Time Course of Attention for Alcohol Cues in Abstinent Alcoholic Patients: The Role of Initial Orienting

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Objective: Addicted people are characterized by enhanced attention for drug cues leading to drug use. However, there is little research on the component processes of attention in individuals with alcoholism. Here, we examine 2 distinct components of attention in abstinent alcohol-dependent individuals and social drinkers of alcohol, that is to say, the initial orienting to alcohol-related cues, and the maintenance of attention to them.

Method: The present study used an "alcohol" version of the visual probe detection task with alcohol-related or neutral pictures being presented briefly (i.e., 50 ms), to assess initial orienting, or longer (i.e., 500 and 1,250 ms), to assess the maintenance of attention.

Results: Only alcoholic patients were faster in detecting a probe displayed immediately after pictures related to alcohol presented for 50 ms than in detecting the same probe replacing non–alcohol-related pictures. However, when pictures were presented for 500 ms, only social alcohol drinkers were faster in detecting the probe replacing alcohol scenes. At a stimulus of 1,250 ms duration, no group showed attentional bias toward alcohol cues. In addition, the severity of alcoholism measured by the total number of prior detoxification treatments was positively correlated with the attentional bias (or "attraction") for alcohol pictures presented for 50 ms.

Conclusions: These results show that, subsequent to initial visual orienting to alcohol-related cues, abstinent patients' attention was disengaged from these stimuli, thus suggesting a visual approach-disengagement attentional pattern. The influence of these findings on relapse was discussed.

Key Words: Alcoholism, Alcohol Cues, Attention Biases, Visual Probe Task.

REPEATED DRUG USE is associated with a bias to attend to drug-related rather than to other stimuli (e.g., Field et al., 2004; Franken, 2003; Noël et al., 2005). For instance, when participants have to name the color of words with a certain emotional charge (i.e., the emotional Stroop task), alcohol-dependent individuals and heavy alcohol drinkers are slower than light and non–alcohol drinkers in naming the color of alcohol-related rather than non–alcohol-related words (e.g., Johnsen et al., 1994; Stetter et al., 1995; Lusher et al., 2004). In a task consisting of identifying transient changes in visual scenes, people drinking "heavily" detected substance-related changes more quickly than light and nonalcohol drinkers (Jones et al., 2003). This is consistent with the idea that alcohol cues "hijack" limited attentional resources and thereby reduce the processing resources available for other cognitive functions. Also, when presented with alcohol-related words on the periphery of their visual field, alcoholic patients were poorer at completing a centrally presented odd/even number decision task than when either non–alcohol-related words, nonwords, or no peripherally presented stimuli were present (Waters and Green, 2003). Taken together, these findings demonstrate that alcohol cues command limited attentional resources, and thereby reduce the processing resources available for other cognitive functions.

However, these cognitive procedures may not represent appropriate measures of attentional allocation. For instance, some investigators (e.g., de Ruiter and Brosschot, 1994) have argued that, in the "emotional Stroop" procedure, color-naming delays might arise either from attention being directed toward the meaning of the emotional word or by a stronger attempt to ignore that meaning. Hence, some investigators have preferred the use of a modified dot probe task, which provides a more specific measure of attentional allocation. In the visual probe task, participants are presented with a series of pairs of words or pictures on a computer screen, one above the other, followed by a visual probe shown in the location of one of the words/pictures (MacLeod et al., 1986). Participants are instructed to indicate, as quickly as possible, whether the probe appeared in the upper or lower position on the computer screen. The hypothesis being examined

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was that probe detection would be faster when the probe replaces stimuli related to the emotionally salient compared with a neutral stimulus (MacLeod et al., 1986). As reviewed by Franken (2003), drug users respond faster to probes that appeared in the location of drug-related, as opposed to neutral pictures, thus suggesting that their attention was being preferentially allocated to the spatial location of drug-related cues. This attention bias has also been found for drug-related pictures in opiate addicts (Lubman et al., 2000), for smoking-related pictures in tobacco smokers (e.g., Ehrman et al., 2002), for cannabis-related words in recreational cannabis users (Field et al., 2004), and for alcohol-related pictures in heavy social drinkers (Field et al., 2004; Townshend and Duka, 2001).

Relative to neutral cues, the presentation of alcohol cues, in SPECT, PET, and fMRI studies, revealed that alcoholic patients show a robust activation of the brain reward circuitry including the ventral striatum (e.g., Braus et al., 2001), the insula (e.g., Myrick et al., 2004), as well as the amygdala/hippocampus, and the anterior cingulate (e.g., Myrick et al., 2004; Schneider et al., 2001). The contribution of additional prefrontal regions (e.g., dorsal and orbital) is obvious only in alcohol-addicted individuals who are still actively using, but not in patients undergoing treatment. This suggests that the perception of an opportunity to use drugs significantly affects responses to the presentation of drug cues (for a recent review, see Wilson et al., 2004).

The involvement of attentional biases in alcohol consumption was demonstrated by Coxet et al. (2002). They found attentional bias for alcohol cues to be a reliable predictor of alcohol relapse during a detoxification treatment. Furthermore, the intensity of self-reported craving for alcohol was correlated to their proneness to maintain their attention toward alcohol-related pictures (Field et al., 2004). Taken together, these data suggest that attentional bias for alcohol cues is involved in alcohol relapse.

The main weakness of most recent research on attention bias in drug dependence is the lack of a theoretical distinction between the mechanisms involved in the initial orienting and the maintenance of attention to relevant stimuli (e.g., Allport, 1989). Initial orienting is conceived as a rapid automatic process that can be detected when the stimuli are presented for brief durations (< 200 ms). Conversely, biases in maintaining attention are more likely to be revealed when stimuli are presented for longer durations (> 500 ms).

Research addressing the time course of attention for alcohol cues and its relationship with the motivation to drink alcohol has revealed mixed results (Field et al., 2004; Stormark et al., 1997). In an attention cue–induced paradigm, participants had to identify in 1 of 2 locations the presence of an asterisk (Stormark et al., 1997). The correct location of the asterisk was cued by an alcohol-related or a neutral word presented for 100 or 500 ms. Alcoholic patients, who were now abstinent, were faster than light social drinkers in detecting the asterisk cued by alcohol-related words that were displayed for 100 ms. However, they were slower than social drinkers in detecting the target when the alcohol-related words were displayed for 500 ms (Stormark et al., 1997). These results suggest that recently abstinent alcohol-dependent individuals exhibit an initial attentional orienting toward alcohol cues, before avoiding alcohol-related cues. In contrast, when using the visual probe task, and in comparison with light social drinkers, heavy social drinkers had an attention bias for alcohol pictures presented for longer durations (500 and 2000 ms), but not for a shorter duration (e.g., 200 ms) (Field et al., 2004). These data suggest that alcohol-dependent individuals who are now abstinent, and alcohol-abusing individuals who are current drinkers, exhibit distinct attention bias for alcohol-related cues. To summarize, the attraction for alcohol-related stimuli has been shown in light, heavy, and abstinent alcohol-dependent individuals. But the time course of abstinent alcoholics' (ALC) attention from the initial orienting to the later stages of attentional processing (i.e., maintenance of attention) remains to be investigated. There is only 1 study that found a bias for initial orienting to verbal alcohol-related cues in ALC (Stormark et al., 1997), followed by an attentional disengagement from these stimuli. However, in this study, the size of the sample of 2-month sober alcoholic patients was very small (3 women and 7 men), the intensity of the craving for alcohol was not reported, and the longest display duration was 500 ms. Here, we have compared the time course of attention for alcohol-related pictures in abstinent and recently detoxified alcoholic patients, and in current social alcohol drinkers, using a modified version of the visual probe task. The time to respond to visual probes that replaced alcohol-related pictures displayed for a very brief duration (50 ms) was used as a measure of initial orienting. As Field et al. (2004) found in a visual probe task that heavy drinkers shift their attention from neutral toward alcohol-related photographs presented for 500 ms, our display times assessing the maintenance of attention were 500 and 1,250 ms.

METHODS

Participants

All subjects were adults (> 18 years old), and they provided informed consent that was approved by the appropriate human subject committees at the Brugmann Hospital. The demographic data on the 2 groups are presented in Table 1. Thirty-six, recently detoxified, individuals with alcoholism (ALC) were recruited for this study from the Alcohol Detoxification Program of the Psychiatric Institute, Brugmann Hospital, Brussels, Belgium. They were tested between 18 and 21 days after ceasing to drink. They all received complete medical, neurological, and psychiatric examinations at the time of selection (Table 1). The participants had to meet DSM-IV criteria for alcohol dependence (American Psychiatric Association, 1994) [made by a board-certified psychiatrist (P.V.)]. The reasons for exclusion were other current DSM-IV Axis I diagnoses, a history of significant medical illness, head injury resulting in a loss of con-

Table 1. Demographic and Clinical Variables of Abstinent Alcoholic Subjects (ALC) and Social Drinkers of Alcohol (SDA) Who Participated in the Study

	ALC	SDA
Total *N*	36	28
Age (y): Mean ± SD	45.6 ± 8.2	44.2 ± 10.1
Gender (male/female)	23/13	19/9
Education (years): Mean ± SD	12.2 ± 3.42	12.7 ± 2.92
Daily quantity of alcohol (g)	250.9 ± 167.7	25.5 ± 9.4
Duration of alcoholism (y)	15.8 ± 9.6	—
Number of prior detoxification treatment	3.4 ± 2.4	—
Abstinence (d)	20.2 ± 1.5	2.5 ± 1.1
Cumulated diazepam doses during detoxification (mg)	720 ± 190	—
Beck Depression Inventory	6.4 ± 5.3	0.7 ± 0.9
State Trait Anxiety Inventory (STAI)-state	39.8 ± 12.1	26.5 ± 7.6
STAI-trait	48.8 ± 10.5	34.2 ± 7.4
Craving intensity (0–4)	1.03 ± 1.3	—

sciousness for longer than 30 minutes that would have affected the central nervous system, use of other psychotropic drugs or substances that influence cognition, and overt cognitive dysfunction. To increase the reliability of information, alcoholic subjects and their families were interviewed separately. Blood levels of folate, vitamin B12, and B-carotene were measured. The detoxification regimen had consisted of administration of B vitamins and a gradual decrease in the doses of sedatives (diazepam). Depression and anxiety were rated using the Beck Depression Inventory (BDI; Beck, 1987; Beck and Steer, 1993) and the Spielberger State Trait Anxiety Inventory (STAI Trait & State; Spielberger, 1993).

Social Drinkers of Alcohol

Twenty-eight social drinkers of alcohol (SDA) matched for sex, age, and educational level to the alcoholic group were recruited by word of mouth from the community; the participants were not paid for their participation. The inclusion criterion for this group was to drink occasionally; nonalcohol drinkers were excluded. We also excluded anyone with an Axis I psychiatric diagnosis assessed by the Structural Clinical Interview for DSM-IV; who had been diagnosed with a drug abuse disorder during the year preceding the enrollment in the study; or who had consumed more than 54 g/d of alcohol for longer than 1 month. On the basis of the results of their medical history and physical examination, they were judged to be medically healthy. SDA were asked to avoid the use of drugs, including narcotic pain medication, for the 5 days prior and the consumption of alcohol during the 24 hours before testing.

Cognitive Assessment

The pictorial stimuli used in the visual probe task consisted of 40 color photographs of alcohol-related scenes (e.g., man holding beer glass to mouth, bottles of whisky). Each neutral was matched to an alcohol-related photograph in the sense that they were identical (i.e., same environment, same people), with the exception of the alcohol-related cue (e.g., man holding beer or water bottle to mouth, glass of wine or of milk). An additional 40 picture pairs (both unrelated to alcohol) were prepared for use as fillers, and ten pairs were used for practice, or as filler trials. The pictures were digitized and converted to an indexed 256-color palette. All tasks were programmed in e-prime (version 1.1) software, and they were presented on a Pentium III PC, with a 15 inch VGA monitor, attached to a 2-button response box and standard keyboard.

Procedure

After an informed consent document was signed, all participants were asked to rate "how strong your urge to drink alcohol is right now" on an anchored scale, which ranged from 0 (not at all) to 4 (extremely). They then completed the visual probe task. Participants were seated at a desk, 1 m from a computer monitor. Each trial began with a central fixation cross displayed for 500 ms, which was then replaced by a pair of pictures, side by side, for 50, 500, and 1,250 ms. Participants were instructed to look at the fixation cross at the start of each trial. Immediately after the offset of the picture pair, a dot probe was presented in the position of 1 of the 2 preceding pictures, and it lasted until the participant responded. Participants were instructed to press, as quickly as possible, 1 of the 2 response buttons to indicate the location of the probe. To control the change of attentional biases over the course of these trials, the order of stimulus duration blocks (50, 500, and 1,250 ms) was counterbalanced. Participants were allowed a break midway through the task.

After 10 practice trials, the main task was composed of 180 trials (120 targets and 60 fillers). During the target trials, each of the 40 alcohol-related and non–alcohol-related (control) picture pairs was presented 3 times: once for each of the 3 stimulus durations (50, 500, and 1,250 ms). The probe appeared in the location of either the alcohol-related or the control picture with equal frequency; i.e., there were an equal number of trials with each probe type. The 20 filler picture pairs were also presented 3 times, i.e., once for each stimulus duration. Target and filler trials were presented in a random order for each participant. Each picture was 95 mm high by 130 mm wide when displayed on the screen, and the distance between their inner edges was 25 mm. The distance between the 2 probe positions was 100 mm. After the computer tasks, participants completed the Beck Depression Inventory and the State-Trait Anxiety Inventory.

RESULTS

The composition of ALC and SDA groups was similar in age, education, and gender. However, ALC were more depressed and anxious (State/Trait) than SDA [$t(62) = 6.3$, $p < 0.001$, $t(62) = 4.9$, $p < 0.001$ for anxiety-state/$t(62) = 6.04$, $p < 0.001$ for anxiety-trait; respectively].

Visual Probe Task

Reaction times (RTs) data from filler trials and trials were recorded with errors discarded. To eliminate outliers, RTs were excluded if they were greater than 2,000 ms, and then if they were more than 2.5 SD above the mean. Attentional bias scores were calculated, separately, for each participant at each stimulus duration, by subtracting mean RTs to probes replacing alcohol pictures from mean RTs to probes replacing non–alcohol-related pictures, such that positive bias scores reflect an attentional bias toward alcohol-related cues. Trials where the probe replaced alcohol pictures were termed "congruent trials," and trials where the probe replaced control pictures were termed "incongruent trials." The mean attention bias scores were initially analyzed by way of repeated-measures ANOVAs with group (ALC, SDA), stimulus duration (50, 500, and 1,250 ms), and 6 presentation duration orders (50 ms first, followed by 500 and then 1,250 ms; 50 ms first, followed by 1,250 and then 500 ms; 500 ms first, followed by 50 and then 1,250 ms; 500 ms first, followed by 1,250

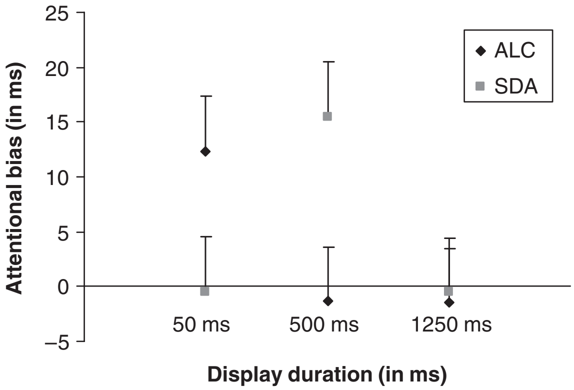

Fig. 1. Attention bias score for alcohol-related pictures presented for 50, 500, and 1,250 ms (mean ± SE of the mean) shown separately for abstinent alcoholics and social drinkers of alcohol.

and then 50 ms; 1,250 ms first, followed by 500 and then 50 ms; 1,250 ms first, followed by 50 and then 500 ms). Analyses revealed that no main effect of presentation duration order [$F(2, 62) = 1.38$, $p > 0.05$], no main effect of group [$F(1, 62) = 1.12$, $p > 0.05$], and no interaction involving presentation order was significant. Thus, the subsequent analyses were performed regardless of the order of presentation. A 2×3 ANOVA of the RTs bias scores with group (ALC, SDA) as the between-subject variable and stimulus duration (50, 500, and 1,250 ms) as the within-subject variable with depression and anxiety scores as covariates was performed. We found that the main effect of group was significant [$F(2, 118) = 4.76$, $p = 0.01$] but not the main effect of stimulus duration [$F(1, 59) = 0.13$, $p = 0.77$]. The interaction group×condition reached the significance [$F(2, 118) = 4.3$, $p = 0.02$]. As can be seen in Fig. 1, ALC had significantly greater bias scores than SDA when pictures pairs were presented for 50 ms [$t(1,62) = 2.3$, $p < 0.05$] and SDA showed a greater bias for alcohol-related pictures at 500 ms, compared with ALC [$t(1,62) = 2.1$, $p < 0.05$]. At 1,250 ms, ALC and SDA performed similarly [$t(1,62) = 0.13$, $p = 0.90$].

To evaluate the presence of initial orienting and attentional maintenance biases in the 2 groups, we used planned 1-sample *t*-tests compared with 0 for the bias score in each condition. We found that a positive bias toward the alcohol-related pictures presented for 50 ms was significant in the ALC [$t(35) = -3.4$, $p < 0.01$] and that a positive bias toward the alcohol-related pictures presented for 500 ms was significant in SDA [$t(27) = -2.6$, $p < 0.01$].

Relationship between Clinical Variables and Cognitive Measures (See Table 2)

We considered the correlation in ALC between the number of prior alcohol detoxes, the duration of alcoholism, the cumulated diazepam doses during detoxification, the depression and anxiety scores, the intensity of craving at the time of the experiment, and the attentional bias (RTs on incongruent trials minus RTs on congruent trials) at the 3 stimulus durations (50, 500, and 1,250 ms). After correction with the Bonferroni method, we found by using parametric Pearson's analyses only a positive correlation between the total number of prior treatments and the attentional bias score at 50 ms [$r = 0.66$, $p < 0.01$] (see Fig. 2). None of the other correlations were found to be significant.

DISCUSSION

The object of the present study was to investigate in abstinent alcohol-dependent participants (ALC) 2 distinct attentional biases (i.e. initial orienting and maintenance) for alcohol-related pictures. We found that relative to SDA, ALC had an enhanced attentional bias for alcohol-related pictures presented at the shortest stimulus duration (i.e., 50 ms), thus indicating the presence of initial orienting attentional bias. When pictures were presented for 500 ms, ALC were not quicker in detecting a probe

Table 2. Correlation Analyses Between Clinical Variables and Attentional Biases at 50, 500, and 1,250 ms in SDA ($n = 36$)

	Number of prior detoxes	Duration of alcoholism (in years)	Cumulated doses of diazepam	Beck Depression Inventory (BDI)	State Trait Anxiety Inventory (STAI) state	STAI trait	Craving (0–4)	Attentional bias		
								50 ms	500 ms	1,250 ms
Number of prior detoxes										
Duration of alcoholism (in years)	0.37									
Cumulated doses of diazepam	0.22	0.19								
BDI	0.25	0.18	0.15							
State Trait Anxiety Inventory (STAI)-state	0.30	−0.14	−0.14	0.54*						
STAI-trait	0.03	0.11	−0.12	0.52*	0.45					
Craving intensity (0–4)	−0.13	0.40	−0.15	0.18	−0.14	0.11				
Attentional bias at (ms)										
50	0.66**	0.08	0.13	−0.23	−0.07	−0.28	−0.14			
500	0.03	0.03	0.17	0.12	−0.05	0.09	−0.10	0.25		
1,250	0.07	−0.05	0.20	−0.02	0.11	0.31	−0.08	−0.08	−0.21	

*$p < 0.05$,
**$p < 0.01$ after Bonferroni correction.

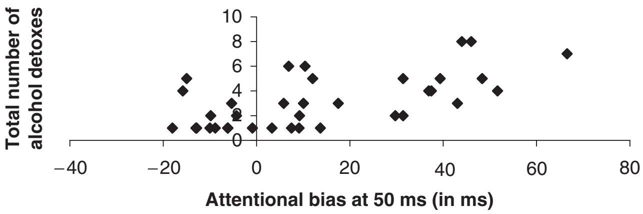

Fig. 2. Relationship between attentional bias for alcohol cues presented for 50 ms and the number of alcohol detoxification treatments in abstinent alcoholics ($n = 36$).

replacing alcohol-related pictures, thus attesting the absence of attentional bias. In contrast, SDA exhibited the inverse attentional pattern, that is, no attentional preference for alcohol-related pictures presented for 50 ms and an enhanced attentional bias for alcohol-related pictures displayed for 500 ms. At 1,250 ms, neither ALC nor SDA showed preference for alcohol.

The presence of initial orienting attention toward alcohol cues found in ALC is compatible with another study that used verbal stimuli in a similar but not identical procedure (Stormark et al., 1997). This result contrasts with that observed in nondependent heavy social drinkers where no initial orienting bias was found (Field et al., 2004). A reason for the presence of initial orienting bias toward alcohol cues only in ALC could be that the attention-grabbing properties of alcohol-related stimuli (or "attentional bias") trigger a cascade of cognitive mechanisms that result in the consumption of the first drink after a period of abstinence. In turn, the consumption of that first or few drinks can then unleash a series of homeostatic and pharmacological mechanisms that escalate to their becoming alcohol dependent.

Another related finding of the present study was a positive correlation between the intensity of initial orienting bias for alcohol cues and the severity of alcoholism (i.e. total number of prior alcohol detoxes), suggesting that a greater initial orienting bias is associated with a more severe degree of alcoholism. This finding supports the idea that, at a certain point of the development of problematic use of alcohol, motivation to take a drink is tightly linked to early attentional allocation for alcohol cues. Interestingly, Malcolm and colleagues (2000) showed that recurrent detoxifications may also intensify obsessive thoughts about alcohol, drinking urges, and behaviors, thus suggesting a possible linkage between attentional bias for alcohol cues, some aspects of craving, and alcohol use. The observed relationship between attentional bias, and dependence severity, would be predicted by the Robinson and Berridge's "Incentive Motivational Theory" (Robinson and Berridge, 1993, 2003).

The correlation between the intensity of the craving reported just prior to the experiment and the initial orienting bias for alcohol cues was not significant, indicating that these aspects might be weakly associated. However, it is possible that the use of a scale with too restricted a range (4-point scale) accounted for the failure to find a relationship between subjective craving and attentional bias.

In the 500 ms condition, SDA exhibited an attentional bias for alcohol cues. These results are compatible with the study by Field et al. (2004), showing, by using a dot probe detection task, that individuals who reported to drink more than 20 units of alcohol per week (heavy drinkers) responded faster to probes that appeared in the location of alcohol-related pictures than individuals drinking less than 10 U of alcohol per week (light drinkers). In the present study, the social drinkers reported drinking an average of 182 g of alcohol per week, which is closer to the definition of a heavy than a light drinker in the study by Field et al. One explanation could be that social drinkers have a more positive evaluative bias for alcohol-related pictures than ALC and light alcohol drinkers (Field et al., 2004). Further investigations using tasks that measure subjective ratings of pleasantness could be used to test this hypothesis.

More intriguing is the absence of attentional bias for alcohol clues, in SDA, at 1,250 ms, whereas previously, both 500 and 1,250 ms durations were considered as assessing the maintenance of attention (e.g. Field et al., 2004). This result could reflect a weakness in the visual dot probe task for assessing the different components of attentional biases. An alternative explanation could be that, at 500 ms, SDA were displaying a positive attitude toward alcohol (i.e., that they enjoyed social drinking, and had no reason to hide this). But the maintenance of attention at 1,250 ms is likely to be influenced by strategic cognitive processes, which, in turn, may be influenced by motivational variables (e.g., craving for alcohol) (LaBerge, 1995). One way to address this question is to monitor alcoholics subjects' eye movements and craving while they complete the visual probe task with alcohol-related and matched control pictures, thus providing directly observable and ecologically valid measures of attentional biases. For instance, research indicated that tobacco smokers tended to maintain their gaze longer when looking at smoking-related pictures, as opposed to control pictures, whereas nonsmokers did not demonstrate this attentional bias (Mogg et al., 2003). Moreover, in smokers, biases in the maintenance of attention to drug-related cues were associated with subjective drug craving and with behavioral approach tendencies for drug-related cues (for a review, see Field et al., 2005).

The presence of an attentional bias toward stimuli presented for 50 ms, followed by the absence of attentional bias at 500 and 1,250 ms in ALC, is in line with the vigilance-avoidance pattern of attentional biases for concern-relevant stimuli in anxious individuals. For instance, Mogg and Bradley (2006) found that, in comparison with normal participants, individuals with strong phobia for spiders showed a greater attentional bias for briefly (200 ms) presented spider pictures. Furthermore, this bias in the phobic group was significantly reduced as the duration of exposure to the spider pictures increased, so that the attentional bias was no longer evident when pictures were presented for 2,000 ms. The absence of attention bias for maintaining attention on alcohol-related cues in ALC could be explained, as before, by their effort to remain abstinent at the time of the experiment.

The presence of a distinct attentional pattern toward alcohol cues in patients with 3 to 4 weeks of abstinence at least 7 days after stopping all detoxification medication, that is to say at the moment when they are usually discharged from our hospital, raised the important question of the contribution of these attention biases to alcohol relapse. One study indicates that attention biases for alcohol-related stimuli are reliable predictors of relapse (Cox et al., 2002). One way to explain the relationship between attention biases and relapse could be that ALC's attention biases might, at some point, result in alcohol-related representations breaking into awareness (i.e., being brought into working memory), so that they become expressed as intrusive thoughts. Given the potential influence of intrusive thoughts and craving on alcohol use and relapse (May et al., 2004), initial orienting for alcohol cues could play significant roles both in the development of alcoholism and in relapse after a period of abstinence. One puzzling question, however, is that why abstinent ALC were able to disengage from alcohol cues in the 500 ms condition, whereas at some point they lose this ability in everyday life, thus allowing intrusive thoughts to enter the conscious awareness. In addition, many factors such as "stress," "anxiety," "depression," or "executive control" could serve as strong modulators of the intensity of attention biases toward alcohol cues.

Another important question concerns the influence of abstinence from alcohol on the initial orienting of attention toward alcohol cues. In other terms, does early attentional bias reflect the attempt to quit drinking rather than alcohol dependence? Further studies comparing abstinent and non-ALC with other abstinent and nonabstinent individuals will be helpful to elucidate this question.

Finally, the initial orienting bias for alcohol cues found in ALC was around 12 to 15 ms. The degree of this attentional bias is closely similar to that reported by other studies (e.g., Field et al., 2004). However, it is hypothesized that this bias might be stronger if cues were tailored according to individual differences (e.g., beer, wine, liquor).

In essence, by using a visual probe task in ALC and SDA, we found distinct attention bias patterns that are dependent on stimulus duration. This suggests that these biases do not operate equally throughout the entire process of attention. ALC exhibited early attentional bias induced by alcohol-related stimuli in a time window that preceded the disappearance of this attentional bias. These findings suggest that attention bias toward drug stimuli involves separate processes that can be altered selectively by different aspects of addiction. To generalize these findings, further investigations using alternative means to assess attentional biases would be required.

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