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Investigating attentional bias and the effects of subjective craving in male regular cannabis-users, utilising a dot-probe task

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ABSTRACT

Cannabis is a widely used illegal substance with various potential health risks, such as memory impairments and psychosis. Furthermore, previous research has implicated that repeated drug-use is associated with attentional biases for drug-related stimuli. These attentional biases are related to, and influenced by, individual differences in subjective craving.

This study investigated 40 male cannabis-users and 40 male non-users, aged 18-24. Participants completed a dot-probe task to assess attentional biases for cannabis-related words. Cannabis-users also completed Heishman *et al.*'s (2009) Short-Form Marijuana Craving Questionnaire, to assess craving levels and analyse any interactions with dot-probe reaction times.

Study 1 aimed to determine whether cannabis-users elicited attentional biases for cannabis-related words. Study 2 examined whether craving had any effect on attentional bias.

Results indicated that cannabis-users, compared to non-users and regardless of craving level, showed significant attentional bias for cannabis-related words. Although craving level did not significantly influence attentional bias, this may have resulted from using a small, uneven sample. Findings support previous theories of addiction, where salient stimuli grab users' attention without equal distribution.

Attentional bias and subjective craving are huge factors in repeated drug-use. Consequently, cessation techniques could be adapted to help avoid prevalent environmental cues and aid cognitive avoidance strategies.

| KEY WORDS: | Attentional Bias | Cannabis | Craving | Dot-probe task | Marijuana Craving Questionnaire |

Introduction

Cannabis and Addiction

West (2006) outlined the key characteristics of addiction, or dependence, as a strong desire to perform a specific behaviour with an impaired ability to control partaking. Furthermore, the behaviour is repeated, despite causing physical or psychological harm. Therefore, addiction has both physical and psychological components.

Cannabis is one of the most frequently used illegal drugs, most prevalent amongst males aged 16-24 years old. In 2008, 17.9% of 16-24 year olds in England and Wales were cannabis-users (United Nations Office on Drugs and Crime, 2009). Furthermore, even higher rates of cannabis-use have been found in university students in the UK, USA and Australia (Gledhill-Hoyt *et al.*, 2000). Many health risks have been associated with cannabis-use. Longitudinal studies have linked adolescence and early 20's use with substantial effects on later depression, substance-use disorders, lower degree attainment, lower income, higher unemployment, and lower levels of relationship satisfaction (Brook *et al.*, 2002; Fergusson & Boden, 2008). Prolonged use has also been linked with cognitive decline and memory impairment (Hall *et al.*, 2003). Moore *et al.* (2007) conducted a systematic review of 35 studies and found an increased risk of psychotic outcomes from regular cannabis-use of around 40%, although the association may not be causal and may be partially attributed to confounding factors or bias. Furthermore, Hall and Degenhardt (2000) found limited clinical evidence to implicate any psychotic disorder that would not have occurred without cannabis-use. Consequently, the cannabis health risks debate is unresolved, despite cannabis-use still being an illegal activity. Furthermore, cannabis is most commonly smoked, leading to inherent smoking-related risks, such as chronic bronchitis symptoms and poorer lung function (Hall & Solowij, 1998). Lastly, cannabis has been described as a 'gateway' drug, which increases the chances of using harder drugs. However, despite findings suggesting a general causal model, the extent and mechanisms remain unclear (Fergusson *et al.*, 2006). The effects of cannabis-use on cognitive processing need further investigation to determine its role in repeated use.

Attentional Bias and Subjective Craving within Addiction

Substance-users can be unaware of the automatic factors that influence their repeated drug use (Wiers *et al.*, 2007). Waters and Feyerabend (2000) suggest that users become aware of addiction-related stimuli in their environment more easily than other people through attentional bias, and these stimuli could elicit conditioned responses, which might increase craving levels (Baker, Brandon, & Chassin, 2004; Tiffany, 1990). Attentional bias describes 'a discrete change in the direction in which a person's attention is focussed so that he/she becomes aware of a particular part or aspect of their stimulus environment' (Williams *et al.*, 1997, p.73). Thus, attention is not evenly distributed, where attention gained by one stimulus decreases attention to the other (Mathews & MacLeod, 2002). Typically, craving is a state of extreme desire (Kozlowski & Wilkinson, 1987), although with regards to repeated drug-use, craving

refers to 'any desire or urge, even a weak one, to use substances' (Kozlowski *et al.*, 1989, p.443), and is considered a continuous measure (Franken, 2003).

Many theories have provided explanations for the development of attentional biases and subjective craving from substance addiction. Field and Cox (2008) suggest classically conditioning availability expectancy or Pavlovian responses to repeated pairings of rewarding substance effects combined with substance-related environmental cues. For example, the rewarding effects of cannabis, such as relaxation, paired with the sight or smell of a cannabis-spliff. The Motivational model, emphasising goal pursuit (Hoelscher *et al.*, 1981; Klinger 1978, 1996), suggests the goal of using allows easier distraction by, and increased priority towards, substance–related stimuli, thus grabbing attention (Cox & Klinger, 1988, 2004). Therefore, users selectively and automatically respond to related stimuli (Cox, Fadardi & Pothos, 2006; Cox, Klinger & Fadardi, 2006). However, the most convincing addiction explanations are integrated theories, combining conditioning with cognitive and neurobiological psychological perspectives. The Incentive-sensitisation model (Robinson & Berridge, 1993, 2001, 2008) postulates that lasting neuro-adaptations can occur, where each repeated use produces an increasingly larger 'sensitized' dopaminergic response for the substance and related stimuli, causing prevalent attentional bias towards reward-related stimuli (Schultz, 1998; Wickelgren, 1997) and subjective craving. Robinson and Berridge (1993, p.261) suggest the repetition also causes increased substance saliency, where the substance 'becomes attractive and wanted', along with increased motivational properties, as the goal of using is a high priority. Consequently, attentional biases are strongly associated with highly motivated drug-seeking behaviour (Field & Cox, 2008), future relapse and continued addiction. Despite the various possible roots of attentional bias, most theories suggest regular users will elicit attentional bias towards substance-related stimuli.

Equally, subjective craving has been implicated as a major factor in repeated use and relapse (Everitt, 1997). Franken (2003) further extended the incentive-sensitisation theory, postulating that subjective craving plays a vital role in addiction. Franken (2003) suggested a positive feedback loop in which subjective craving increases when drug-related stimuli are the biased focus of attention, which in turn increases the salient stimuli status in a 'mutually excitatory relationship' (Field & Cox, 2008, p.3), supported by Kavanagh *et al.* (2005) and Ryan (2002). Despite the clear link between attentional bias and subjective craving in maintaining drug addiction, there is deliberation as to the relationship directionality (McCusker, 2001; Sayette *et al.*, 2000). Field and Eastwood (2005) trained participants to attend to alcohol-related stimuli and observed increased attentional bias and increased craving levels, supported by Field, Duka *et al.* (2007), utilising a control group. However, no craving reduction was found when trained to avoid related stimuli. Further significant positive correlations have been found in tobacco smokers (Mogg & Bradley, 2002; Mogg *et al.*, 2003, 2005), alcoholics (Field, Christiansen et al., 2007; Field *et al.*, 2004b, 2005), cocaine-users (Copersino *et al.*, 2004; Franken *et al.*, 2000), heavy caffeine users (Yeomans *et al.*, 2005) and cannabis-users (Field *et al*, 2004a; Field, 2005). Furthermore, manipulated increases in craving levels have increased attentional bias for related-stimuli in tobacco smokers (Field *et al.*, 2004c; Waters & Feyerabend, 2000) and alcoholics (Duka & Townshend, 2004; Schoenmakers *et al.*, 2008).

Other Factors that can affect Attentional Bias and Subjective Craving

Other factors can affect the amount of attentional bias and subjective craving found, such as impulsivity or impaired inhibitory control (Field & Christiansen et al., 2007), substance availability (Hogarth & Duka, 2006), or cognitive avoidance strategies (Fadardi & Cox, 2006). Abstinent users may not elicit attentional bias or subjective craving due to consciously suppressing craving levels and diverting attention away from substance-related cues (Field & Cox, 2008). Furthermore, the level and frequency of substance use is directly proportional to the amount of attentional bias and subjective craving shown. Field (2005) and Field *et al.* (2004a) found positive correlations between attentional bias for cannabis-related words and the quantity and frequency of use in recreational users, but not heavy users (Field *et al.,* 2006), possibly due to a threshold level of use (Field & Cox, 2008). Similar results were found with alcoholics using a Dot-probe task (Townshend & Duka, 2001; Field *et al.,* 2004b) and Flicker paradigm (Jones *et al.,* 2002). Results support the Motivational (Cox & Klinger, 1988, 2004) and Incentive-motivational (Robinson & Berridge, 1993) models of addiction. Substance-related stimuli have stronger salience in heavier-users, although lighter-users might simply respond to fewer cues (Fadardi *et al.,* 2006).

Measuring Attentional Bias and Subjective Craving

Various methodologies have successfully measured substance-related attentional biases, such as the Addiction Stroop task or Dot-probe task. However, Stroop interference has been found to vary due to practice levels (Cox *et al.,* 2006), and individual differences, such as age (Sladekova & Daniel, 1981) or visual reasoning and short-term memory (Koch *et al.,* 1999). Although, Stafford (2000) found severe methodological issues with Koch *et al.*'s (1999) study.

Dot-probe task participants are presented with stimulus pairs, one substance-related and one neutral, and respond to locations where a dot-probe replaces one stimulus. Posner *et al.* (1980) proposed participants would respond faster to dot-probes replacing a visual area already being attended to. Therefore, substance-users, compared to non-users, are expected to react faster when the dot-probe replaces substance-related stimuli (Field, 2006). Various presentation times, or Stimulus Onset Asynchrony (SOA), ranging from 17-2000 ms produce opposing results. Field *et al.* (2004b) found attention bias in alcoholics at 500 ms and 2000 ms but not 200 ms, whereas Noel *et al.* (2006) found attentional bias at 50 ms but not 500 ms in abstinent alcoholics, thus implicating different processes. Short SOA's allow one initial automatic attention shift (Duncan *et al.,* 1994), whereas long SOA's allow disengagement (Theeuwes, 2005), multiple shifts, and avoidance. According to most literature, 50-500 ms SOA's remove conscious control (Townshend & Duka, 2003, 2007).

Schmukle (2005) suggests the paradigm is unreliable, as retest reliability and internal consistency is low. However, with regards to cannabis, Field *et al.* (2006) found attentional bias amongst regular users for cannabis-related stimuli, but not for non-users. It has also successfully measured attentional bias in ketamine-users (Morgan *et al.,* 2008), restrained eaters (Papies *et al.,* 2008), alcoholics (Field *et al.,*

2004b; Townshend & Duka, 2007) and tobacco smokers (Attwood *et al.*, 2008; Bradley *et al.*, 2008; Ehrman *et al.*, 2002; Waters *et al.*, 2003). Furthermore, Mogg *et al.* (2003), using eye-movement measurements, demonstrated that smokers' maintained related-stimuli gaze longer than neutral stimuli. Therefore, despite some study limitations, such as no comparable control group (e.g., Attwood *et al.*, 2008; Papies *et al.*, 2008), dot-probe methodology has proved a reliable measure of attentional bias.

Furthermore, subjective craving levels have been successfully recorded using self-report questionnaires, such as Heishman *et al.*'s (2001) *Marijuana Craving Questionnaire*, used within Field *et al.* (2004a) and Field (2005), with high reliability and validity (Singleton *et al.*, 2002). Recently, a Short-Form MCQ was created with increased internal consistency, reliability and validity (Heishman *et al.*, 2009).

Following on from previous research

Field *et al.* (2004a) investigated the relationship between attentional bias and subjective craving levels in 17 recreational cannabis-users, compared to 16 non-users. A Dot-probe task measured attentional bias towards 16 cannabis-related words compared with 16 frequency-matched neutral words appearing for 500 ms. Craving levels were determined using Heishman *et al.*'s (2001) *MCQ*. Cannabis-users were divided into high and low-craving groups using a median split. Results indicated no significant interaction between cannabis-users and non-users on probe position. However, high-craving users had significant attentional bias for cannabis-related words, whereas low-craving users did not.

However, Field *et al.*'s (2004a) sample group was too small, using only 17 cannabis-users. The control group included tobacco smokers, which could bias results, as one cannabis-related word was 'rizla'. The neutral word set contained words from an alcohol study (Sharma *et al.*, 2001), such as 'shrubbery' and 'bush', which are too similar to cannabis-related words, such as 'weed' and 'grass'. The word frequency list (Carroll *et al.*, 1971) was out of date. Lastly, the elicitation task also used non-users to rank generated words, although only users would produce a valid cannabis-related word set.

Field *et al.* (2006) conducted a similar study with regular cannabis-users, using pictorial pairs and concurrent eye-monitoring software. Results showed cannabis-users had biases maintaining their gaze towards cannabis cues and responded faster, indicating higher levels of attentional bias than non-users. However, accurately matching picture-pairs is difficult due to their composition, resulting in visible differences.

This study follows on from Field *et al.* (2004a), with an improved methodology and increased rigorous controls. This study will investigate male regular cannabis-users aged 18-24, as research suggests they are most at risk (United Nations Office on Drugs and Crime, 2009). Field and Cox (2008, p.4) identified contributing factors of clear attentional bias demonstration, such as an appropriate control group and sufficiently matched neutral stimuli, including 'word length, number of syllables-per-word, and frequency of occurrence of each word in the language'. Cannabis-related

words for the current study have been accurately frequency-matched using the more recent Kilgarriff (1996) *British National Corpus* frequency list. Furthermore, neutral words did not belong to a singular category, as it has been a past limitation (Field *et al.*, 2004), and is unnecessary if they are neutral (Field & Cox, 2008), as confirmed by emotionality testing (John, 1988). Emotionality testing was not required for target words (Bruce & Jones, 2005). *Study 1* utilises the Dot-probe paradigm, using word pairs, as experimental measures are objective and ideal for limiting or controlling extraneous variables. *Study 2* utilises cannabis-users' dot-probe reaction times and Heishman *et al.*'s (2009) *SF-MCQ* to determine craving levels, as self-report measures are quick and easy to complete and distribute, obtaining data that is difficult or unethical to observe or recreate. Field *et al.*'s (2004a) original study used Heishman *et al.*'s (2001) 47-point *MCQ*, proving reliable and valid (Heishman *et al.*, 2001). However, this vastly more recent and shortened version has been edited to improve internal consistency, reliability and overall validity (Heishman *et al.*, 2009).

Aims and Hypotheses

Study 1 aims to identify whether male regular cannabis-users aged 18-24 show attentional bias for cannabis-related words over neutral words, compared to a non-using control group.

According to most previous literature, (1) it is hypothesised (One-Tailed) that cannabis-users, compared to non-users, will show attentional bias for cannabis-related words, responding faster when the dot-probe replaces cannabis-related words.

Study 2 aims to examine the interaction between dot-probe reaction times (replacing congruent and incongruent positions) and cannabis-craving (high or low), using *SF-MCQ* scores, to determine whether subjective craving has any bearing on any attentional bias shown for cannabis-related words.

According to most previous literature, (2) it is hypothesised (One-Tailed) that both craving groups will show increased attentional bias for cannabis-related words, compared to neutral words. (3) It is also hypothesised (One-Tailed) that high-craving users will show increased attentional bias for cannabis-related words, compared with low-craving users, as previous research has implicated greater attentional bias for substance-related stimuli in participants with greater craving levels.

Methodology

Design

An Experimental design is used for *Study 1* and *Study 2*. The dependent variable for both studies is reaction time (in milliseconds). For *Study 1*, the between-subjects independent variable is Cannabis-use (User or Non-user) and the within-subjects independent variable is Probe position, Congruent (dot-probe replaces a cannabis-related word) and Incongruent (dot-probe replaces a neutral word). For *Study 2*, the

between-subjects independent variable is Craving level (High or Low), as indicated by *SF-MCQ* scores, and the within-subjects independent variable is Probe position (Congruent and Incongruent).

To remove possible environmental distractions all participants completed tasks alone at the same time of day. Furthermore, biases resulting from participants' age, gender or tobacco smoking will not be an issue due to recruitment specifications.

Participants

Study 1 used cannabis-users (n = 40) and non-using participants (n = 40), as a control. *Study 2* used dot-probe data from the 40 cannabis-users from *Study 1*, although there is no control group*,* as the test establishes cannabis-craving levels. Cannabis-users had a mean age of 21.6 years, smoked cannabis for a median length of 5 years (range = 2-8 years), used a median amount per week of 4 grams (range = 2-8 grams), and smoked at least every other day. Non-users had a mean age of 20.8 years. Elicitation tasks required 20 further cannabis-users. Participants were recruited using opportunity sampling with a specific target sample. Posters were emailed to all students and distributed around Manchester Metropolitan University asking for male cannabis-users aged 18-24 who smoke 7+ cannabis-joints per week, equating to almost everyday use, which establishes a regular cannabis-user (Melrose *et al.*, 2007). Posters emphasised anonymity, privacy and the protection of information and data. Posters also requested a non-using male control group aged 18-24 who don't smoke tobacco (ensuring smoking-related words are only associated with cannabis), have not used cannabis in 5 years (excluding occasional users) and never used frequently (eliminating any cannabis-craving from prior use). Users attempting to abstain were not used, due to cognitive avoidance strategies (Fadardi & Cox, 2006). All participants spoke fluent English and had vision within normal range.

Apparatus

The self-report *initial elicitation task sheet* (*Appendix 1*) was handed to 10 cannabis-users within the selection criteria, gathering as many valid cannabis-related words for the specific sample as possible. Words were collated, handed to 10 different cannabis-users, and ranked for 'cannabis-relatedness' (*Appendix 2*), on a scale of 0 (Not related) to 10 (Strongly related). The 20 highest-related cannabis words were obtained for the final word pairs (*Appendix 5*) and assessed for number of syllables, length, and frequency of use, using Kigarriff's (1996) *British National Corpus* frequency list, to determine possible neutral words. An *emotionality task* (*Appendix 3*) asked the elicitation group to determine the emotionality of the possible neutral words (John, 1988), in terms of happiness, sadness, anxiety, and anger, along with their 'cannabis-relatedness' (*Appendix 4*). Results were collated to obtain unrelated matched neutral words for the final 20 word pairs (*Appendix 5*).

Standardised instructions, specific for cannabis-users (*Appendix 6*) and non-users (*Appendix 7*), contained unique identification numbers, a space for age, and signed informed consent. Instructions also contained a brief overview of all tasks, estimated completion times and ethical inclusions, such as the right to withdraw, data protection and anonymity.

The Dot-probe task was designed by an MMU computer technician, using Microsoft Visual Basic Net software. To control for variables, the task was completed on the same desk and laptop arrangement. A response box was placed centrally to avoid biases from participants' right or left-handedness. The task included onscreen instructions (*Appendix 8*), allowing the participant to begin when ready and free from distractions, and 4 practice pairs (using household items), to familiarise participants with the answering format. A white 20 mm fixation cross, appeared for 500 ms in the centre of a black screen, which was replaced by a cannabis-related word presented above or below a neutral word (see *Appendix 9*). Words were 8 mm high, 60 mm from the centre, uppercase, white, and Ariel font, to avoid unintentional visual differences. After 500 ms, both words disappeared and one was immediately replaced by a white 5 mm dot-probe, remaining until a response was made regarding the dot-probe's location on a response box (either ↑ or ↓). Half cannabis-related and half neutral words were replaced in a semi-randomised fashion, ensuring that many dot-probe replacements did not occur consecutively in the same location. Each word appeared once at the top of the screen and once at the bottom. The next fixation cross appeared 1000 ms after a response was made. The software recorded all reaction times, along with error rates, for all 80 trials, which included 20 different word pairs. Once finished, a message asked participants to inform the experimenter. Program specifications can be found in the appendices (*Appendix 10*). The task was presented on a laptop with a 2.66GHz Intel-Core 2 Duo processor and 17" high-resolution screen to aid visibility.

The questionnaire was issued after the dot-probe task, so as to not influence results with its clear cannabis link. Cannabis-users completed Heishman *et al.*'s (2009) *SF-MCQ* (*Appendix 11*), with permission granted by the authors, to establish cannabis-craving levels. It included space for identification numbers, response instructions, and an example question and response. The 12-item questionnaire has a randomised order, focusing on 4 sub-scales, measuring compulsivity ($\alpha = 0.69$) (items 2, 7, 10), emotionality ($\alpha = 0.75$) (4, 6, 9), expectancy ($\alpha = 0.72$) (5, 11, 12) and purposefulness ($\alpha = 0.84$) (1, 3, 8). Items are rated by circling a number on a Likert-type scale from 1 (strongly disagree) to 7 (strongly agree), with no reverse items. Total craving scores for all items were a sufficient measure of craving, as used in Field *et al.* (2004a).

Four further cannabis-related questions (*Appendix 12*), relating to frequency, duration and intensity of use (Field *et al.*, 2004a), were then asked with tick-box responses to establish participant usage within the sample.

All participants were issued specific *debrief sheets*, cannabis-users (*Appendix 13*) and non-users (*Appendix 14*), containing relevant websites, experimenter contact details for any further questions or information, and an overview of study aims.

Procedure

Participants received specific *Standardised instructions* (*Appendix 6+7*), including their unique identification number and required participants' age and consenting signature. After reading instructions, participants individually sat at a desk in a quiet room 50cm in front of a laptop. Participants viewed onscreen instructions (*Appendix 8*), indicated their identification number, and completed a practice dot-probe task,

followed by the actual 80-trial dot-probe task. Participants responded to dot-probe locations as quickly as possible using the response box. Upon completion, a message asks participants to inform the experimenter. Cannabis non-users were then issued a specific *debrief sheet* (*Appendix 14*), thanked and given the opportunity to ask questions.

Cannabis-users were then issued Heishman *et al.*'s (2009) *SF-MCQ* (*Appendix 11*), along with 4 extra questions (*Appendix 12*). Participants indicated identification numbers, read response instructions, including an example, then answered all 12 questions. Upon completion, participants were issued a *debrief sheet* (*Appendix 13*) containing questionnaire information, thanked and given the opportunity to ask questions.

Ethical considerations

The majority of cannabis users are not vulnerable. With regards to this study, no special considerations were required to work with participants. Investigating users of a controlled substance requires a large degree of privacy and protection of information. Participants provided informed consent by signing the *Standardised Instructions* (*Appendix 6+7*), and were given the right to withdraw themselves and their data from the study at any time. All data was protected and kept confidential. Participants were kept anonymous, using identification numbers to compare task findings. Deception occurred, as the content of the questionnaire was withheld from initial instructions to deter any priming effect of cannabis-association for the dot-probe task. However, a full debriefing took place after each study, including *Debrief sheets* containing relevant advice websites, experimenter contact details for further questions and study aims (*Appendix 13+14*). Both studies have been conducted in accordance with the British Psychological Society (2009) *Code of Ethics and Conduct*, alongside departmental university *Ethics check forms* (*Appendix 15*).

Results

Study 1

Reaction times (in Milliseconds) for identification of dot-probe position, whether congruent (replacing cannabis-related stimuli) or incongruent (replacing neutral stimuli), as recorded for Cannabis-users (n = 40) and Non-users (n = 40), using the dot-probe task software were entered into SPSS 16. Normality checks suggested that the data was normally distributed (*Appendix 17*). There were no significant outliers and the number of participant errors was minimal (*Appendix 16*). All tables, graphs and analysis derived from raw data (*Appendix 16*) and SPSS outputs (*Appendix 17, 18, 19*). **Table 1** provides Mean reaction times and Standard Deviations for both groups when the dot-probe replaced cannabis-related (congruent) or control (incongruent) words.

Table 1
Mean response times (in Milliseconds) and Standard Deviations for each group to respond to dot-probe locations.

	Congruent	Incongruent	Overall
	M (SD)	*M (SD)*	*M (SD)*
Cannabis-Users (n = 40)	475.15 (56.50)	493.50 (56.31)	484.32 (-)
Non-users (n = 40)	520.85 (71.09)	521.08 (68.94)	520.96 (-)
Whole Sample (N = 80)	498.00 (67.82)	507.29 (64.07)	

When responding to dot-probes replacing cannabis-related words, cannabis-users (M = 475.15) were on average 45.70 ms faster than non-users (M = 520.85). The difference was smaller for the incongruent probe position, where cannabis-users (M = 493.50) were on average 27.58 ms faster than non-users (M = 521.08). Overall, regardless of position, cannabis-users (M = 484.32) responded faster to the dot-probe than non-users (M = 520.96). Furthermore, regardless of group, participants responded faster to dot-probes replacing congruent words (M = 498.00), rather than incongruent words (M = 507.29).

A 2x2 Mixed Factorial ANOVA was performed, the between-subjects independent variable was Cannabis use (User or Non-user), the within-subjects independent variable was Probe position (Congruent and Incongruent), and the dependent variable was reaction time (in milliseconds). A significant main effect was found for cannabis use, $F(1,78) = 6.74$, $p < .05$. A significant main effect for dot-probe position was also found, $F(1,78) = 28.00$, $p < .001$. Furthermore, a significant interaction effect was also found, $F(1,78) = 26.66$, $p < .001$. **Figure 1** illustrates this interaction.
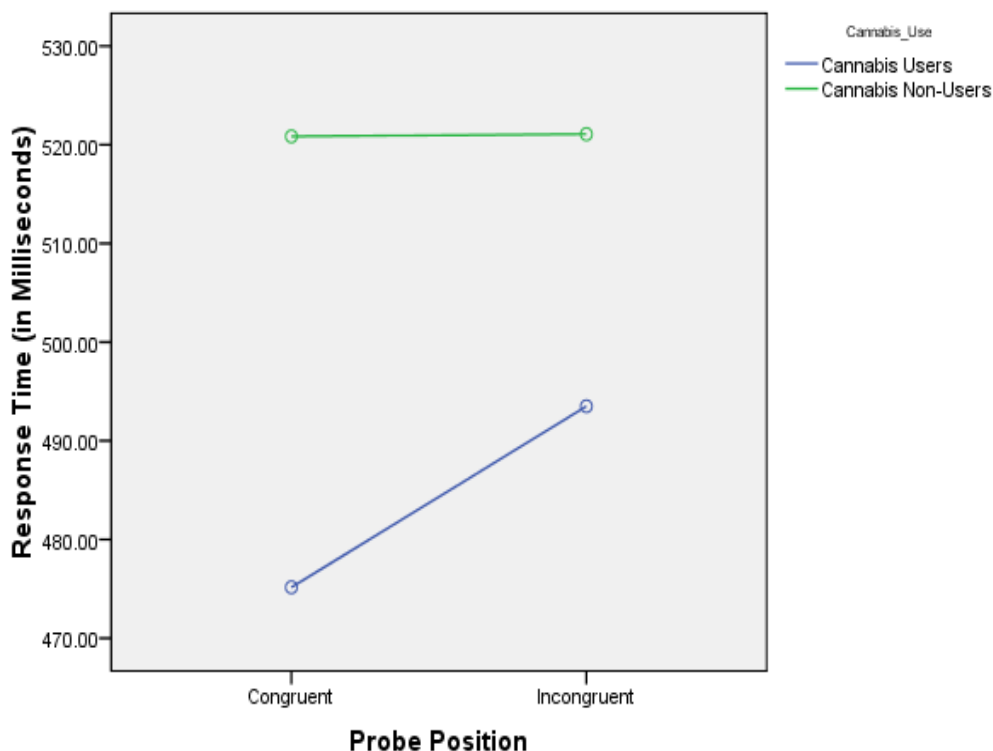
Figure 1: A means plot to illustrate the interaction between participant group, cannabis-users or non-users, and dot-probe position, congruent and incongruent.

As a significant interaction was found within the ANOVA, appropriate Post Hoc tests were performed to further analyse the interaction. Two paired-samples t-tests and 2 independent sample t-tests were conducted (*Appendix 19*). Therefore, the Bonferroni correction required to control for 4 pairwise comparisons (.05 / 4 = .0125) provides a new significance level of $p < .0125$.

The first paired-samples t-test was for cannabis-users, where the independent variable was probe position (congruent and incongruent) and the dependent variable was reaction time. Cannabis-users showed a significant difference in reaction times towards dot-probes in congruent and incongruent positions, $t(39) = 6.45$, $p < .0125$. Cannabis-users reacted significantly faster when the dot-probe was in congruent (M = 475.15), rather than incongruent (M = 493.50), positions. The second paired-samples t-test was for non-users, where the independent variable was probe position (congruent and incongruent) and the dependent variable was reaction time. Non-users showed no significant difference in reaction times towards dot-probes in congruent (M = 520.85) and incongruent (M = 521.08) positions, $t(39) = .11$, $p > .0125$.

The first independent samples t-test was for reactions to dot-probes in the congruent position, where the independent variable was cannabis use (cannabis-users or non-users) and the dependent variable was reaction times. Levene's test for equal variances was not significant. Therefore, equal variances were assumed. Response times towards dot-probes in congruent positions was significantly different between groups, $t(78) = 3.18$, $p < .0125$. Cannabis-users reacted significantly faster (M = 475.15) than non-users (M = 520.85) when the dot-probe was in congruent positions. The second independent samples t-test was for reactions to dot-probes in the incongruent position, where the independent variable was cannabis use (cannabis-users or non-users) and the dependent variable was reaction times. Levene's test for equal variances was not significant. Therefore, equal variances were assumed. No significant difference was found between cannabis-users' (M = 493.50) and non-users' (M = 521.08) response times towards dot-probes in incongruent positions, $t(78) = 1.96$, $p > .0125$.

These Post Hoc tests showed that reaction times were dependent on group and probe position. Cannabis-users' reaction times were significantly faster than non-users when the dot-probe was in congruent positions. Cannabis-users were also significantly faster when responding when responding to dot-probes in congruent positions, compared to incongruent positions.

Study 2

Normality checks suggested that the data was normally distributed (*Appendix 22*). There were no significant outliers and the number of participant errors was minimal (*Appendix 20*). All tables and graphs were derived from raw data (*Appendix 20*) and SPSS outputs (*Appendix 23, 24, 25*). The cannabis-craving questionnaire (*SF-MCQ*) was assessed for internal consistency and reliability using Cronbach's Coefficient Alpha (α) (*Appendix 21*). After analysis the questionnaire had an α value of 0.78, which is above 0.70 and therefore had acceptable internal consistency reliability (Nunnaly, 1978). Participant's attentional bias scores were calculated (where a score of zero represents no attentional bias in either direction) by subtracting their

incongruent response times from congruent response times. Pearson's Bivariate correlation was conducted and showed a significant positive correlation (r = .85, *p* < .001) between Attentional bias scores and *SF-MCQ* craving scores (*Appendix 22*). Cannabis-users (N = 40) were then divided into high (n = 18) and low (n = 22) cannabis-craving groups, using questionnaire scores and a median split (Median = 52). The high-craving group had questionnaire scores of 53 and above and the low-craving group recorded scores of 52 and below. **Table 2** provides Mean reaction times and Standard Deviations for both craving groups, high and low, when the dot-probe was in congruent or incongruent positions.

Table 2
Mean response times (in Milliseconds) and Standard Deviations for each group to respond to dot-probe location.

	Congruent	Incongruent	Overall
	M (SD)	*M (SD)*	*M*
Low Cannabis-craving (n = 22)	485.50 (56.79)	492.64 (56.25)	489.07 (-)
High Cannabis-craving (n = 18)	462.50 (55.05)	494.56 (58.00)	478.53 (-)
All Cannabis-Users (N = 40)	475.15 (56.50)	493.50 (56.31)	

When responding to dot-probes in congruent positions, participants with high cannabis-craving were on average 23.00 ms faster than low cannabis-craving participants. When responding to dot-probes in incongruent positions, participants with low cannabis-craving were on average 1.92 ms faster than high cannabis-craving participants. Overall, the high cannabis-craving group (M = 478.53) responded faster to the dot-probe than the low cannabis-craving group (M = 489.07). Regardless of group, participants responded faster to dot-probes replacing congruent words (M = 475.15), rather than incongruent words (M = 493.50).

A 2x2 Mixed Factorial ANOVA was performed, the between-subjects independent variable was Craving level (High or Low), the within-subjects independent variable was Probe position (Congruent and Incongruent), and the dependent variable was reaction time (in milliseconds). A significant main effect for cannabis-craving group was not found, $F(1,38) = 0.35$, $p > .05$. A significant main effect for probe position was found, $F(1,38) = 89.04$, $p < .001$. Furthermore, a significant interaction effect was also found, $F(1,38) = 37.00$, $p < .001$. **Figure 2** illustrates this interaction.
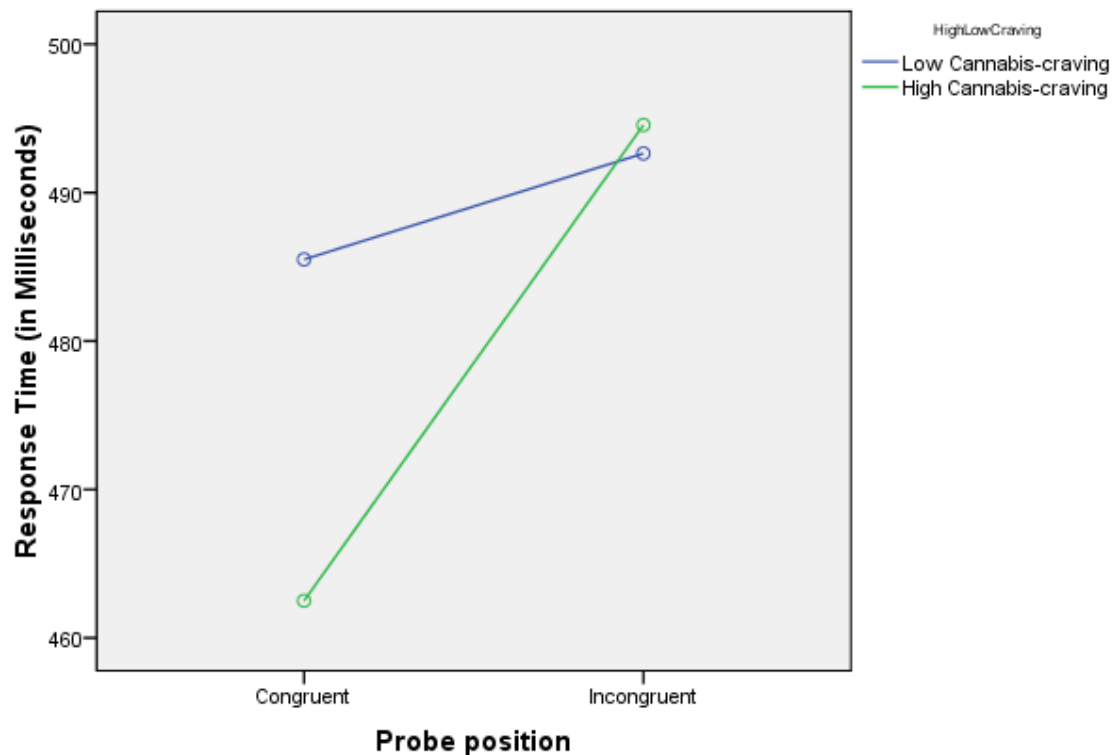
Figure 2: A means plot to illustrate the interaction between cannabis-craving group, high or low, and dot-probe position, congruent and incongruent.

As a significant interaction was found within the ANOVA, four Post Hoc tests were performed with a Bonferroni correction at the new significance level (.05/4 = $p <$ .0125) to further analyse the interaction (*Appendix 25*).

The first paired-samples t-test was for the low cannabis-craving users, where the independent variable was probe position (congruent and incongruent) and the dependent variable was reaction time. Low-craving users showed significantly faster reaction times towards dot-probes in congruent (M = 485.50), rather than incongruent positions (M = 492.64), t(21) = 3.78, $p <$ .0125. The second paired-samples t-test was for high cannabis-craving users, where the independent variable was probe position (congruent and incongruent) and the dependent variable was reaction time. High-craving users reacted significantly faster towards dot-probes in congruent (M = 462.50), rather than incongruent (M = 494.56) positions, t(17) = 8.07, $p <$ .0125.

The first independent samples t-test was for congruent position reaction times, where the independent variable was craving-group (high or low) and the dependent variable was reaction times. Levene's test for equal variances was not significant. Therefore, equal variances were assumed. No significant difference in response times towards dot-probes in congruent positions was found between the high-craving users (M = 462.50) and the low-craving users (M = 485.50), t(38) = 1.29, $p >$ .0125. The second independent samples t-test was for incongruent position reaction times, where the independent variable was craving-group (high or low) and the dependent variable was reaction times. Levene's test for equal variances was not significant. Therefore, equal variances were assumed. No significant difference was found

between high-craving users' (M = 494.56) and low-craving users' (M = 492.64) response times towards dot-probes in incongruent positions. t(38) = .11, *p* > .0125.

These Post Hoc tests showed that both high and low-craving groups reacted significantly faster when dot-probes were in congruent positions, rather than incongruent. There was no significant difference between craving groups when reacting to dot-probes in congruent or incongruent positions.

Discussion

Main Findings

The present study found that cannabis-users were significantly faster than non-users at responding to dot-probes in congruent positions. Cannabis-users were also significantly faster at responding to dot-probes in congruent positions, compared to incongruent positions. Non-users showed no significant difference in reaction times between dot-probes replacing cannabis-related or neutral words. Therefore, *Study 1* successfully identified that male regular cannabis-users, aged 18-24, showed attentional bias for cannabis-related words over neutral words, compared to a non-using control group. In line with hypothesis (1) cannabis-users responded faster when the dot-probe replaced cannabis-related words.

Findings contradicted Field *et al.*'s (2004a) results, although the study had many limitations, with results attributed to a small sample size. Findings from *Study 1* support the Motivational (Cox & Klinger, 1988, 2004) and Incentive-sensitisation (Robinson & Berridge, 1993, 2001, 2008) models of addiction, asserting that attentional biases for extremely salient substance-related stimuli will be prevalent among users (Waters & Feyerabend, 2000). Attention gained by one stimulus decreases attention to the other (Mathews & Macleod, 2002), resulting in faster cannabis-related dot-probe reaction times (Posner *et al.*, 1980). Findings are consistent with many similar studies (e.g., Field *et al.*, 2006; Waters *et al.*, 2003).

Study 2 aimed to examine the interaction between any attentional bias found and subjective craving. Findings indicated that subjective craving does not have a significant interaction with attentional bias shown for cannabis-related words, as there was no significant difference between craving groups regarding dot-probe reaction times to either word type. However, in line with hypothesis (2), both craving groups showed increased attentional bias for cannabis-related words, compared to neutral words. Both high and low-craving users responded significantly faster to dot-probes replacing cannabis-related words, compared neutral words. Findings did not support hypothesis (3), as despite high-craving users responding marginally faster than low-craving users to dot-probes replacing cannabis-related words, the increased attentional bias was not significant. Consequently, cannabis-users showed attentional bias for cannabis-related words, irrespective of craving level.

These findings of attentional bias in both studies could be the result of cannabis-related words being more frequently used in everyday language amongst cannabis-users (experimental group) than non-users (control group), which would bias results.

However, the amount of attentional bias found was too significant to be attributed purely to a possibly more frequently used set of words.

Findings from *Study 2*, apart from the same attentional bias as recorded in *Study 1*, were inconsistent with the majority of previous literature, including Field *et al.*, (2004a). Previous research has indicated that increased craving levels can produce greater attentional bias (e.g., Duka & Townshend, 2004; Field *et al.*, 2004c; Schoenmakers *et al.*, 2008; Waters & Feyerabend, 2000). Furthermore, high-craving users were marginally faster, but not significantly faster, than low-craving users. Subsequently, there are other possible explanations for the lack of significance. Firstly, through using cannabis-users from *Study 1*, the overall sample as immediately halved. Therefore, the small sample size may have limited the power of the study (Field *et al.*, 2004a). Secondly, although Field *et al.* (2004a) separated the craving groups using a median split, in this study it resulted in unequal groups (n = 17 compared to n = 22), which could have reduced the significance of any effects. Lastly, the SOA presentation time used (500 ms) was too long, possibly allowing for disengagement (Theeuwes, 2005).

Broader Real World Implications

Attentional biases are strongly associated with drug-seeking behaviour, future relapse and continued addiction (Field & Cox, 2008). Within this experiment, these biases have shown to be dominant for substance-related stimuli. This knowledge could help guide treatment-related interventions and aid continuous cessation methods. Treatment programs would know possible cues to avoid and their abundance in the user's specific environment. Consequently, the individuals could be taught to employ various avoidance tactics (Fadardi & Cox, 2006).

Limitations

Within the experiment, there were a number of participant limitations, such as a small sample size, especially for *Study 2*. Furthermore, using extremely specific selection criteria for the sample dictates that findings cannot be generalised past the sample population, namely regular cannabis-using males aged 18 to 25 years old. Increasing the sample size and widening the selection criteria could produce equal groups and more ecologically valid and reliable findings, along with a greater variety of subjective craving levels, although it could also increase various sample biases.

There were also various possible limitations surrounding the dot-probe task. Despite the frequency-matching database being more recent than in Field *et al.*'s (2004a) study, it was 14 years old, and may have been ineffective. However, the study was restricted, as there was no relevant modern alternative. Alternatively, the control group could use people who regularly socialise with cannabis-users but do not use themselves. However, those participants may have other biasing factors, such as intentional avoidance.

Presenting stimuli in a top/bottom format required up/down button responses, which could have influenced response times, depending on participants' response

technique. Therefore, presenting the task to one group in the top/bottom format and one equal group in the left/right format would allow for comparisons.

During the dot-probe task any noise, itch, or concentration lapse could influence responses, despite completing the task alone in a quiet room. Distractions, internal or otherwise, are almost impossible to completely eliminate. Although, the software could be adapted to stop the program between responses, allowing the participant to continue when they are ready and free from distractions.

Furthermore, using an SOA of 500 ms might have allowed for disengagement and would influence results (Theeuwes, 2005). Using a variety of SOA's, such as 20 ms, 500 ms, and 2000 ms, would allow for comparisons and could help identify the cause of any discrepancies between results.

A final limitation relates to the cannabis-craving questionnaire (*SF-MCQ*). It is possible that through presenting cannabis-users with 20 cannabis-related words within 80 dot-probe trials that any attentional bias could have subsequently influenced or biased cannabis-craving scores (Franken, 2003). This could be overcome by using a cognitive masking task between dot-probe completion and questionnaire distribution.

Ideas for Future Research

In light of carrying out this investigation, and previously discussing any methodological or procedural limitations, there are a number of further studies that would be beneficial, all utilising a large participant sample (Field *et al.*, 2004a). It would be beneficial to use a variety of different forms of cannabis-user, such as those attempting to quit, abstinent users, and former users, to determine the differences in attentional processing. The variations of abstinent users may elicit cognitive avoidance strategies (Fadardi & Cox, 2006; Field & Cox, 2008), or may show attentional bias, which would rival theories of the relationship between attentional bias and frequency of substance-use (e.g., Field, 2005). Furthermore, with regards to the actual dot-probe task, trials could be retested with word and pictorial pairs, in order to assess retest reliability (Schmuckle, 2005), and determine whether pictorial trials receive greater attentional bias, as they are more naturalistic (see Townshend & Duka, 2001). Lastly, a variety of SOA's could be used in conjunction with concurrent eye-monitoring software, as the software could aid identification of the processes involved (Field *et al.*, 2006; Mogg *et al.*, 2003).

Conclusions

Overall, findings implicate strong evidence that male regular cannabis-users aged 18-24 irrespective of subjective craving levels, elicit attentional bias for cannabis-related words compared to neutral words, when presented for 500 ms during a dot-probe task. Users selectively and automatically respond to related stimuli (Cox, Fadardi & Pothos, 2006).

However, as subjective craving has been sufficiently implicated within previous research to be a major factor in addiction (Everitt, 1997), it is clear that study limitations influenced results.

Consequently, further research is needed into various cognitive biases, including attentional bias, and their relationship with other important factors involved in maintaining addiction, namely subjective craving, as it could give insights into various methods to combat cannabis dependence or reduce the vulnerability to relapse in those attempting to abstain.

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