



# Initial orientation vs maintenance of attention: Relationship with the severity of dependence and therapeutic outcome in a sample of cocaine use disorder patients

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## ABSTRACT

The visual probe paradigm allows for evaluating attentional bias (AB), distinguishing between approach vs avoidance patterns of attention and assessing two different processes when the exposure time to images is manipulated: initial orienting and maintenance of attention. The present study aimed to analyze the predictive capacity of these two processes for substance use disorder severity and therapeutic outcomes of patients with cocaine use disorder in treatment.

The sample consisted of 70 outpatients who were starting treatment at a public service. AB was evaluated using a task based on the visual probe (VP) paradigm with images presented under two conditions: 200 ms vs 1000 ms. Cocaine and alcohol use disorder severity, craving, retention in treatment and relapse in consumption were recorded.

Cocaine AB in the 1000 ms condition was negatively correlated with the cocaine use disorder severity ( $r = -0.26$ ), whilst a positive correlation was found between cocaine craving and cocaine AB ( $r = 0.29$ ). Alcohol use disorder severity negatively correlated with cocaine AB in the 200 ms condition ( $r = -0.24$ ). Logistic regression analysis revealed that, after controlling for gender, age, and substance use disorder severity, cocaine AB in the 200 ms condition predicted dropout and relapse. Our results suggest that patients who adhere to treatment and remain abstinent tend to show avoidance in the 200 ms condition, with effect sizes of  $r = 0.29$  and  $0.30$  respectively. The results suggest that training in avoidance strategies could be a valuable way of maintaining adherence and abstinence, as well as improving control of craving.

## 1. Introduction

Attentional bias (AB) towards drug stimuli is a neuropsychological phenomenon shown in drug users (Field & Cox, 2008), and is considered to be a measure of the subject's motivational state in which drug-related stimuli acquire enhanced salience (Franken & van de Wetering, 2015). AB has been linked to a number of factors related to substance use such as craving (Copersino et al., 2004; Field, Mogg, Mann, Bennett, & Bradley, 2013; Franken, 2003), increased drug use (Garland, Franken, & Howard, 2012; Townshend & Duka, 2001; Rooke et al., 2008) or substance use disorder severity (Ryan, 2002). In addition, AB has been shown to have predictive capacity regarding treatment retention and risk of relapse (Díaz-Batanero, Domínguez-Salas, Moraleda, Fernández-

Calderón, & Lozano, 2018; Charles et al., 2015; Marhe, Waters, van de Wetering, & Franken, 2013; Marissen et al., 2006).

Two types of paradigm have primarily been used when studying AB: the drug-word Stroop task and the visual probe (VP) paradigm. The drug Stroop task provides an indirect measure of the magnitude of AB, measured through differences in reaction time to drug-related stimuli and neutral stimuli. Unlike the drug Stroop task, the VP task allows for evaluating the spatial location of attention and distinguishing between patterns of approach and avoidance bias (Field & Cox, 2008). If the reaction time observed when the dot replaces the substance-related stimulus (congruent trial) is shorter than that observed when it replaces the neutral stimulus (incongruent trial), the pattern is regarded as an approach bias. If, on the contrary, the reaction time is slower when

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the dot replaces the substance-related image, this indicates that the participant is avoiding that stimulus.

Previous work using the VP paradigm has revealed the existence of an approach bias in both heavy drinkers (Townshend & Duka, 2001; Field, Mogg, Zettler, & Bradley, 2004) and abstinent patients (Noël et al., 2006; Vollstädt-Klein, Loeber, Von der Goltz, Mann, & Kiefer, 2009) in comparison with social alcohol consumers. However, patterns of avoidance are also evident among patients who consume alcohol in treatment (Townshend & Duka, 2007). These results have also been observed in patients who use other substances such as opiates (Constantinou et al., 2010; Charles et al., 2015), cocaine (Montgomery et al., 2010) and cannabis (Vujanovic, Wardle, Liu, Dias, & Lane, 2016). Overall, the results indicate the presence of an approach bias in users when compared with former users or a control group. In contrast, patterns of avoidance have been linked to patients under treatment (Liu et al., 2011; Vadhan et al., 2007).

A second element of analysis within the VP paradigm is related to the exposure times of the stimuli presented in the task. This aspect allows us to explore the two processes underlying AB i.e. initial orienting and attention maintenance. Studies on human perception indicate that people require an average of 50 ms to attend to a visual stimulus (Duncan, Ward, & Shapiro, 1994). However, the act of shifting attention toward another stimulus located in another space requires a minimum of 150 ms (Jenkins, Grubert, & Eimer, 2018). Thus, in tasks involving the simultaneous presentation of two images (drug-related vs neutral), the time of exposure to the stimuli could determine which of the two attentional processes is being evaluated. Specifically, when the target stimuli are presented with a duration  $\leq 200$  ms., the initial automatic orienting towards the stimulus is being evaluated, but if the stimuli are presented for a longer period of time, the task evaluates maintenance of attention (Field & Cox, 2008).

In general, the empirical evidence shows that differences between patients, consumers, and control groups are usually observed when using exposure times below 500 ms (Field et al., 2004; Townshend & Duka, 2007; Vollstädt-Klein et al., 2009; Vujanovic et al., 2016). Some authors have also reported an approach-avoidance pattern for patients in treatment, observing an approach pattern when a stimulus is presented for less than 200 ms, followed by a pattern of avoidance when the stimulus is exposed for a longer duration (500 ms and above) (Field et al., 2013; Vollstädt-Klein et al., 2009). In alcohol-dependent patients, relationships have been observed between AB and measures of substance use disorder severity and craving when using exposure times above 200 ms (Garland et al., 2012; Field et al., 2013). However, in cocaine use disorder (CUD) patients, such a relationship has also been found when using an exposure time of 100 ms (Franken, Kroon, & Hendriks, 2000).

Studies that analyze VP performance patterns and outcomes are less frequent and have also yielded contradictory results. For instance, using an exposure duration of 200 ms, some authors have reported an association between approach biases and shorter abstinence periods (Constantinou et al., 2010; Garland et al., 2012), whilst studies using exposures of 500 ms have revealed a link between avoidance patterns and a tendency for patients to remain in treatment (Charles et al., 2015; Vollstädt-Klein et al., 2009). In contrast, other studies have found that the relationships between AB and therapeutic outcomes are rather less clear. Using an exposure duration of 50 ms, Noël et al. (2006) found a direct correlation between AB and the number of prior treatments (although no other correlations were found), whilst Field et al. (2013) found no correlation between AB and treatment adherence when using exposure durations of 200 ms and above. Concerning these contradictory results, Christiansen, Schoenmakers, and Field (2015) suggest that AB is a time-sensitive measure; thus, when AB is measured in a clinical setting, it has a limited capacity to predict a relapse that occurs days, weeks, or months later.

In addition, it should be noted that studies relating VP and treatment outcomes have primarily been conducted with alcohol and opiate users

(Garland et al., 2012; Vollstädt-Klein et al., 2009; Charles et al., 2015; Constantinou et al., 2010). Leeman, Robinson, Waters, and Sofuoglu (2014) point out, however, that cocaine users have differential characteristics in relation to AB. In the drug Stroop task, cocaine users show an AB of greater magnitude compared with non-users or users dependent on other drugs (Carpenter, Schreiber, Church, & McDowell, 2006; Copersino et al., 2004; Liu et al., 2011).

In this regard, it is also important to consider the role of alcohol in the therapeutic process of CUD patients (Gossop, Manning, & Ridge, 2006; Heil, Badger, & Higgins, 2001). One reason for this is that concurrent alcohol consumption among cocaine users is one of the most common patterns of polyconsumption (Liu, Williamson, Setlow, Cottler, & Knackstedt, 2018; Saha et al., 2018). For instance, Magura and Rosenblum (2000) have shown that patients in treatment for cocaine dependency could use alcohol to modulate the effects of cocaine consumption. Moreover, several studies also point to changes in both drinking patterns and health effects when both substances are consumed (Gossop et al., 2006; Pennings, Leccese, & de Wolff, 2002). Finally, in relation to the cognitive factors implied in this association, previous work has suggested the presence of an attentional bias towards alcohol stimuli in cocaine users (Marks, Pike, Stoops, & Rush, 2015). For instance, the study by Díaz-Batanero et al. (2018) has shown that in CUD patients in treatment, it is the alcohol AB that is the predictor of abandonment of treatment. Some studies conducted in this area using tasks that simultaneously include alcohol and tobacco stimuli (MacLean, Sofuoglu, & Waters, 2020; Oliver & Drobos, 2015) seem to indicate that, in AB tasks, the inclusion of stimuli related to substances of concurrent use could help to improve the ecological validity of such procedures.

To date, there are no studies that have explicitly examined the presence of differential AB patterns as a function of exposure times in patients being treated for CUD. Therefore, the present study aimed to analyze the predictive capacity of these two attentional processes (initial orienting and maintenance) in the presence of alcohol and cocaine-related stimuli for measures of substance use disorder severity, concurrent AUD presence, therapeutic adherence, and relapse of patients in treatment. On the basis of results reported in the existing literature, we hypothesized that: 1) there will be a moderate correlation between avoidance patterns in the 1000 ms condition and measures of substance use disorder severity; 2) there will be avoidance AB in those patients who remain in treatment and in those who maintain abstinence from consumption; 3) concurrent AUD will be associated with the presence of an AB towards alcohol-related stimuli.

## 2. Method

### 2.1. Participants

This study included 70 outpatients (85.7% males) who were starting SUD treatment at a public service specialized in addictions (Spain). The average age of the participants was 38.93 (SD = 10.70) years. Patients had to meet the following inclusion criteria: 1) having a diagnosis of cocaine abuse or dependence according to DSM-IV criteria; 2) no diagnosis of mental disorders other than SUD; 3) no vision problems or other physical impairments that would hinder completion of the computerized tests; 4) having the ability to read and write; 5) being of adult age; and, 6) being able to provide written informed consent. Seventy-three patients met the inclusion criteria for participation in the study and were evaluated, although three patients were excluded for not being able to provide the toxicological screening data required for relapse evaluation.

The field work was carried out between March 2017 and June 2019. During this period, all patients starting treatment who met the inclusion criteria were invited to participate in the study. Of the sample, 39.4% of the participants had completed primary education, 51.1% had completed secondary education and the remaining percentage had completed university studies. In terms of employment status, 42.9% were working. The majority of the participants were single (70.4%),

12.7% were married, 12.7% were divorced and 4.2% were widowed.

Following selection of the study participants, substance use disorder severity was evaluated according to DSM-5 criteria, which considers the 30-day period prior to the interview. According to this evaluation, 46.5% of the participants presented a moderate-to-high severity level of dependence on cocaine (4 or more symptoms), and 49.3% of the sample stated that they had used cocaine in the month prior to the interview, for an average of 3.79 days (SD = 3.64), consuming 2.23 g on average (SD = 3.70).

In relation to the consumption and presence of other SUDs, all participants reported having a previous history of alcohol consumption. According to DSM-V criteria, 29.6% showed a moderate-to-high alcohol use disorder severity level, 12.9% for heroin and 25.7% for cannabis. For the 30-day period prior to the interview, 45.6% of participants reported having consumed alcohol, with a mean frequency of 2.90 days (SD = 1.97), and a mean quantity of 14.43 standard drinking units (SD = 21.38). Further, 32.9% of the patients reported having used cannabis in the last 30 days, with a mean number of 5.58 joints (SD = 6.65) and a mean frequency of 11.17 days (SD = 11.45). Of the 12.9% of patients with a moderate-to-high heroin use disorder severity level, all reported use in the last 30 days, with an average quantity of 2.11 g (SD = 3.07) and a frequency of 2.55 days (SD = 2.60). This profile of poly-consumption is common in patients who attend these treatment centers.

## 2.2. Instruments

**Dot Probe Task.** AB was evaluated using a task based on the VP paradigm. This test consists of 24 different pairs of images (8 alcohol-related pairs, 8 cocaine-related pairs and 8 neutral-neutral pairs of images). For the drug-related pairs of images, each of the images with drug stimuli were matched to similar neutral images in terms of shape, color, brightness, and visual complexity. These pairs were presented four times: on one trial for each of the 200 ms congruent, 200 ms incongruent, 1000 ms congruent, and 1000 ms incongruent conditions. In the case of neutral images, the four repetitions of each pair of images were distributed between the two conditions, counterbalancing the position of the image and the dot probe. The test consisted of 96 trials in total (64 trials with substance-related stimuli and 32 neutral trials), along with four example trials that were introduced at the beginning of

the test.

Each test began with the word “Attention!” displayed as a fixation point for 1000 ms in the center of the screen. Two images were then displayed on the right and left sides of the screen, one of which was related to a consumption substance (alcohol or cocaine), and the other being the equivalent neutral stimulus. The exposure time of the images was manipulated to create two conditions: 200 ms or 1000 ms (see Fig. 1).

After the images had been presented, a 27 mm-sized dot appeared, replacing one of the images, and the participants had to indicate the location of this dot by pressing the “Alt-left” key when the dot was presented on the left side, and the “Alt-right” key when it was presented on the right side. The length of time for which the dot appeared following the offset of the image pair varied randomly between 150 and 750 ms. For each trial, we recorded the time taken by the subjects to respond to the dot.

The location of the images was counterbalanced, and they appeared congruently and incongruently (with respect to the position of the dot) for an equal number of times. The order of presentation was randomized for each participant.

The task was programmed in Unity 2D V3.3.2 and presented on an Intel Celeron computer with a 15.6-inch color monitor. Internal consistency values of reaction times measured by dot probe task ranged 0.664–0.761 for cocaine trials and 0.706–0.787 for alcohol trials. The split-half Spearman-Brown coefficients for cocaine AB were 0.674 (Intra-class correlation coefficient, ICC = 0.412) for the 200-ms condition and 0.577 (ICC = 0.348) for the 1000-ms condition. For alcohol AB, the split-half value was 0.648 (ICC = 0.481) for the 200-ms condition and 0.037 (ICC = -0.215) for the 1000-ms condition.

**Substance Dependence Severity Scale (SDSS; Miele et al., 2000).** The Spanish version of this scale was administered, adapted to the DSM-5, which has been shown to have adequate psychometric properties (Dacosta-Sánchez, Fernández-Calderón, González-Ponce, Díaz-Batano, & Lozano, 2019). This instrument evaluates the substance use disorder severity of patients during the month prior to the application of the test, including an evaluation for each substance. In this sample, internal consistency values were equal to or greater than 0.77 in the evaluation of alcohol and cocaine dependence.

**Visual-Analogue Scale for Craving.** This scale was administered to

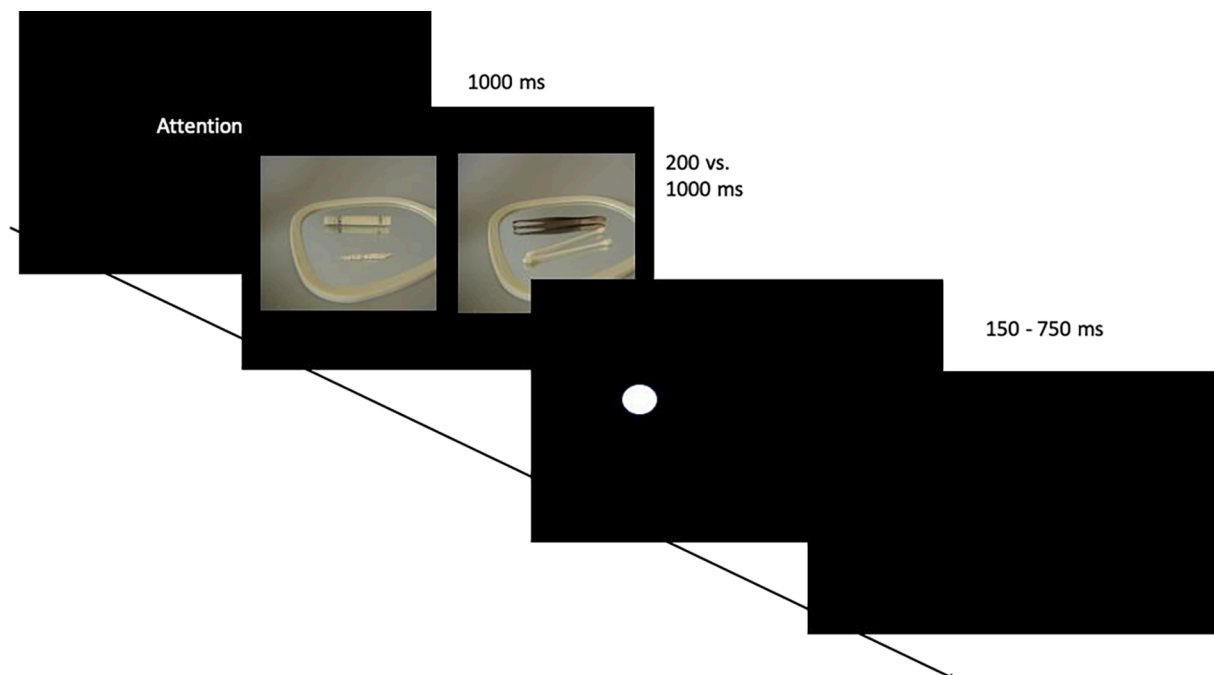


Fig. 1. Sequence of dot probe task used.

evaluate the level of cocaine and alcohol craving, taking as a reference the proposal by Iraurgi, Albet, Jiménez-Lerma, and Landabaso (2009). Specifically, this consisted of a 100-mm scale designed to assess the “desire to consume during the 24 h prior to the interview”. Represented as a thermometer, the left side indicated “no desire” and the right side indicated “unable to resist”.

**Retention in treatment.** Three months after the initial interview, checks were conducted to establish whether the patients in the study were still in treatment or had dropped out. This information was collected from clinical professionals. The patient was considered to have abandoned treatment if they had failed to attend any of their scheduled appointments during this period without explanation and did not make contact with the center during the subsequent three months.

**Relapse.** The relapse of patients was evaluated in relation to consumption of any of the substances for which they were receiving treatment. This included the results of the analyses conducted on the patients during their therapeutic process, as well as the patients’ self-reports of consumption. No information could be obtained from 3 patients because they did not attend the appointments for the toxicological tests, and there was no information regarding their use following the initial interview.

2.3. Analysis

For the visual probe data, trials were excluded (9.8% of trials) if i) a response error was made; ii) an RT was less than 100 ms; iii) the RTs were greater than 2000 ms or greater than 3 SDs above each participant’s mean. AB was calculated separately for cocaine and alcohol by subtracting the RT on congruent trials from that obtained on incongruent trials. A positive AB score is therefore taken to indicate an AB towards drug-related stimuli.

Shapiro-Wilk test revealed a lack of normality in the different AB measurements, so nonparametric tests were used. Spearman’s Rho correlations were calculated between AB scores and measures of substance use disorder severity and craving. AB scores of those patients who dropped out and those who remained in treatment were compared using the Mann-Whitney U test. Similarly, AB scores of each condition of the abstinent patients and relapsers were compared. The effect sizes were estimated with the formula of Rosenthal (1994).

In order to establish the predictive capacity of AB for retention in treatment and relapse, we applied hierarchical logistic regressions, controlling for age and gender. Consumption-related variables were also included in the model. According to the Hosmer-Lemeshow test, both the model for retention ( $\chi^2 = 8.45; p > .05$ ) and relapse ( $\chi^2 = 15.23; p > .05$ ) showed a good fit.

3. Results

Table 1 displays the relationships between AB and measures of craving and substance use disorder severity. In the 1000 ms condition there is a negative correlation between the cocaine use disorder severity ( $r = -0.257$ ). Alcohol use disorder severity is negatively correlated with cocaine AB in the 200 ms condition ( $r = -0.240$ ). A relationship between cocaine craving and cocaine AB is also observed.

**Table 1**  
Spearman correlations between AB and substance use disorder severity measures ( $n = 70$ ).

	Alcohol AB		Cocaine AB	
	200 ms	1000 ms	200 ms	1000 ms
Cocaine use disorder severity	0.019	-0.010	-0.087	-0.257*
Cocaine craving	-0.100	-0.123	0.304*	0.285*
Alcohol use disorder severity	-0.170	-0.180	-0.240*	0.102
Alcohol craving	-0.167	-0.133	0.025	-0.217

\*  $p < .005$ .

Fig. 2 shows a comparison of the AB between the two conditions (200 ms and 1000 ms) for each of the analyzed variables. Patients with concurrent AUD (according to DSM-IV criteria) show an avoidance AB of greater magnitude in the 200 ms condition ( $M = -26.47; SD = 56.21$ ) in comparison with patients without AUD ( $M = -4.64; SD = 27.81$ ), although the differences did not reach significance, ( $Z = -1.88; p = .068; r = 0.22$ ). With regard to treatment outcomes, it is observed that patients who maintain in treatment presented an avoidance bias in the 200 ms condition ( $M = -20.83; SD = 48.62$ ) compared with those who dropped out ( $M = -0.22; SD = 25.50$ ) ( $Z = 2.38, p = .017; r = 0.29$ ). The results also indicate that abstinent patients showed an avoidant AB in the 200 ms condition on trials involving cocaine-related stimuli ( $M = -23.59; SD = 49.69$ ) compared with patients who relapsed ( $M = 0.90; SD = 24.07$ ) ( $Z = 2.42, p = .015; r = 0.30$ ).

Fig. 3 shows the comparison of the AB results between the 200 ms and 1000 ms conditions on trials involving alcohol-related stimuli. No significant differences were found for any of the analyzed variables ( $p > .05$ ).

Tables 2 and 3 show the results of the logistic regression analysis. After controlling for gender, age, and substance use disorder severity, AB towards cocaine stimuli in the 200 ms condition is maintained as a predictor of dropout ( $OR [95\%]: 1.02 [1.01-1.04], p = .025$ ), with this model explaining 22% of the variance. It is also observed that AB towards cocaine stimuli in the 200 ms condition is the variable with the capacity for predicting relapse ( $OR [95\%]: 1.02 [1.01-1.03], p = .043$ ).

4. Discussion

This study presents preliminary findings on the relationship between initial orienting and maintenance of attention and measures of substance use disorder severity and treatment outcomes in CUD patients. To the best of our knowledge, this is one of the first studies to analyze the distinct roles played by these processes in a group of cocaine using patients in treatment. In general, the results provide evidence to partially support our hypotheses and suggest the utility of distinguishing between each of these processes, as well as analyzing the patterns of AB.

In relation to the first hypothesis, a number of studies conducted with alcohol users have found a relationship between alcohol AB and indicators of substance use disorder severity in trials longer than 500 ms in duration (e.g., Garland et al., 2012; Field et al., 2013; Townshend & Duka, 2001; Field et al., 2004). The results of the present study, conducted with CUD patients, are in line with those reported in previous studies. Specifically, our results indicate that patients with greater substance use disorder severity seem to show an AB characterized by the avoidance of cocaine images, a finding that has also been reported in previous studies with patients in treatment (Field et al., 2013; Liu et al., 2011; Vadhan et al., 2007; Vollstädt-Klein et al., 2009). These results are complemented by our observation of a positive correlation between cocaine AB and craving, which is congruent with the findings of other research (Field et al., 2013; Franken et al., 2000).

Thus, taken together, these findings suggest that craving is positively associated with cocaine AB, and patients with more severe levels of dependence tend to move their attention away from cocaine-related stimuli. Such avoidance has also been observed in opiate-using patients in treatment (Charles et al., 2015) and ex-patients (Constantinou et al., 2010). It should be noted that whilst only minimal levels of craving and substance use disorder severity were observed in some of the participants of the present study, the relationships found suggest the importance of considering the interaction between craving and the substance use disorder severity in AB processes. Similar to our results, Field et al. (2013) found an AB characterized by the avoidance of alcohol cues, although this was mediated by the level of craving. According to Field et al. (2013), AUD patients with high levels of craving have difficulties in implementing avoidance strategies. In relation to this result, Goldstein and Volkow (2002) point out that craving is associated with a learned response that links the drug and related stimuli (environmental

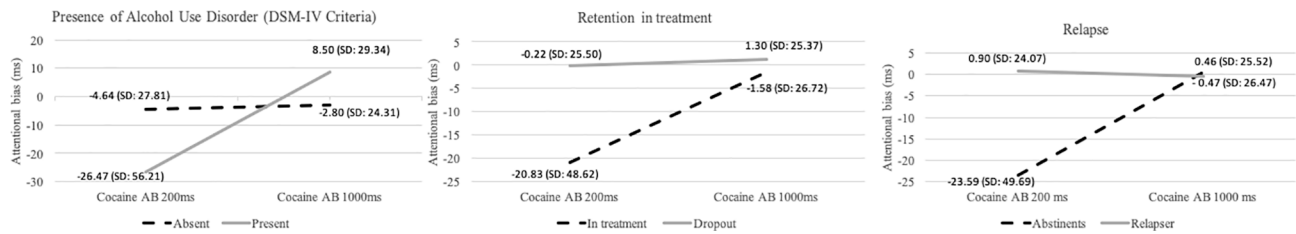


Fig. 2. Mean scores (SD) on cocaine AB in each group.

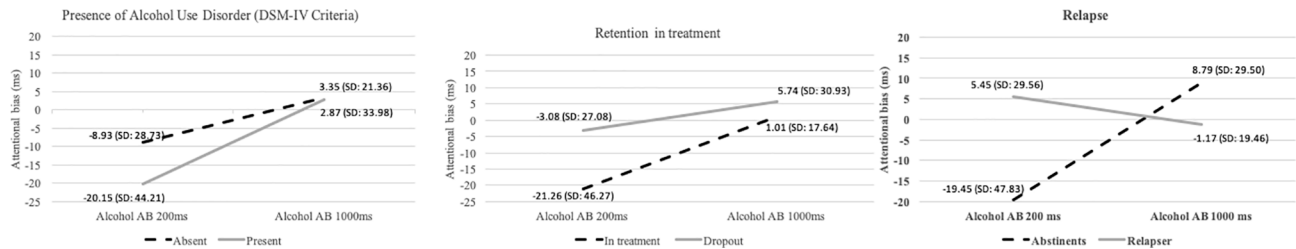


Fig. 3. Mean scores (SD) on alcohol AB in each group.

Table 2  
Logistic regression predicting treatment adherence.

	B	SE	p	OR	CI 95%	
					Lower	Upper
Constant	1.16	1.68	0.491	3.19		
$X^2 = 1.99, p = .370; r^2 = 0.03; Nagelkerke r^2 = 0.04$						
Gender	-0.40	0.84	0.632	0.66	0.13	3.46
Age	-0.02	0.03	0.564	0.98	0.93	1.04
$X^2 = 3.91, p = .689; r^2 = 0.08; Nagelkerke r^2 = 0.11$						
Alcohol use disorder severity	0.04	0.03	0.178	1.03	0.98	1.51
Cocaine use disorder severity	0.01	0.02	0.986	1.00	0.96	1.04
Quantity of alcohol	-0.04	0.02	0.133	0.96	0.91	1.02
Quantity of cocaine	0.44	0.30	0.142	1.56	0.86	2.81
Alcohol craving	-0.49	0.23	0.836	0.95	0.60	1.51
Cocaine craving	0.36	0.16	0.829	1.03	0.75	1.43
$X^2 = 10.41, p = .034; r^2 = 0.21; Nagelkerke r^2 = 0.28$						
Alcohol AB 200 ms	0.02	0.01	0.217	1.02	0.99	1.04
Alcohol AB 1000 ms	0.01	0.01	0.839	0.99	0.97	1.02
Cocaine AB 200 ms	0.03	0.01	0.023	1.02	1.01	1.05
Cocaine AB 1000 ms	0.01	0.01	0.543	1.01	0.98	1.03

Table 3  
Logistic regression predicting relapse.

	B	SE	p	OR	CI 95%	
					Lower	Upper
Constant	2.97	1.79	0.093	19.60		
$X^2 = 4.14, p = .126; r^2 = 0.05; Nagelkerke r^2 = 0.07$						
Gender	-1.68	0.92	0.067	0.18	0.30	1.12
Age	-0.02	0.03	0.400	0.98	0.92	1.03
$X^2 = 3.53, p = .739; r^2 = 0.10; Nagelkerke r^2 = 0.14$						
Alcohol severity of dependence	0.05	0.03	0.098	1.05	0.91	1.11
Cocaine severity of dependence	0.01	0.02	0.572	1.01	0.97	1.05
Quantity of alcohol	-0.02	0.03	0.371	0.97	0.93	1.03
Quantity of cocaine	0.04	0.12	0.717	1.05	0.82	1.33
Alcohol craving	-0.23	0.22	0.298	0.79	0.51	1.22
Cocaine craving	0.16	0.19	0.410	1.17	0.80	1.70
$X^2 = 10.96, p = .027; r^2 = 0.23; Nagelkerke r^2 = 0.30$						
Alcohol AB 200 ms	0.01	0.01	0.395	1.01	0.98	1.03
Alcohol AB 1000 ms	-0.01	0.01	0.304	0.99	0.95	1.02
Cocaine AB 200 ms	0.03	0.01	0.021	1.03	1.01	1.06
Cocaine AB 1000 ms	-0.01	0.01	0.457	0.99	0.95	1.01

cues or images related to the substance) in an intense way. Therefore, even if patients attempt to use avoidance strategies, these could be counteracted by high levels of craving.

In terms of our second hypothesis, and in line with the results reported by other authors (Constantinou et al., 2010; Field & Cox, 2008), our findings suggest that relapse and abandonment of the therapeutic process appear to be associated with AB when using shorter stimulus exposure times. Garland et al. (2012) point out that when attention is automatically oriented toward drug cues, cognitive resources may be diverted away from attempts to implement the coping strategies required to manage abstinence. This explanation is also congruent with the postulates of the Impaired Response Inhibition and Salience Attribution model (I-RISA; Goldstein & Volkow, 2002). According to this model, those patients with a lower capacity to inhibit automatic responses will make fewer adaptive decisions and, therefore, may experience more difficulties in remaining in treatment. Thus, the observation in this study that patients with an avoidance AB in the 200 ms condition are those who adhere to treatment and remain abstinent could suggest a cognitive mediating role of automatic AB in decision making (Cox,

Fadardi, & Pothos, 2006). Avoidance has previously been observed in patients who try to remain abstinent and who are using active strategies to avoid substance-related stimuli (Vadhan et al., 2007; Vollstädt-Klein et al., 2009). In view of the results reported here, such a mediating role might only be in operation when subjects are exposed to automatic response conditions, and not during conscious processing.

Finally — and contrary to our expectations — the results reported here could be taken to indicate that patients with concurrent AUD tend to avoid cocaine stimuli but not alcohol stimuli. These results differ from those found by Marks, Pike, Stoops, and Rush (2015), which point to the specificity of attentional bias to the substance for which patients meet dependence criteria. Further, we did not find that attentional bias towards alcohol stimuli has an impact on the probability of relapse in patients with AUD, a result observed in Díaz-Batanero et al. (2018). A greater cocaine use disorder severity of the patients in this study can partially explain these results, with this substance being the one that evokes a greater emotional response in these patients, minimizing the effect of AB towards alcohol stimuli. Previous studies have also found no difference in alcohol AB between dependent patients and social drinkers

when using exposure times over 500 ms (Field et al., 2004; Noël et al., 2006; Vollstädt-Klein et al., 2009). It should be noted that, in the present study, the observed low stability of the alcohol AB scores in the 1000 ms condition could limit the interpretation of this measure as an outcome indicator. Further work is needed to investigate the relationship between the attentional bias towards concurrently used substances.

From a clinical standpoint, the results of the present study indicate the need to consider various factors that could be useful for designing therapeutic interventions. First, our results suggest the importance of detecting patterns of AB. Lee, Cho, and Lee (2014) link patterns of approach or avoidance with the stage of contemplation within the processes of change proposed by Prochaska and DiClemente (1992). In the latter, patients beginning treatment are interested in changing, although they are not yet highly committed. That is, they are ambivalent about the possibility of change, weighing up the benefits and costs of quitting consumption. According to Lee et al. (2014), patients capable of resolving this ambivalence would then move on to the preparation phase, which would involve the implementation of an action plan aimed at achieving change. The pattern of avoidance in short exposure times observed in patients under treatment could constitute evidence of the patient's state of motivation for change.

Second, the results suggest that training in avoidance strategies could be considered a valuable approach for maintaining adherence and abstinence. In this regard, Schoenmakers et al. (2010) point out that training on the avoidance of consumption stimuli decreases the vulnerability of the patient to relapse. This might decrease the probability of the cue eliciting an emotional response in the patient that could possibly lead them to consume again. A systematic review conducted by Heitmann, Bennik, van Hemel-Ruiter, and de Jong (2018) indicates that, although attention bias modification (ABM) techniques do not conclusively reduce symptoms of addiction, clinically meaningful effects are more likely to occur using multi-session ABM interventions. In the specific case of patients with CUD, Leeman et al. (2014) point to the use of ABM techniques, together with strategies developing executive functions, for minimizing the cognitive interferences experienced by these types of patients during the cessation of consumption.

Finally, on the basis of the preliminary findings presented in this paper, it could be worth considering the automatic processes generated by consumption habits. Several authors have emphasized the importance of using therapeutic procedures that improve the ability to control craving (Cox, Fadardi, Intriligator, & Klinger, 2014). According to Cox et al. (2006), the intention to avoid consumption requires conscious reflection on the advantages of remaining abstinent, which would only be possible in those patients whose craving levels are low. Conversely, patients with high craving levels would have greater difficulty inhibiting AB towards consumption-related stimuli. Strategies aimed at inhibiting these automatic processes would provide patients with tools that could improve decision-making and contribute towards therapeutic recovery.

Whilst the results presented here constitute a body of evidence that is worthy of consideration, we should also note a number of limitations. First, there is a gender imbalance in our sample, although this reflects the gender distribution of CUD patients in treatment (European Monitoring Centre for Drugs & Drug Addiction, 2019). Although in this study, as in others (e.g., Liu et al., 2011) no relationship was found between gender and AB, this is an aspect that should be explored in future studies.

Second, the sample size used could limit the generalizability of our conclusions. However, it is worth bearing in mind that follow-up studies with similar objectives to those of this study are relatively scarce (Charles et al., 2015; Constantinou et al., 2010; Garland et al., 2012), and therefore the evidence gathered here is of value for future meta-analyses and review studies. Further, it should be noted that the present work constitutes one of the studies with the largest sample size among those published, and the first, to our knowledge, carried out in patients with CUD. The difficulties of accessibility and follow-up of these samples mean that, in general terms, the sample sizes used in this type of study are unavoidably reduced.

Additionally, it is necessary to consider the usual presence of other mental disorders in patients with SUD, since certain comorbidities could affect performance on attentional tasks (Pasche, 2012; Sokhadze et al., 2008). Although for this study, we decided to control for the presence of other disorders, it will be necessary to consider this factor in future work.

Similarly, in relation to other variables that can affect the execution of cognitive tasks in consumers, tobacco consumption and deprivation should be considered (Cohn, Ehlke, & Cobb, 2017). Although those patients with this habit were given the opportunity to smoke during the breaks in the test, in future works it will be necessary to consider the relevance of controlling this variable.

Moreover, in recent years, several authors have questioned the reliability of the tasks that evaluate attentional bias (Ataya et al., 2012; Field & Christiansen, 2012; Schmukle, 2005; Rodebaugh et al., 2016). In the present study, reliability values for the 200 ms trials are within the recommended range - and similar to those obtained in other previous studies (Jones, Christiansen, & Field, 2018; Molloy & Anderson, 2020; Soleymani, Ivanov, Mathot, & Jong, 2020). Although the trials appear reliable, the small number of trials per condition should be taken into account in considering accuracy of the measures.

Finally, the variability in the definition and application of certain methodological components in the published studies could hinder the comparison of results. One such aspect is the design of the VP task itself, which differs between studies in terms of the stimulus presented on test. In the present study, as in those published previously (e.g., Constantinou et al., 2010; Noël et al., 2006; Townshend and Duka, 2007; Townshend & Duka, 2001; Vollstädt-Klein, Loeber, Von der Goltz, Mann, & Kiefer, 2009), the presentation of a dot as a probe could command a greater degree of exogenous attention compared with those that use a directional arrow (e.g., Schoenmakers et al., 2010; Field et al., 2013; Charles et al., 2015). Moreover, exposure times differ considerably between studies, making it difficult to compare results in relation to the orienting and maintenance processes. In this regard, reaction times in tests with exposure times greater than 500 ms are a more indirect indicator of AB than fixation times in eye tracking techniques (Marks et al., 2014). Thus, the use of reaction times can make the interpretation of these attentional mechanisms difficult, particularly when long exposure times are used. However, the empirical evidence provided by these indicators may be useful to the extent that they can be more readily applied when measuring the AB of patients during treatment and temptation episodes, by using, for example, portable devices (Leeman et al., 2014).

Similarly, the operational definition of outcome indicators in this study (adherence and relapse). The review study conducted by Domínguez-Salas, Díaz-Batanero, Lozano, and Verdejo-García (2016) points to 14 different ways of operationalizing treatment adherence in the 28 studies analyzed. As these authors point out, in order to progress in this field, there is a need to reach consensus regarding an operationalized definition of treatment outcomes and other methodological issues.

Thus, despite the limitations indicated, we consider that the results of this study serve to advance our knowledge about the cognitive approach to addiction, which has considerable applied value for the development of therapeutic strategies.

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#### Authors contributions

CDB, OML and FFC has contributed on the conception and design of study. FFC, OML and OMLR has contributed on the acquisition of data.

CDB and OML had participated on the analysis of data. FFC, CDB, JALM and EMB had participated on the interpretation of data. FFC and CDB had drafted the manuscript. All authors have revised the manuscript critically for intellectual content and approved the final version of the manuscript submitted.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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