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Test-Retest Reliability of Eye Tracking During the Visual Probe Task in Cocaine-Using Adults

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Abstract

Background—Stimuli associated with cocaine use capture attention. Evidence suggests that fixation time measured on the visual probe task is a valid measure of cocaine cue attentional bias. The aim of this experiment was to demonstrate the test-retest reliability of cocaine cue attentional bias as measured by fixation time during the visual probe task.

Methods—In a within-subject, repeated-measures design, thirty-six non-treatment seeking cocaine-using adults completed a visual probe task with eye tracking.

Results—Participants displayed an attentional bias to cocaine-related images as measured by fixation time across two occasions ($F(1, 35) = 56.5, p < 0.0001$). A Pearson correlation indicated significant test-retest reliability for this effect ($r = 0.51, p = 0.001$). Response time failed to detect an attentional bias and test-retest reliability was low ($r = 0.24, p = 0.16$).

Conclusion—Fixation time during the visual probe task is a reliable measure of cocaine cue attentional bias in cocaine-using adults across time.

Keywords

Attention; Cocaine; Reliability; Cue Reactivity; Visual Probe; Eye tracking

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Conflict of Interest The authors declare no conflicts of interest relevant to this research.

1. INTRODUCTION

Stimuli associated with substance use capture attention (Field and Cox, 2008). Allocating a disproportionate amount of time attending to substance-related stimuli, relative to control stimuli, is referred to as attentional bias. The central role of attentional bias in drug-seeking behavior makes it a promising treatment target in the human laboratory and clinic, but the utility of measuring attentional bias is contingent upon the reliability of the measure. Attentional bias can be directly and objectively measured with eye-tracking technology because fixation direction and duration indicate fine grain patterns in attentional allocation (Rayner, 1998).

The visual probe task adapted with eye-tracking technology is a sensitive measure of attentional bias in individuals who abuse cocaine (Marks et al., 2014). Our laboratory previously adapted eye-tracking technology to the visual probe task to measure cocaine cue attentional bias (visual probe task described in detail in Marks et al., 2014). Cocaine-using individuals ($n=15$) fixated on cocaine-related images significantly longer than neutral images, whereas controls ($n=15$) did not display an attentional bias, indicating discriminant validity. Importantly, this bias remained stable across two sessions, separated by an intersession interval of 7 to 14 days. Test-retest reliability, however, was not directly assessed previously due to the small sample size. No other studies have been conducted to examine the test-retest reliability of fixation time during the visual probe task.

The utility of studying attention to cocaine-related cues depends upon the identification of a reliable measure of attentional bias. Studies that have assessed the reliability of the visual probe task have only measured response time, consistently finding test-retest reliability (Schmukle, 2005; Spiegelhalter et al., 2011) and internal reliability (Ataya et al., 2012) to be poor. This study sought to demonstrate the test-retest reliability of cocaine cue attentional bias as measured by fixation time during the visual probe task.

2. METHODS

2.1 Participants

Data from 36 adult participants who reported current cocaine use (i.e., past 30 days) and completed the visual probe task on two separate occasions were included in this analysis. No participants were excluded from any analyses. The sample size was determined by a power analysis indicating that with a significance level of 0.05, the power to detect a Pearson's r correlation of 0.50 would be at least 80 percent. All participants provided written informed consent and completed screening questionnaires on current and past physical and mental health, measures of current psychological functioning, and detailed substance use history (Sevak et al., 2011). Individuals with a current prescription for a psychiatric medication or dependence on any drug that could produce significant withdrawal symptoms during testing (e.g., opioids or benzodiazepines) were excluded. The Institutional Review Board of the University of Kentucky approved all protocols and informed consent documents.

2.2 Procedure—Data were gathered during routine screening and laboratory protocols, employing identical experimental procedures during collection of the visual probe data.

Participants completed the visual probe task, after sobriety was verified, at two separate time points (mean interval = 91.6 days, SD = 100.3, range = 7 - 336). Before each measurement, participants were instructed not to consume stimulants (excluding nicotine) within four hours of their scheduled session to decrease the likelihood of participants being acutely intoxicated during testing. Participants who smoked tobacco were permitted to smoke prior to each session. All participants passed a field sobriety test and provided a breath sample negative for alcohol prior to each session. Drug urine screens were conducted at the outset of each session as described previously (Marks et al., 2014).

2.3 Visual Probe Task—Participants completed the visual probe task operated using E-prime experiment generation software (Psychology Software Tools, Pittsburgh, PA) on a PC. Fixation time data were collected using Tobii T120, T60-XL, and X2-60 eye trackers (Tobii Technology, Sweden). Three models were utilized due to shared resources with another laboratory and upgrades to technology over time. The Time 2 assessment was completed on the same eye tracker for 26 participants and on different eye trackers for 10 participants. Attentional bias was measured using the visual probe procedure described previously (Marks et al., 2014). The primary outcome variables were fixation time to cocaine and neutral images and response time to probe location (milliseconds; ms).

2.4 Data Analysis—Statistical significance was set at the $p < 0.05$ level for all analyses. Descriptive and graphical methods were used to determine that data were normally distributed. Attentional bias scores were analyzed across the three eye trackers at Time 1 and 2 using unpaired *t*-tests. Attentional bias scores did not differ significantly as a function of eye tracker at either Time 1 (t values = $-1.1 - 0.5$, $p > 0.05$) or Time 2 (t values = $-1.4 - 1.5$, $p > 0.05$). Eye tracker model was not included as a covariate in subsequent analyses.

Fixation and response time data were analyzed using a two-way, repeated-measures analysis of variance (ANOVA; StatView, Cary, NC, USA). The factors were Cue Type (Cocaine and Neutral) and Time (Time 1 and Time 2). The mean-square error term was used to conduct Tukey's Honestly Significant Difference (HSD) *post hoc* tests. Cohen's *d* effect sizes were reported for all *post hoc* comparisons. Bivariate Pearson correlations (*r*) assessed test-retest reliability and the correlation between fixation and response time. Partial correlational analyses (*pr*) controlled for the influence of time between measurements.

3. RESULTS

3.1 Demographics

Thirty-six participants (19 female, 17 male) completed the study. Thirty were African American, five were Caucasian, and one was of mixed race. Participants were 39 ± 9 (mean $\pm$ SD) years old with 12 ± 2 years of education. All participants reported current cocaine use, using 11 ± 8 days in the month prior to screening, and 14 ± 8 years in total. Thirty-one participants reported consuming alcohol (15 ± 14 standard drinks per week). Twenty-nine participants were daily cigarette smokers (11 ± 8 cigarettes per day). In the past 30 days, twenty-seven participants reported marijuana use (13 ± 11 days), eleven reported opiate use (4 ± 4 days), seven reported benzodiazepine use (3 ± 2 days), and two reported amphetamine use (2 ± 1 days).

3.2 Visual Probe Fixation Time

On average, fixations were made on $87 \pm 3\%$ of trials. The ANOVA results revealed a significant main effect of Cue Type ($F(1, 35) = 56.5, p < 0.0001$). Participants fixated on cocaine-related images significantly longer than neutral images during Time 1 and 2 (Table 1). The main effect of Time ($F(1, 35) = 0.3, p = 0.6$) and the interaction between Cue Type and Time ($F(1, 35) = 1.4, p = 0.2$), were non-significant, indicating test-retest reliability. A positive bivariate Pearson correlation between attentional bias scores at Time 1 and 2 further indicates significant test-retest reliability ($r^2 = 0.26$, Fig. 1). The partial correlation is consistent with the bivariate correlation, indicating that the time interval between measurements did not influence the test-retest reliability of cocaine cue attentional bias (Table 1).

3.3. Visual Probe Response Time

Response time data only included critical trials in which a correct response was made longer than 100 ms after the probe appeared ($97 \pm 3\%$ of trials). The ANOVA results revealed a significant main effect of Time ($F(1, 35) = 7.3, p = 0.01$). Response time to probes replacing both cocaine and neutral images was significantly faster on Time 2 than 1 (Table 1). The non-significant bivariate Pearson correlation between attentional bias scores at Time 1 and 2 further indicates low test-retest reliability. The partial Pearson correlation indicates that the time interval between measurements did not influence the reliability estimate (Table 1). Response time did not correlate significantly with fixation time at Time 1 ($r = 0.26, p = 0.12$) or Time 2 ($r = 0.19, p = 0.27$).

4. DISCUSSION

This study replicates previous research, finding that cocaine-using individuals fixate on cocaine-related images significantly longer than matched, neutral images and extends those results by demonstrating that the magnitude of this attentional bias is reliable across two repeated measurements (Marks et al., 2014). To our knowledge, the present study is the first to report the test-retest reliability of fixation time during the visual probe task. The test-retest reliability of attentional bias (i.e., the difference in fixation time between cocaine-related images and neutral images) therefore indicates that attentional allocation to both cocaine-related images and neutral images remains stable over time. This reliability of fixation time, as an index of attentional bias, indicates that it is well suited for longitudinal research both in the human laboratory as well as the clinic.

In contrast to fixation time, response time to probes replacing cocaine and neutral images did not differ. Previous studies measuring response time using the visual probe task have similarly failed to find strong evidence for cocaine cue attentional bias in the absence of moderators such as alcohol administration (Marks et al., 2014; Montgomery et al., 2010). In addition, the present study found that response time for both cocaine and neutral stimuli decreased at Time 2, which may be due to practice effects. The low test-retest reliability of response time during the visual probe task is consistent with previous reports (Marks et al., 2014; Schmukle, 2005; Spiegelhalter et al., 2011).

Several limitations of the present study should be noted. First, the test-retest reliability of attentional bias at time intervals shorter than one week has not been assessed. Repeated cue exposure at shorter intervals might decrease cue salience and thus, attentional bias. Second, with an average time interval of three months between measurements, test-retest reliability might be inflated due to a potential “washout period”. However, partial Pearson correlations indicate that the time interval did not influence test-retest reliability, suggesting that fixation time attentional bias is a robust effect. The variable time interval may therefore be interpreted as a strength of the experimental design. Third, test-retest reliability is contingent upon the quality of the eye-tracking technology. However, three different eye-tracking models were employed in the present study and attentional bias did not differ as a function of model. This finding is promising for future studies utilizing different eye trackers models. Fourth, a non-cocaine-using control group would further inform whether this attentional bias is specific to cocaine users. A previous study, however, demonstrated that non-cocaine users do not display a cocaine cue attentional bias (Marks et al., 2014).

Converging evidence indicates that fixation time is a sensitive and reliable method of measuring attentional allocation to cocaine-related cues. In contrast, response time during the visual probe task has not been demonstrated to be reliable. Future studies, which seek to test hypotheses necessitating repeated assessments of cocaine cue attentional bias, should examine attentional allocation by measuring fixation time during the visual probe task.

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REFERENCES

- Ataya AF, Adams S, Mullings E, Cooper RM, Attwood AS, Munafò MR. Internal reliability of measures of substance-related cognitive bias. *Drug Alcohol Depend.* 2012; 121:148–151. [PubMed: 21955365]
- Field M, Cox WM. Attentional bias in addictive behaviors: a review of its development, causes, and consequences. *Drug Alcohol Depend.* 2008; 97:1–20. [PubMed: 18479844]
- Marks KR, Roberts W, Stoops WW, Pike E, Rush CR. Fixation time is a sensitive measure of cocaine cue attentional bias. *Addiction.* 2014; 109:1501–1508. [PubMed: 24894879]
- Montgomery C, Field M, Atkinson AM, Cole JC, Goudie AJ, Sumnall HR. Effects of alcohol preload on attentional bias towards cocaine-related cues. *Psychopharmacology.* 2010; 210:365–375. [PubMed: 20352412]
- Rayner K. Eye movements in reading and information processing: 20 years of research. *Psychol. Bull.* 1998; 124:372–422. [PubMed: 9849112]
- Schmukle SC. Unreliability of the dot probe task. *Eur. J. Pers.* 2005; 19:595–605.
- Sevak RJ, Vansickel AR, Stoops WW, Glaser PEA, Hays LR, Rush CR. Discriminative-stimulus, subject-rated and physiological effects of methamphetamine in humans pretreated with aripiprazole. *J. Clin. Psychopharmacol.* 2011; 31:470–480. [PubMed: 21694622]
- Spiegelhalter K, Jahne A, Kyle SD, Beil M, Doll C, Feige B, Riemann D. Is smoking-related attentional bias a useful marker for treatment effects? *Behav. Med.* 2011; 37:26–34. [PubMed: 21347907]

Highlights

- Attentional bias was demonstrated to cocaine cues in cocaine users.
- Attentional bias was reliable across two assessments separated by 91.6 ± 100.3 days.
- Future studies can use repeated assessments of cocaine cue attentional bias to examine attentional allocation.

Figure 1.

Regression line showing the significant positive correlation ($r = 0.51$) between cocaine cue attentional bias as measured by fixation time during the visual probe task at Time 1 and 2.

Table 1

Mean attentional bias difference score [$\pm$ 95% confidence interval] and Cohen's d effect size between cocaine and neutral images in milliseconds. Correlations and partial correlations reported between Time 1 and 2 attentional bias scores.

Measure	Time 1		Time 2		Correlation	
	Attentional Bias Score	d	Attentional Bias Score	d	r	pr
Fixation Time	136.1 [98.9 - 173.2] *	1.3	113.8 [76.7 - 151.0] *	1.2	0.51 *	0.50 *
Response Time	12.02 [-25.1 - 49.2]	0.1	5.27 [-31.9 - 42.4]	0.1	0.24	0.24

^a Asterisk indicates a significant effect, $p < 0.05$.

^b d indicates Cohen's d

^c r indicates bivariate correlation

^d pr indicates partial correlation