

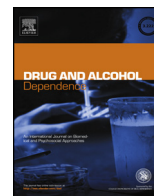


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Short communication

Drug-related stimuli impair inhibitory control in cocaine abusers

Erika Pike^{a,b}, William W. Stoops^{a,b}, Mark T. Fillmore^b, Craig R. Rush^{a,b,c,*}

^a Department of Behavioral Science, University of Kentucky College of Medicine, Medical Behavioral Science Building, Lexington, KY 40536-0086, USA

^b Department of Psychology, University of Kentucky Arts and Sciences, Kastle Hall, Lexington, KY 40506-0044, USA

^c Department of Psychiatry, University of Kentucky College of Medicine, 3470 Blazer Parkway, Lexington, KY 40509-1810, USA

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ABSTRACT

Background: Cocaine users show impaired inhibitory control on cued go/no-go tasks and attention bias to drug-related stimuli in the emotional Stroop task. The results of a previous study suggested that there is a relationship between inhibitory control and attention bias in alcohol drinkers such that the presentation of alcohol-related images as a go cue in a cued go/no-go task significantly impaired inhibitory control compared to neutral images as a go cue. The present study determined the generality of these previous findings by assessing inhibitory control in cocaine users utilizing a modified cued go/no-go task with cocaine or neutral images as the cues.

Methods: Non-treatment seeking cocaine users ($N=30$) completed the modified task after completing detailed measures of demographics and drug use. Participants were matched on basic demographic factors and were assigned to groups in which they saw either a cocaine or neutral image as the go cue.

Results: Participants assigned to the cocaine image go cue condition had a significantly higher proportion of inhibitory failures to the no-go target than their counterparts assigned to the neutral cue condition, but there were no group differences on reaction time (i.e., accuracy was not traded for speed).

Conclusions: Cocaine users were less able to inhibit pre-potent responses when a cocaine-related image served as the go cue than when a neutral image served as the go cue, consistent with previous research in alcohol users. The outcomes suggest that cocaine-related cues produce disinhibition, perhaps contributing to the high incidence of relapse or continued cocaine use.

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1. Introduction

Inhibitory control is impaired in cocaine users, as measured by stop-signal (Fillmore and Rush, 2002) and go/no-go tasks (Lane et al., 2007; Verdejo-García et al., 2007; Verdejo-García and Pérez-García, 2007). The results of previous studies have shown that when individuals are prepared to respond, but must inhibit their response at the last moment, cocaine-using individuals fail to inhibit responding more frequently than matched controls (Fillmore and Rush, 2002; Lane et al., 2007; Verdejo-García et al., 2007; Verdejo-García and Pérez-García, 2007). Additionally, cocaine users that had poorer inhibitory control also had a greater attention bias to cocaine-related words on the emotional Stroop task (Liu et al., 2011). Although studies have shown impaired inhibitory control and increased attention bias in cocaine users using independent tasks, the influence of cocaine-related stimuli on inhibitory control

has not yet been investigated within the same task (Fillmore and Rush, 2002; Lane et al., 2007; Liu et al., 2011; Verdejo-García et al., 2007; Verdejo-García and Pérez-García, 2007).

A recent study investigated the relationship between inhibitory control and attention bias to drug-related stimuli in alcohol users. The findings showed that when alcohol-related images preceded a target that required individuals to withhold a response, individuals showed greater problems inhibiting pre-potent responses than when a neutral cue, such as a picture of a stapler, was used. An interaction between attention bias to alcohol cues and inhibitory control was observed in alcohol users, such that attention bias toward alcohol images increased behavioral activation, which undermined participants' ability to inhibit responding (Weafer and Fillmore, 2012). Whether the finding of increased inhibitory failures following alcohol cues in drinkers translates to other substances, such as cocaine, is unknown.

The purpose of the present study was to investigate the influence of cocaine-related cues on inhibitory control in cocaine abusers using a modified version of the Attentional Bias-Behavioral Activation task, which has been described in detail previously (Weafer and Fillmore, 2012). Response activation was measured by reaction time to respond to go targets and inhibition was measured

* Corresponding author at: University of Kentucky Medical Center, Department of Behavioral Science, Lexington, KY 40536-0086, USA. Tel.: +1 859 323 6130; fax: +1 859 257 7684.

E-mail address: crush2@email.uky.edu (C.R. Rush).

by proportion of inhibitory failures to no-go targets. We hypothesized that the proportion of inhibitory failures to no-go targets that followed cocaine images as a go cue would be significantly greater than to no-go targets that followed neutral images as the go cue. We further hypothesized that the proportion of inhibitory fails to no-go targets would be low following no-go cues and that reaction time to go targets following no-go cues would be slowed, but that image type would not influence response activation or inhibition. Finally, we hypothesized that accuracy of responding to go targets and reaction time following a go cue would not be influenced by image type.

2. Methods

2.1. Participants

Thirty non-treatment seeking adult participants (13 women and 17 men), primarily recruited through word of mouth and postings on community bulletin boards, completed this study. All participants reported using cocaine within the last month. Potential participants were excluded if they reported a current prescription for a psychiatric medication or dependence on any drug that could produce significant withdrawal symptoms during testing (e.g., opiates or benzodiazepines), as participants were asked to abstain from drug use for 12 h prior to testing. Participants completed screening questionnaires on current and past physical and mental health, measures of current psychological functioning, and a detailed drug use history (Sevak et al., 2011). Participants were paid for their participation. The University of Kentucky Institutional Review Board approved all procedures and recruitment methods.

2.2. Procedure

After completing screening, eligible participants completed the Attentional Bias-Behavioral Activation task during the same appointment. A between-subjects design was used, such that half of the participants were assigned to the cocaine go condition and half to the neutral go condition (see below). The two groups were matched on demographic and drug use factors. A between-subjects design was used because participants learn to anticipate which cue would signal a go or no-go target and there were concerns that having participants switch conditions (i.e., cocaine and neutral go cues) would disrupt the learning that takes place during the task.

2.3. Attentional Bias-Behavioral Activation (ABBA)

The ABBA task is a modified cued go/no-go reaction time task, which was administered using E-prime experiment generation software (Psychology Software Tools, Pittsburgh, PA) on a PC computer (Weaver and Fillmore, 2012). The task took approximately 15 min to complete and consisted of five blocks of 50 trials. A trial involved a sequence of events during which a fixation point (+) was presented for 800 ms, followed by a blank white screen for 500 ms, a cue image (cocaine or neutral) was presented for one of five stimulus onset asynchronies (SOA; i.e., 100, 200, 300, 400, and 500 ms), and finally a go or no-go target, which was displayed until a response occurred or 1000 ms elapsed. There was a 700 ms interval between all trials. The presentation of cocaine and neutral images were divided evenly between trials. The total number of events during which participants were prepared to respond (i.e., go cue), but needed to inhibit responding (i.e., no-go target) occurred on 25 of the 250 trials.

The cues consisted of cocaine-related images (e.g., powder with a razor blade, crack cocaine) or neutral images (e.g., stapler, paper towel roll). All images (15 cm × 11.5 cm) were presented in the center of the computer monitor against a white background. After a SOA, the cue image either turned solid green (go target) or solid blue (no-go target). Participants were instructed to press the forward slash (/) key on the keyboard, which was marked with a green sticker, as soon as a green (go) target appeared. Participants were instructed to withhold responses when a blue (no-go) target appeared.

The task consisted of two conditions: cocaine go condition and a neutral go condition. In the cocaine go condition 80% of go targets were preceded by a cocaine cue and 20% of go targets were preceded by a neutral cue. In the cocaine go condition 80% of the no-go targets were preceded by a neutral cue and 20% of no-go targets were preceded by a cocaine cue. In the neutral go condition 80% of go targets were preceded by a neutral cue and 20% were preceded by a cocaine cue. In the neutral go condition 80% of the no-go targets were preceded by a cocaine cue and 20% of the no-go targets were preceded by a neutral cue. For half of the participants the cocaine image served as the go condition and for the other half, the neutral image served as the go condition.

2.4. Criterion measures and data analysis

An alpha level of $p \leq 0.05$ was used to determine significance for statistical outcomes of a priori hypotheses (Keppel, 1991). Independent-samples *t*-tests were used

Table 1

Demographics of the cocaine group, neutral group (mean [SEM]), and *t*-values from comparisons between group means (no significant differences were observed between groups).

Measure	Cocaine group	Neutral group	<i>t</i> -Value
Age	42.5 (2.1)	38.2 (2.4)	1.4
Gender (# male)	10	7	0.1
Race ^a			2.2
African American	10	11	
Caucasian	5	3	
Hispanic	0	1	
Years of education	12.1 (0.5)	11.5 (0.5)	0.8
Alcohol			
Drinks per day	0.7 (0.7)	2.5 (2.4)	0.8
Drinks per week	10.3 (4.7)	15.5 (9.5)	0.5
Drinks per month	47.2 (20.2)	75.4 (47.0)	0.6
Cigarettes per day	7.6 (1.8)	12.9 (2.3)	1.8
Marijuana			
Days per month	10.7 (3.4)	13.9 (2.9)	0.7
Years used	25.3 (2.1)	25.2 (2.6)	0.0
Cocaine			
Days per week	3.5 (0.7)	4.0 (0.5)	0.6
Days per month	14.6 (3.0)	16.5 (2.3)	0.5
Years used	18.6 (2.6)	16.5 (2.2)	0.6
Positive urine screen	0.7 (0.1)	0.8 (0.1)	0.8

^a Chi square analysis for race used the expected values of 9 African American and 6 Caucasian participants per group, as that is consistent with the racial representation we have observed in our previous studies.

to compare demographics for each group (i.e., the cocaine go and neutral go conditions) for continuous variables and a chi-square analysis was conducted to compare gender and race distribution between groups. Performance in the cocaine go and neutral go condition was compared to assess the degree to which cocaine images increased response activation and decreased response inhibition. Reaction time and proportion of inhibitory fails were analyzed to assess differences in response activation and inhibition, respectively (Weaver and Fillmore, 2012). Unpaired *t*-tests were used for between-groups comparisons of the proportion of inhibitory fails when a no-go target was presented following a go cue and reaction times to a go target following a go cue. Pearson correlations were used to assess associations between primary outcomes from the task and demographic and drug use variables. A Bonferroni correction for multiple correlations was used for these post hoc analyses, which adjusted the significant *p*-value to <0.0025 .

3. Results

3.1. Demographics

The groups did not differ significantly on any of the demographic characteristics or drug-use variables (Table 1).

3.2. ABBA task performance

3.2.1. Response inhibition and activation following go cues. The *t*-test revealed a significant increase in inhibitory fails to a no-go target following a cocaine image as the go cue compared to a neutral image as a go cue ($t(28) = 2.30$, $p < 0.05$; Fig. 1). There was no significant difference in response time to go cues following cocaine or neutral images (Fig. 1).

3.2.2. Response inhibition and activation following no-go cues. There were no significant differences between groups for the proportion of inhibitory fails following a no-go cue or for reaction time to go targets following no-go cues (data not shown).

3.3. Post hoc correlations

There were no significant correlations between inhibitory failures to no-go targets following go or no-go cues or reaction time to go targets following go or no-go cues and the demographic or drug use variables ($r(28)$ values < 0.933 , p values > 0.0025).

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