Psychological Medicine

cambridge.org/psm

Psychotic-like experiences with cannabis use predict cannabis cessation and desire to quit: a cannabis discontinuation hypothesis

Musa Sami[1,2], Caitlin Notley[3], Christos Kouimtsidis[4,5], Michael Lynskey[6] and Sagnik Bhattacharyya[1,2]

[1]Institute of Psychiatry, Psychology & Neuroscience, King's College London, UK; [2]South London and Maudsley NHS Foundation Trust, UK; [3]Norwich Medical School, University of East Anglia, Norwich, UK; [4]Surrey and Borders Partnership NHS Foundation Trust, UK; [5]Department of Medicine, Division of Brain Sciences, Imperial College London, UK and [6]National Addiction Centre, Addiction Sciences Building, King's College London, UK

Original Article

Cite this article: Sami M, Notley C, Kouimtsidis C, Lynskey M, Bhattacharyya S (2018). Psychotic-like experiences with cannabis use predict cannabis cessation and desire to quit: a cannabis discontinuation hypothesis. *Psychological Medicine* **49**, 103–112. https://doi.org/10.1017/S0033291718000569

Received: 18 August 2017
Revised: 5 February 2018
Accepted: 12 February 2018
First published online: 23 March 2018

Key words:
Cannabis; cessation; discontinuation; marijuana; pattern of use; psychosis risk; psychotic-like experiences

Author for correspondence:
Sagnik Bhattacharyya, E-mail: sagnik.2.bhattacharyya@kcl.ac.uk

Abstract

Background. Evidence suggests that cannabis-induced psychotic-like experiences may be a marker of psychosis proneness. The effect of such experiences on cannabis use has not systematically been examined.

Methods. We undertook a mixed-methods online survey of 1231 cannabis users (including 926 continued users) using the Cannabis Experiences Questionnaire. We examined the effect of psychotic-like and pleasurable experiences on cessation of cannabis and intention to quit. Socio-demographic variables, cannabis use parameters and substance misuse history were included as covariates. Free-text data explored subjective reasons for changes in use.

Results. Cessation of cannabis use was associated with greater psychotic-like experiences [$p < 0.001$, Exp(B) 1.262, 95% confidence interval (CI) 1.179–1.351], whilst continued cannabis users were more likely to report pleasurable experiences [$p < 0.001$, Exp(B) 0.717, 95% CI 0.662–0.776]. Intention to quit cannabis in continued users was associated with greater psychotic-like experiences [$p < 0.003$, Exp(B) 1.131, 95% CI 1.044–1.225], whilst intention to not quit was significantly associated with increased pleasurable experiences [$p < 0.015$, Exp(B) 0.892, 95% CI 0.814–0.978]. Whereas former users clearly ascribed cessation to negative experiences, continued users who expressed intention to quit less readily ascribed the intention to negative experiences.

Conclusions. Elucidation of psychotic-like experiences may form the basis of a therapeutic intervention for those who wish to quit. Cessation in those with cannabis-induced psychotomimetic experiences may offset the risk for the development of a psychotic disorder, in this higher risk group.

Introduction

Cannabis use is widespread with an estimated 125–203 million users worldwide (Degenhardt & Hall, 2012). Initiation of cannabis use has been associated with increased risk of onset of psychotic symptoms, whilst continued use is associated with the persistence of such symptoms (Kuepper *et al.* 2011) and onset of a psychotic disorder (Moore *et al.* 2007; Marconi *et al.* 2016). This is consistent with meta-analytic and independent evidence that continued cannabis use is associated with greater risk of relapse in those with a pre-existing psychotic disorder (Schoeler *et al.* 2016*a*, *b*) and that this association is more likely than not to reflect a causal effect of continued cannabis use on outcome (Schoeler *et al.* 2016*c*). This convergence of evidence suggests that the persistence of use is a key determinant of the effect of cannabis use on outcome both in healthy and unwell cannabis users. Therefore, understanding what factors influence the persistence of use or indeed trigger cessation or a desire to quit is critical to developing effective interventions that may help limit harm from cannabis use.

Work to date has focused on established social constructs as predictors of cessation and has demonstrated that increasing age and maturity are associated with cessation (the 'maturing out' hypothesis) (Kandel & Logan, 1984), whilst social context, poor health and prior illicit drug use are associated with ongoing use (Kandel & Raveis, 1989). Other work has also pointed towards peer involvement and school problems (van den Bree *et al.* 2005) as well as psychological dependence and drug myths (Little *et al.* 2013) as associated with the persistence of cannabis use in young people.

Experiences during the transient intoxication state immediately following cannabis use, which can constitute both pleasurable and undesirable experiences, have also been examined to determine their effect on subsequent use. Both early and persisting pleasurable experiences have been shown to be associated with heavier use and dependence (Le Strat *et al.* 2009;

CAMBRIDGE UNIVERSITY PRESS

Scherrer *et al.* 2009). However, evidence is equivocal about the effect of undesirable experiences on subsequent cannabis use patterns, with studies showing both association with decreased (Lyons *et al.* 1997; Zeiger *et al.* 2010) as well as heavier or problematic use (Grant *et al.* 2005; Scherrer *et al.* 2009). This may reflect the fact that existing literature examining the association between undesirable experiences during cannabis use and subsequent pattern of use have focused on a wide array of undesirable effects, including drowsiness, confusion and nausea rather than on effects such as 'psychotic-like experiences', which arguably are perhaps the most distressing and frightening experiences in someone expecting to enjoy a relaxing effect. Unlike the relatively rare occurrence of a psychotic disorder associated with cannabis use (Moore *et al.* 2007; Marconi *et al.* 2016), psychotic-like experiences, such as paranoia, hallucinations or dysphoria, are not uncommon, reported by up to 15% of cannabis users in a community sample (Thomas, 1996). Whether the occurrence of undesirable experiences such as psychotic-like experiences in particular whilst using cannabis has an influence on subsequent cannabis use behaviour is therefore an important question to examine. However, to our knowledge, this has not been systematically examined to date.

Employing a well-validated (Barkus *et al.* 2006; Bianconi *et al.* 2016; Quinn *et al.* 2017) self-report questionnaire that has been used to record subjective experiences associated with cannabis use, previous and more recent exploratory factor analyses have shown that the immediate transient experiences associated with cannabis use cluster into 'paranoid-dysphoric experiences' and 'pleasurable experiences'(Barkus *et al.* 2006; Quinn *et al.* 2017). Hence, in the present study, we sought to investigate whether experiences during cannabis use (both psychotomimetic and pleasurable) are associated with cessation of use or a future intention to quit in a non-clinical sample. We hypothesised that (i) psychotic-like experiences would be associated with cessation of cannabis use and a desire to quit, whereas (ii) pleasurable experiences would conversely be associated with continuation of cannabis use and a desire to continue. Furthermore, we triangulated analysis using a mixed-methods approach to qualitatively explore subjective reasons reported by users as being linked to continued use. We inductively coded qualitative data independently of the quantitative analysis in order to allow participants' own views relating to changes in their patterns of use (continuation, escalation, more 'measured' use or complete cessation) to their reported cannabis experiences to emerge.

Methods

Ethical approval was obtained from the King's College, London Research Ethics Committee (REMAS). We have followed the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) guidelines for reporting of cross-sectional studies (von Elm *et al.* 2007).

A web-based modified version of the Cannabis Experiences Questionnaire (CEQ) was administered to an internet sample.

Sample selection

Participants were recruited through advertising on the study recruitment pages at King's College London, the London Cannabis Club, cannabis advocacy sites such as CLEARUK and social media including Facebook, Twitter and Tumblr. An internet domain name for the survey was registered and advertised (www.thecannabissurvey.com). Adults aged 18 years and above who had previously used cannabis were invited to complete the survey. A small-scale raffle (£10–£50 Amazon voucher for three participants on completion) was offered as an incentive. The survey ran over a 10-month period from December 2015 until September 2016. We aimed for a sample size of 1000 as this would be the largest population-derived sample assessed with the CEQ to date (Barkus *et al.* 2006; Bianconi *et al.* 2016; Quinn *et al.* 2017).

Measures

The CEQ was developed to investigate participants' self-reports of experiences with cannabis (Barkus *et al.* 2006). It has demonstrated validity and reliability having been administered in student, online, non-clinical and clinical cohorts (Barkus *et al.* 2006; Barkus & Lewis, 2008; Bianconi *et al.* 2016; Quinn *et al.* 2017). We have used the modified version previously in a clinical sample via face-to-face and telephone interview with demonstrable acceptability in collecting cannabis use data. We used a modified version previously administered in our centre (Di Forti *et al.* 2009, 2012; Schoeler *et al.* 2016*b*, *c*). For brevity, and in order to facilitate data collection, the survey restricted itself to nine intoxication experiences and did not collect data on the after effects of cannabis use. Prior to this, we had not tested the modified version online, although other groups have administered alternative versions of the CEQ to electronic and online sample and reported acceptable psychometric properties (Barkus & Lewis, 2008; Quinn *et al.* 2017).

Predictor variables

The administered survey included six items focusing on psychotic-like experiences (fearfulness, feeling of going crazy, feeling nervy, suspiciousness, seeing visions and hearing voices) and three items on pleasurable effects (being full of plans, feeling happy, being able to understand the world better). These were scored on a Likert scale assessing the frequency of ever having experienced the specified effect using established anchor points (1 rarely or never, 2 from time to time, 3 sometimes, 4 more often than not, 5 almost always).

Outcome variables

Outcome variables were collected as dichotomous 'yes/no' answers (i) for all those who had ever used cannabis whether they continued to use; and (ii) in a further question restricted to those who continued to use cannabis, whether they intended to quit in the future.

Covariate variables

Socio-demographic variables collected were: age, sex (male, female) and occupational status. Additional parameters of cannabis, alcohol and other drug use collected included: age of first cannabis use, frequency of cannabis use (every day, a few times a week, a few times each month, a few times each year, only once or twice), other substance misuse history for tobacco, alcohol, cocaine, ecstasy and non-prescribed medication (used regularly, used frequently, used less than five times, never used). History of lifetime contact with mental health services or requiring treatment was collected as a dichotomous (yes/no) variable.

https://doi.org/10.1017/S0033291718000569 Published online by Cambridge University Press

Qualitative data

Free-text fields were used for the collection of qualitative data with specific questions on: reasons for initiation, continuation and/or cessation of cannabis use, thoughts about future cessation or continuation of use, subjective reasons given for changes in the patterns of use.

Statistical analysis

CEQ scores for psychotic-like experiences and pleasurable experiences were calculated by simple summation of Likert scales as followed previously (Barkus *et al.* 2006). The range of total possible scores for psychotic-like experiences was 6–30, whereas pleasurable experiences score ranged from 3 to 15. Since psychotic and pleasurable experiences represent underlying continua, summed scores were treated as a continuous variable.

Descriptive statistics for the predictor, covariate and outcome variables were estimated as means and standard deviations (S.D.) for continuous variables (psychotic-like experiences score, pleasurable experiences score, age, age of first use of cannabis), and as frequencies and percentages for all other variables (sex, occupation, frequency of cannabis use, any prior mental health contact, history of use of: alcohol, tobacco, non-prescription medications, cocaine and ecstasy).

First exploratory analyses, including *t* tests for continuous variables and χ^2 test for categorical variables, were undertaken to compare the cessation *v.* continuation user groups and further within continued users to compare those with future intention to quit *v.* those with no intention to quit. Multivariable binary logistic regression analyses were undertaken to examine the association between psychotic-like experiences and pleasurable experiences as predictors with cessation/continuation and future intention to quit/no intention to quit as outcomes. In order to account for potential confounders, the following measures were included in these models as covariates: age, sex, occupation, age of first use of cannabis, frequency of cannabis use, past drug history and contact with mental health services. All predictor and covariate variables were entered into the regression model simultaneously. Checking variation inflation factor (VIF) confirmed that there was no multicollinearity amongst predictor and covariate variables at a conservative threshold (VIF<2.5 in all instances).

Missing data: Fisher's 2 × 2 exact test was undertaken to see if there was a significant effect of missing data between groups (continued *v.* discontinued and future intention to quit *v.* no intention to quit) for all covariates (age, sex, occupation, mental health contact, age of first use, frequency of first use, alcohol, tobacco, non-prescribed medication, cocaine and ecstasy history) (see Table 1). There were no significant differences in the rates of missing data between the groups for continued users who had intention to quit *v.* no intention to quit. There were furthermore no significant differences in the rates of missing data for continued *v.* discontinued users for all covariates except for occupation (4.6% *v.* 1.0%, $p = 0.03$) and frequency of use (3.0% *v.* 7.2%, $p < 0.01$); however, even in these two instances, the overall differences in the proportions of missing data between the groups were adjudged to be small and there was no evidence of systematic bias in missing data. Consequently, we undertook a complete-case analysis (where there were no missing data for all covariates specified above) to account for missing data (see online Supplementary material) in preference to imputation methods.

Sensitivity analyses: We re-ran the statistical analyses with the complete-case data excluding participants with a history of psychotic or manic illness. Furthermore to ensure that those who reported discontinuation would be objectively considered to have ceased use, we re-ran the analysis with discontinued users restricted to the group who had reported last use of cannabis to be at least 6 months previously. To ensure that any relationships were not accounted for by infrequent or experimental users, we checked whether the relationship between experiences and discontinuation/future discontinuation survived across differing levels of use by running the logistic regression with data split by frequency of use. In this case, frequency of use was removed as a covariate from logistic regression models.

Statistical analysis was undertaken in SPSS version 20.

Qualitative analysis

Open-ended questionnaire responses to questions on reasons stated for discontinued cannabis use (experiences), descriptions of negative experiences, and stated reasons for changes in the patterns of use over time were transcribed, collated and inductively coded by an independent researcher who had not been involved in the design of the quantitative survey (CN). Following a thematic approach (Braun & Clarke, 2006), no *a priori* coding structure was applied, but themes were allowed to 'emerge' naturally from the data and were grouped in meaningful ways to assist with the interpretation of the data. Analysis was discussed and verified at regular team meetings. This analysis was undertaken independently but in parallel with the quantitative analysis.

Results

Demographics

In total, 1425 participants responded to the survey. Five participants were excluded due to being under 18. Of the remaining, data were available for 1231 participants who had ever used cannabis (see Fig. 1). Complete-case data were available for 940 participants. Summary demographic and predictor, outcome and covariate data are reported in Table 1. In total, 845/1231 (68.6%) were male, whereas 375/1231 (30.5%) were female. Age ranged from 18 to 77 years (mean 29.5, median 26, standard deviation 10.3). Four hundred and sixty-nine (38.1%) of the respondents reported previous mental health contact. Whilst this was not quantified based on free-text information, this appeared to be mostly related to anxiety, depression or stressful experiences and involved treatment within the primary care setting or by counselling. Twenty-five out of 1231 (2.0%) participants included in the analysis referred to a diagnosis of psychotic or manic illness.

Although we did not routinely ask for country, 494/531 (93.0%) of those who agreed to a follow-up study gave their place of residence in the UK, with 23/531 (4.3%) responding from Sweden, although there were also a few responses from the USA, Brazil, Mauritius, Greece and Zimbabwe.

Cannabis use

Nine hundred and twenty-six out of 1231 (75.2%) participants continued to use the substance. One hundred and sixty-seven out of 907 (18.4%) continued users agreed that they would like to stop in the future. In all users, pleasurable experiences were

https://doi.org/10.1017/S0033291718000569 Published online by Cambridge University Press

Table 1. Demographic data

		All (n = 1231)	Ceased (n = 305)	Continued (n = 926)	Sig.*	Sig (msng)†	Intention to quit (n = 166)	No intention to quit (n = 741)	Sig.*	Sig (msng)†
Age		$\bar{x}$ = 29.5, sem = 0.31	$\bar{x}$ = 29.5, sem = 0.57	$\bar{x}$ = 29.5, sem = 0.36	0.97		$\bar{x}$ = 25.1, sem = 0.61	$\bar{x}$ = 30.4, sem = 0.41	<0.01	
	Missing	102 (8.3)	27 (8.9)	75 (8.1)		0.72	15 (9.0)	58 (7.8)		0.64
Sex	Male	845 (68.6)	122 (40.0)	723 (78.1)	<0.01		117 (70.5)	592 (79.9)	<0.01	
	Female	375 (30.5)	182 (59.7)	193 (20.8)			48 (28.9)	140 (18.9)		
	Missing	11 (0.9)	1 (0.3)	10 (1.1)		0.31	1 (0.6)	9 (1.2)		0.70
Occupation	Full time	600 (48.9)	137 (44.9)	463 (50)	<0.01		71 (42.8)	384 (51.8)	<0.01	
	Part time	109 (8.9)	25 (8.2)	84 (9.1)			14 (8.4)	69 (9.3)		
	Unemployed	107 (8.9)	12 (3.9)	95 (10.3)			12 (7.2)	82 (11.1)		
	Student	369 (30.0)	128 (42.0)	241 (26.0)			66 (39.8)	168 (22.7)		
	Missing	46 (3.8)	3 (1.0)	43 (4.6)		0.03	3 (1.8)	38 (5.1)		0.06
Mental health contact	Yes	469 (38.1)	133 (43.6)	336 (36.3)	0.39		55 (33.1)	273 (36.8)	0.37	
	No	762 (61.9)	172 (56.4)	590 (63.7)			111 (66.9)	468 (63.1)		
Age at first cbs use		$\bar{x}$ = 16.7, sem = 0.11	$\bar{x}$ = 17.5, sem = 0.18	$\bar{x}$ = 16.4, sem = 0.13	<0.01		$\bar{x}$ = 16.2, sem = 0.24	$\bar{x}$ = 16.5, sem = 0.14	0.50	
	Missing	4 (0.3)	1 (0.3)	3 (0.3)		1.00	1 (0.6)	2 (0.3)		0.46
Cbs frequency of use	Every day	547 (44.4)	43 (14.1)	504 (54.4)	<0.01		87 (52.4)	417 (56.2)	0.49	
	More than once a week	271 (22.0)	36 (11.8)	235 (25.4)			40 (24.1)	195 (26.3)		
	Few times monthly	162 (13.2)	55 (18.0)	107 (11.6)			24 (14.5)	83 (11.2)		
	Few times yearly	132 (10.7)	84 (27.5)	48 (5.2)			10 (6.0)	38 (5.1)		
	Once or twice	69 (5.6)	65 (21.3)	4 (0.4)			2 (1.2)	2 (0.3)		
	Missing	50 (4.1)	22 (7.2)	28 (3.0)		<0.01	3 (1.8)	6 (0.8)		0.22
Alcohol history	Regular use	717 (58.2)	214 (70.2)	503 (54.3)			92 (55.4)	411 (55.5)	0.34	
	Infrequent use	323 (26.2)	46 (15.1)	277 (29.9)	<0.01		52 (31.3)	225 (30.4)		
	Use <5 times	31 (2.5)	2 (0.7)	29 (3.1)			3 (1.8)	26 (3.5)		
	Never use	23 (1.9)	3 (1.0)	20 (2.2)			2 (1.2)	18 (2.4)		
	Missing	137 (11.1)	40 (13.1)	97 (10.5)		0.21	17 (10.2)	61 (8.2)		0.44
Tobacco history	Regular use	633 (51.4)	113 (37.1)	520 (56.2)	<0.01		102 (61.5)	418 (56.4)	<0.01	
	Infrequent use	256 (20.8)	78 (25.6)	178 (19.2)			33 (19.9)	145 (19.6)		
	Use <5 times	125 (10.1)	42 (13.8)	83 (9.0)			11 (6.6)	72 (9.7)		
	Never use	80 (6.5)	32 (10.5)	48 (5.1)			3 (1.8)	45 (6.1)		
	Missing	137 (11.1)	40 (13.1)	97 (10.5)		0.21	17 (10.2)	61 (8.2)		0.44
	Regular use	53 (4.3)	8 (2.6)	45 (4.9)	0.28		9 (5.4)	36 (4.9)	0.76	

Non-prescribed med history	Infrequent use	163 (13.2)	35 (11.5)	128 (13.8)		19 (11.5)	109 (14.7)		
	Use <5 times	224 (18.2)	54 (17.7)	170 (18.4)		30 (18.1)	140 (18.9)		
	Never use	654 (53.1)	168 (55.1)	486 (52.5)		91 (54.8)	395 (53.3)		
	Missing	137 (11.1)	40 (13.1)	97 (10.5)	0.21	17 (10.2)	61 (8.2)		0.44
Cocaine history	Regular use	75 (6.1)	11 (3.6)	64 (6.9)	<0.01	12 (7.2)	52 (7.0)	0.99	
	Infrequent use	252 (20.5)	40 (13.1)	212 (22.9)		37 (22.3)	175 (23.6)		
	Use <5 times	302 (24.5)	67 (22.0)	235 (25.4)		42 (25.3)	193 (26.0)		
	Never use	465 (37.8)	147 (48.2)	318 (34.3)		58 (34.9)	260 (35.1)		
	Missing	137 (11.1)	40 (13.1)	97 (10.5)	0.21	17 (10.2)	61 (8.2)		0.44
Ecstasy history	Regular use	136 (11.1)	26 (8.5)	110 (11.9)	<0.01	18 (10.8)	92 (12.4)	0.53	
	Infrequent use	300 (24.4)	55 (18.0)	245 (26.5)		50 (30.1)	195 (26.3)		
	Use <5 times	252 (20.5)	51 (16.7)	201 (21.7)		38 (22.9)	163 (22.0)		
	Never use	406 (33.0)	133 (43.6)	273 (29.5)		43 (25.9)	230 (31.0)		
	Missing	137 (11.1)	40 (13.1)	97 (10.5)	0.21	17 (10.2)	61 (8.2)		0.44

All data count (%) unless specified otherwise; x̄, mean; sem, standard error of the mean; cbs, cannabis.
*Significance using t tests for continuous variables, χ^2 tests for proportions (infrequent categories combined if count <5).
†Significance for missing data – Fisher's exact test 2 × 2 contingency test.

more frequently reported than psychotic experiences. Age of first cannabis use ranged from 7 to 55 years (mean 16.7, median 16, S.D. 3.7).

Cannabis experiences

Pleasurable experiences exceeded psychotic-like experiences. Nine hundred and fifteen out of 1123 (81.4%) respondents in this sample reported that they experienced happiness either most or all of the times they used cannabis, whilst 66/1119 (5.9%) of respondents endorsed 'feeling nervy', the most common dysphoric experience. A considerable proportion of cannabis users had ever experienced psychotic or dysphoric experiences when using cannabis: feeling suspicious: 524/1117 (46.9%); feeling nervy: 491/1119 (43.9%); feeling fearful: 302/1123 (27.1%); seeing visions: 187/1118 (16.7%); feeling like going crazy or mad: 145/1121 (12.9%); and hearing voices: 100/1117 (9.0%).

Cannabis experiences cessation v. continuation

Psychotic-like experiences and pleasurable experiences scores by ceased and continued users are shown in Table 2. Those who had ceased reported greater frequency of experiencing psychotic-like experiences ($t = 7.05$, $p < 0.001$), whereas continued cannabis users were significantly more likely to report pleasurable experiences than those who had ceased ($t = -16.67$, $p < 0.001$). These findings remained when the complete data set was analysed and further when those with a history of psychotic or manic illness were excluded (see online Supplementary data).

Results from a logistic regression analysis are summarised in Table 3. Cessation of cannabis use was significantly associated with psychotic-like experiences (higher score predicts cessation), pleasurable experiences (lower score predicted cessation), age (older age predicted cessation), sex (being female predicted cessation) and frequency of cannabis use (less frequent use predicted cessation). Tobacco use was also borderline significant ($p = 0.51$), indicating more frequent tobacco use predicted continuation.

Cannabis experiences in continued users: no intention to quit v. future intention to quit

Within continued cannabis users, future intention to quit was significantly associated with greater psychotic-like experiences ($t = 3.95$, $p < 0.001$) and lower pleasurable experiences ($t = -2.37$, $p = 0.017$) (see Table 4). These findings were replicated when the complete data set was analysed (see online Supplementary data). Logistic regression (Table 5) analyses suggested that future intention to quit was significantly associated with psychotic-like experiences (higher score predicted future intention to quit), pleasurable experiences (lower score predicted future intention to quit), age (lower age predicted future intention to quit), sex (being females predicted future intention to quit) and history of tobacco use (more frequent use predicted future intention to quit). History of non-prescribed medication use was also borderline significant ($p = 0.49$, less frequent use predicted future intention to quit).

Sensitivity analyses

On sensitivity analyses, when the complete data set was analysed (i) with those with psychosis or manic illness excluded and (ii)

https://doi.org/10.1017/S0033291718000569 Published online by Cambridge University Press

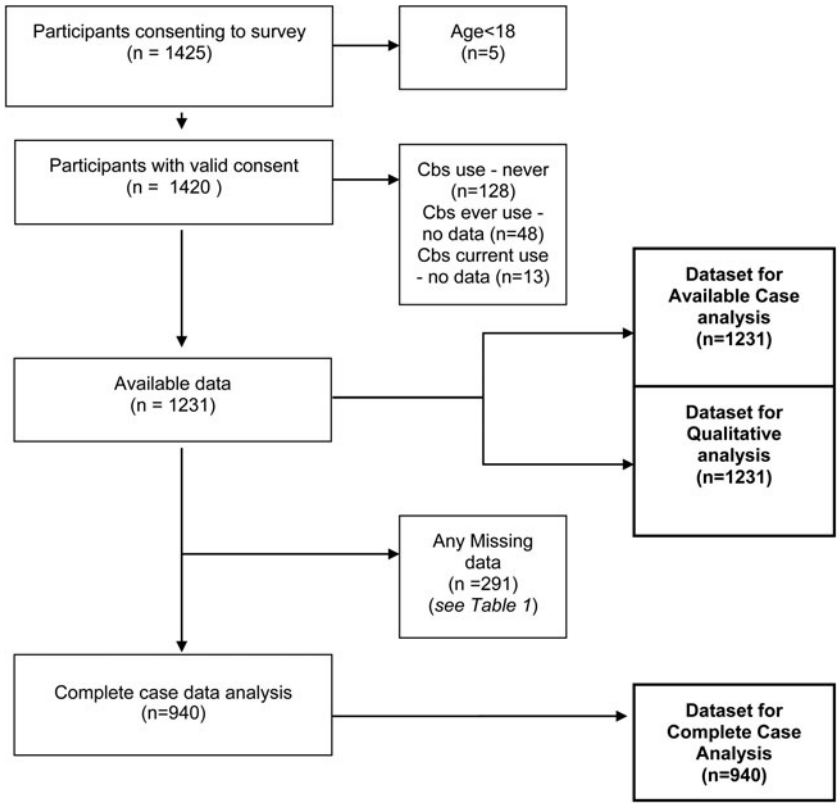

Fig. 1. Participant flow chart. cbs, cannabis.

restricted to discontinued users who reported last use of cannabis more than 6 months previously, psychotic-like experiences and pleasurable experiences significantly predicted cessation in the same direction. The same relationship between psychotic-like experiences and pleasurable experiences remained statistically significant when restricted to daily users (see online Supplementary data).

Qualitative analysis

In total, 1107 unique participants provided qualitative feedback. Three hundred and twelve unique 'open' codes were inductively derived from the data. Qualitative coding broadly identified the dominant themes of significant negative experiences as impacting on continued cannabis use (see online Supplementary data on coding 'Why did you stop/negative psychological symptoms'). Within coding of responses to the question 'Why have patterns of use changed?', 121 codes were broadly categorised into individual-, interpersonal-, community-, organisational- and policy-level themes. Additional themes related specifically to the constituents of cannabis, the micro-context of use and the concept of 'maturation'. Drawing on the subjective participant perspectives, negative experiences were linked to the type of cannabis used, particularly strong types of cannabis (skunk) and synthetic cannabis. Participants made clear links between their negative experiences, their cannabis use and their future intentions, such that negative experiences were considered to be somewhat protective of future cannabis use (see online Supplementary data on coding 'Why have patterns of use changed/negative effects'). Indeed, our coding clusters are particularly around individual-level factors, suggesting that an experience at the individual level of perception and interpretation is critical in informing continued patterns of cannabis use. Those who did not report severe negative experiences also discussed future intention to discontinue cannabis use, but intentions in these cases were framed around 'growing older', moving away from cannabis use and discontinued use to match life events (notably getting married, starting a family, starting full-time employment) (see online Supplementary data on coding 'Would you like to stop using cannabis one day/maturing out').

Table 2. Cannabis experiences mean scores by group: discontinuation *v.* continuation

	Ceased users			Continued users			
	Male	Female	All	Male	Female	All	*t*-statistic and *p* value[a]
Psychotic-like experiences	9.93 (0.44) *n* = 102	10.04 (0.36) *n* = 157	10.02 (0.28) *n* = 260	7.90 (0.09) *n* = 657	8.24 (0.23) *n* = 172	7.98 (0.08) *n* = 839	*t* = 7.05 ***p* < 0.001**
Pleasurable experiences	8.97 (0.32) *n* = 103	7.42 (0.27) *n* = 162	8.02 (0.21) *n* = 266	11.91 (0.08) *n* = 663	11.28 (0.20) *n* = 174	11.78 (0.08) *n* = 847	*t* = −16.67 ***p* < 0.001**

Psychotic-like experiences: CEQ score psychotic-like experiences; pleasurable experiences: CEQ score pleasurable/pleasurable experiences. *In boxes:* mean score (SEM) number in group.
[a]Independent samples *t* test for cessation *v.* continuation. Positive *t*-statistic in the direction of cessation.

https://doi.org/10.1017/S0033291718000569 Published online by Cambridge University Press

Table 3. Logistic regression for cannabis discontinuation/continuation by co-variate

					95% CI for EXP(B)	
	B	S.E.	Sig.	Exp(B)	Lower	Upper
Psychotic-like Experiences	0.233	0.035	**<0.001**	1.262	1.179	1.351
Pleasurable experiences	−0.333	0.041	**<0.001**	0.717	0.662	0.776
Age	0.049	0.012	**<0.001**	1.050	1.026	1.075
Sex	0.593	0.233	**0.011**	1.809	1.146	2.856
Occupation	−0.003	0.086	0.974	0.997	0.842	1.181
Mental health contact	−0.347	0.229	0.130	0.707	0.451	1.108
Age of first cannabis use	−0.015	0.034	0.651	0.985	0.922	1.052
Frequency of cannabis use	0.824	0.104	**<0.001**	2.279	1.859	2.795
Alcohol history	−0.225	0.207	0.276	0.798	0.532	1.197
Tobacco history	0.235	0.121	0.051	1.265	0.999	1.603
Non-prescribed medications history	0.055	0.137	0.686	1.057	0.808	1.382
Cocaine history	0.276	0.165	0.094	1.318	0.954	1.820
Ecstasy history	0.006	0.137	0.962	1.006	0.769	1.317
Constant	−4.371	1.202	<0.001	0.013		

Psychotic-like experiences: CEQ score psychotic-like experiences; pleasurable experiences: CEQ score pleasurable/pleasurable experiences. Positive Bs in the direction of cessation.

Discussion

We investigated the impact of desirable and undesirable transient subjective experiences, such as 'pleasurable' and 'psychotic-like experiences', respectively, on subsequent cannabis use behaviour as indexed by cessation or continuation of cannabis use as well as future intention to quit in those who continue to use cannabis in a large internet-based participant survey. Our results from a combination of quantitative and qualitative analyses converge to demonstrate that psychotic-like experiences are strongly associated with both cannabis cessation and future intention to quit. These results survived controlling for potential confounding factors that may also be associated with these outcomes and is particularly evident in those who use cannabis most frequently.

Qualitative data further support these relationships such that those who have discontinued cannabis are more ready to clearly ascribe this to negative experiences. However, those who intend to stop using cannabis in the future do not necessarily ascribe intention to stop to anticipate negative experiences. Together, the significant association between negative subjective experiences and cessation may suggest that the elucidation of such experiences may form the basis of a therapeutic intervention for those who express a desire to quit.

Conversely, this study clearly demonstrates that pleasurable experiences are associated with continued use and lack of intention to quit. This is in line with the previous studies in this area (Grant *et al.* 2005; Scherrer *et al.* 2009). Cannabis is thus evidently experienced as a pleasurable drug and this would appear to account for its ongoing and continued use.

To date, there is no consensus in the literature as to whether adverse experiences are associated with reduced or heavier use (Lyons *et al.* 1997; Grant *et al.* 2005; Scherrer *et al.* 2009; Zeiger *et al.* 2010). To our knowledge, no prior studies have systematically looked to examine specifically the effect of cannabis-induced psychotic-like experiences on cannabis cessation. Two studies have however reported on incidental findings that support the direction of our findings. Whilst validating the CEQ, Stirling *et al.* noted continued cannabis users to report more positive and less negative experiences than past users ($n = 185$) (Stirling *et al.* 2008). Whilst testing whether psychotic-like experiences are a marker of psychosis proneness, Mason *et al.* noted that a greater acute psychotomimetic state effect was associated with less frequent cannabis use ($n = 140$) (Mason *et al.* 2009). Our data extend previous work by clearly indicating that psychotic-like experiences are associated with cessation and are attributed as one of the main

Table 4. Cannabis experiences mean scores by group in continued users: future intention to quit *v.* no future intention to quit

	Future intention to quit			No intention to quit			
	Male	Female	All	Male	Female	All	*t*-statistic and *p* value[a]
Psychotic-like experiences	8.74 (0.30) $n = 102$	9.27 (0.54) $n = 45$	8.88 (0.27) $n = 148$	7.75 (0.09) $n = 555$	7.88 (0.25) $n = 127$	7.78 (0.08) $n = 691$	$t = 3.95$ **$p < 0.001$**
Pleasurable experiences	11.40 (0.22) $n = 104$	11.30 (0.39) $n = 46$	11.38 (0.19) $n = 151$	12.01 (0.09) $n = 559$	11.27 (0.24) $n = 128$	11.86 (0.08) $n = 696$	$t = -2.37$ **$p = 0.018$**

Psychotic-like experiences: CEQ score psychotic-like experiences; pleasurable experiences: CEQ score pleasurable/pleasurable experiences. *In boxes:* mean score (SEM) number in group.
[a]Independent samples *t* test for future intention to quit *v.* no future intention to quit. Positive *t*-statistic in the direction of future intention to quit.

https://doi.org/10.1017/S0033291718000569 Published online by Cambridge University Press

Table 5. Logistic regression for future intention to quit/no intention to quit by co-variate

					95% CI for EXP(B)	
	B	S.E.	Sig.	Exp(B)	Lower	Upper
Psychotic-like experiences	0.123	0.040	**0.003**	1.131	1.044	1.225
Pleasurable experiences	−0.114	00.047	**0.015**	0.892	0.814	0.978
Age	−0.075	0.016	**<0.001**	0.927	0.898	0.958
Sex	0.737	0.248	**0.003**	2.090	1.282	3.408
Occupation	−0.059	0.080	0.492	0.943	0.797	1.115
Mental health contact	0.204	0.233	0.388	1.226	0.772	1.945
Age of first cannabis use	0.054	0.037	0.150	1.056	0.981	1.136
Frequency of cannabis use	−0.006	0.118	0.957	0.994	0.789	1.252
Alcohol history	0.178	0.172	0.308	1.195	0.848	1.682
Tobacco history	−0.453	0.143	**0.002**	0.635	0.479	0.842
Non-prescribed medications history	0.274	0.137	**0.049**	1.316	1.001	1.730
Cocaine history	−0.079	0.146	0.592	0.924	0.692	1.233
Ecstasy history	−0.002	0.130	0.988	0.998	0.771	1.293
Constant	−1.399	1.261	0.269	0.247		

Psychotic-like experiences: CEQ score psychotic-like experiences; pleasurable experiences: CEQ score pleasurable/pleasurable experiences. Positive Bs in the direction of future intention to quit.

drivers underlying cessation by those who have successfully stopped. Furthermore, by demonstrating an association between psychotic-like experiences and a future intention to cease, which is not consciously recognised as such by continued users, these results also suggest a potential intervention target. Given that our data show psychotic-like experiences in both continued and discontinued users, this may indicate that as pleasurable experiences are predominant, they may over-ride the occasional negative experiences, even if the experience is severe. However, the results of this study may have implications beyond this.

A central argument against the relationship between cannabis use and psychosis risk has been that whereas cannabis prevalence and potency has increased over the last four decades, there has not been a corresponding increase in the population-level incidence of psychotic disorders (Frisher *et al.* 2009) as would be expected if cannabis use were to be causally linked to psychosis risk. This has been argued to critically weaken the case for the association between cannabis and psychosis and remains an ongoing area of controversy (Hill, 2015; Gage *et al.* 2016).

There is now a growing body of evidence to suggest that psychotic-like experiences with cannabis use, such as have been measured in this study, may act as a tractable marker for identifying those at putative psychotic risk. In an independent study, patients with psychotic illness have been shown to experience more profound cannabis effects compared with healthy controls (HCs) (Bianconi *et al.* 2016). Administration of δ-9-tetrahydrocannabinol, the major psychotomimetic constituent of cannabis, has been demonstrated to elicit an increased psychotomimetic response in individuals with a psychotic illness as compared with HCs (D'Souza *et al.* 2005). Furthermore, increased schizotypy, a marker of psychosis proneness, predicts increased psychotic-like experiences in cannabis users (Barkus *et al.* 2006). A large patient–sibling and sibling–control design study has demonstrated increased sensitivity of sub-threshold psychotic experiences to cannabis use amongst sibling pairs of patients with psychosis as compared with controls (Kahn *et al.* 2011). Controlled experimental studies have demonstrated that variations in genes implicated in psychosis such as COMT, AKT1 and DAT1 may moderate greater sensitivity to the psychotomimetic effects of cannabis and its neurophysiological underpinnings in non-clinical populations (Henquet *et al.* 2006; Bhattacharyya *et al.* 2012). Taken together, increased sensitivity to cannabis-induced psychotomimetic experiences have been found in (i) patients with psychosis, (ii) those with psychosis proneness and (iii) those with family history and genetic liability to psychosis, as compared with the general population. Thus, the CEQ psychotic-like experiences score, as measured in this study, may give an indication of psychosis risk, although prospectively designed studies would be required to absolutely quantify this.

If individuals with cannabis-induced psychotic-like experiences (who are at a putatively higher risk of developing disorder) were to discontinue use, as our results suggest, this may off-set the greater risk of developing psychotic disorder associated with cannabis use. We suggest that this might in turn explain the relative stability of the rates of psychotic disorder over time despite the growing use of more potent forms of cannabis. Hence, we posit a discontinuation hypothesis leading to those at the highest risk of cannabis-induced psychosis self-selecting themselves out of a continued use, and hence protecting themselves from the risk of developing enduring psychotic disorders.

Such an explanation is consistent with the evidence that those at clinically high risk of psychosis discontinue cannabis use once breakthrough psychotic symptoms appear (Valmaggia *et al.* 2014) and an independent evidence in the general population that sub-threshold psychotic experiences, measured using the Community Assessment of Psychic Experience (CAPE) questionnaire (as distinct from cannabis-induced psychotic-like experiences), predict cessation of cannabis use over 6 months to 5 years (van Gastel *et al.* 2014).

These results are to be considered in light of certain limitations: the outcome measure reported that self-reported continued

https://doi.org/10.1017/S0033291718000569 Published online by Cambridge University Press

use (yes/no) may vary or wane over time. However, our findings remained in the same direction when we restricted the discontinued group to those who reported last use at least 6 months previously. Further, the cross-sectional nature of our study precludes conclusions regarding the precise nature of these relationships. Nevertheless, the associations reported survived adjustment for multiple potential demographic and substance misuse confounders and were consistent across two different outcome measures. Arguably, the pragmatic design that we have employed using a convenience sample, rather than a probability sample, also limits the generalisability of these results. Whilst this would have been expected to result in under-reporting of psychotic-like symptoms associated with cannabis use as our sample was drawn from advertisements on social media and cannabis campaigning platforms, this did not occur, with around 40% of the sample acknowledging that they have either felt suspicious or nervy at some point from cannabis use. Arguably, the online data acquisition design accorded anonymity allowing for more honest engagement with the survey as evident from the abundant qualitative data. Of note, a higher proportion of our sample (38.1%) reported a lifetime history of mental health contact than would be expected in the general population. Although we adjusted for mental health contact in our data, this did not include substance misuse treatment, which may be seen as a limitation. Further, we cannot completely exclude response bias or recall bias: those who have discontinued are likely to have used cannabis in the more distant past than those who continue use, and those who discontinue may be more likely to highly rate negative experiences. However, these biases are unlikely to have systematically affected the results as negative experiences are also rated similarly in those who continue to use but intend to quit in future.

Finally, one must also consider the items used and the construct validity of the CEQ for the experiences used and the sample studied. Principal component analysis of 55 different experiences (43 immediate, 12 after-effects) in a previous British non-clinical cohort using an electronic survey has demonstrated the nine experiences we administered to load significantly with factor loading >0.5 onto their respective subscales (psychotic-like experiences and pleasurable effects) (Barkus & Lewis, 2008). A further analysis of all the original experiences showed the nine experiences we administered to load similarly onto distinct subscales with a factor >0.5 in the same manner, except for visual hallucinations which were not part of the solution (Stirling *et al.* 2008). A two-factor model for immediate experiences has recently been confirmed in independent non-clinical populations, although notably auditory and visual hallucinations were not part of the final 13-item solution (Quinn *et al.* 2017). However, this latent structure has not been universally validated in clinical populations: in a recent US sample in a first-episode clinical population ($n = 194$), exploratory factor analysis using the original experiences identified four subscales amongst patients: distortions of reality and self-perception; euphoria effects; slowing and amotivational effects; and anxiety and paranoia effects (Birnbaum *et al.* 2017). This is similar, although not identical to another study involving both first-episode patients and controls (patients $n = 252$; controls $n = 207$), where a four-factor model was derived from 14 experiences namely: anxiety-paranoid experiences; cognitive experiences; enjoyable experiences and psychotic experiences (Bianconi *et al.* 2016). One explanation for this could be that cannabis experiences maybe differentially experienced in clinical and non-clinical populations as suggested by the authors of both studies (Bianconi *et al.* 2016; Birnbaum *et al.* 2017); hence, our results in a non-clinical sample cannot be generalised to patient groups, which would need to be studied separately.

Notwithstanding these limitations, using a well-validated measure, which has now been used across multiple non-clinical populations (Barkus *et al.* 2006; Barkus & Lewis, 2008; Stirling *et al.* 2008; Quinn *et al.* 2017) and a mixed-methods approach, we report converging evidence from a quantitative analysis controlling for potential confounders and an independent qualitative analysis that psychotic-like experiences may predict cannabis cessation, whereas pleasurable experiences may predict continued use as well as quantitative evidence that such experiences may also predict future intention to quit or continue cannabis use.

Together, these findings may suggest that psychotic-like experiences associated with cannabis use may have a protective effect on the risk of subsequent psychotic disorder by influencing future and continued cannabis use behaviour, and may go some way to explaining relative stability of rates of psychotic disorder over time. Prospective longitudinal studies are needed to definitively confirm or refute this possibility.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0033291718000569

Declaration of interest. The authors declare no conflict of interest.

Source of funding. SB has been funded by the National Institute for Health Research (NIHR), UK through a Clinician Scientist award (NIHR-CS-11-001) and also supported by the NIHR Biomedical Research Centre for Mental Health BRC Nucleus at the South London and Maudsley NHS Foundation Trust and Institute of Psychiatry, Psychology and Neuroscience, King's College London. MS is funded through a Medical Research Council (UK) Clinical Research Training Fellowship. CN is funded through a Post-Doctoral Fellowship from the UK Society for the Study of Addiction.

Role of the funding source. The views expressed are those of the authors and not necessarily those of the NHS, the NIHR, the MRC, the SSA or the Department of Health. The funders had no role in the preparation, review or approval of the manuscript; and decision to submit the manuscript for publication. All authors have approved the final version of the paper.

Ethical declaration. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

References

Barkus E and Lewis S (2008) Schizotypy and psychosis-like experiences from recreational cannabis in a non-clinical sample. *Psychological Medicine* **38**, 1267–1276.

Barkus EJ, Stirling J, Hopkins RS and Lewis S (2006) Cannabis-induced psychosis-like experiences are associated with high schizotypy. *Psychopathology* **39**, 175–178.

Bhattacharyya S, Atakan Z, Martin-Santos R, Crippa Ja, Kambeitz J, Prata D *et al.* (2012) Preliminary report of biological basis of sensitivity to the effects of cannabis on psychosis: AKT1 and DAT1 genotype modulates the effects of δ-9-tetrahydrocannabinol on midbrain and striatal function. *Molecular Psychiatry* **17**, 1152–1155.

Bianconi F, Bonomo M, Marconi A, Kolliakou A, Stilo SA, Iyegbe C *et al.* (2016) Differences in cannabis-related experiences between patients with a first episode of psychosis and controls. *Psychological Medicine* **46**, 995–1003.

Birnbaum ML, Cleary SD, Ramsay Wan C, Pauselli L and Compton MT (2017) Factor structure of the Cannabis Experiences Questionnaire in a first-episode psychosis sample. *Early Intervention in Psychiatry*, 1–7. doi: 10.1111/eip.12509. [Epub ahead of print].

Braun V and Clarke V (2006) Using thematic analysis in psychology. *Qualitative Research in Psychology* **3**, 77–101.

Degenhardt L and Hall W (2012) Extent of illicit drug use and dependence, and their contribution to the global burden of disease. *The Lancet* **379**, 55–70.

Di Forti M, Iyegbe C, Sallis H, Kolliakou A, Falcone MA, Paparelli A *et al.* (2012) Confirmation that the AKT1 (rs2494732) genotype influences the risk of psychosis in cannabis users. *Biological Psychiatry* **72**, 811–816.

Di Forti M, Morgan C, Dazzan P, Pariante C, Mondelli V, Marques TR *et al.* (2009) High-potency cannabis and the risk of psychosis. *British Journal of Psychiatry* **195**, 488–491.

D'Souza DC, Abi-Saab WM, Madonick S, Forselius-Bielen K, Doersch A, Braley G *et al.* (2005) Delta-9-tetrahydrocannabinol effects in schizophrenia: implications for cognition, psychosis, and addiction. *Biological Psychiatry* **57**, 594–608.

Frisher M, Crome I, Martino O and Croft P (2009) Assessing the impact of cannabis use on trends in diagnosed schizophrenia in the United Kingdom from 1996 to 2005. *Schizophrenia Research* **113**, 123–128.

Gage SH, Hickman M and Zammit S (2016) Association between cannabis and psychosis: epidemiologic evidence. *Biological Psychiatry* **79**, 549–556.

Grant JD, Scherrer JF, Lyons MJ, Tsuang M, True WR and Bucholz KK (2005) Subjective reactions to cocaine and marijuana are associated with abuse and dependence. *Addictive Behaviors* **30**, 1574–1586.

Henquet C, Rosa A, Krabbendam L, Papiol S, Fananás L, Drukker M *et al.* (2006) An experimental study of catechol-o-methyltransferase Val158Met moderation of delta-9-tetrahydrocannabinol-induced effects on psychosis and cognition. *Neuropsychopharmacology* **31**, 2748–2757.

Hill M (2015) Perspective: be clear about the real risks. *Nature* **525**, S14–S14.

Kandel DB and Logan JA (1984) Patterns of drug-use from adolescence to young adulthood. 1. Periods of risk for initiation, continued use, and discontinuation. *American Journal of Public Health* **74**, 660–666.

Kandel DB and Raveis VH (1989) Cessation of illicit drug use in young adulthood. *Archives of General Psychiatry* **46**, 109–116.

Kuepper R, van Os J, Lieb R, Wittchen H-U, Höfler M and Henquet C (2011) Continued cannabis use and risk of incidence and persistence of psychotic symptoms: 10 year follow-up cohort study. *BMJ* (*Clinical Research Ed.*) **342**, d738.

Le Strat Y, Ramoz N, Horwood J, Falissard B, Hassler C, Romo L *et al.* (2009) First positive reactions to cannabis constitute a priority risk factor for cannabis dependence. *Addiction* **104**, 1710–1717.

Little MA, Spruijt-Metz D, Pokhrel P, Sun P, Ann Rohrbach L and Sussman S (2013) Predicting self-initiated marijuana use cessation among youth at continuation high schools. *Frontiers in Psychiatry* **4**, 1–7.

Lyons MJ, Toomey R, Meyer JM, Green AI, Eisen SA, Goldberg J *et al.* (1997) How do genes influence marijuana use? The role of subjective effects. *Addiction* **92**, 409–417.

Marconi A, Di Forti M, Lewis CM, Murray RM and Vassos E (2016) Meta-analysis of the association between the level of cannabis use and risk of psychosis. *Schizophrenia Bulletin* **42**, 1262–1269.

Mason O, Morgan CJA, Dhiman SK, Patel A, Parti N and Curran HV (2009) Acute cannabis use causes increased psychotomimetic experiences in individuals prone to psychosis. *Psychological Medicine* **39**, 951–956.

Moore THM, Zammit S, Lingford-Hughes A, Barnes TRE, Jones PB, Burke M *et al.* (2007) Cannabis use and risk of psychotic or affective mental health outcomes: a systematic review. *The Lancet* **370**, 319–328.

Kahn RS, Linszen DH, van OS J, Wiersma D, Bruggeman R, Cahn W, de Hann L, Krabbendam L, Myin-Germeys I; Genetic Risk and outcome of Psychosis (Group) Investigators (2011) Evidence that familial liability for psychosis is expressed as differential sensitivity to cannabis: an analysis of patient-sibling and sibling-control pairs. *Archives of General Psychiatry* **68**, 138–147.

Quinn CA, Wilson H, Cockshaw W, Barkus E and Hides L (2017) Development and validation of the cannabis experiences questionnaire – intoxication effects checklist (CEQ-I) short form. *Schizophrenia Research* **189**, 91–96.

Scherrer JF, Grant JD, Duncan AE, Sartor CE, Haber JR, Jacob T *et al.* (2009) Subjective effects to cannabis are associated with use, abuse and dependence after adjusting for genetic and environmental influences. *Drug and Alcohol Dependence* **105**, 76–82.

Schoeler T, Monk A, Sami MB, Klamerus E, Foglia E, Brown R *et al.* (2016*a*) Continued versus discontinued cannabis use in patients with psychosis: a systematic review and meta-analysis. *The Lancet Psychiatry* **3**, 215–225.

Schoeler T, Petros N, Di Forti M, Klamerus E, Foglia E, Ajnakina O *et al.* (2016*b*) Effects of continuation, frequency and type of cannabis use on relapse in the first two years following onset of psychosis – an observational study. The Author(s). Published by Elsevier Ltd. This is an Open Access article under the CC BY license, *Lancet Psychiatry* **366**, 1–7.

Schoeler T, Petros N, Di Forti M, Pingault J-B, Klamerus E, Foglia E *et al.* (2016*c*) Association between continued cannabis use and risk of relapse in first-episode psychosis. *JAMA Psychiatry* **35**, 557–574.

Stirling J, Barkus EJ, Nabosi L, Irshad S, Roemer G, Schreudergoidheijt B *et al.* (2008) Cannabis-induced psychotic-like experiences are predicted by high schizotypy: confirmation of preliminary results in a large cohort. *Psychopathology* **41**, 371–378.

Thomas H (1996) A community survey of adverse effects of cannabis use. *Drug and Alcohol Dependence* **42**, 201–207.

Valmaggia LR, Day FL, Jones C, Bissoli S, Pugh C, Hall D *et al.* (2014) Cannabis use and transition to psychosis in people at ultra-high risk. *Psychological Medicine* **44**, 2503–2512.

van den Bree MBM, Pickworth WB (2005) Risk factors predicting changes in marijuana involvement in teenagers. *Archives of General Psychiatry* **62**, 311.

van Gastel WA, Vreeker A, Schubart CD, MacCabe JH, Kahn RS and Boks MPM (2014) Change in cannabis use in the general population: a longitudinal study on the impact on psychotic experiences. *Schizophrenia Research* **157**, 266–270.

von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC and Vandenbroucke JP (2007) The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *The Lancet* **370**, 1453–1457.

Zeiger JS, Haberstick BC, Corley RP, Ehringer MA, Crowley TJ, Hewitt JK *et al.* (2010) Subjective effects to marijuana associated with marijuana use in community and clinical subjects. *Drug and Alcohol Dependence* **109**, 161–166.

https://doi.org/10.1017/S0033291718000569 Published online by Cambridge University Press