Child and adolescent externalizing behavior and cannabis use disorders in early adulthood: An Australian prospective birth cohort study

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Abstract

This study examined the association between age of onset and persistence of externalizing behavior and young adults' cannabis use disorders (CUDs). Data were from a 21 year follow-up of a birth cohort study in Brisbane, Australia. The present cohort consisted of 2225 young adults who had data available about CUDs at 21 years and externalizing behavior at 5 and 14 years. Young adults' CUDs were assessed using the CIDI-Auto. Child and adolescent externalizing behavior were assessed at the 5- and 14-year phases of the study. After controlling for confounding variables, children who had externalizing behavior at both 5 and 14 years (child-onset-persistent) (COP) had a substantial increase in risk of CUD at age 21 years (Odds ratio (OR) = 2.5; 95% CI: 1.5, 4.2). This association was similar for those who had 'adolescent onset' (AO) externalizing behavior. However, there was no association between 'childhood limited' (CL) externalizing behavior and CUD. Externalizing behavior in adolescence is a strong predictor of subsequent CUD. Smoking and drinking at 14 years partially mediated the link between externalizing behavior and CUD.

1. Introduction

High rates of illicit drug use, including cannabis, by adolescents and young adults continue to be a significant threat to the public health. Use of cannabis usually begins before 20 years of age, with the peak onset at around 16–18 years (Chen & Kandel, 1995). In Australia, three in five persons aged 20–29 years have used cannabis in their lifetime (Australian Institute of Health and Welfare, 2005) and one third of cannabis users meet the criteria for life-time cannabis abuse or dependence (disorders) (Swift, Hall, & Teesson, 2001). Externalizing behavior such as conduct problems, aggression, and delinquency in both childhood and adolescence are recognized risk indicators for future substance abuse or dependence ([Boyle et al., 1992], [Disney et al., 1999], [Fergusson et al., 2005], [Fergusson and Lynskey, 1998], [King et al., 2004] and [Moffitt et al., 2001]). Despite strong evidence for a connection between externalizing behavior and cannabis use, there remains a paucity of knowledge about the independent relationship between the appearance and evolution of externalizing behavior and the development of cannabis use disorders (CUDs) in early adulthood.

Externalizing behavior has been conceptualized into a variety of typologies ([Connor, 2002], [Loeber et al., 1998] and [Nagin and Tremblay, 2005]). The typology of (Moffitt, 1993), (Moffitt, 2006) and (Moffitt et al., 1996) is a prominent one and contrasts with certain others in being based around age of onset and persistence/desistence of externalizing behaviors. In examining pathways of externalizing behavior during childhood and adolescence, Moffitt (2006) and Moffitt et al. (1996) identified three groups: 1 — those who had 'extreme' (above one standard deviation above the mean) externalizing (antisocial) behavior in

childhood but were below that cut-off point in adolescence were referred to as 'childhood limited' (CL) (Moffitt, 2006); 2 — individuals who were not in the 'extreme' range of externalizing behavior in childhood but exceeded the cut-off point in adolescence were described as 'adolescent limited' (AL) (Moffitt, 1993); and 3 — the subgroup of children who had 'extreme' externalizing behavior across childhood and adolescence were defined as 'life-course persistent' (LCP). Those who did not exhibit extreme externalizing behavior at either 5 or 14 years were denoted as 'unclassified' (UNCL).

Moffitt (1993) and (Moffitt et al., 2001) and (Moffitt et al., 1996) argue that the antisocial behavior of people in the LCP group has its origins in "neuro-developmental processes" and leads to persistent antisocial behavior and the development of a range of psycho-social problems as the individuals grow to early adulthood. In comparison, the same authors propose that antisocial behavior of the AL group has its origin in "social processes" and most individuals desist from this antisocial behavior in early adulthood ([Moffitt, 1993] and [Moffitt and Caspi, 2001]). Moffitt (2002a) further suggests that the antisocial behavior of CL individuals is just as severe in childhood as the behavior of those in the LCP group and, despite it becoming significantly attenuated in adolescence, individuals with CL conduct disorder show adverse consequences in adulthood comparable with the LCP group.

Empirical research generally tends to support the typologies proposed by Moffitt (see review by Moffitt, 2006), but there remains a paucity of evidence concerning the applicability of this theoretical perspective to young adults' illicit drug abuse and dependence. To date, there have been very few prospective investigations of the relationship between each pattern of externalizing behavior and substance use problems. In a study of outcomes among sub-groups of antisocial boys, Moffitt et al. (1996) found that LCP and AL antisocial groups had similar prevalences of alcohol and cannabis dependence, and that AL boys had an increased rate of nicotine dependence compared with the LCP group at 18 years. They also found a small rate of substance dependence among CL group. Follow-up of the same cohort when the subjects were 26 years old indicated consistent results (Moffitt, Caspi, Harrington, & Milne, 2002).

Although these studies conducted by Moffitt and colleagues found an association between the typology of antisocial behavior and substance use in early adulthood, their analyses were confined to the simple relationship between the independent and outcome variables; they did not control for potential confounders that could distort the association. Furthermore, they did not examine the association for both genders; the published analyses are restricted to males. More males than females engage in antisocial behaviors, and the antisocial behaviors of males relative to females are more likely to be serious and committed persistently at a high rate (Moffitt et al., 2001). Use of illicit drugs, including cannabis, is more prevalent among adolescent and young adult males (Bauman & Phongsavan, 1999), although the gender difference is not as wide as for antisocial behavior (Moffitt et al., 2001). Hence, research is required to examine whether there are gender differences in the association between the typology of externalizing behavior and later substance use.

Several mechanisms may explain the association between externalizing behavior and substance use problems. One hypothesis is that the two phenomena have a common or shared pathway or, as suggested by Jessor and Jessor (1977) and Donovan and Jessor (1985), they reflect a general syndrome of deviance or problem behavior. In this case, the link between externalizing behavior and CUD is due to other factors (confounders), rather than causal. For example, child and adolescent externalizing behaviors are associated with teenage motherhood, marital disruption, poor maternal mental health, maternal substance use, low socio-economic status, poor family functioning, and parental supervision of the child ([Moffitt, 2002b], [Moffitt, 2006], [Nagin and Tremblay, 2001] and [Weissman et al., 1999]). These family factors are also associated with the later use of substances by children ([Hawkins et al., 1992] and [Hayatbakhsh et al., 2006]).

There is also a large body of evidence showing that other problem behaviors in children are highly correlated with externalizing behavior and may predict later use of substances. For example, Attention Deficit Hyperactivity Disorder (ADHD) and internalizing behavior (anxiety and depression) have been repeatedly reported as being associated with both externalizing behavior and substance use problems ([Gilliom and Shaw, 2004] and [Lynskey and Hall, 2001]), and may precede the development of substance use disorders (King et al., 2004). It follows that the statistical association between externalizing behavior and CUD may reflect etiological factors common to both phenomena. Therefore, it is plausible that any examination of the association between externalizing behavior and CUD should control for these potential confounders.

A second mechanism might be that use of cannabis leads to externalizing behavior such as aggression and delinquency. Goldstein (1985) suggests that cannabis use has psychopharmacological impacts that may lead to behavioral problems. Cannabis abuse may also make the person less concerned about the consequences of his or her behavior and thus to becoming involved in illegal acts. In addition, individuals may engage in behaviors such as violence and stealing to provide financial support for their drug use. Moffitt et al. (1996) and Hussong, Curran, Moffitt, Caspi, and Carrig (2004) suggested that use of cannabis acts as a factor that establishes a persistent pattern of externalizing behavior from adolescence to early adulthood.

A third hypothesis is that externalizing behavior increases the probability of later illicit drug use, either directly or indirectly. For example, it has been suggested that externalizing behavior in children may have a negative impact on parent–child communication and bonding (Reed & Dubow, 1997), which in turn has been found to be associated with the later use of illicit drugs by the children (Ledoux, Miller, Choquet, & Plant, 2002). Alternatively, children with a high level of externalizing behavior are more prone to drop out of school and to poor educational attainment (Moffitt & Silva, 1987), which may lead to early substance use (King et al., 2004), and in turn, be associated with CUD in early adulthood. Specifically, it is hypothesized that children with externalizing behavior in early adolescence initiate use of legal substances, such as tobacco and alcohol (King et al., 2004), and then progress to use of illicit drugs and use disorders. In the proposed model, externalizing behavior in childhood is a root cause while family and individual variables are seen as intermediate consequences that lead on to CUD. If this is true, recognition of mediating factors may provide opportunities for drug prevention programs.

Overall, there is limited evidence showing that the typological modeling of Moffitt (1993) and Moffitt et al. (1996) can predict risk of young adults' illicit drug abuse or dependence independent of factors that can potentially act as confounders. Using a birth cohort, the present study aimed to examine: 1 — the association between each typology of externalizing behavior as measured by maternal report on the Child Behavior Check List (CBCL) (Achenbach & Edelbrock, 1983) and Youth Self Report (YSR) (Achenbach, 1991), and young adults' CUD; 2 — whether these associations are independent of family and individual factors in early childhood; and 3 — whether factors such as mother–child communication, school performance in high school, and early tobacco, alcohol and cannabis use mediate the link between externalizing behavior and CUD in early adulthood. We also intended to test whether these associations differ for males and females. Based on the predictions from Moffitt's typology, we hypothesized that individuals with child-onset-persistent (COP) externalizing behavior are at a substantially greater risk of CUD as young adults relative to the adolescent onset (AO) and childhood limited (CL) groups. We also expected those in AO group would be more likely than UNCL children to develop CUD by early adulthood.

2. Methods

2.1. Participants

We used data from the Mater University study of pregnancy and its outcomes (MUSP) (Najman et al., 2005), a birth cohort study of women recruited at the Mater Misericordiae Hospital in Brisbane, Australia, between 1981 and 1983. Baseline data were collected at the first antenatal visit from 7223 consecutive women who

gave birth to live singleton babies and were followed up at 3–5 days, 6 months, and 5, 14 and 21 years after the birth. Informed consent from the mother was obtained at all phases of data collection and from the young adult at the 21 year follow-up. Ethics committees from the Mater Hospital and the University of Queensland approved each phase of the study.

The present analyses use the baseline, birth, 5-, 14- and 21-year follow-up data (Table 1). Due to financial constraints at the 21-year follow-up, a computerized version of Composite International Diagnostic Interview (CIDI-Auto) (World Health Organization, 1997) was administered to a sub-cohort of 2556 young adults. This study is based on 2225 young adults (51.3% female and 48.7% male) who completed the CIDI-Auto at the 21-year follow-up and for whom data were available on externalizing behavior at 5 and 14 years. Cohort families had an average annual income between AUD 20,800 and AUD 26,000 and were primarily White (95.2% of mothers and 95.9% of fathers); fewer than 4.0% of the participants' fathers or mothers were identified at the child's birth as Australian Aboriginal or Torres Strait Islanders. At baseline (1981–1983) 20.6% of mothers reported having had tertiary education, 64.1% had completed high school and 15.3% had not finished high school education. The average age of participating children were 5.55 years (SD = 0.43) at the 5-year follow-up, 13.90 years (SD = 0.33) at the 14-year assessment, and 20.45 years (SD = 0.84) at the 21-year follow-up.

Table 1: Variables used in the present study

Variables	Source	Instrument
Assessed at first clinic visit		
Mother's age	Mother	*
Mother's education	Mother	*
Assessed at 5 years		
Current family income	Mother	*
Maternal marital status	Mother	*
Current maternal marital quality	Mother	DAS
Maternal anxiety/depression	Mother	DSSI
Maternal smoking	Mother	*
Maternal alcohol consumption	Mother	*
Maternal illicit drug use	Mother	*
Maternal supervision of child	Mother	*
Child externalizing behavior within last 6 months	Mother	CBCL
Child attention problems within last 6 months	Mother	CBCL
Child internalizing behavior within last 6 month	Mother	CBCL
Assessed at 14 years		
Mother–child communication	Mother	PACS
Child school performance	Child	*
Adolescent smoking	Child	*
Adolescent drinking	Child	*
Adolescent ever use of cannabis	Child	*
Adolescent externalizing behavior within last 6 months	Mother	CBCL
Adolescent externalizing behavior within last 6 months	Child	YSR
Cannabis use disorders assessed at 21 years	Young adults	CIDI-Auto

Note: * data collected by self-reported items; DAS = Dyadic Adjustment Scale; DSSI = Delusions States Symptoms Inventory; CBCL = Child Behavior Check List; YSR = Youth Self Report; PACS = Parent–Adolescent Communication Scale; CIDI-Auto = Composite International Diagnostic Interview—computerized version.

2.2. Instruments

2.2.1. Measurement of outcome

At the 21-year phase of the study, we used the CIDI-Auto to assess a life-time diagnosis of both cannabis abuse and dependence, according to DSM-IV diagnostic criteria (American Psychiatric Association, 1994). The CIDI has been used in a range of epidemiological studies and has been shown to be a reliable and valid survey instrument (Teesson, Hall, Lynskey, & Degenhardt, 2000). The CIDI-Auto can be self-administered by the respondent, or administered by a technician interviewer who reads the questions as they appear on the screen. In the present study, the CIDI-Auto was administered by trained research staff. It was completed in the presence of the interviewer and the participant only, and participants were informed that all answers provided by them were confidential and private and that the information they provided would be de-identified through the use of a unique code number (no names or identifying details were entered into the CIDI-Auto program when it was administered via a laptop computer).

The DSM-IV specifies 11 criteria for substance use disorders that are equally applicable to all classes of psychoactive substances including alcohol, cocaine, opiates, cannabis, sedatives, stimulants and hallucinogens. Dependence is measured by seven criteria, at least three of which must be met for a diagnosis to be established. Abuse is measured by four additional criteria, and a diagnosis is made if at least one criterion is met (and a diagnosis of dependence is absent). Criteria for each diagnostic outcome are assumed to have equal weighting. Participants who, at age 21, met the DSM-IV criteria for life-time diagnosis of cannabis dependence or abuse were categorized as having a CUD. We also assessed abuse or dependence relating to other illicit drugs including: heroin, amphetamines, ecstasy, cocaine, hallucinogens, inhalants, and others. Participants who reported having symptoms of abuse or dependence for other illicit drugs were classified as having other illicit drug use disorders.

2.2.2. Measurement of child and adolescent externalizing behavior

Replicating Moffitt's typologies requires the identification of those individuals who exhibited high levels of externalizing behavior in early childhood and adolescence. Child and adolescent externalizing behavior was assessed using the externalizing behavior sub-scales of the Child Behavior Checklist (CBCL) (Achenbach & Edelbrock, 1983) and the Youth Self Report (YSR) version of the CBCL (Achenbach, 1991), respectively. Because of resource constraints at the 5-year follow-up, mothers completed a short form (33-item) of the CBCL. Prior analyses (Najman et al., 1997) using a sub-sample of respondents indicated a strong correlation between the short (10-item) and long forms of the CBCL for the externalizing behavior ($r = 0.94$) sub-scale. The mean score for externalizing behavior at 5 years was 5.97 (6.25 for males and 5.71 for females, $p < .01$) out of a possible maximum of 20.0.

The YSR (Achenbach, 1991) was administered at the 14-year follow-up. It consists of 112 items assessing youth problem behavior including a 31-item externalizing behavior sub-scale addressing aggression and delinquency. The mean score for externalizing behavior at 14 years was 12.75 (12.84 for males and 12.66 for females, p value < .05) out of a possible maximum of 46.0. We applied a cut-point of one standard deviation above the sex-specific mean to define externalizing behavior at 5 years and at 14 years. Using these measures, we distinguished four categories of externalizing behavior as follows: 1) Childhood limited (CL) externalizing behavior: Those individuals who exhibited externalizing behavior in childhood but who were no longer in the most extreme externalizing group in adolescence; 2) Adolescence onset (AO) externalizing behavior: Those who exhibited significant externalizing behavior in adolescence but not in childhood; 3) Child-onset-persistent (COP) externalizing behavior: Those who exhibited significant externalizing behavior in both childhood and adolescence; and 4) Unclassified (UNCL) group: Those who were not in 'extreme' range of externalizing behavior in either childhood or adolescence.

2.2.3. Measurement of confounding factors

As discussed earlier, the association between externalizing behavior and CUD could be confounded by other covariates. A variable is considered a confounder if it is not intermediate in the pathway relating exposure to outcome but is associated with both the exposure and the outcome of interest and distorts the true relationship ([Beaglehole et al., 1993] and [Wassertheil-Smoller, 2004]). For the purpose of this study, a group of variables in the MUSP data were considered possible confounders. These included: socio-economic status (SES), maternal marital status and quality, maternal mental health, maternal substance use, and child internalizing behavior and attention problems at 5 years. Measures of maternal SES included maternal age and education (did not complete high school, completed high school, and post high school education) assessed when the child was born, and gross family income at the 5-year follow-up.

Maternal marital status was self-reported by mothers at the 5-year follow-up as being married, de-facto (living together), single, or un-partnered (separated, divorced, or widowed). The quality of maternal marital relationships at 5 years was assessed using a short form of the Dyadic Adjustment Scale (DAS) (Spanier, 1976). Maternal cigarette smoking in the last week, alcohol consumption, and use of illicit drugs (yes/no) in the last month were also assessed at the 5-year follow-up.

We assessed maternal mental health at the 5-year follow-up using the short form of the Delusions-Symptoms-States Inventory (DSSI) (Bedford & Foulds, 1978). The DSSI is an 84-item self-report inventory of current mental state. All items begin with the word 'recently' which more concretely is explained to subjects as 'during the last month or so'. The items are divided into 12 sets of seven questions including sets concerning anxiety and depression. The DSSI has been widely used and its validity has been established (Morey, 1985). The mother's approach to supervision of the child was measured at the 5-year follow-up using a six-item scale of maternal supervision (Cronbach's alpha = 0.73). At the 5-year follow-up, the CBCL (Achenbach & Edelbrock, 1983) was used to assess measures of child problem behavior, including internalizing behavior and attention problems.

2.2.4. Measurement of mediating factors

A mediating factor is a variable that constitutes a link between a risk factor and the outcome of interest (Baron & Kenny, 1986). Potentially mediating variables existing in MUSP included: mother–child communication, child school performance, and child cigarette smoking, alcohol consumption, and cannabis use measured at 14 years. The Parent–Adolescent Communication Scale (Barnes & Olson, 1982) was used to assess mother–child communication at the 14-year follow-up. This scale has two sub-scales addressing openness in family communication and problems with family communication. In this paper responses from mothers to the 10-item problem sub-scale were used as the measure of mother–child communication (Cronbach's alpha = 0.78).

In the 14-year survey, we asked children to describe their school performance in English, Mathematics, and Science. Options for each question were: 1— below average, 2— a bit below average, 3— average, 4— a bit above average, and 5— above average. The level of smoking and drinking by the adolescent at 14 years was assessed by asking about the number of cigarettes smoked and glasses of alcohol consumed per day during the week preceding the survey. At the 14-years follow-up a sub-sample of adolescents (*n* = 1319) were also asked whether they had used cannabis before (no/yes).

2.2.5. Dealing with loss to follow-up

To determine whether loss to follow-up at 21 years affected the validity of our findings, we undertook a sensitivity analysis using inverse probability weights reflecting the chances of having missing outcome data (Hogan, Roy, & Korkontzelou, 2004). We began by constructing a logistic regression model examining the association of all other covariates used in our primary analyses with having complete data or not. The regression coefficients from this model were then used to determine probability weights for the covariates

in the main analyses. In the current study, loss to follow-up was predicted by child and adolescent externalizing behavior, gender, mother's education, family income, maternal depression and maternal illicit drug use at 5 years, and by mother–child communication, adolescent school performance and smoking at 14 years. The results from subsequent analyses including inverse probability weighting based on these factors did not differ from the unweighted analyses presented here, suggesting that our results were not substantially affected by selection bias.

3. Statistical analysis and results

Of the cohort of children who provided information about childhood and adolescent externalizing behavior, 2225 completed the CIDI-Auto for cannabis abuse and dependence in early adulthood. Some 21.2% met the criteria for either cannabis dependence (10.8%) or abuse (19.1%) and are the subjects described in further analyses as having a CUD. Overall, 9.1% (n = 203) met the criteria for other illicit drug use disorders, of whom 144 had concurrent CUD. Regarding the typologies of externalizing behavior, 72.8% of respondents did not meet the criteria for externalizing behavior (UNCL) at either 5 or 14 years, 11.5% and 12.4% had externalizing behavior limited to childhood (CL) or adolescence (AO), respectively, and 3.3% exhibited externalizing behavior at both 5 and 14 years (COP).

We used chi square tests and univariate logistic regression to estimate the unadjusted risk (odds ratio (OR) and 95% confidence intervals (95% CI)) of having CUD by age 21 for each category of child and adolescent externalizing behavior (with the reference category being UNCL) (Table 2). Externalizing behavior at 5 years was modestly associated with CUD. Children who had externalizing behavior at 14 years were more likely (OR = 2.7; 95% CI: 2.0, 3.5) to have had CUD by early adulthood. The association for those who exhibited externalizing behavior at both 5 and 14 years (COP) was stronger than for the AO group. By contrast, there was no significant difference between CL and UNCL groups in terms of later development of CUD.

Table 2: Proportion (%) and univariate risk of young adults' cannabis use disorders according to childhood background

Variables	N	Proportion of young adults with cannabis use disorders	
		(%)[a]	OR (95% CI)
Externalizing behavior at 5 years			
One SD above the mean	330	25.2	1.3 (1.0–1.7)
Remainder	1895	20.5	1.0*
Externalizing behavior at 14 years			
One SD above the mean	350	37.4	2.7 (2.1–3.5)
Remainder	1875	18.1	1.0**
Typologies of externalizing behavior (at 5 and 14 years)			
Childhood limited	256	20.7	1.2 (0.9–1.7)
Adolescent onset	276	36.6	2.7 (2.0–3.5)
Child-onset-persistent	74	40.5	3.2 (2.0–5.1)
Unclassified	1619	17.7	1.0**

Note: OR = odds ratio; 95% CI = 95% confidence interval; overall association of CUD with this variable was significant, * $p < 0.05$; ** $p < 0.01$.

[a] The percentage with cannabis use disorders within each category.

As the second objective, we tested whether associations between externalizing behavior and young adults' CUD is independent of a selected group of possible confounders. We first examined the relationship between each covariate included in the study and both the explanatory (externalizing behavior) and

outcome (CUD) variables. Table 3 shows that the gender of the child, maternal marital status, maternal mental health, maternal smoking and illicit drug use were significantly associated with both externalizing behavior and CUD. However, mother's age and education, family income, maternal alcohol use, maternal supervision, child internalizing behavior and attention problem were associated with only once of externalizing behavior or CUD.

Table 3: Associations of background factors with externalizing behavior and young adults' cannabis use disorders

Variables[a]	Higher risk group *	Externalizing behavior	CUD
Child's gender	Males	0.003	<0.001
Family income at 5 years	Lower income	0.006	NS
Mother's age [b]	Lower age	0.001	NS
Mother's education [b]	Lower education	NS	0.003
Marital status at 5 years	Un-partnered	0.005	0.001
Marital quality at 5 years		NS	NS
Maternal depression	Higher depression	<0.001	0.009
Maternal anxiety	Higher anxiety	<0.001	0.015
Maternal smoking	Heavier smokers	<0.001	<0.001
Maternal alcohol consumption	Heavy drinkers	0.013	NS
Maternal illicit drug use	Users	<0.001	<0.001
Maternal supervision	Lower supervision	<0.001	NS
Child internalizing	Higher score	<0.001	NS
Child attention problem	Higher score	<0.001	NS
Mother-child communication [c]	Poorer	<0.001	0.006
Adolescent school performance[c]	Poor performance	<0.001	<0.001
Adolescent smoking [c]	Heavy smokers	<0.001	<0.001
Adolescent alcohol use [c]	Heavy users	<0.001	<0.001
Adolescent cannabis use[c]	Ever users	<0.001	<0.001

* *p* value (chi square for categorical and f ratio for continuous independent variables) for the association between covariates in the study and typology of externalizing behavior and CUD.
[a] Measured at the 5-year follow-up unless otherwise indicated.
[b] Assessed at first clinic visit.
[c] Assessed at the 14-year follow-up.

One way to control for confounders when examining the relationship between an independent variable and a categorical outcome is to use multiple logistic regression (Wassertheil-Smoller, 2004). Accordingly, we developed progressive multivariate models (Table 4) including the covariates that were associated with both exposure and outcome, giving first priority to those that had a stronger relationship in term of p value and likelihood ratio. As noted above, unadjusted results show that CL externalizing behavior was not associated with increased risk of CUD while COP group carried a substantial increase in risk of CUD by age 21 years (OR = 3.2; 95% CI: 2.0, 3.5). This association had a smaller point estimate for the AO group (OR = 2.7; 95% CI: 2.0, 5.1). Adjustment for child's gender slightly reduced the magnitude of the associations for the COP group but not for other groups. As a likelihood ratio test revealed no statistically significant difference between the results before and after the inclusion of an interaction term for gender and externalizing behavior (*p* = 0.67), the remainder of the paper reports the analyses for the overall sample. Further adjustment for maternal smoking and illicit drug use, maternal marital status, and maternal mental health (depression and anxiety) at the 5-year follow-up somewhat attenuated the association for COP externalizing behavior (OR = 2.5; 95% CI: 1.5, 4.2), but not for AO group. The findings of the multivariate analyses indicated that the association between externalizing behavior and CUD is substantially independent of a range of confounding variables.

Table 4: Multivariate risk of young adults' cannabis use disorders by typologies of childhood and adolescence externalizing behavior adjusted for confounding variables

Cannabis use disorders	Adjusted OR (95% CI)		
	CL	AO	COP
Unadjusted*	1.2 (0.9–1.7)	2.7 (2.0–3.5)	3.2 (2.0–5.1)
Adjusted for			
Child's gender*	1.1 (0.8–1.5)	2.7 (2.1–3.6)	2.9 (1.8–4.8)
Maternal smoking*	1.1 (0.7–1.5)	2.7 (2.0–3.6)	2.8 (1.7–4.6)
Maternal illicit drug use*	1.1 (0.7–1.5)	2.6 (2.0–3.5)	2.7 (1.6–4.5)
Maternal marital status*	1.1 (0.8–1.5)	2.6 (1.9–3.5)	2.5 (1.5–4.2)
Maternal depression*	1.0 (0.7–1.4)	2.5 (1.9–3.4)	2.5 (1.5–4.2)
Maternal anxiety*	1.0 (0.7–1.4)	2.6 (1.9–3.5)	2.5 (1.5–4.2)

Note: 'Unclassified' externalizing behavior considered reference category; CL childhood limited; AO adolescent onset; COP childhood onset persistent.

✻ Significance level for the logistic regression models *p* < 0.001.

For testing the impact of a selected group of possible mediating factors, we conducted a two step analysis (Baron & Kenny, 1986) (Table 3). First, we tested the separate associations of the main independent variable (typology of externalizing behavior) and the outcome with the presumed mediators (mother–child communication, child school performance, and child early smoking, alcohol and cannabis use at 14 years). The analyses indicated all of the candidate mediators were associated with both externalizing behavior and young adults' CUD. Therefore, we progressively controlled the association between externalizing behavior and young adults' CUD for child smoking, alcohol and cannabis use, mother–child communication, and child school performance at 14 years (Table 5).

Table 5: Multivariate risk of young adults' cannabis disorders by typologies of childhood and adolescence externalizing behavior, adjusted for mediating factors

Cannabis use disorders	Adjusted OR (95% CI)		
	CL	AO	COP
Adjusted for covariates in Table 4	1.0 (0.7–1.4)	2.6 (1.9–3.5)	2.5 (1.5–4.2)
Adolescent smoking*	1.0 (0.7–1.4)	2.1 (1.6–2.9)	2.2 (1.3–3.7)
Adolescent alcohol use*	0.9 (0.6–1.3)	1.9 (1.4–2.6)	2.0 (1.2–3.5)
Adolescent cannabis use*	0.9 (0.6–1.3)	1.8 (1.3–2.5)	2.1 (1.2–3.6)
Mother–child communication*	1.0 (0.7–1.4)	1.9 (1.3–2.6)	2.1 (1.2–3.7)
Child school performance*	1.0 (0.7–1.4)	1.9 (1.3–2.6)	2.0 (1.1–3.5)

Note: 'Unclassified' externalizing behavior considered reference category; CL childhood limited; AO adolescent onset; COP childhood onset persistent.

✻ Significance level for the logistic regression models *p* value < 0.001.

Controlling for adolescent smoking and alcohol consumption led to a moderate attenuation in the magnitude of the association of both AO and COP with young adults' CUD, suggesting that these adolescence factors partially mediate the association between AO and COP externalizing behavior and CUD. Addition of adolescent cannabis use, mother–child communication and school performance at 14 years had no significant impact on the magnitudes of effects, indicating that these variables do not mediate the impact of externalizing behavior on young adults' CUD.

Overall, 15.7% of children exhibited extreme externalizing behavior of AO or COP type, of whom 37.4% developed CUD by 21 years. Of the 84.3% children in the UNCL or CL groups, 18.1% met the criteria for CUD as young adults. Using the risk ratios in Table 2, there is an estimated 'population attributable risk' (Wassertheil-Smoller, 2004) of 14.4%, suggesting that almost one seventh of CUD in this sample might be attributed to externalizing behavior in the COP and AO groups, if the statistical associations reflect cause-and-effect.

3.1. Sensitivity analyses

We conducted several sensitivity analyses to test the validity of findings. First, one item of the externalizing behavior sub-scale of YSR is related to use of alcohol or drugs for non-medical purposes. One could argue that this might cloud the interpretation of adolescent externalizing behavior as a predictor of later substance use disorders or that the association could be continuity of substance use over time. Hence, we deleted the item from the externalizing behavior sub-scale and repeated analyses presented in Table 5. Except for a very modest attenuation in the point estimate of the associations, there was no alteration in the findings.

In a second analysis, we examined the association between typologies of externalizing behavior and formal 'cannabis dependence' in young adulthood. There was no material change in our findings compared with those for CUD, indicating that the results presented here are robust. In addition, there might be a possibility that some cases of CUD have developed by the age of 14 years, the point at which externalizing behavior was measured. Thus, we excluded 55 participants (2.5% of the sample) who reported (at 21 years) onset of cannabis abuse or dependence before 14 years of age. Again, the findings of the multivariate analyses did not materially change compared with those presented in Table 5, although there was a modest attenuation in the magnitude of the association.

At the 21-year follow-up, young adults were asked about the use of cannabis in the last month. Options for response were: have never used, used every day, every few days, once or so, and not in the last month. Based on the frequency of use reported at the 21-year follow-up, ever-users of cannabis were divided into two categories, 'occasional' use and 'frequent' use, referring to use of cannabis 'once in last month' or 'not in the last month', and 'every day' or 'every few days', respectively. In a complementary analysis we tested the association between typologies of child and adolescent externalizing behavior and young adults' frequency of cannabis use. The findings indicated similar patterns of associations with externalizing behavior to those presented here.

Of 471 young adults who met DSM-IV criteria for CUD, 30.6% (144) were classified as having life-time other illicit drug use disorders. We repeated the multivariate logistic regressions after excluding that sub-cohort. The findings of these analyses were consistent with those presented in Table 5, indicating that adolescent externalizing behavior predicts young adults' CUD with or without other illicit drug use disorders.

4. Discussion

Previous investigations tend to support the typological grouping proposed by Moffitt (1993) and Moffitt et al. (1996). There is, however, no adequate evidence showing that Moffitt's theory applies to the development of illicit drug problems, including CUD, by early adulthood. Using a birth cohort study, we examined: (1) the prospective association between typologies of externalizing behavior during childhood and adolescence, and young adults' CUD; (2) whether these associations are confounded by selected covariates; and (3) whether selected factors such as child early substance use, mother–child communication, and child school performance mediate the link between externalizing behavior and CUD. We found that the presence of 'extreme externalizing behavior' at 14 years (COP and AO) predicts later CUD independent of, or in combination with, other illicit drug use disorders, regardless of childhood behavior at 5 years. Further, the risk of CUD is similarly predicted by AO and COP externalizing behavior. However, individuals with CL

externalizing behavior do not have a greater risk of CUD in early adulthood. The present study did not found a significant gender interaction in the association between externalizing behavior and young adults' CUD. In regard to the second objective of the study, our data suggest that the association between externalizing behavior and CUD is not a reflection of confounding factors but is partially explained by child smoking and alcohol consumption at 14 years.

The finding that persistent externalizing behavior in childhood and externalizing behavior in adolescence predict the risk of CUD in early adulthood is consistent with previous studies ([Boyle et al., 1992], [Disney et al., 1999], [Fergusson et al., 2005], [Fergusson and Lynskey, 1998], [King et al., 2004] and [Moffitt et al., 2001]). The inconsistencies in the size of associations between this and other investigations might be due to the differences in the design of the studies, including different methods of measurement of both externalizing behavior and outcome, and variation in follow-up intervals. Moreover, most of previous studies have not disentangled the impacts of 'persistent' versus CL externalizing behavior on later CUD.

We found that both COP and AO externalizing behavior predict CUD in early adulthood. Our findings thus support Moffitt et al.'s (1996,2002) data indicating that individuals with life-course persistent antisocial behavior had greater substance use at 18 and 26 years, but contradict the contention that externalizing behavior of those in the adolescent limited group is confined to the teenage years and does not result in a higher rate of psycho-social problems (as measured by cannabis use disorders) in adulthood (1993; 1996). Although our unadjusted results suggested greater risk of CUD in early adulthood among those who have had COP externalizing behavior than individuals in the AO group, this difference disappeared when the association was controlled for selected confounding variables. Moffitt et al. did not adjust their findings for variables that might have confounded the link between externalizing behavior and later substance use.

Of those children who exhibit externalizing behavior in early childhood, only those in whom this behavior persists into adolescence are at an increased risk of CUD as young adults. Externalizing behavior limited to childhood does not predict CUD in young adults. This finding contradicts the hypothesis proposed by Moffitt and her colleagues that members of the 'childhood limited' group do not completely shed their pattern of externalizing behavior later in their lives, and instead carry "low-level-chronic" externalizing behavior from childhood to adolescence or from adolescence to adulthood, and manifest poor adjustment in early adulthood ([D'Unger et al., 1998] and [Fergusson et al., 2000]). Although recent studies by Moffitt and other researchers have demonstrated that those individuals who are classified as having CL externalizing behavior have negative outcomes as young adults, it appears that this relationship does not hold for CUD. However, the lack of relationship between CUD and CL externalizing behavior does not rule out other kinds of low-level problems.

4.1. Explanations of the pathways

The first possible explanation of the link between externalizing behavior and cannabis disorders is that both are separate manifestations of common causal factors (Akers, 1984), either genetic (Iacono, Carlson, Taylor, Elkins, & McGue, 1999) or environmental (Moffitt, 2006), or some combination of them. Our study does not have the capacity for testing genetic influences, but a similar effect for both COP and AO indicates that one genetic pattern cannot totally explain these associations. In addition, our multivariate model showed that the magnitude of the apparent association for the COP and AO groups is not due to the measured confounding factors.

A second possibility is that CUD is a direct or indirect consequence of child externalizing behavior (Fergusson & Woodward, 2000). Our analyses revealed that part of the association between childhood and adolescent externalizing behavior and CUD is explained by early smoking and alcohol use, suggesting that these factors are mediating variables on the path from externalizing behavior to CUD. However, the present study indicates that other mediating variables, adolescent cannabis use, mother–child communication, and child

school performance, are not intermediates between externalizing behavior and CUD. It could be argued that the reporting period of 'the past week' used for the measurement of adolescent smoking and drinking may underestimate the influence of these factors on the association between externalizing behavior and CUD. Given the relatively low point prevalence of substance use among youth at this age, it is plausible to expect a greater impact of early substance use if the life-time use to age 14 had been measured.

Alternatively, it has been suggested that early-onset of externalizing behavior places adolescents at risk for initiation of drug use because their behavior problems alienate them from ordinary youth groups while fostering affiliation with more deviant teenagers. It is, moreover, reasonable to suspect that a child's peer group may influence the development of substance use disorders. We were unable to test this hypothesis in the MUSP.

4.2. Limitations

The first and possibly most important limitation of the current study is that, unlike Moffitt, we have only two measurement points – childhood and adolescence – for identifying extreme externalizing behavior, with a 9-year gap between the points. This raises the possibility that those adolescents categorized as having onset of externalizing behavior at 14 years also exhibited such behavior earlier, in mid-childhood. If our AO group was not truly 'adolescent onset' this could explain their greater risk of CUD in young adulthood. However, it should be noted that the best longitudinal data on the development of externalizing behavior, especially physical aggression, indicate the rarity of aggression emerging after school entry (Broidy et al., 2003). Therefore we believe our AO group is unlikely to include a significant level of misclassified individuals who actually had COP externalizing behavior.

Second, this study measured the outcome as reported at 21 years; one could argue that this time is still a transition point between adolescence and early adulthood and that later assessment of CUD might alter the magnitude of the association between typologies of externalizing behavior, in particular the AO category, and CUD. Third, the use of self-reported school performance as a potential mediator may have caused inaccurate estimation of the impact of this variable. In addition, we were unable to assess the impact of other potential mediating factors as affiliation with deviant peers.

Another limitation is the sizeable reduction in the sample between the 5- and 21-year surveys. Compared with the 4578 subjects who provided information related to child and adolescent externalizing behavior at the 5- and 14-year follow-ups, only 48.6% completed the CIDI-Auto as young adults. The incompleteness of the follow-up might have influenced our results in two different ways. If the null hypothesis is true, that is, if externalizing behavior is not associated with young adults' CUD, differential loss to follow-up by either exposure or outcome could not result in an apparent relationship. On the other hand, if the alternate hypothesis is true and drop-out is differential by either exposure or outcome, it is likely that the results presented here underestimate the true association between externalizing behavior in children and CUD. Repeated analyses of the impact of attrition on findings from the MUSP suggest such impacts are rare (Mamun, Lawlor, O'Callaghan, Williams, & Najman, 2005). In any case, as described in the Methods, we have used inverse probability weighting and found that selective attrition is unlikely to have had any material impact on our results.

4.3. Implications

Our findings suggest that both child-onset-persistent (COP) and adolescent onset (AO) externalizing behavior are significantly related to young adults' CUD. If one accepts that externalizing behavior leads to CUD, our findings may have implications for both prevention and treatment of cannabis and other illicit drug use disorders. Modifying externalizing behavior might be considered for inclusion in prevention programs aimed at reducing the risk of CUD in young people ([Bor, 2004] and [Spoth et al., 1999]). However, as the

calculation of population attributable fraction indicates, if systematic screening for externalizing behavior were feasible, and early intervention were completely effective in preventing CUD, the impact of such a strategy on the overall frequency of CUD would still be relatively modest. Since early smoking and alcohol use mediate a part of the pathway between externalizing behavior and CUD, intervention to delay the initiation of smoking and alcohol use may reduce the risk of CUD.

5. Conclusion

The present study was conducted in Brisbane, Australia, where both use of cannabis and CUD are common among young adults. Overall, within the limitations that apply, the findings of this study indicate that externalizing adolescents and persistence of externalizing behavior from childhood through to adolescence are associated with a substantially increased risk of CUD in early adulthood. It seems reasonable to conclude that prevention of externalizing behavior will have some impact on the development of CUD. While delaying initiation of smoking and alcohol may reduce later risk of CUD, additional prospective follow-up studies are needed to identify other mediating factors that might explain the link between externalizing behavior and use of cannabis and to define and test pre-emptive interventions to modify them.

Acknowledgements

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