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Cannabis use, cognitive functioning and behaviour problems

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Quality of social perception moderates associations between cannabis use and psychological problems

Huijbregts, S.C.J., Griffith- Lendering, M.F.H., Vollebergh, W.A.M., & Swaab, H. Quality of social perception moderates associations between cannabis use and psychological problems. *Manuscript submitted for publication.*

Abstract

Objective: Genetically and/or environmentally determined risk dispositions might increase vulnerability of cannabis users to experience psychological problems. Such risk dispositions may be expressed as (specific) cognitive weaknesses. The present study examined whether relatively poor social perception skills in combination with cannabis use would result in higher levels of psychological problems.

Method: Cannabis users (N = 75, mean age 24.6 years) were compared to non-users (N = 75, mean age 24.7 years) with respect to performance on two social perception tasks (Face Recognition (FR) and Matching Facial Emotions (MFE), which can be distinguished from FR because it requires emotion recognition and greater working memory capacity) and the extent of self-reported psychological problems. Analyses of (co-) variance were used to determine whether quality of social perception mediated or moderated possible associations between cannabis use and psychological problems.

Results: Cannabis users performed significantly more poorly than controls on the two social perception tasks, and reported more psychological problems than non-users. Quality of social perception moderated associations between cannabis use and psychological problems in that only users with relatively poor performance on the MFE reported elevated levels of psychological problems (i.e. insufficiency of thoughts and actions, distrust, depression, and psychoneuroticism). Further specification of the user group showed that the moderation effect could be attributed to heavy cannabis users versus moderate- and non-users. No interactions were found between cannabis use and FR-performance.

Conclusion: Heavy cannabis use and relatively poor (complex) social perception skills exacerbate each other's effects on psychological well-being.

Introduction

Cannabis is the most widely used substance after tobacco and alcohol in Western countries, with a particularly high prevalence among adolescents and young adults (European Monitoring Centre for Drugs and Drug Addiction, 2009; Substance Abuse and Mental Health Services Administration, 2008). Cannabis use has been associated with poor psychosocial adjustment (Fergusson & Boden, 2008; Fergusson et al., 2002; Griffith-Lendering et al., 2011a) and different (sometimes subclinical) forms of psychopathology, such as psychosis (Arseneault et al., 2002; Degenhardt et al., 2003a; Griffith-Lendering et al., in press; Moore et al., 2007), antisocial behaviour (Fergusson et al., 2007; Griffith-Lendering et al., 2011b; Monshouwer et al., 2006; Rey et al., 2002) and depression (Degenhardt et al., 2003b; Fergusson & Boden, 2008; Patton et al., 2002; Rey et al., 2002). In addition, reduced educational achievement (Lynskey & Hall, 2000) and cognitive difficulties have been reported. Domains of cognitive impairment include executive function (EF), implicit cognition, episodic memory, and emotional processing (Pope et al., 2001; Solowij, 1998; Solowij et al., 2002; Stacy & Wiers, 2010; Verdejo-Garcia et al., 2008). Many of these difficulties have been observed among users of other drugs as well (Fernández-Serrano et al., 2011). Moreover, there are quite some discrepancies among reported findings (see, for example, Fisk & Montgomery, 2008; Pope et al., 2001), which can, in part, be attributed to methodological differences between studies. One of these methodological issues concerns the definition or operationalization of broad cognitive concepts such as executive function and emotional processing. Core EF-abilities include inhibitory control and working memory, which are multi-faceted concepts themselves (cf. Christ et al., 2010; D'Esposito et al., 1999; Nigg, 2000). Core aspects of emotional processing include social perception (e.g. emotion recognition), Theory of Mind (i.e. the ability to "mentalize"), empathy, and reward/punishment sensitivity (Adolphs, 2002; Beer et al., 2004; Dodge & Rabiner, 2004; Ochsner, 2008; Pettit and Mize, 2007). Studies have often used task paradigms addressing combinations of different (social-) cognitive skills. Examples include decision-making and implicit cognition tasks, which require working memory, and cognitive and motivational inhibitory control (Busemeyer & Stout, 2002; Stacy & Wiers, 2010; Whitlow et al., 2004). Aspects of cognition for which it is more difficult to consider them as constellations of other cognitive constructs and that appear to be impaired in cannabis users are prospective memory and motivational inhibitory control (Griffith-Lendering et al., 2012; Solowij et al., 2002). A

further consistent finding is a slower processing and/or motor speed among cannabis users (Kelleher et al., 2004).

In the present study we focused on social perception, which constitutes a basic element of social information processing (Dodge & Rabiner, 2004) and has not yet been extensively investigated among cannabis users. Social perception tasks may or may not involve emotion recognition. The amygdalae play an important role in emotion recognition (Adolphs, 2002; Ochsner, 2008). Among long-term cannabis users reduced amygdala volumes have been observed (Yucel et al., 2008). Also, Phan et al. (2008) reported reduced amygdala reactivity during social information processing after administration of delta-9-tetra-hydrocannabinol (Δ^9 -THC), the principle constituent of cannabis inducing positive emotional states as well as anxiety and psychosis-like symptoms (D'Souza et al., 2004). Gruber et al. (2009) showed reduced amygdala activity during emotion perception in chronic cannabis users. Although these studies yielded relatively consistent results, thereby using stimuli that required the ability to recognize emotions from facial expressions, they did not focus on the quality of emotion recognition. Only one recent study, by Platt and colleagues (2010), did focus on performance during an emotion recognition task. Cannabis users were significantly slower than controls at identifying emotional expressions in a paradigm where facial expressions gradually changed from neutral to more intense expressions of sadness, anger or happiness. Although the authors discussed the possible implications of their findings for vulnerability to psychological problems in cannabis users, they did not investigate this further. We sought to extend the research by Platt and colleagues by examining social perception in relation to psychological problems among cannabis users. With respect to type of psychological problems, we focused on subclinical levels of psychosis/schizophrenia, and internalizing and externalizing behaviour problems, all of which have been related both to cannabis use (Arseneault et al., 2002; Degenhardt et al., 2003a; Fergusson et al., 2002; Moore et al., 2007) and to social perception impairments (Demenescu et al., 2010; Germine & Hooker, 2011, Kohler et al., 2010; Marsh & Blair, 2008; Rössler et al., 2011). Interrelations between psychological problems and cognitive weaknesses in cannabis users have not yet been clearly established. Moreover, it is unclear whether cannabis users with cognitive difficulties are more prone to (experiencing) psychological problems than cannabis users without such difficulties. We hypothesized that cannabis users would perform more poorly than non-users on face recognition- and matching emotions from facial expressions-tasks, and would report more psychological problems. It was also hypothesized that relatively poor social perception

skills and cannabis use would disproportionately increase the chances of experiencing psychological problems.

Method

Participants

Participants were classified as cannabis users if they reported using cannabis every month during the past year and as non-users if they reported the use of cannabis zero times during the past year. Based on these criteria, 75 cannabis users (mean age: 24.6, SD=3.7, with an abstinence period of at least 24 hours) and 75 non-users (mean age: 24.7, SD=3.7) were recruited among University of Leiden undergraduate students and through advertisements on internet forums concerning cannabis topics. Written informed consent was obtained from all participants before the start of the study. Ethical approval for this study was granted by Leiden University's Education and Child Studies Ethics Committee.

Measures

Cannabis use

Cannabis use was assessed by asking participants about their lifetime use, their use during the past year and month (yes/no, plus frequency of use). Participants also reported on the use of alcohol (weekly yes/no), tobacco (daily yes/no) and other drugs including stimulants (cocaine, (met)amphetamine), opioids (heroin, methadone), and 3,4-methylenedioxymethamphetamine (MDMA: Ecstasy) (monthly: yes/no) (cf. Griffiths-Lendering et al., 2012; Huizink et al., 2006; Monshouwer et al., 2006) (Table 1).

Psychological problems

The Symptom Checklist-90 (SCL-90) (Derogatis, 1973; Elliot et al., 2006), a 90-item self-report symptom inventory developed to measure psychological symptoms and distress, was used to measure psychological problems. It was designed to be appropriate for use not only in clinical populations but also for use within community samples. The SCL-90, for which items are rated on five-point scales reflecting the extent to which problems were experienced in the past 7 days, generates the following scales: Somatic complaints (12 items), Insufficiency of thoughts and actions (9 items), Distrust (18 items), Depression (16 items), Anxiety (10 items), Hostility (6 items), Agoraphobia (6 items) and Sleeping problems (3 items). In addition, a global score is obtained, called Psychoneuroticism, using the overall

score of the 90 items. Internal reliability of the different scales ranges from .77-.97 (Cronbach's alpha).

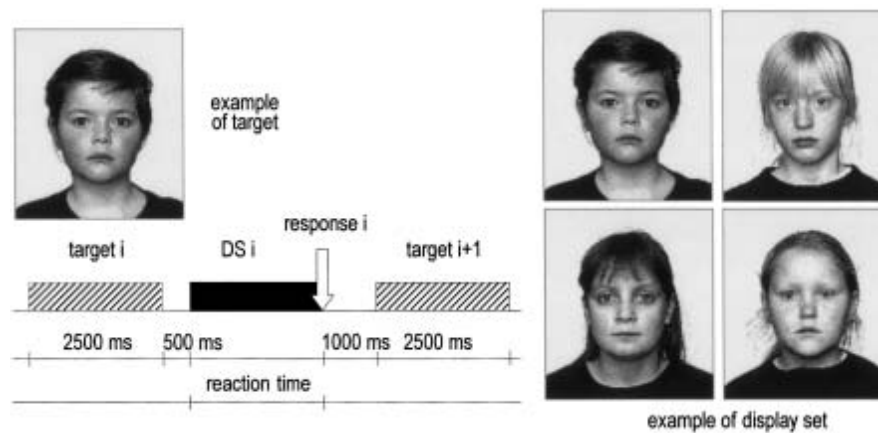
Social perception

Two tasks from the Amsterdam Neuropsychological Tasks (ANT, De Sonneville, 1999), a battery of computerized tests, were used to assess social perception. Test-retest reliability, construct-, criterion-, and discriminant validity of the ANT-tasks are satisfactory and have extensively been described elsewhere (e.g. De Sonneville et al., 2002; Serra et al., 2003; Huijbregts et al., 2010). Before each part of a task the participants were given a standard verbal instruction and were given the opportunity to ask questions and to practice.

Face Recognition (FR)

This task (duration: 5 minutes) examined the ability to recognize neutral faces. A target-face was presented on the monitor for 2.5s. Following the presentation of the target face, a set of four photographs of individuals was presented and participants had to indicate whether or not the target individual appeared in the set of four (Figure 1). The gender and age category of the target (i.e. boys, girls, men or women) match those of the subsequently shown set of four faces. A yes-response was given by pressing the mouse button below the index finger of the preferred hand; a no-response required a press of the mouse button below the index finger of the non-preferred hand. There were 40 trials, in half of which the display set contained the target face.

Figure 1. Stimulus example (target face + display set) and timing of the trials for the Face Recognition task



Matching of Facial Emotions (MFE)

This task (duration: 10 minutes) measured the ability to match emotions using facial expressions. The expressed emotions are happiness, sadness, anger and fear. In each of the 160 trials, two (digitized photographs of) faces expressing a particular emotion were presented simultaneously on the computer screen. The participants had to press the yes-button when the two faces expressed the same emotion and the no-button when the facial emotions did not match (Figure 2). MFE may be considered a more demanding task than FR. The tasks can also be distinguished based on the fact that MFE specifically involves emotion recognition, whereas FR does not.

Figure 2. Stimulus examples for the Matching Facial Emotions task



Data analysis

First, Pearson correlations were calculated to get an impression of which psychological problems were associated with cannabis use (lifetime, past year and month).

Next, group differences between cannabis users and non-users regarding psychological problems and performance on the social perception tasks were investigated using General Linear Model (GLM) univariate and multivariate analyses of variance. Accuracy and speed of task performance were first analyzed separately. In order to account for potentially slower processing speed among cannabis users and to account for possible speed-accuracy trade-offs, ratio variables (i.e. number correct/mean RT for correct responses) were calculated and used as dependent variables in further analyses of task performance. In order to investigate the role of social perception in potential differences between cannabis users and non-users regarding psychological problems, participants were assigned to groups with either relatively poor or relatively good social perception (based on mean RT-corrected accuracy scores during the tasks). Next, two-way (multivariate) analyses were performed with cannabis use and social perception as between-subjects factors and the scales of the SCL-90 as dependent variables. Separate analyses were performed for social perception operationalized as Face Recognition and Matching Facial Emotions. Control variables (gender and other substance use) were included in the analyses as covariates when they were related to both dependent and independent variables.

In order to get an impression of possible dose-dependency, the two-way multivariate analyses of variance were repeated comparing non-users to relatively moderate users (<40 times in the past year) and relatively heavy users (≥ 40 times in the past year).

Results

Lifetime cannabis use correlated significantly with SCL-90 dimensions insufficiency of thoughts and actions ($r = .19$, $p = .012$), depression ($r = .17$, $p = .025$), anxiety ($r = .21$, $p = .006$), hostility ($r = .24$, $p = .002$), and the overall psychoneuroticism score ($r = .21$, $p = .007$), with a trend for the correlation with distrust ($r = .13$, $p = .067$). Cannabis use in the last 12 months was significantly correlated with insufficiency of thoughts and actions ($r = .18$, $p = .014$), distrust ($r = .17$, $p = .023$), and hostility ($r = .21$, $p = .006$), with trends for the correlations with psychoneuroticism ($r = .14$, $p = .051$) and

anxiety ($r = .13$, $p = .060$). Similar correlations were observed for cannabis use in the last four weeks and SCL-90 dimensions (insufficiency of thoughts and actions: $r = .14$, $p = .047$; distrust: $r = .18$, $p = .019$; hostility $r = .20$, $p = .007$; and psychoneuroticism $r = .12$, $p = .078$). For the other dimensions of the SCL-90, somatic complaints, agoraphobia, and sleep problems, no significant correlations with any of the cannabis measures were observed. Therefore, these were dropped from further analyses.

Group comparisons

Error rates on both the FR- and the MFE tasks were significantly higher for cannabis users compared to non-users [FR: $F(1,148) = 18.0$, $p < .001$, partial $\eta^2 = .11$; MFE: $F(1,148) = 10.8$, $p = .001$, partial $\eta^2 = .07$]. Cannabis users were also significantly slower than non-users in the MFE-task [$F(1,148) = 5.9$, $p = .017$, partial $\eta^2 = .04$], but there was no significant difference in response speed for the FR-task [$F(1,148) = 1.2$, $p = .28$, partial $\eta^2 = .01$]. Significant group differences regarding both speed and accuracy in the MFE-task were present for pairings involving matches of all four different emotions, i.e. happiness, sadness, anger and fear (see Table 2 for descriptive statistics on task performance and psychological problem ratings). In order to incorporate in further analyses the fact that cannabis users performed less accurately and more slowly than non-users in the MFE-task, and in order to take into account the possibility of speed-accuracy trade-off in the FR-task, ratio-variables (number correct/mean RT for correct responses) were used. A MANOVA comparing users and non-users on the FR- and MFE ratio-scores showed a significant multivariate group effect [$F(2,147) = 5.4$, $p = .006$, partial $\eta^2 = .07$], with significant univariate effects for both tasks: FR: $F(1,148) = 4.0$, $p = .047$, partial $\eta^2 = .03$; MFE: $F(1,148) = 10.7$, $p = .001$, partial $\eta^2 = .07$, indicating poorer performance of cannabis users. Cannabis users differed from non-users with respect to gender distribution (relatively more men among cannabis users) (Table 1), and women performed better on the social perception tasks (FR: $t(146) = -1.9$, $p = .06$; MFE: $t(146) = -2.7$, $p = .008$). However, entering gender as a covariate in the above analyses did not affect the group differences on social perception between cannabis users and non-users

With respect to behavior problems significant differences between users and non-users were observed for insufficiency of thoughts and actions [$F(1,132) = 4.1$, $p = .044$, partial $\eta^2 = .03$] and hostility [$F(1,132) = 6.0$, $p = .016$, partial $\eta^2 = .04$], with

further trends for anxiety [$F(1,132) = 3.3$, $p = .070$, partial $\eta^2 = .03$] and psychoneuroticism [$F(1,132) = 3.5$, $p = .065$, partial $\eta^2 = .03$]. All results indicated higher scores for cannabis users; these were also observed for distrust and depression, although here the group differences were not significant (Table 2).

When FR- or MFE-scores were introduced to these analyses as covariates in order to examine possible mediation effects, the only difference between cannabis users and non-users that was significantly reduced was that for insufficiency of thoughts and actions when the MFE-score was controlled for [$F(1, 131) = 2.5$, $p = .12$, partial $\eta^2 = .02$].

Table 1. Descriptive information on cannabis users ($n=75$) and non-users ($n=75$)

	Users	Non-users	$t / \div^2$
Age (Mean, SD)	24.7 (3.7)	24.6 (3.7)	$t(148) = 0.0$
Male	66.7 %	30.7 %	$\div^2 (1) = 21.2^{**}$
Daily smokers	41.3 %	9.3 %	$\div^2 (1) = 20.3^{**}$
Weekly alcohol	92.0 %	76.0 %	$\div^2 (1) = 7.1^*$
Monthly MDMA	14.7%	5.3%	$\div^2 (1) = 3.6^+$
Monthly cocaine	4.0%	1.3%	$\div^2 (1) = 1.0$

** $p < .01$; * $p < .05$; + $p < .10$

Table 2. Means error rates and RTs (SD's) of cannabis user and non-user groups on the social perception tasks and mean scores on the Symptom Checklist-90

		<i>Non-users</i> (<i>n</i> = 75)	<i>Moderate users</i> (<i>n</i> = 41)	<i>Heavy users</i> (<i>n</i> = 34)
Face Recognition	ER	1.6 (1.2)	2.9 (2.2)	2.7 (2.0)
	RT	1281 (259)	1310 (303)	1341 (237)
MFE Happiness	ER	0.9 (0.7)	1.2 (1.6)	1.7 (1.9)
	RT	1194 (240)	1310 (334)	1278 (266)
MFE Sadness	ER	6.4 (3.9)	8.7 (5.1)	9.1 (4.0)
	RT	1819 (383)	1986 (490)	1971 (373)
MFE Anger	ER	5.5 (4.0)	6.4 (5.3)	7.8 (4.4)
	RT	1778 (382)	1904 (422)	1908 (350)
MFE Fear	ER	4.9 (3.5)	5.9 (4.3)	8.1 (4.5)
	RT	1797 (398)	1959 (494)	1944 (338)
Somatic complaints		15.7 (3.6)	16.5 (5.5)	15.2 (3.0)
Insuff. thoughts and actions		12.3 (3.5)	13.1 (4.3)	14.5 (4.5)
Distrust		22.3 (5.0)	22.1 (4.3)	25.7 (8.0)
Depression		20.6 (5.3)	22.4 (7.6)	22.4 (7.3)
Anxiety		11.9 (3.0)	13.1 (5.3)	13.2 (3.1)
Hostility		7.0 (1.3)	7.6 (3.0)	8.6 (3.8)
Agoraphobia		7.4 (1.2)	7.4 (1.7)	7.6 (1.1)
Sleep problems		4.6 (2.4)	4.6 (2.1)	4.2 (1.3)
Psychoneuroticism		112.1 (21.6)	118.1 (29.0)	122.8 (27.8)

Moderate users: reported use of cannabis < 40 times/past year; Heavy users: reported use of cannabis ≥ 40 times/past year. MFE: Matching Facial Emotions. ER: Error Rate. RT: Reaction Time (msec).

Moderation effects

When groups with relatively poor and relatively good social perception were formed (split at mean for FR- and MFE-ratio scores) and introduced to the analyses as a second independent variable (next to cannabis use) some clear moderation effects emerged for performance of the MFE-task. Significant interactions between cannabis use and MFE-performance were observed for insufficiency of thoughts and actions [$F(1,130) = 5.6$, $p = .019$, partial $\eta^2 = .04$], distrust [$F(1,130) = 4.0$, $p = .048$, partial $\eta^2 = .03$], depression [$F(1,130) = 4.5$, $p = .036$, partial $\eta^2 = .03$], and psychoneuroticism [$F(1,130) = 5.0$, $p = .027$, partial $\eta^2 = .04$]. These moderation effects indicated that psychological problems of cannabis users were evident among those who also performed relatively poorly on the MFE-task (see Figure 3a-d). Cannabis users did not differ from non-users when they performed relatively well on this task (see Table 3 for results of contrast analysis). Similar, but non-significant patterns were observed for anxiety and hostility.

In analyses where cannabis use was further subdivided into relatively moderate (<40 times in the past year) and relatively heavy use (≥ 40 times in the past year), significant interactions were again observed for insufficiency of thoughts and actions [$F(2,128) = 4.2$, $p = .017$, partial $\eta^2 = .06$], distrust [$F(2,128) = 3.4$, $p = .018$, partial $\eta^2 = .06$], and psychoneuroticism [$F(2,128) = 3.4$, $p = .037$, partial $\eta^2 = .05$], with a trend for depression [$F(2,131) = 2.7$, $p = .07$, partial $\eta^2 = .04$] (see Figure 4a-d). These interactions indicated that psychological problems were particularly observed for heavy cannabis users with relatively poor social perception as measured by the MFE.

Cannabis users and non users differed with respect to gender distribution, and they also used tobacco, alcohol, and MDMA more often than non-users (Table 1). None of these factors were significantly associated with psychological problems. Adding them as covariates did not affect the interactions between cannabis use and MFE-performance predicting psychological problems. No significant interactions were observed between cannabis use and FR-performance when predicting psychological problems.

Table 3. Helmert contrasts for psychological problems

	Contrast Estimate (SE), Sig.							
	<i>Insufficiency of thoughts and actions</i>		<i>Distrust</i>		<i>Depression</i>		<i>Psychoneuroticism</i>	
Level 1 vs. later	.553 .002**	(.18),	.424 (.18),	.019*	.484 .008**	(.18),	.501 (.19),	.008**
Level 2 vs. later	-.007 (.22),	.976	.071 (.22),	.750	-.001 (.22),	.995	.072 (.23),	.751
Level 3 vs. Level 4	-.261 (.23),	.260	-.418 (.24),	.078	-.214 (.23),	.356	-.316 (.24),	.189

* $p < .05$; ** $p < .01$

Level 1: Cannabis use + poor social perception; Level 2: Cannabis use + good social perception;

Level 3: No use + poor social perception; Level 4: No use + good social perception

Figure 3. Moderating effects of social perception quality (MFE-performance) on associations between cannabis use and psychological problems

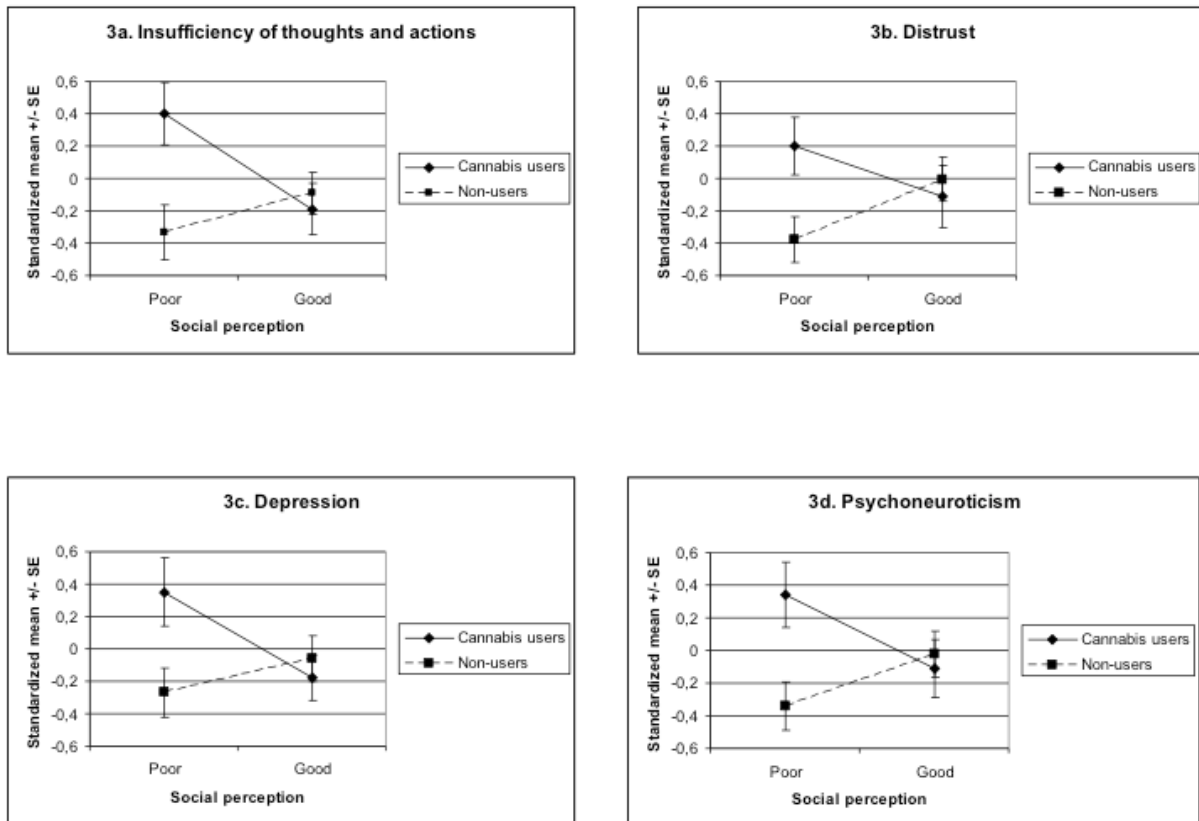
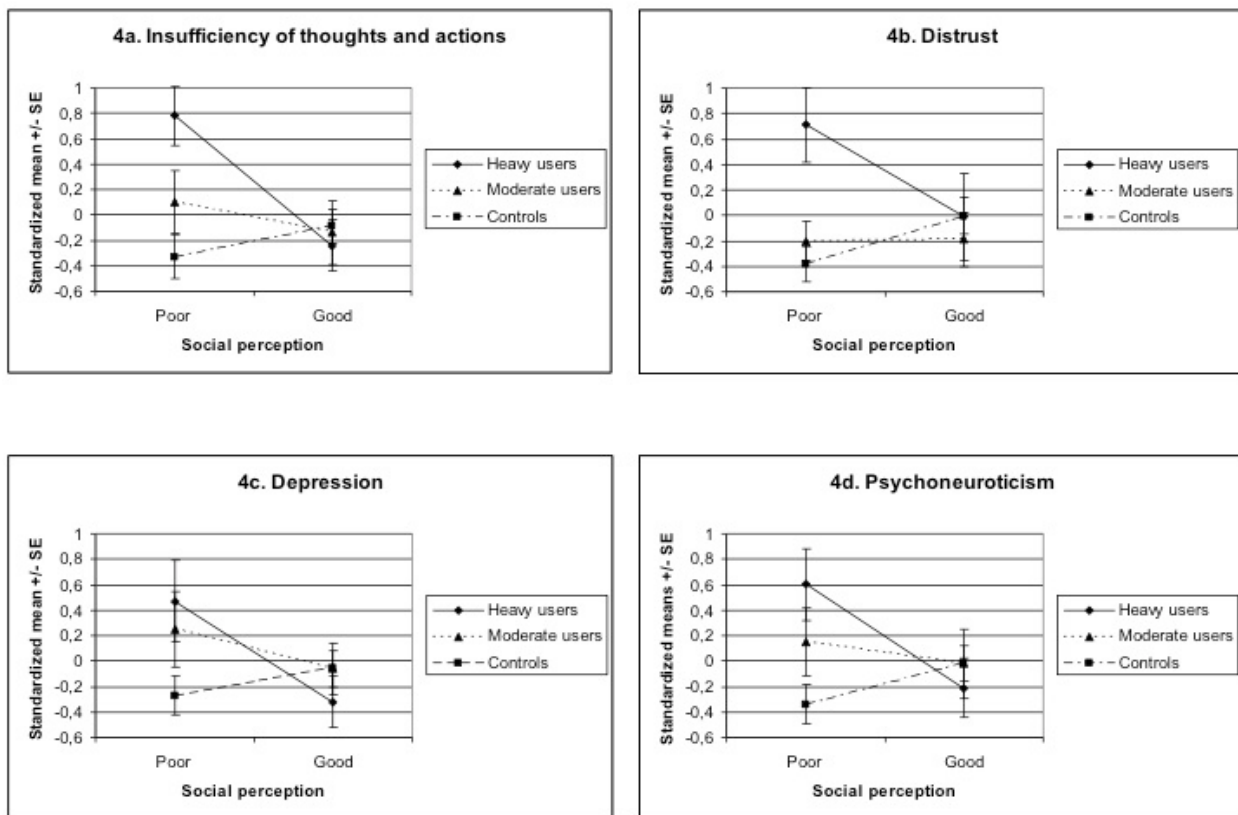


Figure 4. Exposure-dependent moderating effects of social perception quality on associations between cannabis use and psychological problems



Discussion

The results of this study show that compared to non-users, cannabis users reported more insufficiency of thoughts and actions, hostility, anxiety and psychoneuroticism. Furthermore, cannabis users performed more poorly than non-users on the social perception tasks, with the greatest differences observed for the matching emotions task. Another important question was whether quality of social perception would mediate or moderate associations between cannabis use and psychological problems. Whereas there was little evidence supporting mediation effects (except for insufficiency of thoughts and actions), the moderation hypothesis was confirmed by the finding of interactions between cannabis use and performance on the Matching Facial Emotions-task in predicting insufficiency of thoughts and actions, distrust, depression, and psychoneuroticism. Cannabis users who performed relatively poorly on that task had the most pronounced psychological problems. Cannabis users with relatively good performance on the task did not report elevated levels of psychological problems compared to non-using controls. It is important to note that no such interactions were observed when the Face Recognition-task was

used to measure social perception. Thus, the moderating effects are only apparent when the social perception task is either more demanding (for example, because of the requirement of additional cognitive skills in order to perform the task) or when it specifically involves the perception of emotional expressions. It should also be noted that it is not entirely clear yet whether these results are specific to cannabis use. Group differences and interactions were not affected by introducing other substance use or gender as covariates to the analyses. However, in order to measure other substance use dichotomous measures were used and, even though cannabis users more often reported the use of other substances as well, other substance use did not predict the type of psychological problems measured here. More continuous variables incorporating dosage or frequency of use, as selected to measure cannabis use, may be preferable for other substances as well (cf. Fernandez-Serrano et al., 2010). The associations between cannabis use and psychosis/schizophrenia-type (subclinical) psychological problems appears to concur with results from earlier studies (Arseneault et al., 2002; Degenhardt et al., 2003a; Moore et al., 2007; Rössler et al., 2011), although one should be careful in categorizing hostility and anxiety/depression as part of the spectrum of psychosis-/schizophrenia-type problems. They could represent independent psychological problems as well.

Whereas this study does not cover directionality of effects, relatively strong evidence exists indicating that cannabis use precedes or increases the risk of psychosis/schizophrenia-type problems (possibly on top of the so-called self-medication effects where increased vulnerability to develop psychosis is “soothed” with substance use) (Casadio et al., 2011). It is however clear that only a minority of cannabis users develop actual psychosis, and there is an intensive search under way for factors that might compound the effects of psycho-active cannabis ingredients in this respect. Most attention has been given to genetic factors enforcing susceptibility towards development of psychosis (Caspi et al., 2008; Henquet et al., 2008). Although inevitably influenced by genetic and environmental factors as well, specific cognitive weaknesses may, in combination with cannabis exposure, also increase chances of developing psychosis. This is what the present study suggests for social perception (as measured by the MFE), although it may be argued that better instruments could be available for detecting psychosis, also at a subclinical level in generally healthy populations (e.g., the Community Assessment of Psychic Experiences – CAPE, Stefanis et al., 2002; or the Symptom Checklist-90-R, Olsen et al., 2004; Rössler et al., 2011) and that a wider range of instruments should be used to cover (and clearly distinguish) all possible (combinations of) (social-)cognitive abilities where relative weakness could increase mental health effects of cannabis use. This view is supported by neurophysiological data: whereas a relatively singular pathway from cannabis to psychosis has been proposed, in which excessive Δ^9 -THC- stimulation of cannabinoid (CB₁-) receptors on GABAergic and

glutamatergic terminals causes disruptions in dopaminergic projections from the brain stem to the striatum (Morrison & Murray, 2009), there are relatively high concentrations of CB₁-receptors throughout the prefrontal and anterior cingulate cortices (Casadio et al., 2011; Yacubian and Büchel, 2009). This, in turn, would suggest more widespread (social-)cognitive abnormalities that might increase the risk of experiencing psychological problems following heavy and prolonged cannabis use.

When these issues are further resolved, a clinical implication of our findings could be that social perception will be targeted in programs aimed at reducing the risk of psychopathology following cannabis use and possibly even in programs aimed at the prevention or treatment of addiction. Whereas more evidence is required to confirm a role for social perception in addiction progression, our findings do indicate more serious social perception deficits among heavier, and thus more likely to be addicted users. Recreational cannabis users and addicted substance users appear to have different cognitive outcomes (Everitt et al., 2008; Kalivas & Volkow, 2005; Stacy & Wiers, 2010). Whereas this has particularly been investigated with respect to inhibitory control (indicating more comprehensive inhibitory control deficits for addicted substance users), similar distinctions may be present for other aspects of cognition as well.

In conclusion, it may be stated that this study has provided evidence showing that cannabis users have problems with social perception in comparison to non-using controls, particularly when these social perception skills involve emotion recognition and need to be used in combination with other (e.g. working memory) skills. Moreover, heavy cannabis users experience significantly more psychological problems when they have relatively poor social perception skills.

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