

Youth marijuana use: a review of causes and consequences

Lawrence M Scheier^{1,2} and Kenneth W Griffin³

The legalization of medical and recreational marijuana has raised concerns about a potential increase in the availability and illegal use of marijuana by adolescent minors. To better understand the etiology, patterns, and consequences of adolescent marijuana use, this article reviews high quality, methodologically rigorous, longitudinal studies that focus on the role of personality factors such as sensation-seeking in the etiology of use, developmental trajectories of use and the effects of chronic use, potential gateway effects of marijuana on other illicit drugs, and its role in the onset of psychiatric disorders in adolescents and young adults. Implications are discussed in terms of mechanisms that account for initial and continued use of marijuana by adolescents, how use is associated with key developmental milestones and adult role socialization, and the potential of marijuana use during adolescence in furthering later drug involvement.

Addresses

¹ LARS Research Institute, Inc., Scottsdale, AZ, USA

² Prevention Strategies, Greensboro, NC, USA

³ George Mason University, Department of Global and Community Health, College of Health & Human Services, USA

Corresponding author: Scheier, Lawrence M (scheier@larsri.org)

Current Opinion in Psychology 2021, **38**:xx–yy

This review comes from a themed issue on **Cannabis**

Edited by **Ken Winters** and **Joel Mader**

<https://doi.org/10.1016/j.copsyc.2020.06.007>

2352-250X/© 2020 Elsevier Ltd. All rights reserved.

Introduction

With medical and recreational marijuana use becoming more widespread, a concern has been whether increased availability of marijuana may have unintended consequences for young people who use marijuana before they become adults. To better understand the etiology, patterns, and consequences of adolescent marijuana use, this article reviews the scientific literature examining causes, trends, and consequences of youth marijuana use. Much of this research examines etiologic factors for adolescent marijuana use, including parent-child relations (i.e. attachment), parenting (i.e. discipline and monitoring) and the home environment (i.e. marital strife), peer social influences, and personality factors that contribute to use. We also review the large literature on patterns and

trajectories of youth marijuana use. Finally, we highlight key studies on the physical and mental health [1[•],2] consequences of marijuana use, including whether prolonged or excessive use interferes with psychosocial adjustment and disrupts adult role socialization. A careful review of the literature reveals that prominent areas of concern have included effects of chronic use on neuro-psychological functioning (i.e. cognitive impairment), whether marijuana is a gateway drug and leads to other substance use, its contribution to psychiatric problems and also substance use disorders. In this paper we briefly review these different literatures with a special emphasis on evidence obtained from naturalistic longitudinal studies that monitor development over time.

Marijuana is quite popular worldwide and remains the most commonly used illicit drug by US youth. The latest annual US national surveillance data shows that 44% of high school seniors have used marijuana in their lifetime, more than one in three seniors used marijuana in the past year, and more than one in five used marijuana in the past 30 days [3[•]]. This proliferation in consumption is matched by the highest levels yet of past 30-day daily use (1.3%, 4.8% and 6.4% among 8th, 10th, and 12th grade youth, respectively); a trend paralleled by continued annual declines in perceived risks associated with use. There is also concern that many youths replace nicotine with marijuana (THC or hash oil) in battery-powered vaporizers [4,5], a pattern that has been noted with increasing frequency in both regional [6] and national surveys of youth vaping preferences [3[•],7].

Etiology of adolescent marijuana use

The linkages between personality and marijuana use has historical precedent stemming from the return of soldiers from Vietnam and a nationwide surge in activism and protest activity during the 1960s. The changing political climate and movement toward anti-establishment norms fostered interest in the role of alienation (i.e. sense of isolation), social criticism (i.e. anti-establishment sentiments), and tolerance for deviance as personality factors that interact to socialize problem behaviors [8[•]]. A consistent finding was that rebellious youth who decried conventional norms (i.e. church attendance), evidenced little academic motivation (i.e. poor grades) and who valued their independence (i.e. autonomy) were more likely to use marijuana [9]. This early work was then reinforced by a number of longitudinal studies examining factors contributing to marijuana use during adolescence including, in particular emphasizing the predictive role of personality when controlling for parenting, parent-child relations, and peer social influences [10–12].

The now classic Rocky Mountain longitudinal study implicated unconventional behavior and disaffection with society as contributors to problem behaviors [9,13] including among other deviant behaviors marijuana use [14]. Problem behavior theory suggests that poor motivation to comply with social regulation, low academic orientation, along with social criticism and alienation make youth deviance prone. Continued dissatisfaction with conventional institutions and poor performance in school encourages disaffected youth to violate social norms, act against authority, and adopt socially intolerant behaviors including smoking marijuana. The view that adolescents are immature, ‘fun-seeking’ rebellious creatures by nature encouraged researchers to focus on sensation seeking as one of several facets of personality contributing to marijuana use [15]. High sensation-seeking youth act more impulsively, take risks, lack behavioral control, and seek novelty in their environments [16]. As a result, these youth are more susceptible to acting on a whim, being adventuresome, thrill seeking, and engaging in dangerous behaviors with little forethought including using drugs like marijuana.

There is now considerable evidence linking sensation seeking and also trait impulsivity (acting rashly without reflection or deliberation) as precursors to adolescent marijuana use. This includes cross-sectional studies involving nationally representative data [17], general population studies prospectively tracking youth over time [18,19], laboratory behavioral assessments [20], case-control comparisons of users and non-users [21], at-risk groups [22], substance-use-naïve youth followed longitudinally [23] and genetically informed twin studies [24]. Two additional facets of sensation seeking, neurobehavioral disinhibition and behavioral undercontrol, have been implicated in marijuana use as risk phenotypes with neural underpinnings [25*,26,27]. Neural systems that regulate behaviors underlying disinhibition are tied to effortful control and incentive reactivity both responsive to novelty and reward motivational cues. Failure to invoke top down regulatory systems at the neural circuitry level weakens cognitive control functions making youth overly responsive to immediate reward cues (i.e. spontaneity) and cognitively aroused attending more to salient physiological cues and affective tone (i.e. emotional states). This diverts their attention from executive cognitive functions (i.e. response inhibition, strategic planning, and problem-solving) that would promote concerted decision-making skills, including, for instance, a consideration of potential future consequences of using marijuana [25*].

Developmental trajectories of adolescent marijuana use

Numerous longitudinal studies using person-centered strategies have identified discrete trajectories of marijuana use [28–31,32**]. Although the number and

composition of trajectory subgroups may vary from study to study, one consistent finding heralds a prototypical ‘chronic or persistent’ marijuana user group (usually encompassing only 5–10% of the total sample but with some noted exceptions [33,34]). Chronic users are characterized by early onset and continued increasing marijuana use across the lifespan. They have a greater preponderance of adverse outcomes including more criminal activity, stressful life events, drug-using friends, interpersonal problems (i.e. arguments with partner), lowered life satisfaction and work achievement, more depression, anxiety, school-related problems (i.e. lower grades, poorer academic performance, higher odds of dropping out of school, and lower educational attainment post-secondary) [35,36*], greater sexual risk behaviors, externalizing disorders, and prevalence of substance use disorders (SUDs) [31,32**,37**,38,39] including nicotine and alcohol dependence/abuse [30], compared to non-use or low use trajectory groups. Other notable problems include greater occupational stress and financial strain [40] and difficulty navigating psychosocial adjustment, the latter including failure to adopt adult roles such as marriage, pregnancy and parenting [33,34,41–44].

Consequences of adolescent marijuana use

Confusion over whether marijuana has long-term consequences has promoted considerable debate and led to a changing political landscape with regard to its legalization. In all but 11 US states marijuana remains a federally classified Schedule I substance under the Controlled Substance Act owing to its high potential for abuse [45,46**]. Notwithstanding, 33 states have responded to the popular ground swell urging legalization of marijuana based on its therapeutic potential including treating chronic pain [47,48], psychiatric conditions [49,50], and mitigating nausea and vomiting in patients undergoing chemotherapy [51] where conventional treatments may not work. The flowering tops of the *cannabis sativa* plant contain oils and resin that produce the psychoactive compound Δ^9 -tetrahydrocannabinol (THC). The effects of inhaling combustible marijuana joints (or using a hookah) are reported to produce a calming and relaxing sensation. Many users point to reduced inhibitions, the pleasant feeling of being ‘high,’ and a sense of euphoria that can be obtained with social recreational use [52–54]. The drug’s pharmacology and binding properties with endocannabinoid brain receptors (THC is a CB₁ agonist) has been well documented [55,56].

Marijuana and the gateway hypothesis

The gateway hypothesis suggests that drug use involvement proceeds in an invariant sequence beginning first with alcohol or cigarettes then involving marijuana followed by pills, psychedelics, cocaine and heroin, albeit not in a causal manner [57*]. The premise is built around interviews conducted with drug users asking them to recollect the various stages of drug use that characterized

their involvement [58,59]. Individuals whom reported use of cocaine, pills (amphetamines and tranquilizers) and heroin, had invariably commenced their drug use with alcohol or cigarettes before progressing to marijuana. Evidence supporting the progression model comes primarily from two sources, longitudinal studies monitoring development over time and behavior genetic twin studies. In both cases, investigators included statistical controls for theoretically relevant factors that could also account for progression. For the most part these included peer social influences, personality (i.e. risk-taking and nonconformist values), age of onset, family (i.e. poverty and marital conflict) and neighborhood contextual factors (i.e. illicit drug trafficking) that might independently account for developmental progression.

Even with controls for confounding, there is conflicting evidence with some studies asserting that marijuana consistently precedes use of other drugs [60,61], while other studies provide limited evidence to support this hypothesis [62]. In some cases, effects fade with inclusion of statistical controls for 'life course' measures and in other cases alternative sequences underscore the lack of temporal precedence from marijuana to other illicit drugs [63–66]. Studies providing evidence of progression hinge on a dose-response relationship conveying the influence of age of onset and regularity of marijuana use [67]. Also, selective recruitment is an important consideration as marijuana users differ from non-users or users of other drugs like alcohol and cigarettes in key ways that could make them more vulnerable to progression.

Genetically informed studies can shed some light on the progression argument by examining twins who vary in the age of onset to marijuana (<17 versus older). This discordant twin design teases apart the contribution of the shared environment from genetic liability as both twins are raised in the same home subject to a consistent set of child-rearing practice and a similar home context. Differences in behavior that are not attributed to the home environment thus reflect either nonshared characteristics of the individual (i.e. sensation seeking) or genetic liability, the latter which is stronger in monozygotic compared to dizygotic twins. Rejection of both shared environment and genetics as explanations would then attribute developmental progression to perhaps pharmacological sensitization by marijuana that triggers further drug involvement. A study of Australian [68] adolescent male twins showed that the twin commencing marijuana use before age 17 showed much higher odds of progressing to other drug use (2.3–5.2 higher), alcohol dependence (1.85), and drug abuse/dependence (1.98) compared to the twin with a later onset (adjusted for known risk factors). A similar study of Dutch [69] twins showed that for the marijuana-using twin unadjusted odds ranged from 6.8 for recreational party drug use to 14 for hard drug use, but became nonsignificant when models were adjusted for control

factors (i.e. age of onset, tobacco, alcohol use, aggressive and rule breaking behavior). A third general population study that culled discordant adolescent twin pairs (monozygotic and dizygotic and sibling pairs) showed that the marijuana using twin was 83% more likely to use hard drugs as a young adult than the non-using twin [70]. One other twin study used the magnitude of within-pair differences rather than discordant age of onset to predict within-pair hard drug use differences in same-sex twin pairs. The authors concluded that marijuana's role in drug escalation is more than likely genetically influenced rather than reflecting other spurious sources of influence. This is because the gateway effect held for dizygotic but not monozygotic twins [71].

Marijuana use and the risk of psychiatric disorders

Considerable evidence implicates marijuana use in the development of psychiatric disorders. The strength of this evidence is based on both epidemiological [72] and population-based longitudinal studies that link age of onset and chronic use with a wide range of mental health problems. With few exceptions [73,74], systematic reviews [75–79,80*] and meta-analyses point toward marijuana use as contributing to depression [81,82,83*,84], psychotic disorders [85–88], and in some cases even suicidal behavior [89–92] independent of confounding. Compiled across studies, odds ratios for psychotic disorders ranged from 1.17 for comparing users to non-users to 1.67 comparing heavy to light users. This increases to 2.58 using pooled data in meta-analysis [78]. A consistent finding across studies is a dose-response effect with more pronounced adverse outcomes at higher levels of consumption [76–79,80*,81,82].

Birth cohort studies that track youth longitudinally from before marijuana onset also reinforce that early onset and chronic marijuana use is associated with greater risk of psychiatric disorders [73,88]. In the Dunedin birth cohort study, weekly marijuana use, by age 15, quadrupled the odds of schizophreniform diagnosis at age 26 [93]; however, this effect was no longer significant when the model was adjusted for childhood psychotic symptoms. Marijuana was also implicated as a risk factor for externalizing disorders [83*] from age 18–21 but for males only (OR = 1.56). Other cohort studies also show that daily marijuana use is a risk factor for psychosis [89], marijuana dependence in late adolescence is a risk factor for psychotic symptoms (OR = 2.3) at age 21 [86], daily marijuana use assessed at age 14–15 increases the risk for depression and anxiety seven years later (OR = 5.6) and weekly marijuana use increases the risk almost twofold for the same outcomes (OR = 1.9) compared to non-users; however, this latter finding was for females only [84]. In all of these studies, individuals were tracked from before marijuana onset and models controlled for prodromal symptoms at baseline, family factors (household climate and socioeconomic disadvantage), and behaviors (smoking and alcohol

use) at earlier ages that may also predispose individuals to heavy marijuana use as well as mental health problems. Interestingly, a US birth cohort study found no evidence of a causal relationship between adolescent (< age 17) onset of marijuana problems (dependence or abuse) and having a depressive episode (age 19–24) in the past year using propensity score adjusted models to control covariate differences [94].

Conclusions

A consistent body of evidence suggests that early initiation and sustained chronic use of marijuana conveys numerous deficits including impaired well-being, negative health effects, impairment to cognitive functioning, and increased risk of psychiatric problems. For the most part, these findings hold up even with the addition of important control measures capturing different facets of interpersonal and intrapersonal functioning. Importantly, studies using a longitudinal developmental perspective, and tracking youth from adolescent to emerging adulthood, consistently find deficits in various forms of psychosocial functioning, fostering problems in psychosocial adjustment that can be tied to earlier and continued use of marijuana. These deficits arise from failure to navigate certain developmental tasks considered essential to adult role socialization [95]. Included are finishing school, establishing a sense of identity, finding a career vocation, and forming intimate bonds that are a prelude to marriage and parenting [34,41,96**]. The fact that a large body of this work used general population samples suggests that, when maintained for prolonged periods of time, social recreational marijuana use, if left unabated, conveys debilitating effects across the lifespan.

The bulk of the evidence seems to suggest that adolescence represents a critical period of development during which time neuromaturation reaches new heights particularly in brain regions (i.e. prefrontal networks) that control decision-making and inhibitory control [97]. Harm to these brain structures from excessive marijuana (or other drug) use, specifically disruption of neuromaturation [98*], can hinder development of important higher cognitive functions that facilitate the transition to adult thinking [99]. Of concern is the current potency of marijuana and the new strains being cultivated along with new route of administration (i.e. vaping) and how these changes affect functioning. This brings to mind the possibility that extant knowledge regarding health effects may be dominated by historical uses of marijuana. A new wave of mental, physical, and social complications may arise from both exposure through legalization and the deleterious pharmacological effects associated with more potent marijuana.

Even given the considerable weight of evidence suggesting adverse effects, there are several methodological concerns that should be considered. For instance,

methodological variation between studies can hinder determining whether marijuana is the main contributor to deficits. Regardless of focus, sample sizes varied considerably between studies, as well as did the time frame studied, the length of time used to track individuals, and recruitment strategies. Moreover, studies varied considerably in what confounders were statistically controlled, and in many cases, there was tremendous variation in the operational definition used to gauge ‘heavy’ consumption.

Similar concerns surface with regard to the role of marijuana elevating risk for psychiatric illness. Discussion revolves around confounder control, diagnostic heterogeneity, concerns over reverse causation and the observation that marijuana use and psychological problems can share causal etiological pathways. In this respect, prospective longitudinal studies help to disentangle the contribution of premorbid conditions that may also predispose youth to later mental health problems independent of early marijuana use [100]. In addressing the proverbial chicken versus the egg conundrum, there is the potential that youth susceptible to mental health disorders are more likely to use marijuana to mask symptoms of psychiatric illness [101]. Such a self-medication view reinforces that some individuals may be predisposed to marijuana use as a means of regulating mood [102,103*]. This is consistent with studies that find high rates of cannabis use disorders in children with a history of conduct disorders and likewise among youth with internalizing disorders (i.e. anxiety and depression) who encounter a wide range of biological, personality, and contextual factors that may contribute to both their marijuana use and mental health problems [100,81].

Not discussed at length in this review are the plausible etiological mechanisms that instigate initial involvement and maintain continued use across the lifespan. The ‘amotivational syndrome,’ [104,105] has been suggested as a broad catchall to capture the lack of initiative, apathy, and motivational deficits that characterizes disaffected youth [106]. Early onset users that continue their drug involvement pull away from the social bonds that would normally allow them to introject conventional values, adopting instead nonconformist behaviors that put them at odds with prosocial role models. This is a mainstay of social control theory, suggesting the importance adopting mainstream conformist attitudes [107,108]. In essence, conventional institutions are socializing agents, encouraging youth to refrain from norms transgression and rules violation as these activities are incommensurate with assuming adult work and family roles [109].

Social interactional continuity [110] suggests that differential association guides marijuana-using youth to socially engage with like-minded peers who also use drugs, feel alienated and engage in social criticism [111]. Once their behaviors become deeply enmeshed into deviant social-

interactional pathways, it is hard to shift into new behavior patterns without reorganization of the self. Still, the processes that link early involvement with later outcomes needs to be further explored using both methodological designs and statistical approaches capable of modeling developmental phenomenon. There is myriad of ways for youth to engage in drug-using behavior as part of identity exploration, numerous factors that can amplify their use, and multiple ways they can mature out as they transition to adulthood [112,113].

Conflict of interest statement

Nothing declared.

CRedit authorship contribution statement

Lawrence M Scheier: Conceptualization, Methodology, Writing - original draft, Visualization, Supervision. **Kenneth W Griffin:** Investigation, Writing - review & editing.

Acknowledgements

The authors acknowledge their affiliated institutes for continued support during construction of the manuscript and providing the necessary resources to complete the current study. Neither author declares a conflict of interest.

References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

- of special interest
- of outstanding interest

1. Cohen K, Weizman A, Weinstein A: **Positive and negative effects of cannabis and cannabinoids on health.** *Clin Pharmacol Ther* 2019, **105**:1139-1147.

An excellent contemporary review of the health effects of cannabinoids. Very comprehensive and up-to-date information covering both mental and physical health.

2. Volkow ND, Baler RD, Compton WM, Weiss SR: **Adverse health effects of marijuana use.** *N Engl J Med* 2014, **370**:2219-2227.
3. Johnston LD, Miech RA, O'Malley PM, Bachman JG, Schulenberg JE, Patrick ME: **Monitoring the Future National Survey Results on Drug Use 1975–2019: Overview, Key Findings on Adolescent Drug Use.** Ann Arbor: Institute for Social Research, University of Michigan; 2019.

A definitive source of surveillance data gathered annually on US secondary school students that monitors drug use trends over time as well as changes in risk and protective factors related to drug use.

4. Budney AJ, Sargent JD, Lee DC: **Vaping cannabis (marijuana): parallel concerns to e-cigs?** *Addiction* 2015, **110**:1699-1704.
5. Kowitz SD, Osman A, Meernik C, Zarkin GA, Ranney LM, Martin J, Heck C, Goldstein AO: **Vaping cannabis among adolescents: prevalence and associations with tobacco use from a cross-sectional study in the USA.** *BMJ Open* 2019, **9**:e028535.
6. Morean ME, Kong G, Camenga DR, Cavallo DA, Krishnan-Sarin S: **High school students' use of electronic cigarettes to vaporize cannabis.** *Pediatrics* 2015, **136**:611-616.
7. Miech RA, Patrick ME, O'Malley PM, Johnston LD, Bachman LG: **Trends in reported marijuana vaping among US adolescents, 2017-2019.** *JAMA* 2020, **323**:475-476.
8. Jessor R, Jessor SL, Finney J: **A social psychology of marijuana use: longitudinal studies of high school and college youth.** *J Pers Soc Psychol* 1973, **26**:1-15.

A seminal study that examined common pathways to marijuana use and other problem behaviors. Very theoretically rich discussion of problem behavior theory that included personality, environmental and behavior

systems as predictors of involvement and increased drug use from junior high school to adulthood.

9. Jessor R, Jessor SL: **Problem Behavior and Psychosocial Development.** Academic Press; 1977.
 10. Brook JS, Lukoff IF, Whiteman M: **Initiation into adolescent marijuana use.** *J Genet Psychol* 1980, **137**:133-142.
 11. Brook JS, Brook DW, de La Rosa M, Duque LF, Rodriguez E, Montoya ID, Whiteman M: **Pathways to marijuana use among adolescents: cultural/ecological, family, peer and personality influences.** *J Am Acad Child Adolesc Psychiatry* 1998, **37**:759-766.
 12. Brook JS, Brook DW, Gordon AS, Whiteman M, Cohen P: **The psychosocial etiology of adolescent drug use: a family interactional approach.** *Genet Soc Gen Psychol Monogr* 1990, **116**:111-267.
 13. Jessor R, Graves TD, Hanson RC, Jessor SL: **Society, Personality, and Deviant Behavior: a Study of a Tri-ethnic Community.** New York: Holt, Rinehart, & Winston; 1968.
 14. Jessor R, Jessor SL: **Theory-testing in longitudinal research on marijuana use.** In *Longitudinal Research on Drug Use: Empirical Findings and Methodological Issues.* Edited by Kandel DB. Hemisphere; 1978:41-71.
 15. Donohew RL, Hoyle RH, Clayton RR, Skinner WF, Colon SE, Rice RE: **Sensation seeking and drug use by adolescents and their friends: models for marijuana and alcohol.** *J Stud Alcohol* 1999, **60**:622-631.
 16. Zuckerman M: **Sensation Seeking: Beyond the Optimal Level of Arousal.** Hillsdale: Erlbaum; 1979.
 17. Lee-Winn AE, Mendelson T, Johnson RM: **Associations of personality traits with marijuana use in a nationally representative sample of adolescents in the United States.** *Addict Behav* 2018, **8**:51-55.
 18. Crawford AM, Pentz MA, Chou C-P, Li C, Dwyer JH: **Parallel developmental trajectories of sensation seeking and regular substance use in adolescents.** *Psychol Addict Behav* 2003, **17**:179-192.
 19. Malmberg M, Kleinjan M, Vermulst AA, Overbeek G, Monshouwer K, Lammers J, Engels RC: **Do substance use risk personality dimensions predict the onset of substance use in early adolescence? A variable-and person-centered approach.** *J Youth Adolesc* 2012, **41**:1512-1525.
 20. Felton JW, Collado A, Shadur JM, Lejuez CW, MacPherson L: **Sex differences in self-report and behavioral measures of disinhibition predicting marijuana use across adolescence.** *Exp Clin Psychopharmacol* 2015, **23**:265-274.
 21. Dougherty DM, Mathias CW, Dawes MA, Furr FM, Charles NE, Liguori A, Shannon EE, Acheson A: **Impulsivity, attention, memory, and decision-making among adolescent marijuana users.** *Psychopharmacology* 2013, **226**:307-319.
 22. Campbell LF, Wilmoth K, Mason M: **Association of exposure to neighborhood drug activity, neurobehavioral traits, and marijuana use among at-risk African American females.** *Addict Behav* 2015, **50**:45-50.
 23. Squeglia LM, Jacobus J, Nguyen-Louie TT, Tapert SF: **Inhibition during early adolescence predicts alcohol and marijuana use by late adolescence.** *Neuropsychology* 2014, **28**:782-790.
 24. Miles DR, van den Bree MBM, Gupman AE, Newlin DB, Glantz MD, Pickens RW: **A twin study on sensation seeking, risk taking behavior and marijuana use.** *Drug Alcohol Depend* 2001, **62**:57-68.
 25. Zucker RA, Heitzeg MM, Nigg JT: **Parsing the undercontrol-disinhibition pathway to substance use disorders: a multilevel developmental problem.** *Child Dev Perspect* 2011, **5**:248-255.
- An excellent review of the literature on personality traits (behavioral undercontrol) and how they relate to the etiology of drug use.
26. Iacono WG, Malone SM, McGue M: **Behavioral disinhibition and the development of early-onset addiction: common and specific influences.** *Ann Rev Clin Psychol* 2008, **4**:325-348.

27. Kirisci L, Tarter RE, Vanyukov M, Reynolds M, Habyech M: **Relation between cognitive distortions and neurobehavior disinhibition on the development of substance use during adolescence and substance use disorder by young adulthood: a prospective study.** *Drug Alcohol Depend* 2004, **76**:125-133.
28. Brook JS, Lee JY, Finch SJ, Brook DW: **Developmental trajectories of marijuana use from adolescence to adulthood: relationship with using weapons including guns.** *Aggress Behav* 2014, **40**:229-237.
29. Homel J, Tompson K, Leadbeater BJ: **Trajectories of marijuana use in youth ages 15-25: implications for postsecondary education experience.** *Stud Alcohol Drugs* 2014, **75**:674-683.
30. Flory K, Lynam D, Milich R, Leukefeld C, Clayton R: **Early adolescent through young adult alcohol and marijuana use trajectories: early predictors, young adult outcomes, and predictive utility.** *Dev Psychopathol* 2004, **16**:193-213.
31. Schulenberg JE, Merline AC, Johnston LD, O'Malley PM, Bachman JG, Laetz VB: **Trajectories of marijuana use during the transition to adulthood: the big picture based on national panel data.** *J Drug Issues* 2005, **35**:255-279.
32. Windle M, Wiesner M: **Trajectories of marijuana use from adolescent to young adulthood: predictors and outcomes.** *Dev Psychopathol* 2004, **16**:1007-1027.
- A good illustration of person-centered strategies (growth mixture modeling) to examine developmental trajectories of cannabis use from adolescence to young adulthood. The analyses examine both predictors and consequences of trajectory membership.
33. Brook JS, Lee JY, Finch SJ, Seltzer N, Brook DW: **Adult work commitment, financial stability, and social environment as related to trajectories of marijuana use beginning in adolescence.** *Subst Abuse* 2013, **34**:298-305.
34. Epstein M, Hill KG, Nevell AM, Guttmanova K, Bailey JA, Abbott RD, Kosterman R, Hawkins JD: **Trajectories of marijuana use from adolescence into adulthood: environmental and individual correlates.** *Dev Psychopathol* 2015, **51**:1650-1663.
35. Brook JS, Stimmel MA, Zhang C, Brook DW: **The association between earlier marijuana use and subsequent academic achievement and health problem: a longitudinal study.** *Am J Addict* 2008, **17**:155-160.
36. Lynskey MT, Hall W: **The effects of adolescent cannabis use on educational attainment: a review.** *Addiction* 2000, **95**:1621-1630.
- One of several methodologically sound studies based on an Australian birth cohort followed longitudinally that reports on the effects of early and sustained involvement in cannabis use on educational attainment in a critical period of adolescence where motivations to succeed and further one's education are vital to adult role socialization.
37. Brook JS, Zhang C, Leukefeld CG, Brook DW: **Marijuana use from adolescence to adulthood: developmental trajectories and their outcomes.** *Soc Psychiatry Psychiatr Epidemiol* 2016, **51**:1405-1415.
- An excellent illustration of using a community-based sample to illustrate discrete trajectories of cannabis use over an extended time frame and then relate trajectory group membership to relevant outcomes.
38. Ehrenreich H, Nahapetyan L, Orpinas P, Song X: **Marijuana use from middle to high school: co-occurring problem behaviors, teacher-related academic skills and sixth-grade predictors.** *J Youth Adolesc* 2015, **44**:1929-1940.
39. Kosty DB, Seeley JR, Farmer RF, Stevens JJ, Lewinsohn PM: **Trajectories of cannabis use disorder: risk factors, clinical characteristics and outcomes.** *Addiction* 2016, **112**:279-287.
40. Thompson K, Leadbeater B, Ames M, Merrin GJ: **Associations between marijuana use trajectories and educational and occupational success in young adulthood.** *Prev Sci* 2019, **20**:257-269.
41. Brook JS, Adams RE, Balka EB, Johnson E: **Early adolescent marijuana use: risks for the transition to young adulthood.** *Psychol Med* 2002, **32**:79-91.
42. Brook JS, Lee JY, Brown EN, Finch SJ, Brook DW: **Developmental trajectories of marijuana use from adolescent to adulthood: personality and social role outcomes.** *Psychol Rep* 2011, **108**:339-357.
43. Ellickson PL, Martino SC, Collins RL: **Marijuana use from adolescence to young adulthood: multiple developmental trajectories and their associated outcomes.** *Health Psychol* 2004, **23**:299-307.
44. Terry-McElrath YM, O'Malley PM, Johnston LD, Schulenberg JE: **Young adult longitudinal patterns of marijuana use among US national samples of 12th grade frequent marijuana users: a repeated-measures latent class analysis.** *Addiction* 2019, **114**:1035-1048.
45. Arado TAC, Mentkowsi A: **Medical marijuana: an overview of select resources.** *North Illinois Univ Law Rev* 2014, **35**:461-509.
46. Caplan G: **Medical marijuana: a study of unintended consequences.** *McGeoge Law Rev* 2012:127-146.
- An excellent annotated bibliography and review of legal case law and state statutes regarding medical marijuana use. The authors present both case law and findings from federal agencies that support medical marijuana use or various legal contentions regarding evidence.
47. Jensen B, Chen J, Furnish T, Wallace M: **Medical marijuana and chronic pain: a review of basic science and clinical evidence.** *Curr Pain Headache Rep* 2015, **19**:50.
48. Hill KP: **Medical marijuana for treatment of chronic pain and other medical and psychiatric problems: a clinical review.** *JAMA* 2015, **313**:2474-2483.
49. Sarris J, Sinclair J, Karamacoska D, Davidson M, Firth J: **Medicinal cannabis for psychiatric disorders: a clinically-focused systematic review.** *BMC Psychol* 2020, **20**:24.
50. Wilkinson ST, Radhakrishnan R, D'Souza DC: **A systematic review of the evidence for medical marijuana in psychiatric indications.** *J Clin Psychol* 2016, **77**:1050-1064.
51. Brown D, Watson M, Schloss J: **Pharmacological evidence of medicinal cannabis in oncology: a systematic review.** *Support Care Cancer* 2019, **27**:3195-3207.
52. Becker HS: **Becoming a marijuana user.** *Am J Sociol* 1953, **59**:235-243.
53. Simons J, Correia CJ, Carey KB: **A comparison of motives for marijuana and alcohol use among experienced users.** *Addict Behav* 2000, **25**:153-160.
54. Green B, Kavanagh D, Young R: **Being stoned: a review of self-reported cannabis effects.** *Drug Alcohol Rev* 2003, **22**:453-460.
55. Grotenhermen F: **Pharmacokinetics and pharmacodynamics of cannabinoids.** *Clin Pharmacokinet* 2003, **42**:327-360.
56. Pertwee RG: **The diverse CB1 and CB2 receptor pharmacology of three plant cannabinoids: Δ^9 -tetrahydrocannabinol cannabidiol and Δ^9 -tetrahydrocannabivarin.** *Br J Pharmacol* 2008, **153**:199-215.
57. Kandel DB, Jessor R: **The gateway hypothesis revisited.** In *Stages and Pathways of Drug Involvement: Examining the Gateway Hypothesis*. Edited by Kandel DB. Cambridge University Press; 2002:365-372.
- A chapter written by seminal authors that revisits the argument regarding stage-sequence developmental progression models and whether the tenets of the gateway hypothesis implies 'causation.'
58. Kandel DB: **Stages in adolescent involvement in drug use.** *Science* 1975, **190**:912-914.
59. Kandel DB, Faust R: **Sequences and stages in patterns of adolescent drug use.** *Arch Gen Psychol* 1975, **32**:923-932.
60. Kandel DB, Yamaguchi K, Chen K: **Stages of progression in drug involvement from adolescence to adulthood: further evidence for the gateway theory.** *J Stud Alcohol* 1992, **53**:447-457.
61. Yamaguchi K, Kandel DB: **Patterns of drug use from adolescence to young adulthood: II. Sequences of progression.** *Am J Public Health* 1984, **74**:668-672.
62. Van Gundy K, Rebellon CJ: **A life-course perspective on the "Gateway Hypothesis."** *J Health Soc Behav* 2010, **51**:244-259.

63. Collins LM, Graham JW, Rousculp SS, Hansen WB: **Heavy caffeine use and the beginning of the substance use onset process: an illustration of latent transition analysis.** In *The Science of Prevention: Methodological Advances from Alcohol and Substance Abuse Research*. Edited by Bryant KJ, Windle M, West SG. American Psychological Association; 1997:79-100.
64. Vaughn M, Wallace J, Perron B, Copeland V, Howard M: **Does marijuana serve as a gateway to cigarette use for high-risk African-American youth?** *Am J Drug Alcohol Abuse* 2008, **34**:782-791.
65. Patton GC, Coffey C, Carlin JB, Sawyer SM, Lynskey M: **Reverse gateway? Frequent cannabis use as a predictor of tobacco initiation and nicotine dependence.** *Addiction* 2005, **100**:1518-1525.
66. Timberlake DS, Haberstick BC, Hopfer CJ, Bricker J, Sakai JT, Lessem JM, Hewitt JK: **Progression from marijuana use to daily smoking and nicotine dependence in a national sample of U.S. adolescents.** *Drug Alcohol Depend* 2007, **88**:272-281.
67. Hall WD, Lynskey MT: **Is cannabis a gateway drug? Testing hypotheses about the relationship between cannabis use and the use of other illicit drugs.** *Drug Alcohol Rev* 2005, **24**:39-48.
68. Lynskey MT, Heath AC, Bucholz KK, Slutske WS, Madden PA, Nelson EC, Statham DJ, Martin NG: **Escalation of drug use in early-onset cannabis users vs. co-twin controls.** *JAMA* 2003, **289**:427-433.
69. Lynskey MT, Vink MJ, Boomsma DI: **Early onset cannabis use and progression to other drug use in a sample of Dutch twins.** *Behav Genet* 2006, **36**:195-200.
70. Lessem JM, Hopfer CJ, Haberstick BC, Timberlake D, Ehringer MA, Smolen A, Hewitt JK: **Relationship between adolescent marijuana use and young adult illicit drug use.** *Behav Genet* 2006, **36**:498-506.
71. Cleveland HH, Wiebe RP: **Understanding the association between adolescent marijuana use and later serious drug use: gateway effect or developmental trajectory?** *Dev Psychopathol* 2008, **20**:615-632.
72. Han B, Compton WM, Blanco C, Jones CM: **Time since first cannabis use and 12-month prevalence of cannabis use disorder among youth and emerging adults in the United States.** *Addiction* 2019, **114**:698-707.
73. McLaren JA, Silins E, Hutchinson D, Mattick RP, Hall W: **Assessing evidence for a causal link between cannabis and psychosis: a review of cohort studies.** *Int J Drug Policy* 2010, **21**:10-19.
74. McLoed J, Oakes R, Copello A, Crome I, Egger M, Hickman M, Smith GD: **Psychological and social sequelae of cannabis and other illicit drug use by young people: a systematic review of longitudinal, general population studies.** *Lancet* 2004, **363**:1579-1588.
75. Arseneault L, Cannon M, Witten J, Murray RM: **Causal association between cannabis and psychosis: examination of the evidence.** *Br J Psychiatry* 2004, **184**:110-117.
76. Casadio P, Fernandes C, Murray RM, Di Forti M: **Cannabis use in young people: the risk for schizophrenia.** *Neurosci Biobehav Rev* 2011, **35**:1779-1787.
77. Chadwick B, Miller ML, Hurd YL: **Cannabis use during adolescent development: susceptibility to psychiatric illness.** *Front Psychiatry* 2013, **4**.
78. Moore HM, Zammit S, Lingford-Hughes A, Barnes TRE, Jones PB, Burke M, Lewis G: **Cannabis use and risk of psychotic or affective mental health outcomes: a systematic review.** *Lancet* 2007, **370**:319-328.
79. Minozzi S, Davoli M, Bargagli AM, Amato L, Vecchi S, Perucci C: **An overview of systematic reviews on cannabis and psychosis: discussing apparently conflicting results.** *Drug Alcohol Rev* 2010, **29**:304-317.
80. Semple DM, McIntosh AM, Lawrie SM: **Cannabis as a risk factor for psychosis: systematic review.** *J Psychopharmacol* 2005, **19**:187-194.
- A very balanced and comprehensive systematic review that canvasses multiple theoretical arguments linking cannabis and psychosis in case-control and general population studies.
81. Degenhardt L, Hall W, Lynskey M: **Exploring the association between cannabis use and depression.** *Addiction* 2003, **98**:1493-1504.
82. Lev-Ran S, Roerecke M, Le Foll B, McKenzie K, Rehm J: **The association between cannabis use and depression: a systematic review and meta-analysis of longitudinal studies.** *Psychol Med* 2013, **44**:797-810.
83. McGee R, Williams S, Poulton R, Moffitt T: **A longitudinal study of cannabis use and mental health from adolescence to early adulthood.** *Addiction* 2000, **95**:491-503.
- An excellent use of a longitudinal birth cohort examining the natural course of health behavior with appropriate controls for early child behaviors based on multi-informant reporting to show causal relations between adolescent cannabis (age 15) and young adult mental health problems (age 21).
84. Patton GC, Coffey C, Carlin JB, Degenhardt L, Lynskey M, Hall W: **Cannabis use and mental health in young people: cohort study.** *BMJ* 2002, **325**:1195-1198.
85. Anglin DM, Corcoran CM, Brown AS, Chen H, Lighty Q, Brook JS, Cohen PR: **Early cannabis use and schizotypal personality disorder symptoms from adolescence to middle adulthood.** *Schizophr Res* 2012, **137**:45-49.
86. Fergusson DM, Horwood LJ, Swain-Campbell NR: **Cannabis dependence and psychotic symptoms in young people.** *Psychol Med* 2003, **33**:15-21.
87. Henquet C, Krabbendam L, Spauwen J, Kaplan C, Lieb R, Wittchen H-U, van Os J: **Prospective cohort study of cannabis use, predisposition for psychosis, and psychotic symptoms in young people.** *BMJ* 2005, **330**:11.
88. Smit F, Bolier L, Cuijpers P: **Cannabis use and the risk of later schizophrenia: a review.** *Addiction* 2003, **99**:425-430.
89. Fergusson DM, Horwood LJ, Ritter EM: **Tests of causal linkages between cannabis use and psychotic symptoms.** *Addiction* 2005, **100**:354-366.
90. Pedersen W: **Does cannabis use lead to depression and suicidal behaviours? A population-based longitudinal study.** *Acta Psychiatr Scand* 2008, **118**:395-403.
91. Rasic D, Weerasinghe S, Asbridge M, Langille DB: **Longitudinal associations of cannabis and illicit drug use with depression, suicidal ideation and suicidal attempts among Nova Scotia high school students.** *Drug Alcohol Depend* 2013, **129**:49-53.
92. Wilcox HC, Anthony JC: **The development of suicide ideation and attempts: an epidemiologic study of first graders followed into young adulthood.** *Drug Alcohol Depend* 2004, **76**(Suppl): S53-S67.
93. Arseneault L, Cannon M, Poulton R, Murray R, Caspi A, Moffitt TE: **Cannabis use in adolescence and risk for adult psychosis: longitudinal prospective study.** *BMJ* 2002, **325**:1212-1213.
94. Harder VS, Stuart EA, Anthony JC: **Adolescent cannabis problems and young adult depression: male-female stratified propensity score analysis.** *Am J Epidemiol* 2008, **168**:592-601.
95. Krohn MD, Lizotte AJ, Perez CM: **The interrelationship between substance abuse and precocious transitions into adult statuses.** *J Health Social Behav* 1997, **38**:87-103.
96. Newcomb MD: **Consequences of teenage drug use: the transition from adolescence to young adulthood.** *Drugs Soc* 1987, **1**:25-60.
- A classic work that examines two competing hypotheses regarding the effects of early and continued drug use: developmental hiatus where youth miss acquiring important skills and developmental acceleration where youth move swiftly through adolescent tasks as part of their association with older drug-using peers. Both transitions harm adult role socialization.
97. Spear LP: **The adolescent brain and age-related behavioral manifestations.** *Neurosci Biobehav Rev* 2000, **24**:417-463.

98. Lenroot RK, Giedd JN: **Brain development in children and adolescents: insights from anatomical magnetic resonance imaging.** *Neurosci Biobehav Rev* 2006, **30**:718-729.
An excellent review of the neurodevelopmental changes experienced from childhood to adolescence and the corresponding neuroanatomical structures that underlie behavior.
99. Steinberg L: **Risk taking in adolescence: new perspectives from brain and behavioral science.** *Curr Dir Psychol Sci* 2007, **16**:55-59.
100. Wittchen U-U, Fröhlich C, Behrendt S, Günther A, Rehm J, Zimmermann P, Lieb R, Pekonigg A: **Cannabis use and cannabis use disorders and their relationship to mental disorders: a 10-year prospective-longitudinal community study in adolescents.** *Drug Alcohol Depend* 2007, **88S**:S60-S70.
101. Di Forti M, Morrison PD, Butt A, Murray RM: **Cannabis use and psychiatric and cognitive disorders: the chicken or the egg?** *Curr Opin Psychiatry* 2007, **20**:228-234.
102. Paton S, Kessler R, Kandel DB: **Depressive mood and adolescent illicit drug use: a longitudinal analysis.** *J Gen Psychol* 1977, **92**:267-287.
103. Khantzian EJ: **The self-medication hypothesis of substance use disorders: a reconsideration and recent applications.** *Harvard Rev Psychiatry* 1997, **4**:231-244.
An update to an earlier and quite seminal paper that outlines the role of mood and affect regulation in addictive disorders; considered a prominent clinically based theory that explains psychological motivations for drug use based on self-regulation vulnerabilities with implications for treatment.
104. Creason CR, Goldman M: **Varying levels of marijuana use by adolescents and the amotivational syndrome.** *Psychol Rep* 1981, **48**:447-454.
105. McGlothlin WH, West LJ: **The marijuana problem: an overview.** *Am J Psychiatry* 1968, **126**:370-378.
106. Lak A, Luk JW: **Testing the amotivational syndrome: marijuana use longitudinally predicts lower self-efficacy even after controlling for demographics, personality, and alcohol and cigarette use.** *Prev Sci* 2018, **19**:117-126.
107. Hirschi T: *Causes of Delinquency.* University of California Press; 1969.
108. Janowitz M: **Sociological theory and social control.** *Am J Sociol* 1975, **81**:82-108.
109. Staff J, Schulenberg JE, Maslowsky J, Bachman JG, O'Malley PM, Maggs JL, Johnston LD: **Substance use changes and social role transitions: proximal developmental effects on ongoing trajectories from late adolescence through early adulthood.** *Dev Psychopathol* 2010, **22**:917-932.
110. Caspi A, Bem DJ, Elder GH: **Continuities and consequences of interactional styles across the life span.** *J Pers* 1989, **57**:375-406.
111. Orcutt JD: **Differential association and marijuana use: a closer look at Sutherland (with a little help from Becker).** *Criminology* 1987, **25**:341-358.
112. Chen K, Kandel DB: **Predictors of cessation of marijuana use: an event history analysis.** *Drug Alcohol Depend* 1998, **50**:109-121.
113. Jochman KA, Fromme K: **Maturing out of substance use: the other side of etiology.** In *Handbook of Drug Use Etiology: Theory, Methods and Empirical Findings.* Edited by Scheier LM. American Psychological Association; 2010:565-578.