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Research Article

Association between Cannabis use, Depression and Apathy: A Study of an Internet Community Sample of Young Adults

Abstract

The trait of amotivation is commonly clinically described among chronic cannabis abusers but few empirical studies have provided data on this dimension. Thus, our objective was to determine to what extent apathy, evaluated in a multidimensional approach, is associated with cannabis use and misuse in a community sample of young adults. 677 participants with a mean age of 20.5 years completed several web-formatted self-reports including the Lille Apathy Rating Scale (LARS) adapted to a self-report format (LARS-SR) and the 13-item Beck Depression Inventory (BDI-13). Participants were asked about their use of cannabis and, if appropriate, the Cannabis Abuse Screening Test (CAST) was completed. The problematic CU according to the CAST presented higher scores on the LARS-SR total score, LARS-SR subscales "intellectual curiosity", "emotion", and "action initiation" and the BDI-13 in comparison with non-problematic users. Regression analyses revealed that both apathy and depression were significant predictors of the CAST categories (non-symptomatic vs. moderate/severe). Despite some limitations, our study about the impairment of motivational functioning provides some new insight into the clinical implications of problematic patterns of cannabis use. Indeed, apathy was associated with both cannabis use and more severe patterns of cannabis use as evaluated with the CAST. The use of a scale investigating apathy as a multidimensional construct reveals that only some apathy dimensions seem involved in cannabis misuse independently of depression.

Introduction

Today, the use of illicit substances among adolescents and young adults is a major public health concern. Cannabis is the illegal substance most commonly abused by French young people [1]. This high prevalence of consumers is reflected in the large number of specialized care demands motivated by problematic cannabis use, even if in most cases this use is recreational [2]. While dependence occurs in approximately 9% of users [3], problems associated with cannabis use may arise before addiction appears. Some patterns of use (e.g., use before midday, solitary use) have been consistently associated with adverse effects and in order to detect this problematic use in the general population, a standardized and sensitive scale has been developed and widely validated: the Cannabis Abuse Screening Test [4-6].

The evaluation of affective style and emotional functioning has become an important topic in the process of understanding the underlying mechanisms of substance use disorders [7-10]. The association between substance use and affective pathology, such as depressive and anxiety states, has been well demonstrated during adolescence and adulthood [11-15].

Beyond depression, since the early 1970s, the traits of passivity or amotivation have commonly been clinically described among chronic cannabis abusers. The term "amotivational syndrome" was proposed to describe decreased motivation, reduced ability to concentrate, loss of effectiveness, decreased capacity to carry out complex plans or prepare realistically for the future [16]. Some researchers suggest that this amotivational state could be linked to the biological action of cannabis on the brain, in particular dopamine synthesis. These brain effects could be sustained by the increasing concentration of THC consistently reported [17]. Although clinically well recognized, the syndrome is questioned in the empirical literature [16]. However, the numerous psychosocial correlates (i.e., poor school achievement, cognitive impairments) regularly associated with heavy cannabis use confirm the need to clarify it [17,18]. One way to study this non-consensual complex multidimensional entity is to investigate apathy, which appears to be a key component of the amotivational syndrome.

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Apathy is defined as a multidimensional psychopathological state affecting cognitive, behavioral (sensory and motor) and emotional functioning, conceptualized as reduced motivation corresponding to goal-directed behaviors [19]. Descriptions of the syndrome are quite heterogeneous, however there is a relative consensus that it is mostly characterized by a reduced interest in and a diminution of everyday life activities, a lack of initiative and interest, a trend to quit initiated action prematurely (lack of perseverance in voluntary action), indifference and a flattening of affect [19,20].

Apathy is mostly studied in neurological and neurodegenerative diseases (Alzheimer's, Parkinson's, Huntington's, dementia with Lewy bodies, focal frontal lesions, traumatic brain injury, cerebrovascular accidents) but some researchers have underlined that apathy should be considered a transnosographic psychopathological state found in psychiatric diseases such as major depressive episodes and schizophrenia. Recently, some diagnostic criteria have been proposed for apathy syndrome in neuropsychiatric disorders [21-23], although empirical studies favored a dimensional approach to apathy. Apathy is associated with a quantitative reduction in adaptive behaviors.

Despite their overlapping constructs, depression and apathy should be considered separate dimensions, as they can both co-occur and standalone [19,24,25]. Apathy is a motivational disorder whereas depression is an affective one and some studies, using validated apathy scales, have shown that apathy is a clinically distinct syndrome warranting specific treatment interventions [26]. However, because the two constructs share several common symptoms (e.g., fatigue, loss of pleasure, reduced concentration), they could easily be confused in a clinical setting without standardized evaluations [19], particularly in cannabis abusers who often have difficulty in identifying or expressing feelings [8,12,27]. Moreover, some suggest that the two dimensions could have a cumulative effect on the expression of symptoms [28].

In their construction, apathy measures were not designed as a geriatric rating scale and should be suitable for adolescent and adult populations with various clinical disorders [19]. However, only a few studies have investigated apathy in other conditions than neurological or schizophrenia and depression. Yet, even before the concept was studied in these pathologies, Meerloo questioned its role in TV addiction as early as 1962 [29]. More recently, Marin & Wilkosz [30], proposed considering cannabis dependence as a possible condition associated with apathetic syndrome.

Some studies have reported data about apathy in substance use disorders using different methdological approaches and with heterogenous results. Barnwell, et al. [31], revealed no significant difference on the Apathy Evaluation Scale (AES) [32], in a community sample comparing 243 adult daily cannabis users and 244 non-users. Conversely, Looby and Earleywine [33], in their large community sample (n=2500) with the AES apathy measure, reported significantly lower motivation levels in cannabis-dependent participants than in cannabis daily users without dependence. Some research has also been conducted with a neurobiological perspective. Bloomfield, et al. [34], observed a reduction in the dopaminergic synthesis in the striata associated with the apathy level (evaluated with a self-report form of the AES) in 14 chronic cannabis users. Shollenbarger, et al. [35], reported a significant correlation between white matter abnormalities and depressive and apathy symptoms in 37 regular cannabis abusers, but failed to demonstrate significant differences in apathy level with the controls. Using a derived apathy measure (i.e., the Apathy subscale of the Neuropsychiatric Interview (NPI); Frontal System Behavior Scale (FrSBe); see [24], two studies reported more apathy in cocaine-dependent subjects than in non-drug-using controls [36,37]. Another study revealed that apathy was associated with the intensity of the hedonic response during cocaine intake, but was independent of the craving response [38]. Looby and Earlywine [39], highlighted more apathy in methamphetamine users; a paradoxical effect considering the stimulant properties of the substance.

The relative scarcity and heterogeneity of the literature highlight the need for a better understanding of the link between apathy and substance use, cannabis in particular. Moreover, because patterns of cannabis use differ between adolescents and adults (i.e., use before midday and intensity of smoking more frequent in young than in older adults), specific studies in samples of young adults are needed [4].

Thus, our objective was to determine to what extent apathy, evaluated in a multidimensional approach, is associated with cannabis use and misuse in a community sample of young adults. We hypothesized that the current cannabis users would have higher mean levels of depression and apathy than the non-users (not current users and never users), and that apathy would be associated with the problematic use of cannabis independently of depression.

Methods

Participants

Participants were recruited online from February to April 2016. An announcement about the research, requesting that people interested in participating in the study should follow a given URL, was posted on various social networks. The announcement was also sent by email to the private social networks of the investigators. An additional message asked them to forward the request to their friends favoring a "snowball procedure". Questionnaires were posted online on the secure Lime Survey platform. In accordance with the Helsinki declaration, an easily understandable information sheet about the objective and procedure of the study was first provided. Participants had to give their consent before they could access the questionnaires. Moreover, at the end of the questionnaire, the contact details of the investigators were presented once again, and some public mental health consultation centers were mentioned in case of need.

Overall, 1421 participants connected to the platform, 676 of whom were excluded because of incomplete data (183 suspended their Lime Survey connection after the information

letter, 135 at the time of the consent form, 244 at the socio-demographic questionnaire, 81 during or after the LARS-SR and BDI-13 completion and 33 during the substance use section). Of the 745 remaining, 68 participants were excluded because they presented other exclusion criteria: outside the age limit (from 18 to 25 years old) (n=23); declared they were suffering from a neurological disorder (n=17) or an invalidating somatic chronic condition (n=3); recently hospitalized in a psychiatry unit (n=4); currently under psychotropic medication (n=16); declared an estimated French speaking level under 7 on a 10-point scale (n=1); declared a degree of honesty in the answers given under 7 on a 10-point scale (n=4).

Materials

Participants completed several self-reports including:

An ad-hoc socio-demographic questionnaire: in addition to classic data (age, gender, level of education, professional activity), several precise but easily understandable questions were formulated in order to assess the exclusion criteria (listed above).

The Lille Apathy Rating Scale (LARS) [20,40], adapted to a self-report format for this study (LARS-SR). In its original format, the LARS is a 33-item apathy scale administered using a subjective semi-structured interview exploring nine domains [i.e., everyday productivity (EP) (e.g., "*What do you do during the day? Tell me about your day-to-day life*"); interest (INT) (e.g., "*What are you interested in? What do you like doing to keep yourself occupied?*"); taking initiative (INI) (e.g., "*In general, do you decide to do things or does someone have to push you a little?*"); novelty seeking (NS) (e.g., "*Do you like visiting places you've never been to before?*"); voluntary actions (VA) (e.g., "*When you decide to do something, are you easily able to make an effort or is it difficult?*"); emotional responses (ER) (e.g., "*When you watch a film, do you easily become emotional or moved?*"); concern (C) (e.g., "*Do you like to ask how your family and friends are on a regular basis?*"); social life (SL) (e.g., "*When you meet friends, do you enjoy spending time with them or it is a chore?*"); self-awareness (SA) (e.g., "*After having taken a decision, do you sometimes think that you've made the wrong choice?*")]. Items and domains were derived from the apathy literature and the LARS was developed to address the limitations of existing tools and to include an assessment of the various components of apathy [24]. The factorial analysis produced four factors: intellectual curiosity (INT+NS+M+SL/4), self-awareness (SA), emotion (ER+C/2) and action initiation (EP+INI/2) [20].

The self-report format of the LARS (LARS-SR) has only 31 items, as the two items evaluating reaction time were not adaptable for self-report and were removed. As in the original version, participants were first asked to report their standard day-to-day activities, which were coded on a five-point Likert-type scale (ranging from -2 to 2) according to their number and diversity. Then participants had to report their areas of interest. These answers were coded with two items: the first was about the number of pastime (1: none or just one; 0: many; -1: plenty) and the second concerned their frequency (1: less than once a week; 0: once or many times a week; -1: no enough

time for pastime activities). Afterward, participants responded to the remaining 28 items, having a binary responses format (true: 1 or false: -1) as in the original version. The binary (yes/no) scale allows a self-reported adaptation since the "yes"-or-"no" format reduces subjective interpretations as much as possible. Thus, the LARS-SR comprises 31 items and the overall score ranges from -32 (best possible score – no apathy) to +32 (worst possible score – severe apathy). The LARS has been validated in Parkinson's disease [20] and schizophrenia [41] and a caregiver version has been developed [40]. The scale also exhibited good psychometric properties in the healthy control group sample [20,41].

The 13-item Beck Depression Inventory (BDI-13): [42,43], individuals were asked to respond to statements on the basis of how they have felt over the past week. BDI-13 scores were considered a continuous variable (total score varied from 0 to 39).

Investigation of cannabis use: some questions were proposed in order to evaluate the use of cannabis. They included whether or not they had ever used cannabis, age of first use, and use during the past 12 months.

If participants declared having used cannabis during the previous year, they were invited to complete the Cannabis Abuse Screening Test (CAST). The CAST is a validated unidimensional scale assessing cannabis-related problems through 6 items: non-recreational use; memory disorders; being encouraged to reduce or stop using cannabis; unsuccessful attempts to quit and problems linked to cannabis use. All items are answered on a five-point scale (0 "never", 1 "rarely", 2 "from time to time", 3 "quite often", 4 "very often"). The total score ranged from 0 to 24. Empirical cut-off points for the CAST, ordering individuals along a continuum of problems, have been determined: non-symptomatic (score ≤ 2), moderate (score from 3 to 6) and severe (score ≥7). Its psychometric properties have been assessed in representative samples of adolescents and in small samples of young adults in various European countries [4].

Data management and statistical analysis

Descriptive statistics for quantitative measures (mean, variance, standard deviation) and for qualitative measures (percentage) were first calculated. Chi-squared tests were used to estimate the group effect for categorical measures.

Then, two distinct comparative approaches were used.

First, in order to test the simple effect of cannabis use, the sample was separated into three distinct groups: those declaring having used cannabis during the past 12 months, labeled as Current Cannabis Users (C-CU); those declaring having tried cannabis during their life, but not having used it during the previous year (Not Current Cannabis Users – NC-CU); and a third group declaring that they had never tried cannabis (Never Cannabis Users – N-CU). ANOVA with Tukey post-hoc analyses were used to compare these three groups on the different self-report scores.

Secondly, in order to test the effect of the severity of problematic cannabis use, the sample of Current Cannabis Users (C-CU) was separated into two groups according to their results on the CAST: the non-symptomatic versus the moderate and severe problematic users. Then, independent-sample t-tests were calculated to determine the differences in dimensional measures. In addition to this two-group approach, ANOVA with Tukey post-hoc analyses were calculated in order to compare the distribution of the exhibited effects between the non-symptomatic, moderate and severe CAST categories.

Next, several models of multivariate logistic regression analyses were designed with the CAST group (non-symptomatic vs. moderate or severe problematic users) as the dependent variable, the LARS-SR total score and subscale scores as predictors, and the BDI-13 score as a systematic covariable. Separate models were calculated for each of the four LARS-SR subscales.

Finally, six distinct models of multivariate logistic regression analyses were designed with the 6 items of the CAST as the dependent variable, the LARS-SR total score as predictor, and the BDI-13 score as a systematic covariable.

All analyses were carried out with SPSS-24 and hypotheses were tested with a two-sided significance level of 0.05.

Results

The final sample comprised 677 participants (291 males – 386 females) with a mean age of 20.5 (SD=1.9) ranging from 18 to 25 years. The socio-demographic and psychometric characteristics of the participants are described in Table 1. The correlation between the LARS-SR and the BDI-13 was significant and moderate (r=.312, p<.001).

Comparison between current (C-CU), not current (NC-CU) and never (N-CU) cannabis users

The ANOVAs highlighted some overall effects of the groups for age, the LARS-SR total score and the emotion subscale (Table 1).

The post-hoc analyses revealed that the participants that had experience of cannabis in their lifetime but had not used it during the previous year (NC-CU) were older (mean difference=.546; p=008) and more apathetic (mean difference =-1.42, p=.032), notably on the emotion subscale of the LARS-SR (mean difference =.473, p=.001) than the participants who had never tried cannabis (N-CU).

Then, there was no significant difference between the mean age of the first cannabis use of the C-CU (mean age (SD) = 15.9 (1.8)) and the NC-CU (mean age (SD) =16.3 (1.9)) participants (F=2.22, p=.137).

Determination of problematic cannabis use for the current users

The CAST mean score in the subsample of participants who reported current cannabis use (n=225) was 3.5 (SD=4.2); scores ranged from 0 to 19.

The use of the empirical cut-off points for the CAST in these 225 participants ordered individuals along a continuum of problems: non-symptomatic (n=130, 57.8%), moderate (n=44, 19.6%) and severe (n=51, 22.7%).

Differences between non-symptomatic and problematic cannabis users

Descriptive and comparative statistics between non-

Table 1: Participant characteristics.					
	All (*N*=677)	Current-CU (*n*=225)	Not Current-CU (*n*=180)	Never-CU (*n*=272)	ANOVA/Chi², p
Age: mean (*SD*)	20.5 (1.9)	20.5 (1.9)	20.8 (1.9)	20.3 (1.9)	*F*=4.45, *p*=.012
Gender: *n* (%)					
Male	291 (43)	118 (40.5)	74 (25.4)	99 (34)	χ²=13.3, *p*=.001
Female	386 (57)	107 (27.7)	106 (27.5)	173 (44.8)	
Years of education*: *n* (%)					
9	18 (2.7)	12 (66.7)	2 (11.1)	4 (22.2)	χ²=21.5, *p*<.0001
12	439 (64.8)	128 (29.2)	112 (25.5)	199 (45.3)	
≥ 14	220 (32.5)	85 (38.6)	66 (30)	69 (31.4)	
Employment status: *n* (%)					
Student	560 (82.7)	167 (29.8)	148 (26.4)	245 (43.8)	χ²=21.7, *p*<.0001
Employed	84 (12.4)	42 (50)	23 (27.4)	19 (22.6)	
Unemployed	33 (4.9)	16 (48.5)	9 (27.3)	8 (24.2)	
LARS-SR: mean (*SD*)	-19 (5.9)	-19 (6.1)	-18.1 (6.0)	-19.5 (5.6)	*F*=3.18, *p*=.042
Intellectual curiosity	-2 (0.8)	-2.1 (0.8)	-1.9 (0.8)	-2 (0.8)	*F*=1.36, *p*=.258
Emotion	-2.5 (1.4)	-2.4 (1.5)	-2.2 (1.5)	-2.7 (1.3)	*F*=6.24, *p*=.002
Action initiation	-1.7 (1)	-1.6 (1.1)	-1.6 (1)	-1.8 (1)	*F*=2.29, *p*=.102
Self-awareness	-2.7 (1.6)	-2.6 (1.6)	-2.7 (1.7)	-2.7 (1.6)	*F*=.23, *p*=.791
BDI-13: mean (*SD*)	6.3 (5.1)	6.5 (5.2)	6.4 (5.1)	6.2 (5.0)	*F*=.178, *p*=.837

CU: Cannabis user; na: not applicable; *SD*: Standard deviation * years of schooling since the first grade

symptomatic and problematic cannabis users on the CAST are presented in Table 2.

Participants presenting a moderate or severe problematic cannabis use had a higher LARS-SR total score (p=.001). This significant intergroup difference was also found for the LARS-SR subscales "intellectual curiosity" (p=.020), "emotion" (p=.009) and "action initiation" (p=.003). Moreover, they had a significantly higher score on the BDI-13 (p<.0001).

The ANOVA exploring the differences between the three categories of the CAST (non-symptomatic, moderate and severe) revealed that severe users were more apathetic than non-symptomatic users on the LARS-SR (mean difference=−3.6, p=.001) and the action initiation subscale (mean difference=−.63, p=001).

No significant differences were highlighted between moderate users and both non-symptomatic and severe users regarding the LARS-SR scores, but a significant effect was found for the BDI-13 scores between moderate and severe categories (mean difference=−2.8, p=.022).

Multivariate logistic regression analyses

Regression analyses revealed that both apathy and depression scores were significant predictors of the CAST categories (non-symptomatic vs. moderate/severe) (β=1.07, p=.010 and β=1.08, p=.008, respectively).

When entering LARS-SR subscales as predictive variables, the BDI-13 score remained a significant predictor for each model. In addition, significant predictive associations were revealed with the "emotion" (β=1.31, p=.006) and "action initiation" (β=1.35, p=.028) scores.

In order to determine precisely which of the behavioral issues investigated in the CAST questionnaire were predicted by apathy, multivariate logistic regression analyses were performed with each CAST item as a dependent variable and LARS-SR and BDI-13 as predictors.

Analyses revealed that solitary cannabis use (item 2) was significantly predicted by the LARS-SR total score (β=1.062, p=.012) as were items investigating problems related to cannabis use (item 6) (β=1.062, p=.022). On the other hand, the item "tried to reduce or stop" was predicted by the BDI-13 score (β=1.079, p=.020) (Table 3).

Discussion

One of the main original features of our research was the transposition of the apathy concept, classically studied in neuropsychiatric disorders, to a young community sample, linked with an addictive behavior studied from a behavioral and psychopathological perspective. Considering the amotivational syndrome frequently described in the clinical presentation of cannabis abusers, we believe that the study of apathy may bring some insight into the understanding of this problematic behavior, widespread among young people. Moreover, whereas there is an extensive literature investigating the links between depression and cannabis use and misuse, few studies have investigated apathy in substance use disorders. Some have revealed specificities in cannabis-dependent and cocaine and methamphetamine abusers, who were found more apathetic than controls [33,36,37,39]. Others failed to demonstrate significant differences between substance abusers and controls [31,35]. However, our study is the first to investigate the presence of apathy in problematic cannabis users using a validated scale, in comparison to non-symptomatic users in a community sample of young adults.

Since our results, once again, confirmed the strong association between problematic cannabis use and depressive symptomatology in a community sample of non-clinical participants [44], regression analyses were calculated in order to determine the discriminability of apathy and depression. As predicted, both depression and apathy total scores were consistently associated with problematic patterns of cannabis use. One of the strengths of our study is also the use of a scale investigating apathy as a multidimensional construct, and revealing that only some apathy dimensions seem involved in cannabis misuse independently of depression: emotion and action initiation. Interestingly, whereas some research has demonstrated some difficulties in self-perception, notably a lack of insight regarding emotional states e.g., alexithymia, [12,27], no significant associations were revealed concerning the self-awareness apathy subscale.

Volkow, et al. concluded their review by stating that

Table 2: *Comparison of non-symptomatic versus current problematic cannabis users (n=225).*

	CAST non-symptomatic (n=130 - 57.8%)	CAST moderate and severe (n=95 − 42.3%)	t-test / Chi², p
Age: mean (SD)	20.4 (1.8)	20.6 (1.9)	t=.782, p=.435
Gender: n (%)			
Male	67 (56.8)	51 (43.2)	χ²=.101, p=.750
Female	63 (58.9)	44 (41.1)	
Age of first cannabis use: mean (SD)	16.5 (1.9)	15.3 (1.5)	t=5.03, p<.0001
CAST total score: mean (SD)	.66 (.75)	7.5 (3.7)	t=-20.3, p<.0001
CAST item details (at least once) n (%)*			
Cannabis before midday	36 (27.7)	82 (86.3)	χ²=75.6, p<.0001
Cannabis when alone	21 (16.2)	85 (89.5)	χ²=118.4, p<.0001
Memory problems	15 (11.5)	72 (75.8)	χ²=95.5, p<.0001
Friends or family	5 (3.8)	59 (62.1)	χ²=91.5, p<.0001
Tried to reduce or stop	0 (0)	38 (40)	χ²=62.5, p<.0001
Problems	6 (4.6)	48 (50.6)	χ²=64.5, p<.0001
LARS-SR: mean (SD)	- 20.1 (5.2)	- 17.3 (6.9)	t=-3.15, p=.001
Intellectual curiosity	-2.2 (0.7)	-1.9 (0.9)	t=-2.36, p=.020
Emotion	-2.6 (1.4)	-2.1 (1.5)	t=-2.62, p=.009
Action initiation	-1.8 (0.9)	-1.3 (1.2)	t=-2.99, p=.003
Self-awareness	-2.6 (1.6)	-2.6 (1.7)	t=.244, p=.886
BDI-13: mean (SD)	5.4 (4.6)	7.9 (5.7)	t=3.56, p<.0001

SD: Standard deviation

* Percentages are presented with reference to the pertaining column (group) (not in line)

Table 3: Logistic regression models with apathy and depression dimensions predicting cannabis problematic use.

CAST Non-symptomatic/moderate and severe (dependent variable)	R²	B	SE	df	p	Exp(B)	95% C.I. for Exp(B)	
							Lower	Higher
Model with total scores (predictors)								
LARS-SR	.110	.064	.025	1	.010	1.066	1.016	1.118
BDI-13		.075	.029	1	.008	1.078	1.019	1.14
Models with the LARS-SR subscores (predictors)								
Intellectual curiosity	.077	.190	.190	1	.319	1.209	.832	1.756
BDI-13		.081	.030	1	.006	1.085	1.023	1.15
Emotion	.115	.273	.100	1	.006	1.314	1.080	1.599
BDI-13		.099	.028	1	<.0001	1.104	1.045	1.166
Action initiation	.099	.302	.137	1	.028	1.352	1.034	1.769
BDI-13		.080	.028	1	.005	1.084	1.025	1.145
Self-awareness	.071	-.005	.085	1	.954	.995	.842	.1.176
BDI-13		.093	.028	1	.003	1.097	1.039	1.158

further studies are needed to determine whether the deficits in motivation are linked to cannabis use disorders rather than cannabis use per se [17]. Our study provides some insight regarding this point since apathy was associated with both cannabis use and problematic patterns of cannabis use. However, the strongest associations were found with the cannabis-related social, cognitive, behavioral and physiological problems. In order to understand better the contribution of the pathological dimension associated with the substance use behavior, it would be helpful to reproduce our study using the new DSM-5 criteria for problematic use of cannabis [45].

Early cannabis initiation was associated with a more severe problematic pattern of cannabis use. This result once again underlines the need to delay the initiation of cannabis use in order to prevent the development of cannabis-related problems such as low educational attainment or poor psychosocial adjustment [14].

In terms of representability, our sample was deliberately chosen in an age range of young adults who tend to exhibit a specific pattern of substance use [4] and it allowed a certain homogeneity of the cannabis use patterns. Moreover, as previously reported, the level of current cannabis users was higher in males, which is a classic gender difference, although this heterogeneity tends to disappear when problematic use is considered [1,46].

However, a major limitation resides in the sample of participants. Overall, 1431 participants connected to the platform and gave their informed consent but 686 were excluded because of incomplete data (48% of the initial respondents). One can question the lack of motivation and perseverance in completing all the questionnaires, which may mean that the most apathetic or depressed participants were *de facto* not included in the analyzed sample.

Nevertheless, this recruitment method presents some advantages since participants should be sincerer in a completely anonymous and depersonalized procedure. Previous studies demonstrated this effect since young participants were found more likely to admit to substance use in a web-based questionnaire than on a paper-and-pencil questionnaire [47,48]. Moreover, we may hypothesize that the electronic format favors completion because of the easy access (adapted format for Smartphones) and enables the inclusion of young adults who are part of a highly connected generation.

One of the measurement limitations resides in the adaptation of the apathy measure to a self-report format in a young community sample, which led to the removal of the reaction time items. The impact of the adaptation is limited by the exclusive multidimensional approach in our study; however, taking into account the relevance of the concept, we consider that further studies exploring the psychometric validated version are needed in participants with efficient cognitive functioning. Moreover, as in a clinical setting, a shortened version should be encouraged [49].

We chose to study the dimensions of depression and apathy only in a psychometric psychopathological perspective. However, considering the empirical literature on cannabis and brain development or damage and the neurobiological evidence about apathy, multidisciplinary research linking both psychometric and biophysiological measures should be encouraged in the future. Taking into account the links between cannabis and psychosis on one hand [17], and between schizophrenia and apathy on the other [41], our study linking cannabis misuse and apathy in young adults raises some questions about potential mediating effects between these dimensions. In addition, a longitudinal assessment of individuals would have enabled us to determine the durability of these effects and/or whether the depressive and apathy syndromes are pre-existent to substance use. Such a design is needed and our results need to be replicated in a clinical setting and not only in a general population

Whatsoever, this work provides an additional view of what studying apathy could contribute to research on addiction.

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