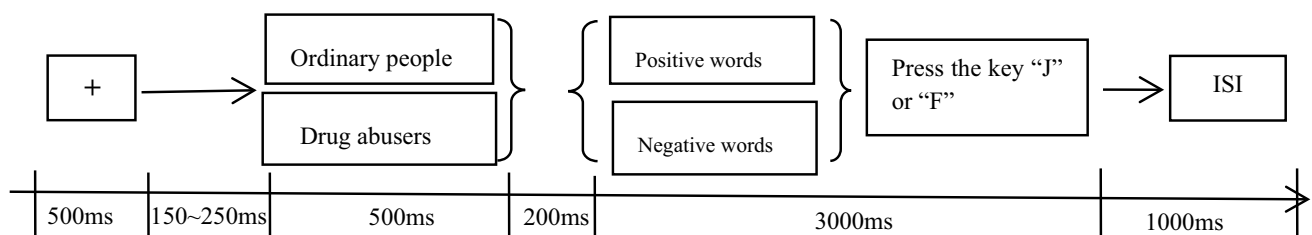


Fig. 1 Flow chart of Experiment 1

For Experiment 2, at first, show participants documents approved by the ethics committee of Jiangxi Normal University. And then, started the experiment procedure, a gaze point “+” was presented in the center of the screen, the gaze point disappeared after 500 ms, after an interval of 150–250 ms the group category words (“Drug abusers” or “Ordinary people”, half were green and half were blue) or white characteristic words (half were positive words and half were negative words) would be presented for 3000 ms. If white words were presented, participants were asked to press the key “J” for positive words and the key “F” for negative words. If colored words were presented, participants were asked to judge the color of the word, participants should press key “J” for blue words and the key “F” for green words, and move to the next trial at an interval of 1000 ms. To balance the order of key presses, half of them were asked to do the opposite. Both group category words and characteristic words were presented in the pseudo-random form. The RTs and the number of correct reactions were recorded automatically by E-Prime 2.0, and the brain waves were recorded by Neuroscan 4.5 in real-time (Fig. 2 and 3).

Results

Experiment 1: classification–verification paradigm

Behavioral results

The RTs and accuracy rates of participants in different experimental conditions are shown in Table 2. The results showed that the main effects of both group

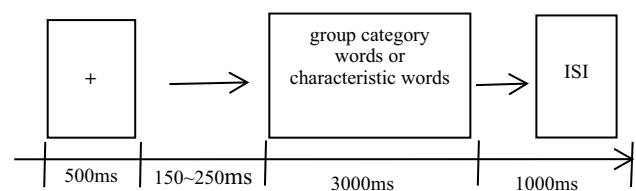
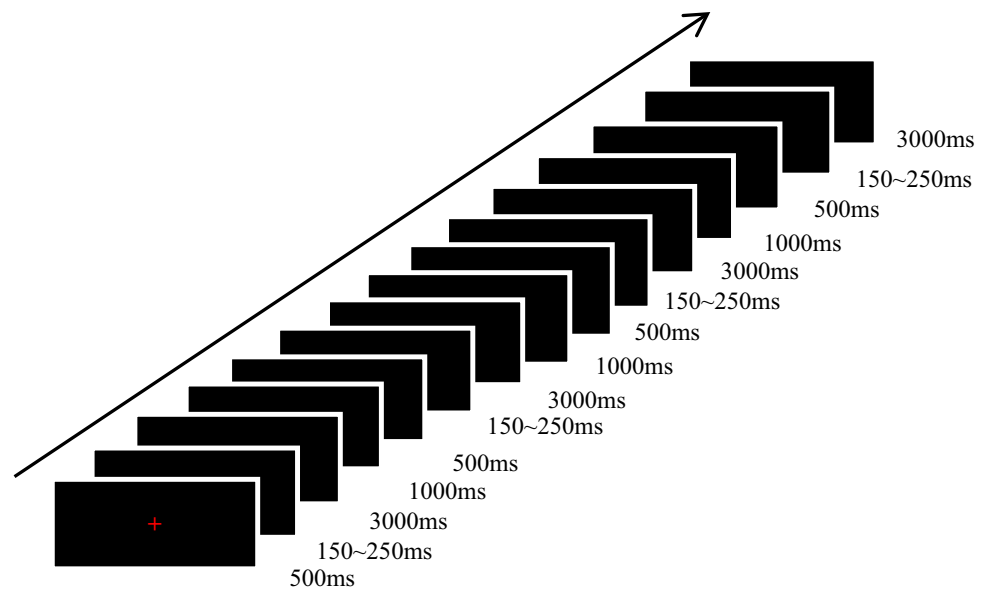


Fig. 2 Flow chart of experiment 2

Fig. 3 Experiment 2 stimulus presentation diagram**Table 2** Descriptive statistics of participants' RTs and accuracy rate under different experimental conditions (ms)

Group category	Characteristic words attributes	Experimental conditions	RT M (SD)	Accuracy rate M (SD)
Ordinary people	Positive words	Ordinary people-Positive words	1053.11 (262.84)	0.94(0.12)
Ordinary people	Negative words	Ordinary people-Negative words	1295.50 (335.24)	0.87(0.12)
Drug abusers	Positive words	Drug abusers-Positive words	1187.72(282.72)	0.87(0.10)
Drug abusers	Negative words	Drug abusers-Negative words	1279.61 (262.71)	0.87(0.07)

category words and characteristic words were significant for the RT indicator. Participants' RTs were significantly longer in the context of the starter word "Drug abusers" ($M = 1233.67$) than in the context of "Ordinary people" ($M = 1174.31$), $F_{(1,17)} = 5.88$, $P < 0.05$, $\eta^2 = 0.26$. participants' RTs were significantly longer in the condition of "Negative words" ($M = 1287.56$) than the condition of "Positive words" ($M = 1120.42$), $F_{(1,17)} = 47.38$, $P < 0.001$, $\eta^2 = 0.74$. The interaction between group category words and characteristic words on RTs was significantly different, $F_{(1,17)} = 6.30$, $P < 0.05$, $\eta^2 = 0.27$. The simple effects test found that participants' RTs in the condition "Drug abusers-Negative words" ($M = 1279.61$) were significantly longer than that in the condition "Drug abusers-Positive words" ($M = 1187.72$), $F_{(1,17)} = 5.81$, $P < 0.05$, in the condition "Ordinary people-Negative words" ($M = 1295.50$) was significantly longer than that in the condition "Ordinary people-Positive words" ($M = 1053.11$), $F_{(1,17)} = 38.54$, $P < 0.05$, in the condition "Drug abusers-Positive words" ($M = 1187.72$) was significantly longer than that in the condition "Ordinary people-Positive words" ($M = 1053.11$), $F_{(1,17)} = 15.74$,

$P < 0.05$. The main and interaction effects for group category words and characteristic words were not significant.

ERP results

The EEG data was processed by offline type superposition to obtain the total average figure (Fig. 4). After the analysis of the peak amplitude and latency of the electrode sites, it was found that the detoxified individuals induced a significant N1 component in the prefrontal-right frontotemporal-central region, a significant P2 and P3 component in the prefrontal-frontotemporal-central region, and a significant N400 component with prolonged latency in the prefrontal-frontotemporal region.

Thirteen electrode sites (FP1, FP2, F3, FZ, F4, F8, FC3, FCz, FC4, FT8, C3, CZ, C4) in the prefrontal-right frontotemporal-central region were selected for averaging, and the results of a two-factor repeated measures ANOVA on the N1 amplitude showed that the main and interaction effects of group category words and characteristic words on the latency and peak amplitude of N1 were not significant.

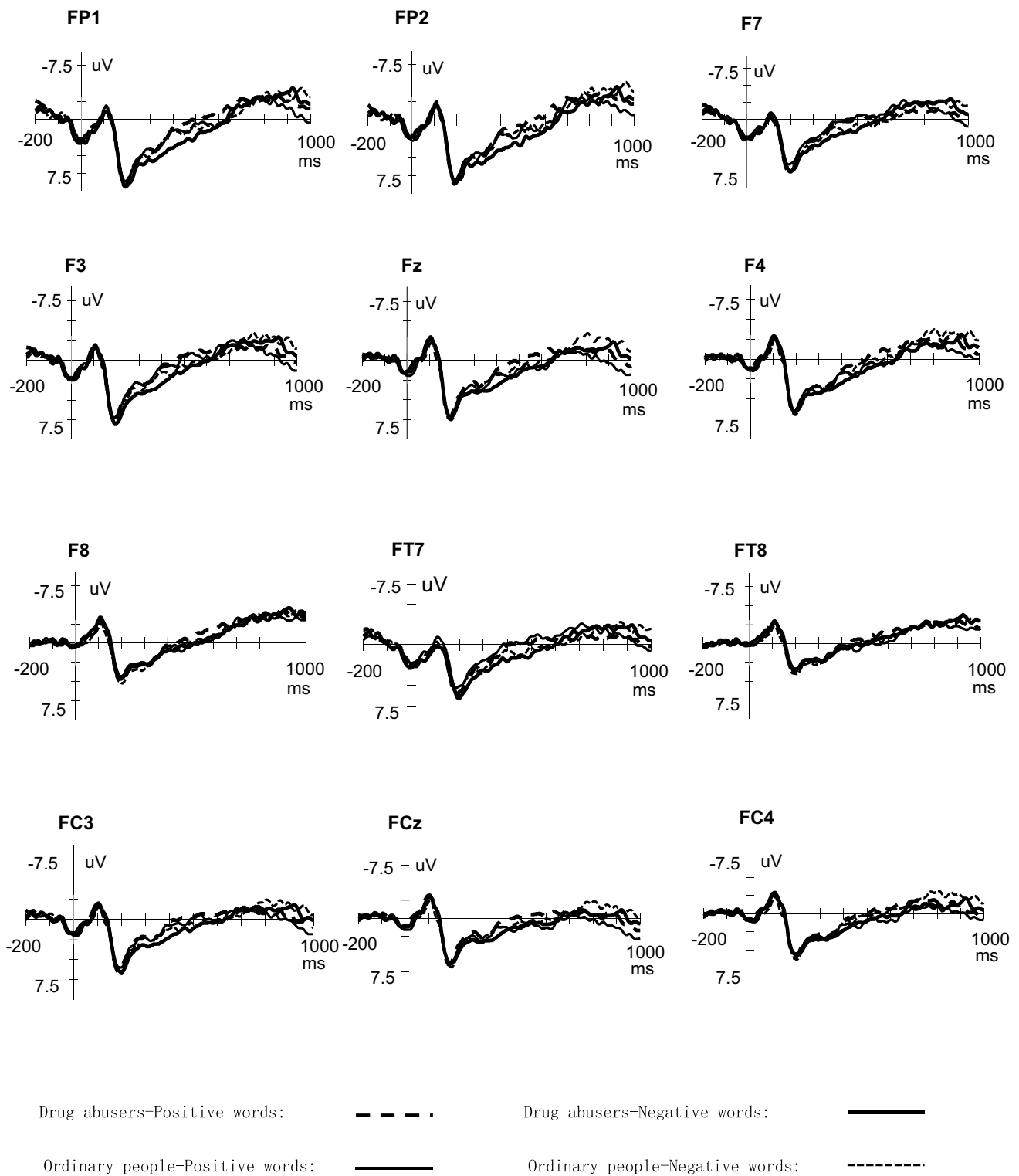


Fig. 4 ERP oscillogram of participants in Experiment 1 under four experimental conditions

The 15 electrode sites (FP1, FP2, F7, F3, Fz, F4, F8, FT7, FC3, FCz, FC4, FT8, C3, CZ, C4) in the prefrontal-frontotemporal-central region were selected for averaging, and the two-factor repeated measures ANOVA on the P2 and

P3 amplitude. It found that a significant main effect of the characteristic words on the P2 peak ($F_{(1,17)}=6.22, P<0.05, \eta^2=0.27$), with the target words "Negative words" inducing a significantly higher P2 amplitude peak ($M=7.67$) than

"Positive words" ($M=7.17$). The main effect of the characteristic words on the P3 peak was marginally significant ($F_{(1,17)}=4.26$, $P=0.055$, $\eta^2=0.20$), with the target words "Negative words" inducing a significantly higher peak ($M=5.84$) than "Positive words" ($M=5.39$).

Nine electrode sites (FP1, FP2, F7, F3, FZ, F4, F8, FT7, FT8) in the prefrontal-frontotemporal region were selected for averaging, and the results of a two-factor repeated measures ANOVA on the peak N400 wave amplitude showed that the main and interaction effects of group category words and characteristic words on the peak N400 were not significant.

Experiment 2: The Extrinsic Affect Simon Task

Behavioral outcomes

Based on the principles of the EAST, only the RTs and accuracy rates of the target stimuli were analyzed rather than the interference stimuli (Table 3).

The results found significant main effects for characteristic words and group category words on RTs indicators. Participants' RTs was significantly longer in the condition of distracting stimuli with "Positive words" ($M=869.09$, $SE=43.24$) than in the condition of "Negative words" ($M=807.35$, $SE=37.91$), $F_{(1,16)}=34.01$, $P<0.001$, $\eta^2=0.68$, in the condition of the target stimulus "Drug abusers" ($M=846.97$, $SE=40.97$) was significantly longer than the "Ordinary people" condition ($M=829.47$, $SE=39.9$), $F_{(1,16)}=7.47$, $P<0.001$, $\eta^2=0.32$. The interaction effect of characteristic words and group category words was significant ($F_{(1,16)}=7.66$, $P<0.05$, $\eta^2=0.32$). Simple effects tests revealed that participants' RTs were significantly longer in the "Drug abusers-Positive words" condition than in the "Ordinary people-Positive words" condition ($F_{(1,16)}=23.05$, $P<0.01$, $\eta^2=0.59$). The RTs in the "Drug abusers-Positive words" condition was significantly longer than in the "Drug abusers-Negative words" condition ($F_{(1,16)}=70.73$, $P<0.001$, $\eta^2=0.82$). The RT in the "Ordinary people-Positive words" condition was significantly longer than in the "Ordinary people-Negative words" condition ($F_{(1,16)}=7.68$, $P<0.05$, $\eta^2=0.32$).

The interaction effect between group category words and characteristic words was significant on the indicator of accuracy rates ($F_{(1,16)}=6.55$, $P<0.05$, $\eta^2=0.29$). Simple effects tests demonstrated that participants' accuracy rates was significantly greater in the "Ordinary people-Positive words" condition than in the "Drug abusers-Positive words" condition ($F_{(1,16)}=5.93$, $P<0.01$, $\eta^2=0.27$). The accuracy rates was significantly greater in the "Drug abusers-Negative words" condition than in the "Ordinary people-Negative words" condition ($F_{(1,16)}=7.12$, $P<0.01$, $\eta^2=0.31$). The accuracy rates in the "Drug abusers-Negative words" condition was significantly greater than that in the "Drug abusers-Positive words" condition ($F_{(1,16)}=8.37$, $P<0.05$, $\eta^2=0.34$). The accuracy rates in the "Ordinary people-Positive words" condition was significantly greater than "Ordinary people-Negative words" condition ($F_{(1,16)}=4.61$, $P<0.05$, $\eta^2=0.22$).

ERP results

The EEG data was processed by offline type superposition to obtain the total average figure (Fig. 5), and statistical tests for latency and amplitude at electrode sites were performed using SPSS 20.0. Participants' latency prolongation significantly of P2, P3, and N400 component in the prefrontal-left frontotemporal-central region when they judged against the target stimulus.

Twelve electrode sites (FP1, FP2, F3, FZ, F4, FC3, FCz, FC4, F7, FT7, T3, C3) in the prefrontal-right frontotemporal-central region were selected for averaging, and the results of a two-factor repeated measures ANOVA on the N1 amplitude showed that the main and interaction effects of group category words and characteristic words on the latency and peak amplitude of N1 were not significant.

Twelve electrode sites (FP1, FP2, F3, FZ, F4, FC3, FCz, FC4, F7, FT7, T3, C3) in the prefrontal-left frontotemporal-central region were selected for averaging, and repeated-measures ANOVA was performed for the P2 amplitude peaks. The results showed that the main effect of group category words on the P2 amplitude peak was significant, with "Drug abusers" inducing a significantly larger P2 peak than "Ordinary people", $F_{\text{peak}(1,16)}=20.25$, $P<0.001$,

Table 3 Descriptive statistics of participants' RTs and accuracy rates under different experimental conditions (ms)

Group category	Characteristic words attributes	Experimental conditions (key consistency)	RTs M(SD)	Accuracy rates M (SD)
Ordinary people	Positive words	Ordinary people-Positive words(J)	850.53(178.07)	0.88(0.26)
Drug abusers	Positive words	Drug abusers-Positive words(J)	887.65(179.92)	0.64(0.43)
Ordinary people	Negative words	Ordinary people-Negative words(F)	808.41(156.15)	0.65(0.43)
Drug abusers	Negative words	Drug abusers-Negative words(F)	806.29(159.81)	0.92(0.22)

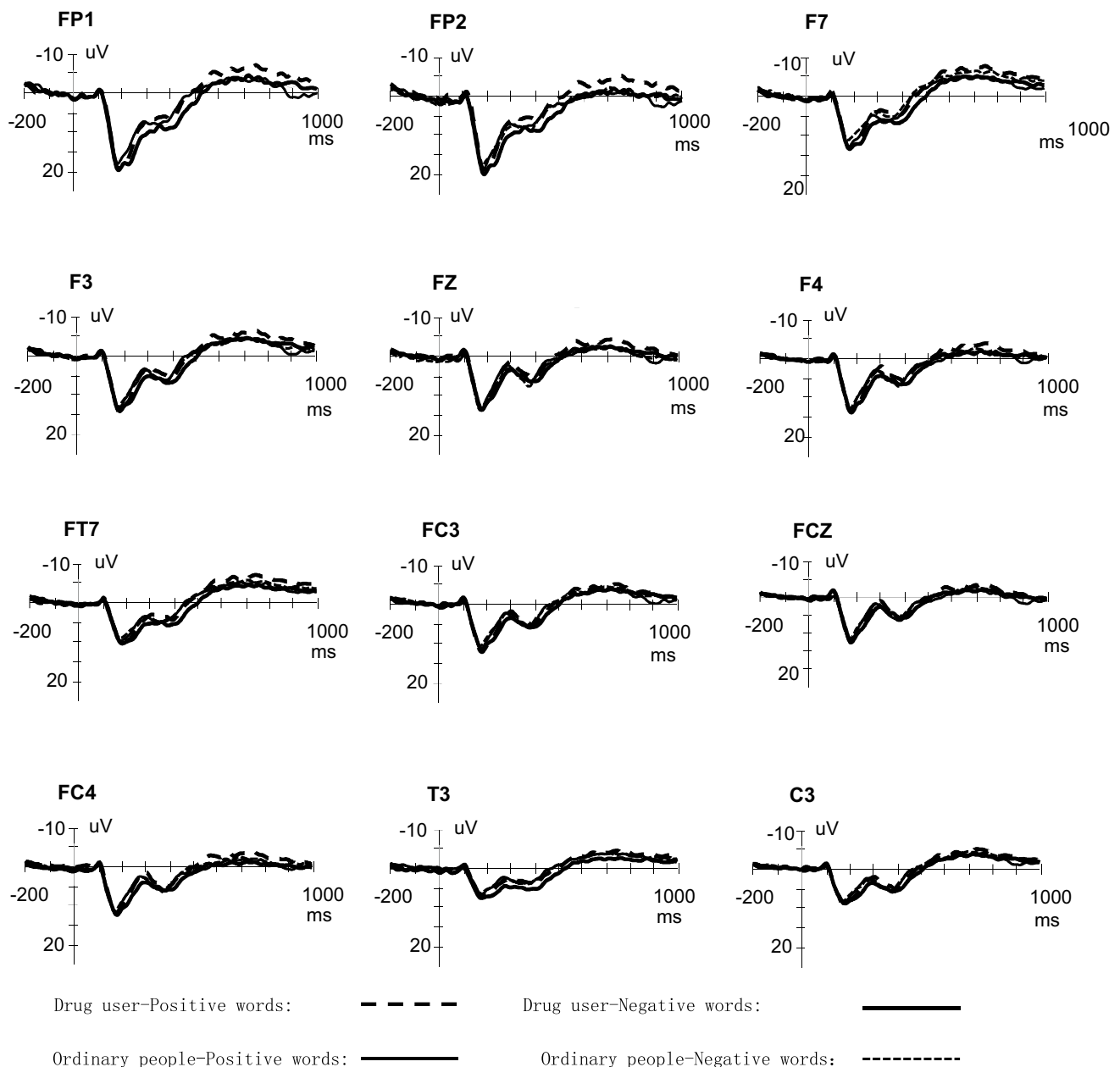


Fig. 5 ERP oscillogram of participants in Experiment 2 under four experimental conditions

$\eta^2=0.56$. The interaction effects of characteristic words and group category words on the peak P2 amplitude were significant. Participants evoked a significantly larger peak P2 in the "Drug abusers-Positive words" condition ($M=15.28$, $SE=1.22$) than in the "Ordinary people-Positive words" condition ($M=14.46$, $SE=1.18$), $F_{\text{peak}(1,16)}=4.54$, $P<0.05$, $\eta^2=0.22$. The P2 peak was evoked in the "Drug abusers-Negative words" condition ($M=16.24$, $SE=1.19$) which was significantly greater than in the "Ordinary people-Negative words" condition ($M=14.04$, $SE=1.08$), $F_{\text{peak}(1,16)}=24.48$, $P<0.001$, $\eta^2=0.61$.

Twelve electrode sites (FP1, FP2, F3, FZ, F4, FC3, FCz, FC4, F7, FT7, T3, C3) in the prefrontal-left fronto-temporal-central region were selected for averaging, and repeated-measures ANOVA was performed for the P3 amplitude peaks. The results showed that the main effects of both characteristic words and group category words were not significant for the P3 peak, but the interaction effects were significant $F_{\text{peak}(1,16)}=5.72$, $P<0.05$. The simple effects test indicated that participants induced a significantly larger P3 peak in the "Drug abusers-Negative words" condition ($M=10.82$, $SE=1.23$) than in the "Ordinary

people-Negative words" condition ($M = 9.28$, $SE = 1.04$), $F_{\text{peak}(1,16)} = 10.72$, $P < 0.05$, $\eta^2 = 0.40$. The P3 peak in the "Drug abusers-Negative words" condition ($M = 10.82$, $SE = 1.23$) was significantly larger than that in the "Drug abusers-Positive words" condition ($M = 9.45$, $SE = 1.16$), $F_{\text{peak}(1,16)} = 7.36$, $P < 0.05$, $\eta^2 = 0.32$.

Twelve electrode sites (FP1, FP2, F3, FZ, F4, FC3, FCz, FC4, F7, FT7, T3, C3) in the prefrontal-left frontotemporal-central region were selected for averaging, and the results of a two-factor repeated measures ANOVA on the peak N400 wave amplitude showed that the main effects of group category words and characteristic words on the peak N400 were not significant, but the interaction effects of characteristic words and group category words on the peak of N400 was significant, $F_{\text{peak}(1,16)} = 10.37$, $P < 0.005$. The simple effects test revealed that participants induced a significantly larger peak of N400 in the "Drug abusers-Positive words" condition than in the "Ordinary people-Positive words" $F_{\text{peak}(1,16)} = 7.65$, $P < 0.05$, $\eta^2 = 0.32$, and a larger peak of N400 in the "Drug abusers-Positive words" condition than in the "Drug abusers-Negative words" condition, $F_{\text{peak}(1,16)} = 18.82$, $P < 0.001$, $\eta^2 = 0.54$.

Discussion

In this study, two experiments were designed to examine the presence of in-group negative stereotypes among drug abusers, Experiment 1 used the "categorization-confirmation" paradigm, and Experiment 2 used the EAST.

In Experiment 1, we found that participants' RTs was significantly longer in the condition of "Drug abusers-Negative words" than the condition of "Drug abusers-Positive words". What's more, the ERP results showed that the main and interaction effects of group category words and characteristic words on the N400 peak were not significant, so hypothesis 1 and 2 were both not proved. This may be due to the prevalence of negative emotion in individuals with chronic drug abuse (Nunes et al., 2004), and the study of Wang et al. (2015) about gender stereotypes proved that in the stereotype consistency group, the expression of stereotype was inhibited by the presence of diffuse negative emotions. In another study of Clore and Huntsinger (2007) also indicated that emotion has moderating effect on individual cognition, positive emotions have promoting effect on the expression of stereotypes, and negative emotions (except anger) have inhibiting effect on the expression of stereotypes.

The other results of Experiment 1 showed that (1) the participants' RTs in the "Drug abusers" condition were significantly longer than those in the "Ordinary people" condition, that is to say the RTs of in-group category word priming was significantly longer than that of out-group, means in-group

category words activation disadvantage effect. This is contrary to the in-group category words activation advantage effect of participants in most stereotype studies on gender (Halevy et al., 2008; Hertel et al., 2001; Hewstone et al., 2002; Dang, 2015; Peng, 2007; Wang, 2001). Combined with the results of Experiment 1 that (2) the participants' RTs in the "Negative words" condition was significantly longer than that in the "Positive words" condition. (3) the results of ERP showed that the peak values of P2 and P3 components in the "negative word" condition were significantly larger than those in the "positive word" condition. We can speculate that this may be because the drug use experienced by drug abusers is socially unacceptable and impermissible, according to *Anti-Drug Law of the People's Republic of China* issued in 2008, they are both offenders and victims, they suffer stigmatization due to their drug use experience (Zeng & Chen, 2020), and they are at a distinct social disadvantage. Some studies have confirmed that disadvantaged groups have an out-group preference-in-group devaluation phenomenon (Peng, 2007; Xu et al., 2014), that is to say, group members in a socially inferior position have in-group inferiority complexes, negative social identities, lower levels of self-esteem (Xu et al., 2014), and tend to perceive the out-group as superior to the in-group they belong (Li & Liu, 2011; Yan & Zuo, 2008). Disadvantaged groups process category words related to their own group with more complex emotions. They are reluctant to underrate their own group but have a real sense of inferiority. Therefore, it may take longer for the subjects to process the in-group category words due to more complex inner activities. In addition, the component of ERP, P2 reflects the individual's automatic processing of social information, is more directed to information with negative features (Bartholow et al., 2003; Smith et al., 2003), and is also related to the early attention system, reflecting early attention vigilance processes. The higher peak of P2 is, the more attention resources are devoted (Dickter & Bartholow, 2007; Ito & Urland, 2003), it suggests that drug abusers may have an early attention bias towards "Negative words", involve more attention resources and spend a longer processing time. Compared to the early component P2, P3 is a later component reflecting attention bias (Jia et al., 2010). It is sensitive to emotional information, and its amplitude is usually biased toward negative textual information during processing (Bartholow et al., 2003; Smith et al., 2003).

Therefore, the EAST was used in Experiment 2 to weaken the drug abusers' conscious control over the experiment, the results showed that the participants' accuracy rates in the "Drug abusers-Negative words" condition was significantly higher than that in the "Drug abusers-Positive words" condition, and the RTs in the "Drug abusers-Negative words" condition was significantly shorter than that in the "Drug abusers-Positive words" condition. The peak of N400 in the "Drug abusers-Negative words" condition was significantly

lower than the "Drug abusers-Positive words" condition. Hypothesis 1 and 2 were all verified, indicating that the drug abusers had negative implicit stereotypes to their own group. In this experiment, significant N400 components were induced in the prefrontal-left frontotemporal-central region of subjects, the N400 component was objective evidence of stereotype activation (Chen & Wang, 2015; Hehman et al., 2014; Jia et al., 2014; Lattner & Friederici, 2003; Wang & Zhang, 2008; Wang et al., 2010; White et al., 2009; Yang et al., 2015). Consistent with the results of the present study, several studies have demonstrated that information that conflicts with the context induces larger waves of N400 than information that is consistent with the context (Kutas & Federmeier, 2000; Wang et al., 2010).

Hypothesis 1 and 2 were verified after two experiments, indicating that Chinese male drug abusers have negative implicit in-group stereotype, which may be due to the following reasons. At first, The subjects of this study were all drug abusers in China. Influenced by collectivist culture, individuals focus more on group homogeneity, rely more on social groups, and what they think of themselves may more depend on others' views of them (Ye, 2004). To a large extent, the emotions of people with collectivist tendencies may be influenced by external factors, such as the assessment of social values and relationships with others (Mesquita, 2001). The Stereotype Content Model (SCM) argues that drug abusers are widely perceived as an extreme marginal group, and they are both unenthusiastic and incompetent, just like criminals (Fiske et al., 2002). Drug abuse is considered seriously deviant behavior, stigmatized as much as crime. Indeed, both *Law of the PRC on Penalties for Administration of Public Security* and the *Anti-Drug Law* define drug use as illegal. As a result, the negative public stereotypes of drug abusers tend to be more severe. Some studies have found higher levels of public stigma against drug abusers compared to those suffering from other psychological or physical disorders (Corrigan et al., 2009; Lloyd, 2013). As mentioned above, negative in-group stereotypes of individuals are transformed by negative public perceptions of their group, and "addict" is a public "stigmatizing" designation of drug abusers. Labeling Theory (Corrigan & Kleinlein, 2005) suggests that once labeled, drug abusers will face negative reactions from others, and then accelerate their socialization into the role of the addict.

Secondly, age stereotype exists at all ages, it may be internalized in childhood, and reinforced in adulthood, at last, keep it up (Levy et al., 2009). The average age of the participants in both experiments of this study was around 35 years old. They faced the age associated stereotype. As an old Chinese saying goes, a man is steadfast at the age of thirty. At this time, they are supposed to take on the responsibility of their family and career, but undergoing drug treatment for their current illegal drug use. Self-discrepancy theory suggests that negative emotions associated with depression and

anxiety arise when there is a rift between the real self and the supposed self (i.e., When there are gaps among the duties, responsibilities, the qualities they are supposed to possess, the morals they are supposed to abide by and what they are doing (Higgins, 1987; Zeng et al., 2018). In China, people are more likely to form a self-concept of interdependence, they care more about what others think of them (Ye, 2004). In addition, drug abusers are in a socially disadvantaged position, they have lower levels of self-esteem and are more likely to have negative emotions (Xu et al., 2014). Being under negative emotions for a long period of time during the detoxification process will have an impact on the detoxification effect of drug abusers and increase the possibility of relapse (Epstein & Preston, 2010). The superimposed effects of the above factors are precisely what repeatedly reinforce the public's negative stereotypes of drug-addicted people, and the public's negative stereotypes of them are in turn internalized by drug abusers to generate even more negative in-group stereotypes, thus forming a vicious cycle.

Limitations and Prospects

Our studies have some limitations. First, in terms of the study population, this study was conducted only on male drug abusers. Given the special situation of female drug abusers on drug abuse (women are engaged in drug production, involved in drug trafficking, and stimulate drug consumption), the negative effects of drug abuse are more severe for women than for men (Auf et al., 2020). Studies have found fundamental physiological differences between genders influence the way of each reacts to drug abuse and the behaviors of they engage in addictive (Becker et al., 2017; Perry et al., 2013). In addition, socioeconomic, psychological and cultural factors differ in their impact on the risk of addiction in men and women (Franconi et al., 2013). Therefore, it is necessary for future research to distinguish or compare drug abusers of different genders when studying drug abuse. In addition, compulsory segregation groups may have stronger negative in-group stereotypes than voluntary drug abusers, and future studies can compare different types of drug rehabilitation groups, such as compulsory segregation, voluntary drug rehabilitation, and community drug rehabilitation, to help further reveal the in-group stereotype characteristics of drug abusers.

Second, in terms of research materials, the words of this study were chosen based on the six virtues and 24 positive forces of positive psychology. These words were rated by healthy people without a history of drug dependence, and there may be some differences between these ratings and the actual situation of drug abusers.

Third, in terms of research methods, although semantic priming paradigms are widely used in stereotype research, different research paradigms may have different effects on the research results. For example, the Implicit Relational

Assessment Procedure (IRAR) has higher detectability in implicit research (Zuo et al., 2021). therefore, future studies can adopt diverse measures of implicit social cognition to help further improve ecological validity.

Nonetheless, the results of this study enlighten us that rehabilitation center can reduce the negative stereotypes or stigmas of the public towards drug abusers through educating them or increasing their contact with each other when doing psychological correction education work (Evans-Lacko et al., 2013), thereby, reducing the negative impact of the external environment on the in-group stereotypes of drug abusers themselves. Furthermore, in the future, this could be used as a theoretical basis to design intervention programs to train the positive strengths of drug abusers and encourage them to focus more on their positive qualities in order to increase confidence and motivation in recovery.

Conclusion

According to the results of this study that the participants' accuracy rates in the "Drug abusers-Negative words" condition was significantly higher than that in the "Drug abusers-Positive words" condition, and the RTs in the "Drug abusers-Negative words" condition was significantly shorter than that in the "Drug abusers-Positive words" condition. The peak of N400 in the "Drug abusers-Negative words" condition was significantly lower than the "Drug abusers-Positive words" condition. So, there is a clear negative in-group stereotype among drug abusers.

Acknowledgements The authors wish to thank participants and staff in Jiangxi compulsory drug rehabilitation center.

Author's Contribution Xiaoqing Zeng: Conceptualization, Methodology, Data Collection, Visualization. Writing—original draft, reviewing, and editing; Xiang Xiao: Software, Writing—original draft; Lingling Xu: reviewing, editing and submission.

Funding This research was funded by grants from the National Social Science Foundation of China (19BGL230).

Data Availability All data generated or analyzed during this study are included in the supplementary information files.

Code Availability Not applicable.

Declarations

Conflicts of interest The authors declare no conflict of interest.

Ethics approval The across-sectional study was carried out in accordance with the recommendations of the Morals & Ethics Committee of the School of Psychology, Jiangxi Normal University (Nanchang, China).

Consent to participate This study is an experimental study, and informed consent has been signed with all participants before the experiment.

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