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Attentional bias for cannabis and nicotine related words in cannabis users

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Abstract

Drug-associated cues can provoke conditioned emotional responses, such as the urge to use drugs. Attentional bias, is the degree to which attention is drawn to drug related stimuli compared to neutral stimuli. In the current study we used a Dutch version of the cannabis Stroop task to measure attentional bias for cannabis words in cannabis users and a control group. We developed a Dutch version of the nicotine Stroop task to measure attentional bias for cigarette related words in cannabis users and a control group. We measured cognitive control using the classical Stroop task. The present study did not find attentional bias differences for cannabis words between cannabis users and a control group. We also found no attentional bias differences for nicotine related words between the groups. In addition, we did not find a relation between attentional bias for cannabis related words and cannabis use and dependence. Similarly, we did not find a relation between attentional bias for nicotine related words and nicotine dependence. We did not find a relation between attentional bias for nicotine related words and nicotine craving, or attentional bias for cannabis words and cannabis craving. Contrary to expectations, within the group of heavy cannabis users the interference score on the classical Stroop task correlated negatively with attentional bias for cannabis related words. This study did not replicate previous studies concerning attentional bias for cannabis related and nicotine related words. Therefore, further research is needed to clearly understand the possible moderating role of cognitive control on the relationship between attentional bias for cannabis related words and cannabis use and dependence.

Attentional bias for cannabis and nicotine related words in cannabis users

Keywords: attentional bias, nicotine, cannabis users, abstainers, dual-process model of addiction, dependence

Introduction

Drug addicts seem to use or relapse more easily in environments associated with prior drug use. To explain this addictive behavior there are three neurobiological models of addiction which explain how drugs can affect the brain: the learning theory, opponent process theory, and the incentive sensitization theory (Robinson & Berridge, 2003). According to the learning theory, addictive drug behavior results from the ability of drugs to promote aberrant learning. The learning theory has several approaches examine the hypothesis that drugs promote aberrant learning. One of the most straightforward approaches is that abnormally strong declarative explicit learning, could contribute to addiction. In explicit learning, people learn at a conscious level about causal relationships between their action (taking drug) and the outcome (drug effect). Besides that, they also learn predictive relationships between particular cues in their environment and the resulting rewards. Abnormally strong explicit learning might distort these expectations about the rewards in two ways. 1. The memories of the drug experience might be abnormally intrusive. 2. Drug could exaggerate or distort the memories of the drug experience such that memory-based cognitive expectations about drugs become excessively optimistic, and it will make inaccurate predictions about the consequences of taking drugs (Robinson & Berridge, 2003).

The opponent process theory says that there are two processes accountable for drug dependence. There is an a-process, this is the response to the drugs. The a-process (activation of mesolimbic dopamine projections) triggers an opponent b-process. The a- and b-processes together will create the subjective experienced state for the person when doing drugs (A-state). The A-state, is pleasant and is followed by an opponent unpleasant B-state. Initially the pleasant A-state is large, followed by a relative small unpleasant B-state (hypothalamicpituitary axis stress system). After repeated exposure to drugs, the b-process will last longer than the a-process. This will lead to an experience dominated by unpleasant symptoms associated with withdrawal (Robinson & Berridge, 2003).

The incentive sensitization theory of addiction says that addictive drugs permanently alter NAcc-related brain systems that mediate a basic incentive-motivational function (the attribution of incentive salience). In other words, the NAcc-related brain systems will be hypersensitive to specific drug effects and to drug associated stimuli. These changes in brain circuits is called neural sensitization and this can lead to drug dependence (Robinson & Berridge, 2003).

The dual-process model of addiction is in line with the above mentioned neurobiological models and is more focused on the implicit cognition in addictive behavior. This model is divided into two different processes. One process is a relatively automatic appetitive or impulsive process and the other process is a controlled or reflective process. So, the tendencies to attend to and approach drug cues, are counterbalanced by cognitive control processes which can inhibit these tendencies. (Stacy & Wiers, 2010).

Drug-associated cues can provoke conditioned emotional responses, such as the urge to use drugs (Ehrman, Robbins, Childress, & O'Brien, 1992). In the context of the dual-process model, drug-associated cues will influence the relatively automatic appetitive or impulsive process which causes drug use. This cognitive influence of drug-associated cues is widely examined with cognitive biases. Cognitive biases can be defined as ''*systematic selectivity in information processing that operates to favour one type of information over another''* (MacLeod & Matthews, 2012, p. 191). According to the dual-process model cognitive biases are the automatic appetitive or impulsive processes. One such bias, attentional bias, is the degree to which attention is drawn to drug related stimuli compared to neutral stimuli. In research attentional bias is often measured with a modified addiction-Stroop task (Cox, Fadardi, & Pothos, 2006). For example, to measure attentional bias for cannabis words in cannabis users, there is an modified cannabis Stroop task. The modified cannabis Stroop task consisted of two subtasks, with either cannabis related words or neutral words. Participants with an attentional bias for cannabis words have an increased reaction time for cannabis words compared with the neutral words (Cousijn et al., 2013).

Variables related to attentional bias for cannabis related cues

The addiction Stroop task has been used to study attentional bias in many different kind of drugs; heroin (Franken, Kroon,Wiers & Jansen, 2000), cocaine (Hester, Dixon & Garavan, 2006), alcohol (Cox, Brown, & Rowlands, 2003), nicotine (Hogart, Mogg, Bradley, Duka, & Dickinson, 2003), and cannabis (Cousijn et al., 2013; Field, 2005). The last mentioned task, the cannabis Stroop task, showed mixed outcomes. Field (2005) found only an attentional bias for cannabis related words in participants who met criteria for cannabis dependence, but not for the recreational users. Field (2005) used the Severity of Dependence Scale for Cannabis (C-SDS; Swift, Copeland, & Hall,1998) to indicate probable cannabis dependence, with a sensitivity of 64% and specificity of 82% compared to the DSM-III-R diagnosis of at least moderate cannabis dependence. However, Cousijn et al. (2013) founded an attentional bias for cannabis words in cannabis users compared to a matched control group. Additionally they found that dependent cannabis users had a stronger attentional bias for cannabis cues compared to non-dependent cannabis users. Cousijn et al. (2013) used the Mini International Neuropsychiatric Interview (MINI; Sheehan et al., 1998) to distinguish dependent cannabis users from normal cannabis users according to DSM major Axis I psychiatric disorders. The MINI has a better sensitivity and specificity to indicate probable cannabis dependence compared with the C-SDS (Swift, Copeland, & Hall,1998) which is used by Field (2005). Differences in the results of Field (2005) and Cousijn et al. (2013) are possible due to differences in the distinctiveness of the questionnaires. The relation between drug use severity and attentional bias were also found in alcoholics. Researchers found a stronger alcohol attention bias in heavy drinkers compared with light drinkers (Cox, Brown, & Rowlands, 2003). The influence of cannabis use and dependence on attentional bias is evident (Field, 2005; Cousijn et al., 2013). Therefore in the current study we only include heavy cannabis smokers and measure the severity of cannabis use and problematic cannabis-related behavior with the Dutch transaltion of the revised 8-item Cannabis Use Disorder Identification Test (CUDIT-R; Adamson et al., 2010).

Almost all studies which examined attentional bias for drug related cues, presented drug related cues specific to a single substance. The specificity of the attentional bias for cannabis related words in participants with a history of using multiple substances is unclear. It is known that a high percentage of cannabis users smokes cigarettes (Richter et al., 2004). It is possible that cannabis users who smoke cigarettes have also an attentional bias for nicotine related words. Therefore it is interesting to investigate besides the attentional bias for cannabis words, also attentional bias for cigarette related words in cannabis users. In the current study we developed a Dutch version of the nicotine Stroop task to measure the attentional bias for cigarette related words in cannabis users and a matched control group.

None of the above mentioned studies investigated both cannabis and nicotine attentional bias in cannabis users with the modified Stroop task. But research of attentional bias in tobacco users is more common. Gross, Jarvik, & Rosenblatt, 1993) found that abstinent smokers had an attentional bias for cigarette related words compared to non-abstinent smokers. They found that non-abstinent smokers showed a significant difference in the opposite direction. They had longer response times for the neutral words compared with the cigarette related words. The researchers found also that the abstinent group reported stronger cigarette cravings than the non-abstinent group. Phillips, Kavanagh, May, &

Andrade, (2004 n.p.) found similar results. Their study consisted of three groups: participants who quit smoking (they had given up smoking within the previous three months), tobacco smokers and abstinent smokers. Abstinent smokers had an greater attentional bias compared with non-abstinent smokers and a control group. They found no difference in attentional bias between the control group (participants who quit smoking) and non-abstinent tobacco smokers. The researchers did not directly examine the role of craving, but instead they examined the mood and frequency of thoughts about cigarettes in the participants. Increases in smoking thoughts and mood were not related with smoking-related biases (Phillips et al., 2004 n.p.).

The results of the above mentioned studies showed that abstinent smokers are more likely to have an attentional bias, and that this is possibly partly attributable to an increased subjective craving. Research of attentional bias and the relation with subjective craving showed similar results. Field (2005) found a relation between subjective cannabis craving and attentional bias for cannabis related words. More recent research confirms this result and found that higher levels of craving were associated with a larger attentional bias in alcoholics (Field et al., 2013). Contrary to these results Cousijn et al. (2013) found no relation between subjective cannabis craving and attentional bias for cannabis related words. However, they found that cannabis users who had reduced cognitive control experienced increased session-induced craving (Cousijn et al., 2013).

Cognitive control is a component of executive functions and is related to conflict monitoring. Cognitive control is an ability we use to decide where we focus our attention on, or which information we have to ignore, inhibit or delay for later processing (Aisenberg et al., 2015). According to the dual-process model of addiction cognitive control is important in the inhibition of appetitive behavioural tendencies. In our study we assessed attentional bias as an indicator of the appetitive behavioural tendencies, and cognitive control was assessed as an indicator of controlled processing. The dual-process model predict that differences in cognitive control will modulate the relationship between appetitive behavioural tendencies and problem severity. It is expected that a person with a greater cognitive control, will be more successful at inhibiting automatic behaviors (Stacy & Wiers, 2010). The thought of cognitive control and the inhibition of automatic behaviors such as drug dependence, is confirmed by Houben and Wiers (2009). They found that positive implicit alcohol associations predicted drinking behavior for individuals with low cognitive control (measures with the classical Stroop task). More recent research in eat behavior found similar results. Kakoschke, Kemps & Tiggemann (2015) found that the consumption of unhealthy food is determined by a combination of automatic and controlled processing. Participants with a high approach bias for food combined with low cognitive control, consumed the most unhealthy snack food (Kakoschke, Kemps & Tiggemann, 2015). Larsen et al. (2014) found also similar results. They found that a stronger attentional bias for nicotine related words, and weaker inhibition skills, were related to higher levels of nicotine dependence. One study examined the relationship between cognitive control, cannabis attentional bias and problematic cannabis use. This study examined if cognitive control would modulate the relationship between attentional bias and cannabis use. Contrary to the aforementioned studies, they found no moderating effect of cognitive control on the relationship between attentional bias and cannabis use (Cousijn et al., 2013).

The purpose of the current study is twofold. First, we want to replicate the findings of previous studies of attentional bias for cannabis and cigarette related words. Therefore we use a Dutch modified cannabis Stroop task (Cousijn et al., 2013) to measure the attentional bias in cannabis users and a matched control group. To measure attentional bias for cigarette related words in cannabis users and a matched control group, we recently developed a Dutch version of the nicotine Stroop task.

1a. Based on previous research using the modified cannabis Stroop task in cannabis users we expected that cannabis users, but not controls show an attentional bias for cannabis related words (Cousijn et al., 2013; Field, 2005).

1b. Based on previous research using the modified Stroop task in tobacco users (Gross, Jarvik, & Rosenblatt, 1993; Phillips, Kavanagh, May, & Andrade, 2004 n.p.) ,and the fact that a high percentage of cannabis users smokes cigarettes (Richter et al., 2004), we expected that cannabis users but not controls show an attentional bias for cigarette related words.

1c. We wonder whether attentional bias for nicotine related words will influence the attentional bias for cannabis related words in cannabis users.

1d. Furthermore we expected that the attentional bias for cannabis related words could be explained by cannabis use and dependence (Cousijn et al., 2013; Field, 2005), measured with the CUDIT-R (Adamson et al., 2010).

1e. and cannabis craving (Field, 2005; Field, 2013; Gross, Jarvik, & Rosenblatt, 1993).

1f. We also expected that attentional bias for nicotine related words could be explained by nicotine craving (Gross, Jarvik, & Rosenblatt, 1993; Phillips, Kavanagh, May, & Andrade, (2004 n.p.).

The second purpose of the current study is to investigate if cognitive control would modulate the relation between attentional bias and drug use and dependence, as predicted by the dual-process model of addiction (Stacy & Wiers, 2010).

2. We expected to find a moderating effect of cognitive control on the relation between cannabis use and dependence and attentional bias for cannabis related words in cannabis users (Houben & Wiers, 2009; Larsen et al., 2014; Kakoschke, Kemps & Tiggemann, 2015).

Methods

Participants

For this experiment we will use two groups divided into: cannabis users (N = 24), and abstainers (N = 23). All the participant were recruited in person on the campus of University College Utrecht, family, friends and relatives who live around the campus of University College Utrecht, and through flyers on the campus of Utrecht University. The group with the abstainers will be the control group.

All the participants need to give written informed consent, and they receive a compensation of €15,00 for the 2-hour experiment.

Inclusion Criteria

The average age of the cannabis group was 21.77 years ranged from 18 to 27 years (SD: 2.599). The age of the cannabis group was normally distributed, with skewness of 0.200 (SE = 0.491) and kurtosis of -0.785 (SE = 0.953). The average age of the control group was 21.77 years ranged from 18 to 27 years (SD: 2.759). The age of the cannabis group was normally distributed, with skewness of 0.686 (SE = 0.491) and kurtosis of -0.169 (SE = 0.953). Potential participants for the cannabis test group had to use cannabis at least five days per week. The participants were excluded if they smoke cannabis on the day of the experiment. Participants in the cannabis group were also excluded if they smoke tobacco on the day of the experiment (Gross, Jarvik, & Rosenblatt, 1993). Potential participants for the control group were excluded if they smoke cigarettes 6 months prior to the experiment and were excluded if they smoke cigarettes or cannabis regularly at some point during their life. Thirteen participants reported never using cannabis; eight participants reported between 1 and 6 lifetime occasions of cannabis; one participant reported 40 lifetime occasions of cannabis; and one participant reported 200 lifetime occasions of cannabis. The participant who reported 200 lifetime occasions of cannabis, also smoked cigarettes at some point in his life regularly. We did additional analysis to determine whether the two participants in the control group with 40 and 200 lifetime occasions of cannabis will influence the scores on attentional bias for cannabis related words (see results).

Setup of the experiment

The experiment consists of a number of different tasks: a number of questionnaires, three different Stroop tasks (cannabis Stroop, nicotine Stroop, and classical Stroop), and a Visual Analogue Scale (VAS) to assess acute craving for cannabis and nicotine before and after completing the three Stroop tasks.

Stroop tasks

For this experiment, three different Stroop tasks will be used, the classical Stroop task, and two modified Stroop tasks: a cannabis Stroop task and a nicotine Stroop task.

The classical Stroop task (Stroop, 1935) will be used as an indicator of general cognitive control. The test consists of 3 separate subtasks, with each presenting a single sheet of paper to the participant containing printed words or solid colour patches. In the first subtask 100 words, each pertaining to one of 4 colours (red, blue, green, yellow), are printed in black ink. Participants have to read the words out loud as quickly as they can. In the second subtask, participants are presented with a sheet of paper on which 100 coloured patches are printed, and this time the participants have to name the colours out loud as fast as they can. In the final subtask, the same words are presented as in the first subtask, only this time they are printed in an incongruent colour. For example, the world ´red´ is printed in yellow ink. Participants again have name to colour the words were printed in out loud as fast as they can. By subtracting the total time required for completing the first and second subtask from the mean time required to complete the third subtask, we can get an indication of cognitive control of the participants.

The cannabis Stroop task were used to measure attentional bias for cannabis words. This Stroop task is developed by Cousijn et al. (2013). A list of 14 different cannabis related words are printed in four different colours (red, blue, yellow, and green) on a paper. The words are presented in seven columns of eight words each. The participants have to name the colour as fast as they can, and the time to complete the task will be recorded.

The nicotine Stroop task were used to measure attentional bias for cigarette related words. The test administration of the nicotine Stroop task is equal to the cannabis Stroop task. To get an indication of the attentional bias for cannabis words and nicotine words, we used a neutral word subtask related to office stationary. By subtracting the time needed to complete the neutral word subtask from the time needed to complete the cannabis word subtask, we can get an indication of attentional bias for cannabis-related words. The order of the three subtasks was counterbalanced across participants to control for order effects.

The neutral and cannabis words were identical to those used in a previous study (Cousijn et al., 2013). In the current study we developed the nicotine Stroop task with 14 words related to cigarettes, using the same norms as (Cousijn et al., 2013). The 14 words related to cannabis, cigarettes and neutral words were all matched for length, number of syllables and word frequency (Table 1).

Questionnaires

General questionnaires were used to collect demographical information and a lifetime history of general drug use. The Dutch translation of the revised 8-item Cannabis Use Disorder Identification Test (CUDIT-R; Adamson et al., 2010) were used to assess the severity of cannabis use and problematic cannabis-related behaviours. The CUDIT-R contains items relating to consumption, dependence, cannabis-related problems and psychological issues. A Visual Analogue Scale (VAS) will be included to assess acute craving for cannabis and nicotine. The Dutch translation of the Fagerstrom Test for Nicotine Dependance (FTND; Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991) will be used to assess the dependence for nicotine. It contains items pertaining to the history, the severity, and pattern of cigarette smoking. Only tobacco users fill in this questionnaire and the score of the FTND ranged from 1 to 8 (a non-tobacco user scores 0 and therefore these scores will be excluded in the analyses concerning nicotine dependence). The State-Trait Anxiety Index (STAI; Spielberger, 1983) is a questionnaire to assess state and trait anxiety in participant. The questionnaire consists of two parts with each 20 items. Twenty items related to trait anxiety and 20 items related to state anxiety. In our study we only use the last mentioned items to assess state anxiety in the participants.

Table 1

The modified Stroop tasks: cannabis words, nicotine words, and control words

Cannabis words*	Nicotine words*	Control words*
Blowen	Vuurtje	Poster
Cannabis	Opsteken	Agenda
Coffeeshop	Tabak	Telefoon
Draaien	Pakjes	Nieten
Grinder	Tabakzaak	Laptop
Hash	Shag	Muis
High	Rook	Tape
Joint	Sigaret	Stoel
Marihuana	Rookhok	Toetsenbord
Nederwiet	Trekje	Paperclip
Stickie	Nicotine	Sticker
Stoned	Peuk	Scanner
Thc	Rookpaal	DVD
Wiet	Paffen	Printen

* A list of Dutch words

Procedure

Participants gave written informed consent and then they filling in the questionnaires (FTND, CUDIT-R, & STAI). The participants had to fill in a VAS scale with regard to their acute craving towards cannabis and nicotine. After filling in the VAS scale the Stroop tasks were administered. The addiction Stroop tasks were always followed by the classical Stroop task to assure no practice effects carried over to the cannabis and nicotine attentional bias scores (Cox et al., 2006). Besides that, the addiction Stroop tasks (nicotine, cannabis, and neutral stroop task) were counterbalanced to control for order effects. After the Stroop tasks we measured acute craving towards cannabis and nicotine using the VAS scale.

Statistical analysis

As can see in Table 2 all the variables for cannabis users are normally distributed and therefore we can use parametric tests in the cannabis group. For the control group are age, attentional bias for cannabis and nicotine words, and the cognitive interference score normally distributed. The cannabis and tobacco related variables are all non-normally distributed and therefore we use non-parametric tests for these variables in the control group (George & Mallery, 2010).

Table 2
Skewness and kurtosis of the dependent and independent variables cannabis group

	Cannabis group		Control group		
	Skewness[1]	Kurtosis[2]	Skewness[3]	Kurtosis[4]	
Age (years)	0.686	-0.169	0.200	-0.785	
Attentional bias cannabis (sec)	-0.189	0.499	0.082	-0.158	
Attentional bias nicotine (sec)	-0.006	-1.013	-0.324	-0.6114	
Cognitive interference (sec)	0.310	-0.541	0.810	-0.118	
Cannabis craving pre Stroop	0.116	-1.526	2.495	5.313	*
Cannabis craving post Stroop	-0.236	-1.499	3.588	13.764	*
Nicotine craving pre Stroop	0.676	-0.623	4.528	20.990	*
Nicotine craving post Stroop	0.698	-1.016	3.012	8.976	*
Cannabis dep. (CUDIT-R)	0.207	-0.794	2.151	3.539	*
Nicotine dep. (FTND)	1.166	0.262	-	-	

Dep = dependence; sec = seconds; CUDIT-R= Cannabis Use Disorder Identification Test (revised) ; FTND= Fagerstrom Test for Nicotine Dependance
[1]Standard error = 0.472; [2] Standard error = 0.918; [3] Standard error = 0.481; [4] Standard error = 0.935
* non parametric variable according (George & Mallery, 2010)

Before examining the formulated hypotheses we compared with an independent t-test the demographic characteristics and the State Trait Anxiety Score to see whether the cannabis and control group are matched on these variables. Besides that we compared the cannabis and smoke related variables (craving, nicotine- and cannabis dependence) between the cannabis and control group with an independent t-test.

To examine hypothesis 1a. ''*We expected that cannabis users, but not controls show an attentional bias for cannabis related words''* 1b. *''We expected that cannabis users but not controls show an attentional bias for cigarette related words''* and 1c. ''*We wonder whether attentional bias for nicotine related words will influence the attentional bias for cannabis related words in cannabis users''* we used a repeated measures ANOVA. With a within-subject factor of two levels (attentional bias for cannabis related words and attentional bias for nicotine related words) and a between-subject factor consisted of the two groups (control group and cannabis group). A secondary analysis was used to examine hypotheses 1a, 1b. and 1c. in heavy cannabis users compared with the control group. More explorative, we used correlational analysis to examine the relationship between the cannabis and nicotine Stroop task in cannabis users and the control group (hypothesis 1c.).

To examine hypothesis 1d. '*'We expected that attentional bias for cannabis related words could be explained by cannabis use and dependence''* we used correlational analysis between attentional bias for cannabis words and cannabis use and dependence measured with the CUDIT-R (Adamson et al., 2010).

To examine hypothesis 1e. ''*We expected that attentional bias for cannabis related words could be explained by subjective craving''* we used correlational analysis between attentional bias for cannabis words and craving in cannabis users.

To examine hypothesis 1f. ''*We expected that attentional bias for nicotine related words could be explained by nicotine craving''* we used correlational analysis between attentional bias for nicotine words and nicotine craving in cannabis users. Additionally we examined the relation between attentional bias for nicotine words and nicotine craving in tobacco smoking cannabis users.

To examine hypotheses 2 '' *We expected to find a moderating effect of cognitive control on the relation between cannabis use and dependence and cannabis attentional bias in cannabis users''* we used a hierarchical regression model. In cannabis users, the CUDIT-R scores was the dependent variable, and in one step we placed the attentional bias score for cannabis words, classical Stroop interference score, and the interaction between these two variables. In tobacco users, the FTND scores was the dependent variable, and in one step we placed the attentional bias score for nicotine words, classical Stroop interference score, and the interaction between these two variables.

Results

Group characteristics

As can see in Table 3, participants in the two groups were matched on the following non-cannabis related demographical variables: age, education, and the State Axiety scores on the State Trait Anxiety Index. Because of the inclusion criteria the cannabis users were more likely to smoke cigarettes (0% vs. 45.8%). Besides that there were in the control group (43.5%) more females included compared to the group with cannabis users (16.67%). In the correlational analysis between nicotine craving and attentional bias for nicotine related words, and nicotine dependence and attentional bias for nicotine related words, we did additional analysis in a group with tobacco users. The group of tobacco users consisted of twelve participants and was a subgroup of the cannabis users (FTND; mean: 3.67, SD: 2.27, ranged 1 to 8).

Table 3

Sample characteristics

	Control group (N=23)		Cannabis group (N=24)		$t(45)=$	p
	Mean	SD	Mean	SD		
Males:	56.5%	-	83.33%	-	4.037[1]	0.045*
Age (years)	21.77	2.76	21.77	2.56	0.00	1.00
Smokers	0%	-	45.8%	-	13.763[2]	0.001*
<u>Education</u>	-	-	-	-	3.071[3]	0.08
University/HBO	100%	-	87.5%	-	-	-
MBO/HAVO	0%	-	12.5%	-	-	-
Cannabis weekly use (gram)	0	0	4.70	5.67	-3.975	0.001*
Cannabis weekly use (days)	0	0	5.91	0.83	-34.935	0.001*
Days of cannabis abstinence	480.5	375.16	1.74	0.62	-3.610[4]	0.009*
Cannabis craving pre stroop	1.35	3.31	43.00	32.16	-6.179	0.001*
Cannabis craving post stroop	1.24	3.70	48.17	33.25	-6.725	0.001*
Nicotine craving pre stroop	0.26	1.05	31.09	30.89	-4.784	0.001*
Nicotine craving post stroop	0.90	2.53	32.22	34.36	-4.358	0.001*
Cannabis dep. (CUDIT-R)	0.43	0.95	17.27	4.56	16.980	0.001*
Nicotine dep. (FTND)	0	0	1.83	2.44	-3.676	0.001*
State Anxiety Score	45.26	3.84	45.35	4.06	-0.75	0.941

dep. = dependency; CUDIT-R= Cannabis Use Disorder Identification Test (revised) ; FTND= Fagerstrom Test for Nicotine Dependance

[1] $\chi^2(1)$ 4.037; $p = 0.045$ [2] $\chi^2(1)$ 13.764; $p = 0.001$ [3] $\chi^2(1)$ 3.071; $p = 0.08$

[4] 13 control group participants had never used cannabis, 2 control group participants have not completed the cannabis questionnaire therefore *t* (31).

* significant

For secondary analysis in the cannabis group we compared the attentional bias scores for cannabis and nicotine related words, and the cognitive interference scores of the classical Stroop task, of heavy cannabis users with the control group. The heavy cannabis users were selected according to the scores on the CUDIT-R using the median split method. Cannabis users with a score of 17 or higher were classified as the heavy cannabis group (CUDIT-R mean: 20.31, sd: 3.04). The CUDIT-R scores in the heavy cannabis group is relative high compared with a previous study of Cousijn et al. (2013) (CUDIT-R mean of their dependent cannabis users was: 15.5, sd: 7.9). For the demographical variables, and the State Anxiety scores on the State Trait Anxiety Index, see Table 4.

Table 4
Sample characteristics Control group and Heavy cannabis users

	Control Group (N=23)		Heavy users (N=13)		*t*(34)=	*p*
	Mean	SD	Mean	SD		
Males:	56.5%	-	76.92%	-	1.498[1]	0.221
Age (years)	21.77	2.76	21.85	3.00	-0.074	0.942
Smokers	0%	-	46.15%	-	12.738[2]	0.001*
Education	-	-	-	-	3.747[3]	0.053
University/HBO	100%	-	84,62%	-	-	-
MBO/HAVO	0%	-	15,38%	-	-	-
Cannabis weekly use (gram)	0.00	0	5.60	7.52	-2.684	0.020*
Cannabis weekly use (days)	0.00	0	5.85	0.90	-23.454	0.001*
Days of cannabis abstinence	480.50	375.16	1.77	0.73	3.609	0.009*
Cannabis craving pre stroop	1.35	3.311	43.92	30.92	-5.052	0.001*
Cannabis craving post stroop	1.24	3.70	51.85	31.68	-5.736	0.001*
Nicotine craving pre stroop	0.26	1.05	26.46	25.92	-3.643	0.003*
Nicotine craving post stroop	0.90	2.53	25.69	29.23	-3,050	0.100*
Cannabis dep. (CUDIT-R)	0.43	0.95	20.31	3.04	-22.964	0.001*
Nicotine dep. (FTND)	0.00	0	1.69	2.14	-2.856	0.014*
State Anxiety Score	45.26	3.84	45.15	4.10	0.78	0.938

dep. = dependency; CUDIT-R= Cannabis Use Disorder Identification Test (revised) ; FTND= Fagerstrom Test for Nicotine Dependance
[1] χ^2(1) 1.498; $p = 0.221$ [2] χ^2(1) 12.738; $p = 0.001$ [3] χ^2(1) 3.747; $p = 0.053$
* significant

Inclusion of the participants with 40 and 200 lifetime occasions of cannabis

In the control group there were two participants with 40 or more lifetime occasions of cannabis. With an independent t-test we examined if these two participants in the control group will influence the scores on attentional bias for cannabis related words in the control group. We found no differences in the attentional bias for cannabis related words between the control group with (mean: 0.06, SD: 2.83) and without the two participants with 40 or more life time occasions of cannabis (mean: 0.0476, SD: 2.92; $t(20) = -0.19$, $p = 0.985$). Therefore we did not exclude these participants.

Results of the modified cannabis and nicotine Stroop task

We used a repeated measures ANOVA to examine hypothesis 1a. ‘’*We expected that cannabis users, but not controls show an attentional bias for cannabis related words’’* 1b. *‘’We expected that cannabis users but not controls show an attentional bias for cigarette related words’’* and 1c. ‘’*We wonder whether attentional bias for nicotine related words will influence the attentional bias for cannabis related words in cannabis users’’*. The repeated measures ANOVA had a within-subject factor of two levels (attentional bias for cannabis related words and attentional bias for nicotine related words) and the between-subject factor consisted of the two groups (control group and cannabis group). No main effect were found for bias score (F (1,45) = 0.027, p = 0.871, η^2 = .005) or group (F (1,45) = 0.002, p = 0.966,

η^2 = .000). This indicates that there were no differences between the scores on the nicotine and cannabis Stroop tasks. No interaction effect were found between bias score and group (F (1,45) = 0.210, p = 0.649, η^2 = .005). This indicates that there were no differences between the scores on the nicotine and cannabis Stroop tasks in and between the two groups. See Table 5. for the mean scores on the cannabis and nicotine Stroop tasks for the two groups.

Table 5
Mean scores for control group and cannabis users

	Control group (N=23)		Cannabis users (N=24)		*t*(45)=	*p*
	Mean	SD	Mean	SD		
Attentional bias cannabis (sec)	0.06	2.83	0.25	3.12	-0.215	0.83
Attentional bias nicotine (sec)	0.36	3.65	0.11	2.42	0.281	0.78
Cognitive interference (sec)	25.80	9.21	27.71	8.42	-0.745	0.46

Sec = seconds

Several studies have indicated that attentional bias is positively related to drug use and dependence. It is possible that cannabis users with high scores on the CUDIT-R (participants above the median split) may show attentional bias differences compared to the control group. Therefore we compared the attentional bias scores of heavy cannabis users with the control group to examine hypotheses 1a, 1b, and 1c. The within-subject factor (bias) consisted of the scores on the cannabis and nicotine Stroop task. The between-subject factor consisted of the two groups (control group and the heavy cannabis users). No main effect were found for bias score (F (1,34) = 0.096, p = 0.759, η^2 = .003) or group (F (1,34) = 0.065, p = 0.800, η^2 = .002). This indicates that there were no differences between the scores on the nicotine and cannabis Stroop tasks. No interaction effect were found between bias score and group (F (1,34) = 0.025, p = 0.875, η^2 = .001). This indicates that there were no differences between the scores on the nicotine and cannabis Stroop tasks in and between the two groups. See Table 6. for the mean scores on the cannabis and nicotine Stroop tasks for the two groups.

Table 6
Mean scores for control group and heavy cannabis users

	Control group (N=23)		Heavy users (N=13)		*t*(34)=	*p*
	Mean	SD	Mean	SD		
Attentional bias cannabis (sec)	0.06	2.83	-0.48	3.37	0.517	0.608
Attentional bias nicotine (sec)	0.36	3.65	-0.39	2.30	0.663	0.512
Cognitive interference (sec)	25.80	9.21	29.47	8.12	-1.198	0.239

Sec = seconds

We used correlational analysis to examine the relationship between the cannabis and nicotine Stroop task in cannabis users and the control group (hypothesis 1c.). The correlational analysis suggested that attentional bias for nicotine related words and attentional bias for cannabis related words correlated for the control group (r (23) = 0.580, p = .004) (Fig. 2), but not for the cannabis group (*r* (24) = 0.198, *p* = .353). Additional analysis without the two outliers in the cannabis group (see Fig. 3) suggested a significant correlation between the two versions of the Stroop task in the cannabis group (*r* (22) = 0.527, *p* = 0.012). This indicates that participants with a small attentional bias for cannabis words also have a small attentional bias for nicotine words, regardless of whether the participants use cannabis or not.

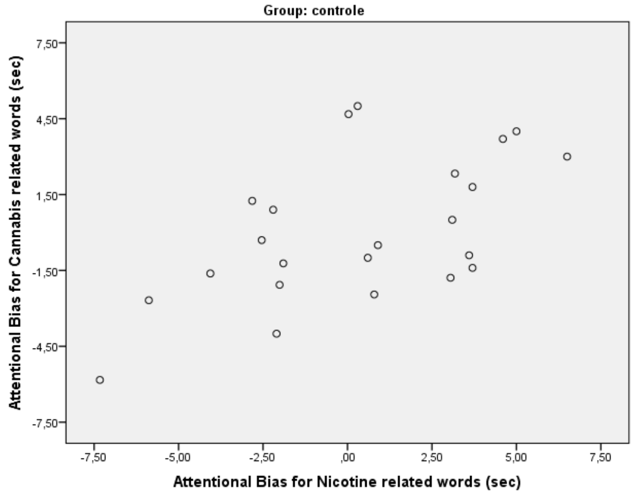

Fig. 2. Scatter plot to illustrate the correlation between the scores on the cannabis Stroop task and the nicotine Stroop task in the control group

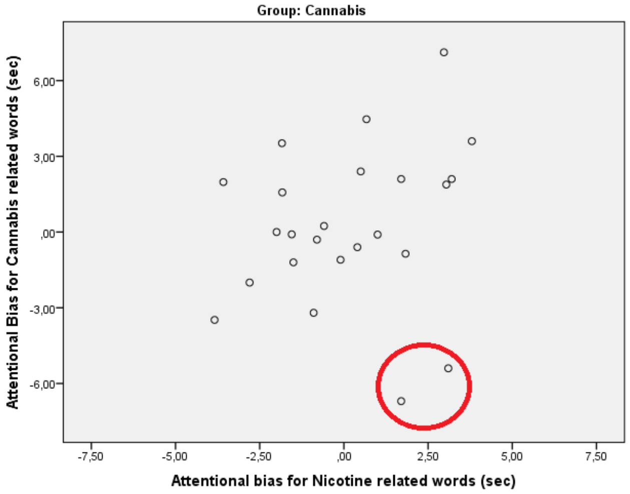

Fig. 3. Scatter plot to illustrate the correlation n between the scores on the cannabis Stroop task and the nicotine Stroop task in the cannabis group.

Relationship between cannabis attentional bias and cannabis use

To examine hypothesis 1d. '*'We expected that attentional bias for cannabis related words could be explained by cannabis use and dependence''* we used correlational analysis between attentional bias for cannabis words and cannabis use and dependence measured with the CUDIT-R (Adamson et al., 2010). There was no significant correlation between the score on the CUDIT-R and attentional bias for cannabis related words in the cannabis group (*r* (24) = -0.212, *p* = .344). This indicates that cannabis use and dependence was not related to attentional bias for cannabis related words.

Relationship between nicotine attentional bias and tobacco use

More explorative, we examined the relationship between nicotine attentional bias and nicotine dependency with correlational analysis. There was no correlation between the scores on the FTND and the attentional bias for nicotine related words in cannabis users who also smokes tobacco (*r* (12) = -0.107, *p* = 0.741). This indicates that nicotine dependency was not related to attentional bias for nicotine related words.

Relationship between cannabis attentional bias and cannabis craving

To examine hypothesis 1e. . ''*We expected that attentional bias for cannabis related words could be explained by subjective craving''* we used correlational analysis between attentional bias for cannabis words and craving in cannabis users. There was no correlation between attentional bias for cannabis words and cannabis craving before the cannabis Stroop task in cannabis users (r (23) = 0.111, p = 0.613) and after the cannabis Stroop task in cannabis users (r (23) = 0.148, p = 0.501). This indicates that there is no relation between attentional bias for cannabis words and cannabis craving before and after the cannabis Stroop task in cannabis users.

Relationship between nicotine attentional bias and nicotine craving

To examine hypothesis 1f. ‘’*We expected that attentional bias for nicotine related words could be explained by nicotine craving’’* we used correlational analysis between attentional bias for nicotine words and nicotine craving in cannabis users. There was no correlation between attentional bias for nicotine words and nicotine craving before the nicotine Stroop task (r (23) = 0.160, p = 0.466) and after the nicotine Stroop task (r (23) = 0.227, p = 0.298) in cannabis users.

A secondary analysis was used to examine the relationship between nicotine craving and nicotine attentional bias in tobacco smoking cannabis users. There was no correlation between attentional bias for nicotine words and nicotine craving before (r (12) = 0.233, p = 0.466) and after the nicotine Stroop task (r (12) = 0.414, p = 0.180) in the tobacco smoking cannabis users. This indicates that there is no relation between nicotine craving and nicotine attentional bias.

Group differences in cognitive control

The mean scores on the classical Stroop task were compared with an independent sample t-test. As seen in Table 5 the scores on the classical Stroop task did not differ between cannabis users (mean: 27.71 sec, SD: 8.42) and the control group (mean: 25.8 sec, SD: 9.21; $t(45) = 0.745$, p = .46). A secondary analysis compared the scores on the classical Stroop between heavy cannabis users and the control group. As seen in Table 6, heavy cannabis users (mean: 29.47, SD: 8.12) have no significantly higher scores on the classical Stroop task compared to the control group (mean: 25.80, SD: 9.21; $t(34) = -1.198$, p = 0.239).

Relationship between cognitive control, and cannabis attentional bias

More explorative we examined the relation between cognitive control and cannabis attentional bias. Therefore we used correlational analysis. Within the group of cannabis users the interference score on the classical Stroop task correlated negatively with attentional bias for cannabis related words (r (24) = -0.614, p = .001).

A secondary analysis was used to examine the relation between the interference score on the classical Stroop task and cannabis attentional bias in heavy cannabis users. There was a significant correlation between the interference score on the classical Stroop task and attentional bias in heavy cannabis users (r (13) = -0.651, p = 0.016) but not for light cannabis users (r (11) = -0.518, p = 0.102). This indicates that heavy cannabis users with higher cognitive interference have lower scores on attentional bias for cannabis words (Fig. 4 & 5).

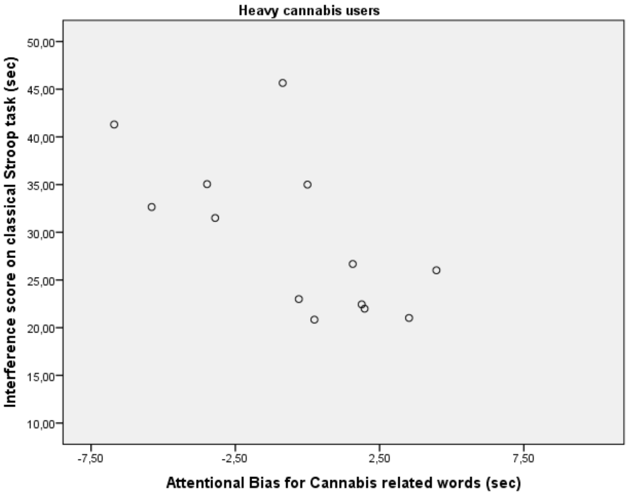

Fig. 4 Scatter plot to illustrate the correlation between the interference scores on the classical Stroop task and attentional bias scores for Heavy cannabis users.

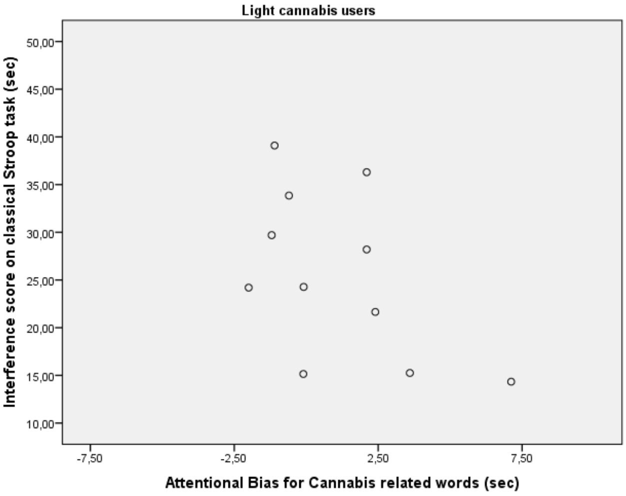

Fig. 4 Scatter plot to illustrate the correlation between the interference scores on the classical Stroop task and attentional bias scores for Light cannabis users.

Relationship between cognitive control, and nicotine attentional bias

More explorative we examined the relation between cognitive control and nicotine attentional bias. Therefore we used a correlational analysis. There was no correlation between cognitive control and nicotine attentional bias in the cannabis users (r (24) = -0.024, p = 0.911). A secondary analysis was used to examine the relation between cognitive control and attentional bias in tobacco smoking cannabis users. There was no correlation between cognitive control and attentional bias in the tobacco smoking cannabis users (r (12) = -0.72, p = 0.824).

Moderating effect of cognitive control on the relation between cannabis- and nicotine attentional bias and problematic use.

We found no correlation between attentional bias for cannabis words and cannabis use and dependence, or attentional bias for nicotine words and nicotine dependence. Therefore it is unnecessary to examine hypothesis 2. '*'We expected to find a moderating effect of cognitive control on the relation between cannabis use and dependence and cannabis attentional bias in cannabis users''* due to the absence of the relation between cannabis use and dependence and attentional bias.

Discussion

The purpose of this study was twofold. First we wanted to replicate the findings of previous studies of attentional bias for cannabis and cigarette related words. Therefore we used a Dutch modified cannabis Stroop task (Cousijn et al., 2013) to measure attentional bias in cannabis users and a matched control group. To measure attentional bias for cigarette related words in cannabis users and a matched control group, we recently developed a Dutch version of the nicotine Stroop task. Additionally we wanted to investigate the possible role of craving and drug use and dependence in attentional bias for cannabis and nicotine related words. Second, aimed to investigate if cognitive control would modulate the relation between attentional bias and drug use and dependence, as predicted by the dual-process model of addiction.

We did not find attentional bias differences between cannabis users compared with a control group and therefore we did not replicate previous findings with the cannabis-Stroop task (Cousijn et al., 2013). Besides that we found no relation between attentional bias for cannabis words and cannabis use and dependence. This is contrary to previous findings (Cousijn et al., 2013; Field, 2005). We also found no relation between cannabis craving and attentional bias for cannabis related words. This confirms the findings of previous research of Cousijn et al. (2013) but is contradictive to the findings of Field (2005). As regards the newly developed Dutch version of the nicotine Stroop task, we found a significant correlation between the cannabis and the nicotine Stroop scores. This indicates that participants with a small attentional bias for cannabis words also have a small attentional bias for nicotine words, regardless of whether the participants use cannabis or not.

We did not find attentional bias differences between cannabis users compared with a control group, and additional heavy cannabis users. Therefore we did not replicate previous findings with the nicotine Stroop task (Gross, Jarvik, & Rosenblatt, 1993; Phillips, Kavanagh, May, & Andrade, 2004 n.p.). Besides that we found no relation between attentional bias for nicotine words and nicotine use and dependence, in cannabis users compared with a control group. This is in line with a previous study (Larsen, 2014) but is contrary to the study of Phillips et al. (2004 n.p). We also found no relation between nicotine craving and attentional bias for nicotine words in cannabis users, and additional in tobacco users which was a subgroup of cannabis users. This suggests that there is no relation between nicotine craving and nicotine attentional bias. This is contradictive to the findings of Gross, Jarvik & Rosenblatt (1993) and Phillips et al., (2004 n.p.). They examined the relation of craving and attentional bias for nicotine related words and found that nicotine craving is positively related to attentional bias for nicotine related words. We found no differences in cognitive control in normal cannabis users and the control group. This is in line with previous studies with the classical Stroop task in cannabis users (Cousijn, et al., 2013; Eldreth, Matochik, Cadet, &

Bolla, 2004). Surprisingly, we found with secondary analysis a negative correlation between the interference score on the classical Stroop task and attentional bias for cannabis words in heavy cannabis users. This indicates that heavy cannabis users with higher cognitive interference, so lower cognitive control, have lower scores on attentional bias for cannabis words. These findings will be discussed in more detail below. We found no relation between the interference score on the classical Stroop task and attentional bias for nicotine words in the control group, cannabis users, heavy cannabis users and tobacco users. This is in line with previous studies (Friese, Bargas-Avila, Hofmann, & Wiers, 2010; Houben & Wiers, 2009).

We did not use a perfectly matched control group as regards the non-cannabis related variables. Researches who find attentional bias differences in cannabis users used perfectly matched control groups as regards the non-cannabis related variables (Cousijn et al., 2013; Field, 2005). We included significantly more males in our cannabis group and the cannabis users were more likely to use tobacco, compared with the control group with no tobacco users. Besides that we found marginal differences in education. A small segment of the cannabis users were more likely to have another education level rather than university, compared with the control group. The aforementioned studies did not examine the role of gender, education level, and tobacco use for attentional bias in cannabis users, but in a follow up study we recommend to use a perfectly matched control group in order to eliminate the possible effects on attentional bias.

Previous studies found a relation between cannabis dependence and attentional bias for cannabis related words. Field (2005) found only an attentional bias in cannabis users who met criteria for cannabis dependence, measured with the Severity of Dependence Scale for Cannabis (C-SDS; Swift, Copeland, & Hall,1998). This questionnaire has a sensitivity of 64% and specificity of 82% compared to the DMS-III-R. In our study we used the CUDIT-R (Adamson et al., 2010) to assess the severity of cannabis use and problematic cannabis-related behaviours. Cannabis users had a mean score of 17.27 (sd: 4.56) and heavy cannabis users had a mean score of 20.31 (sd: 3.04). Cousijn et al. (2013) used also the CUDIT-R to assess the severity of cannabis use and problematic cannabis-related behaviours. The dependent cannabis users in their study had a mean score of 15.5 on the CUDIT-R with a standard deviation of 7.9. The variation of the scores on the CUDIT-R in our present study is relative small compared with the variation in the study of Cousijn et al. (2013). Therefore it is possible that the absence of a relationship between cannabis use and dependence and attentional bias for cannabis related words in our study, is partly attributable to the relatively small variation of the CUDIT-R scores in our cannabis group. Besides that, Cousijn et al.

(2013) used the Mini International Neuropsychiatric Interview (MINI; Sheehan et al., 1998) to score criteria for DSM major Axis I psychiatric disorders, to distinguish dependent cannabis users from normal cannabis users. They found that attentional bias is stronger in dependent cannabis users compared with non-dependent cannabis users. In a follow up study we recommend to use besides the CUDIT-R (Adamson et al., 2010), also the MINI (Sheehan et al., 1998) to make sure that the cannabis users are dependent users.

In our study we found no differences in attentional bias for nicotine related words in cannabis users compared with controls and in tobacco users compared with controls. This is in line with a previous study (Larsen, 2014) but is contrary to the study of Phillips et al. (2004 n.p). In our study we only included cannabis users and controls. The group of tobacco users consisted of twelve participants and was a subgroup of the cannabis users. In a follow up study we recommend to include a tobacco group matched with a control group (abstainers) and a cannabis group, on non-cannabis and non-tobacco related demographical variables.

The FTND (Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991) was used to assess nicotine dependence. A score of 4 or greater (from a scale ranging from 0 to 10) is an indication for nicotine dependence in the participants (Agrawal et al., 2011). In our sample the tobacco group was a subgroup of the cannabis users with a mean score of 3.67 on the FTND. Only six participants had a score of 4 or more. Due to a shortage of tobacco users we used all the tobacco users, including the tobacco users without the indication of nicotine dependence. It is possible that the lack of nicotine dependence in the tobacco users suppressed the attentional bias for nicotine related words in tobacco users. This is in line with the results of the examination of drug dependence in cannabis users and cannabis attentional bias (Field, 2005; Cousijn et al., 2013). It is not clear whether nicotine dependence has an effect on attentional bias, and therefore further examination of the possible role of nicotine dependence is required.

As mentioned above, the lack of attentional bias differences for nicotine words could be explained by the lack of a matched tobacco group and therefore the lack of enough participants with nicotine dependence. Besides that, there is evidence for the role of nicotine abstinence in tobacco users (Phillips, Kavanagh, May, & Andrade, 2004 n.p). Gross, Jarvik, & Rosenblatt (1993) found that abstinent smokers had an attentional bias for cigarette related words compared to non-abstinent smokers. Surprisingly, non-abstinent smokers showed a significant difference in the opposite direction. They had longer response times for the neutral words compared with the cigarette related words. In our study we did not measure carbon monoxide (CO) levels to verify abstinence of tobacco use in the participants who smoke tobacco. Expired carbon monoxide (CO) levels can be measured using a handheld breathalyzer. In a follow up study we can apply the method to measure the expired carbon monoxide (CO) levels, to verify the reported tobacco abstinence (Powell, Tait, & Lessiter, 2001).

Furthermore one of the aims of this study was to develop a Dutch version of the nicotine Stroop task to examine attentional bias for nicotine related words. We found a positive correlation between the scores on the cannabis and nicotine Stroop tasks. This suggests that participants with a small attentional bias for cannabis words have also a small attentional bias for nicotine related words, regardless of whether the participants use cannabis or not. It is conceivable that participants who use both tobacco and cannabis show a different relationship between attentional bias for nicotine and cannabis words, compared with abstainers or participants who only use cannabis. However, this study was unable to demonstrate differences in the relationship between attentional bias for cannabis and nicotine related words. The absence of group differences in the attentional bias scores can be a possible explanation for the lack of these differences in the correlational analysis.

To get an indication of the attentional bias for cannabis and nicotine words, we used a neutral word subtask related to office stationary. Each list of words (cannabis, nicotine, and neutral list) consisted of 14 words and were al matched for length, number of syllables and word frequency (see Table 1). In hindsight, we found some semantic similarities in the nicotine words compared with the cannabis words (list of Dutch nicotine words with semantic similarities compared with cannabis words: vuurtje, opsteken, tabak, shag, trekje). The order of the three lists was counterbalanced across participants to control for order effects. Because of the semantic similarities in the nicotine word card, it is possible that the nicotine word card can provide a small carry-over effect. However, carry-over effects are less likely to appear if the substance-related words are presented in a discrete block separated from the neutral words, which in this study was the case (Cox, Fadardi, & Pothos, 2006). In a follow up study we have to enhance the nicotine Stroop task and examine the validity and reliability of the task in a group of tobacco users. In addition we should ask a representative sample of tobacco users to ascertain the list of nicotine words for saliency and familiarity.

We found no relation between attentional bias for cannabis words and cannabis craving, and attentional bias for nicotine words and nicotine craving. This is in line with the results of Cousijn et al. (2013) but contradictory to the results of Field et al. (2005; 2013). To examine craving, we used a single-item Visual Analogue Scale (VAS). Single-item scales may have limited reliability compared with multiple-items scales. Besides that, asking about the urge to use cannabis or tobacco may mean different things to different individuals (Sayette et al., 2000). In a follow up study we recommend to use a multiple item scale to examine the subjective craving, such as the Marijuana Craving Questionnaire (MCQ; Heishman, Singleton, & Liguori, 2001) which is used in other studies (Cousijn et al., 2013; Field, 2005).

We found no differences in cognitive control in cannabis users and the control group. This is in line with previous studies with the classical Stroop task in cannabis users (Cousijn, et al., 2013; Eldreth, Matochik, Cadet, & Bolla, 2004). We found also no relation between the interference score on the classical Stroop task and attentional bias for nicotine words in cannabis users and additional in tobacco users. This is in line with previous studies (Friese, Bargas-Avila, Hofmann, & Wiers, 2010; Houben & Wiers, 2009). Surprisingly, we found with secondary analysis a negative correlation between the interference score on the classical Stroop task and attentional bias for cannabis words in heavy cannabis users. This indicates that heavy cannabis users with higher cognitive interference, so lower cognitive control, have lower scores on attentional bias for cannabis words. This is contradictive to the dual-process model of addiction (Stacy & Wiers, 2010). We expected to find a relation between attentional bias for cannabis words and cannabis use and dependence, with a moderating effect of cognitive control. We could not find other studies with a negative relation between attentional bias for cannabis words and cognitive control. Lansebergen, Kenemans, & Engeland (2007) suggest that the applied quantification method to score the interference score (the difference score quantification method) on the classical Stroop task, is problematic. They prefer a ratio score to estimate the interference score on the classical Stroop task. A general slowing of speed of word reading and color naming can for instance bias the interference estimate, when using the difference score quantification method. For instance, individuals who are relatively slow in color naming have more problems with the ability to suppress the word reading, resulting in an overestimation of the interference level on the classical Stroop task. In the addiction Stroop task this problem does not exist (addiction Stroop task - neutral Stroop task = attentional bias). The neutral Stroop task corrects the slow color naming, resulting in high interference scores on the classical Stroop task, but a low attentional bias (Lansebergen, Kenemans, & Engeland, 2007). Still this does not explain why heavy cannabis users show a negative relation between attentional bias for cannabis words and cognitive control, but light cannabis users not. To better understand the possible moderating effect of cognitive control of the relation between attentional bias and substance use and dependence, more research is needed.

Conclusion

The present study did not find attentional bias differences for cannabis words between cannabis users and a control group. We developed a nicotine Stroop task to examine attentional bias differences for nicotine related words in the aforementioned groups, and additional in a small group of tobacco users. We did not find attentional bias differences for nicotine related words between the groups. In addition, we did not find a relation between attentional bias for cannabis related words and cannabis use and dependence. Similarly, we did not found a relation between attentional bias for nicotine related words and nicotine dependence. The lack of attentional bias differences may be partly due to the lack of a perfectly matched control group. Besides that we did not use a group with tobacco users to examine the efficacy of the newly developed nicotine Stroop task. Future studies should use a perfectly matched control- and tobacco group to find possible effects of attentional bias for cannabis related words and nicotine related words. Further research is needed to clearly understand the negative relation between cognitive control and attentional bias for cannabis related words in heavy cannabis users.

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