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Cognitive bias and drug craving in recreational cannabis users

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Abstract

Recent theories propose that repeated drug use is associated with attentional and evaluative biases for drug-related stimuli, and that these cognitive biases are related to individual differences in subjective craving. This study investigated cognitive biases for cannabis-related cues in recreational cannabis users. Seventeen regular cannabis users and 16 non-users completed a visual probe task which assessed attentional biases for cannabis-related words, and an implicit association test (IAT) which assessed implicit positive or negative associations for cannabis-related words. Results from the IAT indicated more negative associations for cannabis-related words in non-users compared to users. Among cannabis users, those with high levels of cannabis craving had a significant attentional bias for cannabis-related words on the visual probe task, but those with low levels of craving did not. Results highlight the role of craving in attentional biases for cannabis-related stimuli.

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Keywords: Cannabis; Craving; Drug cues; Attentional bias; IAT

1. Introduction

The motivational value of drug-related cues may contribute to drug seeking in humans (Stewart et al., 1984). For example, according to the incentive-sensitization theory (Robinson and Berridge, 2003), stimuli associated with drugs such as nicotine, alcohol and opiates acquire 'incentive salience'. Consequently, drug-related stimuli are perceived as highly attractive, and they 'grab attention'. These processes, which exert a controlling influence over drug-taking behaviour, are posited to operate automatically, outside awareness, and high levels of incentive salience are associated with the subjective experience of craving. Thus, this and other theories (e.g. Di Chiara, 2000) propose that regular drug use will be associated with evaluative and attentional biases for drug-related cues. An evaluative bias refers to a tendency to evaluate drug-related cues positively, and an attentional bias refers to a tendency for those cues to be selectively attended to at the expense of other stimuli. Therefore, cognitive biases for drug-related cues may index the processes that underlie the shift from experimental use of a drug to drug dependence.

An emerging body of evidence suggests that drug dependent individuals do exhibit both attentional biases (e.g. Stetter et al., 1995; Lubman et al., 2000; Ehrman et al., 2002) and evaluative biases (e.g. Mucha et al., 1999, 2000; Mogg et al., 2003) for drug-related cues, relative to non-dependent controls. Moreover, within addicts, variations in subjective craving are associated with attentional biases for drug-related cues (Sayette et al., 1994; Franken et al., 2000; Hogarth et al., 2003; Mogg et al., 2003). For example, studies have used the modified Stroop task to demonstrate that nicotine-deprived smokers are typically slower to name the colours of smoking-related words than control words, which is consistent with an attentional bias for smoking-related words (e.g. Gross et al., 1993). Other studies have used the visual probe task, which involves the simultaneous presentation of pairs of stimuli (either words or pictures). Immediately after the stimuli disappear, a small probe appears in the location of one of them, and participants are instructed to respond as quickly as possible to the probe. The rationale behind the task is that people respond faster to stimuli that appear in an attended, rather than unattended, region of a visual display (e.g. Posner et al., 1980). Therefore, reaction time (RT) to the probes provides an index of attentional deployment. Studies using this task have

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demonstrated an attentional bias for drug-related pictures in opiate addicts (Lubman et al., 2000) and for smoking-related pictures in nicotine dependent smokers (e.g. Ehrman et al., 2002; Bradley et al., 2003). Franken et al. (2000) used a modified visual probe task and demonstrated that variation in cocaine craving was associated with attentional bias for cocaine-related words.

Excessive cannabis use is of growing concern in Western societies. For example, the number of people seeking treatment for cannabis dependence almost doubled from 1992 to 2002 in the USA (Budney and Moore, 2002) and, of 600 adolescents admitted to treatment programs for cannabis problems, more than 96% met DSM-IV criteria for substance dependence (Tims et al., 2002). However, the concept of cannabis dependence is controversial for numerous reasons, for example, the lack of a clearly defined withdrawal syndrome (Smith, 2002). To date, research has not thoroughly investigated the 'incentive salience' of cannabis-related cues in cannabis users, or the relationship between 'incentive salience' and subjective cannabis craving. It would be theoretically interesting to investigate whether the cognitive biases that have been observed in other drug users would also be present in cannabis users.

Thus, the primary aim of the present study was to examine if regular cannabis users would exhibit attentional biases for cannabis-related stimuli and would find those stimuli 'attractive', relative to non-users. We used cannabis-related and matched control words in a visual probe task in order to investigate attentional biases.

We used the implicit association test (IAT) (Greenwald et al., 1998) to measure the perceived 'attractiveness' of cannabis-related words. The IAT has been used to investigate the perceived valence of drug-related words in samples of smokers and heavy social drinkers (Swanson et al., 2001; Wiers et al., 2002; Palfai and Ostafin, 2003). The task is based on the principle that people will find it easier to categorise stimuli together if those stimuli are strongly associated (e.g. drug-related and positive words) rather than if the stimuli are not associated (e.g. drug-related and negative words). In the version of the IAT employed in the present study, participants were required to categorise stimuli that belonged to one of four categories: two target concept categories ('cannabis-related' and 'environment-related'), and two contrasted attribute categories ('pleasant' and 'unpleasant'). Participants were required to perform a categorisation task that mapped the four categories of stimuli onto two response keys. In one combined task ('cannabis + pleasant'), participants were required to press one key in response to cannabis-related words, and pleasant words, but they were required to press a different response key in response to environment-related words, and unpleasant words. In the other combined task ('cannabis + unpleasant'), the same response key was allocated to cannabis and unpleasant words and a different response key was allocated to environment and pleasant words. The IAT effect is the difference in RTs between these two combined tasks. Thus, if people have implicit cognitions concerning cannabis-related words that are positive, they should be faster on the 'cannabis + pleasant' task, but if their implicit cognitions towards cannabis are negative, they should be faster on the 'cannabis + unpleasant' task (see Fazio, 2001, for a review of automatic activation of associated evaluations).

In summary, the primary aim of this study was to investigate attentional and evaluative biases for cannabis-related words in cannabis users and non-users. Our hypotheses were: (1) cannabis users, relative to non-users, would have implicit positive associations with cannabis-related words on the IAT; (2) cannabis users, but not non-users, would show attentional biases for cannabis-related words; and (3) given predictions that subjective craving should be associated with attentional and evaluative biases for drug-related cues (Robinson and Berridge, 2003), we hypothesised that cannabis users with high levels of craving would show stronger attentional and evaluative biases than those with low levels of craving.

2. Method

2.1. Participants

Participants were recruited from the students and staff at the University of Southampton via poster advertisements and through an online experiment booking system. The group of 17 cannabis users consisted of five males and 12 females, with a mean age of 22.4 years (S.D. = 5.4). The median number of cannabis joints smoked per month was 16 (range 1–240), and the median length of time that cannabis had been smoked regularly was 3 years (range 6 months–14 years). Ten (59%) of the cannabis users reported being daily tobacco smokers. Their mean level of cannabis craving as measured by the Marijuana Craving Questionnaire (MCQ; Heishman et al., 2001) was 3.87 (S.D. = 0.85, range 2.23–4.93) on a 1–7 point scale, with higher values indicating stronger craving. MCQ data was missing from one participant. None of the cannabis users had ever sought treatment for cannabis abuse or dependence. The control group consisted of 16 non-users (4 males and 12 females), who were not currently cannabis users and had no history of cannabis use, other than experimental use. They had a mean age of 20.9 years (S.D. = 7.3). Five (31%) of the control group reported being daily tobacco smokers. The cannabis user and non-user groups did not differ significantly in age, $t = 0.7$, gender ratio, $\chi^2 = 0.1$, or the number of daily tobacco smokers, $\chi^2 = 2.5$, all non-significant (ns). Additional selection criteria for all participants were that they spoke fluent English and had visual acuity within normal limits.

2.2. Materials

The cannabis word set was generated by asking ten people to provide a list of words that they perceived to be highly

31 11 12 33 26 29 28 14 15 27 30

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related to cannabis and its use. The entire list of words was then administered to a different group of ten people (both cannabis-users and non-users, none of whom subsequently took part in the study) who gave each word a score for 'cannabis-relatedness' on a 0–10 rating scale. The 16 words that achieved the highest scores for 'cannabis-relatedness' were then selected. Each of these words was then matched for length and frequency (using the norms of Carroll et al., 1971) with a word that described a feature of the natural environment (e.g. marijuana-shrubbery). The use of environment-related words as the control word set is consistent with Sharma et al. (2001) who used this category of control words in a study investigating attentional bias for alcohol-related words. The 16 cannabis-related words were: cannabis, dealer, dope, ganja, grass, hash, joint, marijuana, high, pot, resin, rizla, roach, spliff, stoned, weed; and the 16 environment-related words were: seawater, ravine, cove, inlet, winds, sand, cliff, shrubbery, bush, fog, holly, daisy, swamp, trench, cactus, hill. An additional eight word pairs (household items) were used as practice and filler stimuli in the visual probe task. The visual probe task and the implicit association test were presented in Inquisit version 1.33 software on a 333 MHz Pentium II PC, with 15 in. VGA monitor, attached to a two button response box.

2.3. Procedure

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Participants ~~initially~~ signed an informed consent form, and then completed the visual probe task and the implicit association test, together with a further colour naming task. The ~~order of tasks~~ was counterbalanced between participants. However, the latter task and its results are not reported ~~due to~~ an experimenter error with its administration, which prevented reliable analysis of the data.

Each trial in the visual probe task started with a central fixation cross shown for 500 ms, which was replaced by the display of a pair of words, one at the top and one at the bottom of the screen, for 500 ms. Immediately after the offset of the words, a small dot probe was presented in the position of one of the words, until the participant gave a manual response. Participants were instructed to press one of two response buttons to indicate the location of the probe. They were also instructed to look at the fixation cross at the start of each trial. There was an inter-trial interval of 1 s.

There were 12 practice trials, in which filler stimuli were presented, followed by two buffer trials and 96 trials in the main task (64 critical trials and 32 filler trials). During the critical trials, each of the 16 cannabis–environment word pairs was presented four times. Each cannabis-related word appeared twice at the top of the screen, and twice at the bottom. The probe appeared in the location of either the cannabis-related or the environment word with equal frequency. During filler trials, the eight filler word pairs were presented four times each. Critical and filler trials were presented in a new random order for each participant. Words were presented in uppercase, and the approximate height of each word was 8 mm. The distance between the middle of each word was 120 mm.

Each trial of the IAT started with a single word, which was presented in the centre of the screen until participants made a manual response. Each stimulus was presented in uppercase, and the approximate height of each word was 12 mm. Participants were instructed to respond to the stimuli as quickly as possible by pressing the left or right hand keys on the response box with their index fingers. Labels were displayed at the top left and top right hand sides of the screen to remind participants of the categories assigned to each key for the current trial block. Immediately after a response was made, the stimulus disappeared from the screen. If an incorrect response was made, a red 'X' appeared in the centre of the screen for 200 ms. There was an inter-trial interval of 1 s.

There were four categories of words to which participants had to respond: cannabis-related words (spliff, marijuana, ganja, hash); environment-related words (seawater, sand, ravine, hill); pleasant words (joy, peace, success, talent) and unpleasant words (slime, brutal, war, failure). The cannabis-related and environment-related words were a subset of the word set described earlier. Pleasant and unpleasant words were a subset of those used in the IAT described by Swanson et al. (2001). 17

In each block of the task, participants responded to the words that were presented by pressing the left or right key on a response box as quickly as possible.

Block 1 was a practice block for the pleasant and unpleasant attribute categories, containing 16 trials in which each pleasant and unpleasant word was presented four times each. Participants were required to press one of the keys (e.g. left) in response to pleasant words, and the other key (e.g. right) in response to unpleasant words. Block 2 was a practice block for the cannabis and environment target concept categories in which each cannabis and environment word was presented four times each, i.e. 16 trials. Participants were required to press one key in response to cannabis words and the other key in response to environment words. Block 3 was a combined categorisation block. Each of the pleasant, unpleasant, cannabis and environment related word was presented four times each, i.e. 64 trials. In this block, one key was allocated to two different types of word: one target category word and one attribute word. For example, in one version of the task, cannabis and pleasant words required a key press on the left key, whereas environment and unpleasant words required a key press on the right key. In the fourth and fifth blocks, the stimulus–response mapping for the pleasant and unpleasant attribute categories was reversed (i.e., if pleasant words had required a left key response in blocks 1 and 3, this was reversed for blocks 4 and 5 so that a right key response was now required). Block 4 was a practice block consisting of 16 trials in which each pleasant and unpleasant word was presented four times each. Block 5 was the final combined categorisation block of 64 trials in which each of the pleasant, unpleasant, cannabis- and environment-related words were presented four times each.

Participants were allocated one of four different versions of the IAT, and the version administered was counterbalanced across participants. The four versions differed in the stimulus–response mapping for cannabis-related words (either the left or right key; this mapping remained the same throughout the task), and in the initial stimulus–response mapping for pleasant words (either the left or right key; this mapping was always reversed in blocks 4 and 5, as described above). This method of stimulus–response mapping was similar to that used by De Jong et al. (2001).

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After completion of the tasks, participants completed a short questionnaire asking about current and past use of cannabis, ~~and cigarette smoking. All~~ cannabis users also ~~completed the Marijuana Craving~~ Questionnaire (Heishman et al., 2001) and they were asked to indicate 'how strong your urge to smoke marijuana is right now' on an anchored rating scale which ranged from 0 (not at all) to 10 (extremely). Participants were then thanked for their time and debriefed.

2.4. Statistical approach

For the visual probe task, the dependent variable was reaction time (RT), and the between-subjects independent variable was group (cannabis user, non-user). There was one within-subjects independent variable (probe condition) which had two levels: 'congruent' (when the probe replaced a cannabis-related word) and 'incongruent' (when the probe replaced an environment-related word).

For the implicit association test, the dependent variable was reaction time and the between-subjects independent variable was group. The within-subjects independent variable was trial block, which had two levels: 'cannabis + pleasant' (when cannabis-related and pleasant words shared the same response key) and 'cannabis + unpleasant' (when cannabis-related and unpleasant words shared the same response key).

For both tasks, the primary analysis was mixed design analysis of variance (ANOVA) which was used to analyse the reaction time data using the independent variables described above. Our additional hypothesis regarding the effect of craving on cognitive biases was tested with further ANOVAs by dividing the cannabis user group into high and low craving groups. Pearson correlations were also used to explore relationships (within the cannabis user group) between task performance and measures of history and frequency of cannabis use, and scores on the marijuana craving questionnaire.

3. Results

3.1. Visual probe task

RT data from filler trials and from trials with errors were discarded. Two participants (one from each group) had outlying high error rates (22 and 48%), as evident from a box and whisker plot, so their data were removed from the analysis. For the remaining participants, the mean percentage of errors was 1%. To eliminate outliers, RTs were excluded if they were less than 200 ms, greater than 2000 ms, and then if they were more than 2 S.D. above the mean (4% of data). A 2×2 ANOVA of the probe RT data with group and probe condition as independent variables showed no significant results. Specifically, we had predicted that cannabis users would be faster to respond to probes replacing cannabis words rather than control words, compared with non-users, but this group $\times$ probe position interaction was not significant ($F(1, 29) = 1.53$, ns).

An additional hypothesis was that an attentional bias for cannabis-related words would be particularly evident in cannabis users with a high level of craving. To test this hypothesis, cannabis users were split into two groups based on a median split of scores on the MCQ (high and low craving groups did not differ significantly in gender ratio). The ANOVA of reaction times to probes was repeated with group (high craving cannabis users; low craving cannabis users; and non-users) as the between-subject variable, and probe position (probe in same versus different location to cannabis-related word) as the within-subject variable. The main effect of craving group was not significant ($F(2, 28) = 0.38$, ns), and the main effect of probe position approached significance ($F(1, 28) = 3.88$, $P = 0.059$). More importantly, there was a significant probe condition $\times$ craving group interaction ($F(2, 28) = 5.33$, $P < 0.05$), reflecting faster RTs to probes replacing cannabis words than control words in the high craving cannabis users ($t(8) = 2.64$, $P < 0.05$), but no difference in low craving cannabis users ($t(6) < 1$, ns), or non-users ($t(14) < 1$, ns), as can be seen in Fig. 1. These results are consistent with an attentional bias for cannabis-related words only in cannabis users with a high level of craving.

To allow correlational analyses, an attentional bias score was calculated for each participant by subtracting mean RTs to probes that replaced cannabis-related words from mean RTs to probes that replaced control words, such that positive scores indicate vigilance for cannabis-related words. Pearson correlations (performed on all cannabis users) showed that the attentional bias scores were positively correlated with MCQ scores, $r = 0.56$, $P < 0.05$, and with the number of joints smoked per month, $r = 0.65$, $P < 0.01$, but not with the number of years of regular cannabis use, $r = -0.36$, ns (MCQ and the number of joints smoked per month were not significantly correlated with each other, $r = 0.28$, ns). Partial correlations indicated that the relationship between the attentional bias and MCQ scores remained significant after controlling for the number of joints smoked per month ($r = 0.52$, $P < 0.05$), and that the relationship between the attentional bias and the number of joints smoked per month remained significant after controlling for MCQ ($r = 0.63$, $P < 0.05$), which suggests that these variables (craving and frequency of drug use) were independently associated with attentional bias.

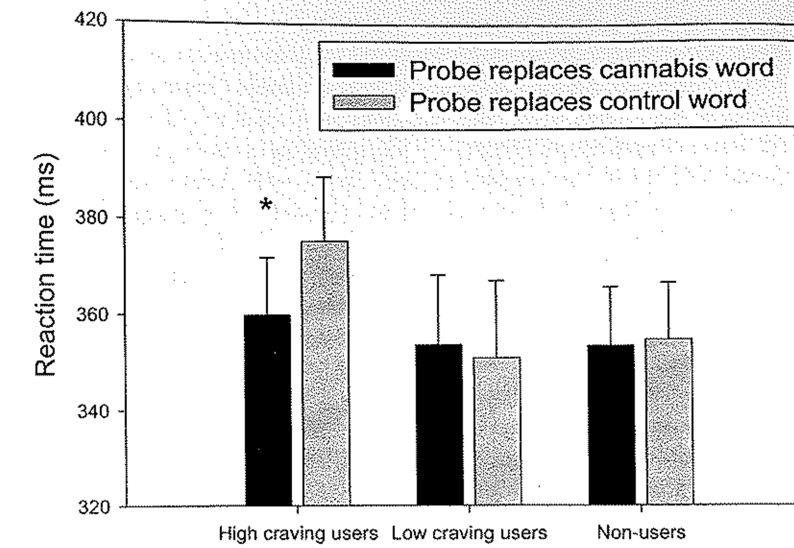

Fig. 1. Mean latencies (in ms with standard error bars) to respond to probes replacing cannabis-related and matched control words during the visual probe task, shown separately for cannabis-users with high- and low-levels of cannabis craving, and non-users. $*P < 0.05$ for probes replacing cannabis-related vs. control words in high craving cannabis users.

3.2. Implicit association test

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Only data from blocks 3 and 5 (combined categorisation blocks) of the IAT were analysed. RT data from trials with errors were discarded (4% of data). To eliminate outliers, RTs were excluded if they were less than 200 ms, greater than 2000 ms, and then if they were more than 2 S.D. above the mean (<1% of data). IAT effects were calculated for each participant by taking the mean latencies to categorise all words in the 'cannabis + pleasant' block (combined categorisation block in which cannabis words and pleasant words utilised the same key) and in the 'cannabis + unpleasant' block (combined categorisation block in which cannabis words and unpleasant words utilised the same key). Our main prediction was for a group difference between cannabis users and non-users on the 'cannabis + pleasant' block versus the 'cannabis + unpleasant' block, i.e. a group × block type interaction effect on RTs. To test this hypothesis, a 2 × 2 mixed design ANOVA was carried out with group (cannabis users versus non-users) as a between-subjects variable, and block type (1. 'cannabis + pleasant' versus 2. 'cannabis + unpleasant') as a within-subject variable. This showed the predicted group × block type interaction, $F(1, 31) = 5.29$, $P < 0.05$. RTs in each condition are shown in Fig. 2. There were no other significant results.

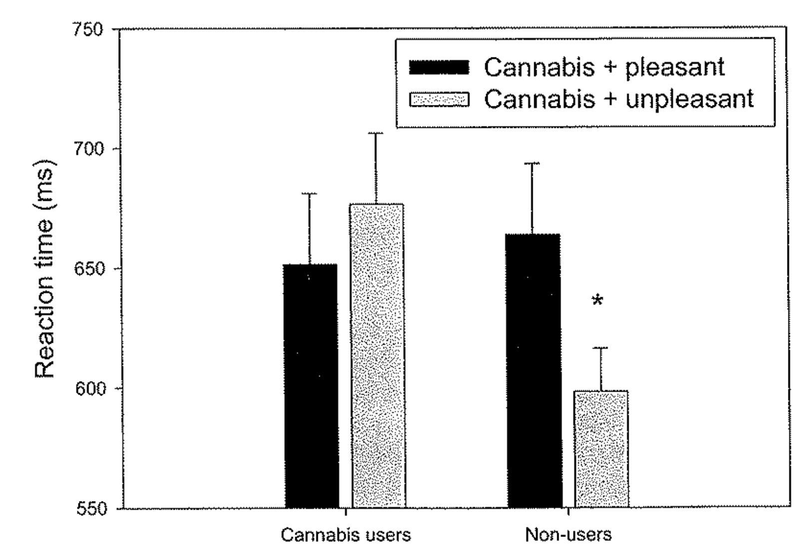

Fig. 2. Mean latencies (in ms with standard error bars) to respond during cannabis + pleasant and cannabis + unpleasant blocks of the IAT, shown separately for cannabis users and non-users. $*P < 0.05$ for cannabis + pleasant vs. cannabis + unpleasant blocks in non-users.