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Longitudinal Trajectories of Marijuana Use from Adolescence to Young Adulthood

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Abstract

Background—Marijuana use is increasingly widespread among adolescents and young adults; however, few studies have examined longitudinal trajectories of marijuana use during this important developmental period. As such, we examined adolescent trajectories of marijuana use and the psychosocial factors that may differentiate individuals who escalate their marijuana use over adolescence and young adulthood from those who do not.

Methods—Participants were 1,204 9th and 10th graders at baseline who were over-sampled for cigarette use and were followed over 6-years, as part of an extensive longitudinal study, the Social and Emotional Contexts of Adolescent Smoking Patterns (SECASP) study. Growth Mixture Modeling (GMM) was used to model trajectories of marijuana use and Mixed Effects Regression analyses were used to examine psychosocial correlates of marijuana use escalation over time.

Results—Our results revealed three trajectories of non-escalating users (low users, medium users, and high users) and one escalating user trajectory. We found that relative to Non-escalators the Escalators had higher cigarette smoking ($p<.0001$), novelty-seeking ($p=.02$), aggressive and anti-social behavior ($p<.007$), and problem behavior related to peer context ($p=.04$). Moreover, there were important time and group by time interactions in some of these relationships. On the other hand, parental control and depression did not differ between escalators and low and medium non-escalating users.

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Declaration of Interest

The authors have no competing financial interests to declare.

Conclusions—Cigarette smoking, novelty-seeking, aggressive and anti-social behavior, and peer influence are related to ‘escalating’ marijuana use throughout adolescence and young adulthood.

1. INTRODUCTION

Marijuana use is increasingly widespread among adolescents and young adults in the US, recently becoming more common than cigarette smoking (1, 2). Among 12th graders in 2013, prevalence of past 30 day marijuana use was 22.7% and of past year use was 36.4% (1). As prevalence rates increase, perceived risk of smoking marijuana regularly is decreasing. In fact, only 39.5% of 12th graders endorsed high levels of perceived risk (1). However, there is growing evidence that significant marijuana use can lead to health problems, such as impaired respiratory cardiovascular functions and accidental injuries, as well as psychosocial problems, with poorer educational outcome, increased risky behavior, aggression, and delinquency (3) (4) (5). Developing brain systems may also be affected by significant marijuana use in important ways. In fact, cognitive and emotional brain systems involved in affect, self-control and self-regulation are still developing in adolescence and keep developing until young adulthood (6), and onset of drug use in early adolescence may lead to altered brain development, resulting in poor self-regulation (7), poorer neuropsychological functions (2), greater dependence and negative outcomes (8). It is therefore important to better understand the developmental progression of adolescent marijuana use patterns, and to characterize risk factors, so that the most vulnerable youths can be identified for prevention or early intervention (9).

Seminal large scale studies in the Seventies and Eighties revealed the importance of a psychosocial framework for studying drug abuse in adolescents (10-13), and of identifying “clusters” of risk and protective factors as they may change in various life phases (14) (15). In particular, Jessor and Jessor (10-12) developed a problem-behavior theory that examined, among other problem behaviors, marijuana use in adolescents. Their studies examined trajectories of change over time in three major systems: personality, perceived environment (i.e., peers, family) and problem behavior. Their findings suggest consistent longitudinal predictive differences between users and non-users, such that the users place lesser value on academic achievement and religious involvement, are more concerned with personal independence and criticism of society, have a more tolerant view of transgression, have greater influence of friends relative to parents, and have friends who approve of drugs. Similarly, Elliott et al.'s (13) findings from a five year national survey with 11 to 17 year olds suggest that bonding to deviant peers is a direct cause of drug delinquency and drug use. Building from these initial and influential studies, recent investigations with a more specific clinical and psychological focus reinforced the point that multiple risk factors related to personality traits, family and peer context (16) (17) need to be further integrate and concurrently examined within a developmental model of marijuana use.

Several personality traits and clinical factors are important risk factors for substance use, including marijuana use. In particular, the personality trait of sensation-seeking, or the ‘willingness to take risks for novel experience or excitement’ (18), associated with hormonal and neurophysiological changes starting in early adolescence, and plays a major role in drug

experimentation in teens. However, sensation seeking's influence on drug use seems to wane with maturation (19) (20). Recent studies have also linked important clinical risk factors like mood regulation to cigarette smoking (21) (22). Similarly, some evidence indicates depression may be related to marijuana use initiation (23), but the role of depression in continued use is unclear. Importantly, different personality and clinical factors may define differing longitudinal trajectories of marijuana use. For instance, there is some evidence that sensation-seeking may be related to earlier onset trajectories, whereas negative emotionality may relate more to escalating trajectories in substance use (24). Yet, these issues have not been clearly disentangled with regard to marijuana use. Finally, other risk factors including problematic family relationship, externalizing behavior, and having friends who smoke seem to facilitate marijuana use (10) (20) (25) (26); however, time-changing effects for these variables have not been well-documented yet.

Recent studies have taken a closer look at longitudinal trajectories specifically for marijuana use from adolescence to young adulthood (27) (28) (29). For instance, Brook et al. (27) examined the developmental trajectory of marijuana use in a 6-year longitudinal study in participants between ages 14 and 27, and identified five longitudinal trajectories of marijuana users: non-users or experimenters, occasional users, quitters or decreasees, increasing users, and chronic users. Relative to the other groups, chronic users reported personal attributes of low self-control, externalizing behavior and sensation seeking. However, in the Brook et al.'s study the personal predictor measures were administered only at one time point, making it difficult to determine if these variables are stable over time, which may differentially impact the trajectories.

Building from the previous literature, the first objective of the present study was to use Growth Mixture Modeling (GMM) to differentiate adolescent trajectories of marijuana use in cohort of adolescents who were oversampled for cigarette smoking at baseline (9th and 10th graders) and who were followed over a 6-year span. Most marijuana users report lifetime cigarette smoking (17). Therefore our sample is similarly at high risk for marijuana smoking, creating a rich sample for examining more fine-grained patterns of marijuana use during adolescence and young adulthood. The second objective was to gain a better understanding of escalating patterns of marijuana use, since it has been suggested that escalation of drug use is a hallmark of persistent addiction liability (30). The third objective was to model the potential predictor variables over multiple time points, to document whether the construct-related effects change over time, and whether they may have different roles in the continuation of marijuana use. The key constructs that we focused on were: 1) Depression/Stress; 2) Temperament; 3) Problem Behavior; 4) Parental Monitoring; and 5) Peer Relations. We hypothesized that our participants would exhibit distinguishable trajectories of marijuana use, revealing escalating versus non-escalating phenotypes (27). We also predicted that the escalating trajectory, relative to the non-escalating one, may be mediated by higher levels of novelty-seeking, depression, and anti-social behavior. Further, we expected that the effects of psychological measures that are more sensitive to maturation (e.g., sensation-seeking), may change over time.

2. METHODS

2.1. Participants

All participants were drawn from the Social and Emotional Contexts of Adolescent Smoking Patterns (SECASP) study, described in detail in Dierker and Mermelstein (31). Ninth (i.e., age 14) and tenth grade (i.e., age 15) students in 16 high schools across the greater Chicago metropolitan area were surveyed about their history of cigarette smoking and oversampled for 'ever smoking' a cigarette in order to maximize opportunities to see smoking escalation. All students reporting smoking cigarettes in the past 90 days were invited to participate, and random samples of those who reported never smoking or smoking less than 100 cigarettes in their lifetime, but not in the past 90 days, were also invited. Of the 3654 students invited, 1344 agreed to participate, and of these 1263 (94%) completed the baseline measurements. All participants completed questionnaires on demographics, psychosocial factors and substance use at baseline, and then at 6, 15, 24, 60 and 72 months. Retention rates at 72 months (i.e., 6 years) were greater than 85%. Participants were included in the current data analyses if they were assessed at more than two time points.

The study was approved by the IRB at the University of Illinois at Chicago. For each participant, consents from parents, as well as assents from the students, were collected.

2.2. Measures

Demographics and Smoking Behavior—Demographic information (i.e., gender, race/ethnicity, mother's education, current educational status, grade point average (GPA) at baseline), and cigarette smoking rate (i.e., cigarettes per day) was obtained from each participant through self-report questionnaires during each measurement wave.

Marijuana Use—At each assessment wave, participants reported how many days per month they smoked marijuana in the past 3 months, using a single item question with 5 ordinal options. For our trajectory analyses the 5 ordinal options were coded as: 0= zero time; 1=once a month or less; 3= more than once a month but less than once a week; 9=more than once a week but less than daily; 27= every day.

Measures of Depression/Stress—With regard to depression symptoms, we adopted the Center for Epidemiological Studies-Depression (CES-D; (32)), to assess adolescent depressive symptoms (i.e., depressed affect, somatic symptoms, psychomotor retardation, and interpersonal difficulties), as experienced in the past week, from 0 (rarely or none of the time) to 3 (most or all of the time). The CES-D validly measures depressive symptoms in high school adolescents (33) (32) (34). The clinical cutoff for adolescents is 22 for boys and 24 for girls, while the adult cutoff is 16 (33). The modified, 4-item *Perceived Stress Scale* (PSS) assesses the degree of subjective stress and the impact of stressful situations in an adolescent's life (35) in the past month, on a scale from 1 (never) to 5 (very often). Strong internal reliability, test-retest reliability, and validity have been documented for the original PSS measure as well as for the 4- item version (35).

Measure of Temperament—A 8-item subscale of the *Tridimensional Personality Questionnaire (TPQ)*; (36), adapted for adolescents (37), was used to assess *adolescent novelty seeking* behavior (i.e., seeking thrills and excitement and preferring to act on feelings of the moment, without regard for rules and regulations). Items are scored on a 4-point Likert-type scale, ranging from 1 (not at all true of me) to 4 (pretty true of me) (coefficient alpha = .73).

Measures of Risk-Problem Behavior—The *Adolescent aggressive and antisocial behavior checklist (ASBC)* is a 22-item scale that measures lifetime frequency of participation in aggressive and antisocial behaviors, based on the Antisocial Behavior Checklist (ASBC; (38, 39), with added items from a longitudinal study on adolescent problem behaviors (38). The scale assesses core domains of Conduct Disorder as defined by the DSM-IV (40): Aggression, Deceit, Police Contact, Rule Violation, Theft and Vandalism, using the following choices: “Never”, “Rarely- Once or twice”, “Sometimes-3 to 9 times”, “Often- More than 10 times” (coefficient alpha = .88 at baseline) (Note: we excluded from the scale one item related to selling marijuana and other illicit substances). The 8-item cannabis Use Disorder Identification Test – Revised (CUDIT-R; (41)) assesses cannabis use problems and dependence using a 4-point Likert scale.

Measure of Parental Monitoring and Authority—The *Parental Restrictive Control (PRC) Questionnaire* (42, 43) asks adolescents to rate the extent to which there are family rules, and the style of decision-making, for ten hypothetical events and behaviors. For the Extent of Rules set of questions, ratings are made on a 5-point scale ranging from 1 (No rules or expectations) to 5 (Firm rules or expectations). For the Decision-Making questions, the proportion of unilateral- parent (items scored as 1), unilateral-teen (items scored as 5), and joint decision making responses (items scored as 2 – 4) are calculated for each respondent.

Measure of Peer Context-Problem Behavior.—A modified 16-item Social Network Inventory for Tobacco Smokers (SNITS) assessed emotional and belonging support from peers who smoked cigarettes, and whether these friends engage in problem (e.g., smoking, drinking) or non-problem (e.g., getting good grades) behaviors (44). For our purposes, we used the “problem behavior” items only (coefficient alpha = .85). Response options ranged from 0 (0 people) to 5 (5 or more people).

2.3. Statistical Analyses

In a first analysis we used Growth Mixture Modeling to identify marijuana use trajectories over time, using frequency of use data from the multiple time points. The number of classes in the model was determined as follows. We first created two a priori defined groups: 1) “never users” (i.e., consistently reported never smoked marijuana in lifetime at all assessment waves), and 2) “non-users” (i.e., reported “ever” smoking marijuana, but never in the past three months, at each assessment wave). We excluded both the never user and non-user groups from our statistical modeling of trajectories since at each point from baseline through the 6 years follow-up, their responses were consistently 0 to past three month use. We then used GMM in MPlus 6 (45), using full maximum likelihood estimation,

in order to identify potentially different marijuana use ‘trajectories’ over time, from baseline to the 6-years wave, among the participants who reported any use during the past three months at an assessment wave. We included only participants who reported smoking marijuana in at least three of the assessments resulting in 941 participants. MPlus 6 estimates the model using all available data; in the present case there were a total of 6032 observations from the 941 participants. We allowed for nonlinear trends across time by modeling both linear and quadratic trends and we allowed the participant's intercept (i.e., a participant's deviation from the class trend) to be a random effect. Eighteen age bins with 0.5 year interval were created (e.g., first bin=14.5-14.9 years, last bin=23+years), and time scores for the slope growth factors were fixed to define the linear growth model.

Our results revealed a four-class solution which included three classes of non-escalating users, who did not significantly escalate their marijuana use over time, and one class of escalating users, who exhibited significant escalating marijuana use over time: *Class 1-High Users*, who smoked marijuana nearly every day (n= 209); *Class 2-Escalating Users* (n=100); *Class 3-Low Users*, who smoked marijuana more than once a month but less than once a week (n= 350); *Class 4-Medium Users*, who smoked marijuana one or more times a week but not every day (n= 282). Low, Medium and High users presented non-escalating trends. Low Users started at a mean marijuana use rate of .24 days/month at baseline, and ended at a mean of .52 days/month at 72-months. Medium users started with a mean of 1.48 days/month (baseline) and ended with mean of 3.03 days/month (72-months). High users started with a mean of 5.5 days/month (baseline) and ended with a mean of 8.78 days/month (72-months). Finally, the Escalating users had a mean marijuana use of 1.71 days/month at baseline, but increased frequency rapidly starting at age 16-17, reaching a mean of 25.2 days/month by 72-months (Figure 1). Supplemental Figure S.1 visualizes the participants’ individual trajectories of marijuana use within each of these groups.

An additional set of analyses addressed the question of whether the “Escalators” and the “Non-escalators” (which included the Low and Medium users groups) may differ, at baseline and over multiple time points, on our psychosocial measures. Since we were primarily interested in predicting escalation or non-escalation from baseline we included in the Non-escalators group the Low and Medium marijuana user groups because at baseline they did not differ significantly from each other and from the Escalators group on important variables such as GPA, cigarette smoking rate, and marijuana use. However, we excluded from the Non-escalators group the High marijuana user group, which was qualitatively different from the Low and Medium users groups because it had already escalated to high use before baseline, and because at baseline this group differed significantly from the Low and Medium user groups in terms of higher cigarette smoking rate and marijuana use, and lower GPA.

Mixed Effects Regression analyses (Type 3 tests of fixed effects; model with group by time interaction) were run using General Linear models (GLM) in SAS (SAS Institute Inc., 2008). T-Test procedures were also performed with SAS. We conducted separate analyses for each of the psychosocial measures. Group (Escalators, Non-Escalators) was our between subjects factor and Time was the within-subjects variable. As detailed in Table 2, while some of the psychosocial measures were assessed at five time points across the longitudinal

span (i.e., at 6, 15, 24, 60, and 72 months) (e.g., CESD-D; PSS), others were assessed only at 3 time points (i.e., at 6, 15 and 24 months) (e.g., ASBC; PRC, SNITS), or 2 time points (i.e., at 6 and 15 months) (e.g., novelty seeking).

3. RESULTS

3.1. Demographics

ANOVAs and Chi-Square analyses examined participant demographic characteristics and cigarette smoking rates for each group at baseline and at the 6-years wave (see Table 1). We found significant group effects for gender, GPA and cigarette smoking rate at baseline, as well as of gender, highest level of education, current educational status, and cigarette smoking rate at 6 years (all p 's $<.05$; see Table 1). Specifically, at baseline Never users had a significantly higher GPA than Non-users [$F(1,262)= 5.80$ $p=.02$], and Low users and Medium Users had a significantly higher GPA than High users [$F(1,558)= 17.69$, $p<.001$ and $F(1,490)= 8.54$, $p=.004$; respectively]. However, Escalators baseline GPA did not differ from that of Non-users [$F(1,233)= 1.14$, $p=.29$] or High users [$F(1,308)= 1.99$, $p=.16$]. In addition, Never users did not differ from Non-users [$F(1,262)= 2.47$, $p=.12$], and Non-users did not differ from Escalators on cigarette smoking rate at baseline [$F(1,233)= 0.15$, $p=.70$]. On the other hand, Low users, Medium users, and Escalators had significantly lower cigarette smoking rates than High users at baseline [$F(1,558)= 41.01$, $p<.001$, $F(1,490)= 35.79$, $p<.001$, and $F(1,308)= 16.47$, $p<.001$; respectively]. Interestingly, by 6 years these patterns changed such that Escalators had similar cigarette smoking rates as High users [$F(1,308)= 1.89$, $p=.17$] and significantly higher cigarette smoking rates than Non-users [$F(1,233)= 5.69$, $p=.02$]. Never users had lower cigarette smoking rates than Non-users [$F(1,262)= 11.15$, $p<.001$] and Low and Medium users had lower cigarette smoking rates than High users at 6 years [$F(1,558)= 58.39$, $p<.001$ and $F(1,490)= 38.20$, $p<.001$; respectively].

3.2. Differences among marijuana Use Groups and Trajectories for Smoking and Psychosocial Variables

Supplemental Table S1 illustrates mean scores and standard deviations on our measures for each of the six groups on each available assessment time.

3.3. Comparison Between Escalators and Non-Escalators Over Time

Daily Cigarette Smoking Rate by Marijuana Trajectory (Table 1; Figure 2)—A significant effect of Group by Time [$F(1,3969)=28.63$, $p<.0001$] indicated that while at baseline the Escalators and the Non-escalators did not differ on cigarette smoking rates, at 6 years the Escalators had significantly higher cigarette smoking rates than the Non-escalators.

Psychosocial Variables by Marijuana Trajectory (Table 2)—With regard to the CES-D, a significant main effect of Time [$F(1, 730)=96.69$, $p<.0001$], indicated that both groups had lower depression scores over time. However, there was no significant Group effect ($p=.74$) or Group by Time interaction ($p=.11$). For the Perceived Stress Scale there was a significant interaction of Group by Time [$F(1,2606)=4.85$, $p<.03$]. T-tests indicated that while the Non-escalators group had higher scores than the Escalators group at baseline

($t=-2.07$; $p<.04$), this difference diminished over time, and there were no significant group differences by 5 and 6 years. With regard to Novelty-seeking, there was a significant effect of Group [$(1, 645)= 5.32$, $p<.02$], indicating that the Escalators had higher novelty seeking scores, and of Time [$F(1,718)=9.31$, $p<.002$], revealing that scores decreased over time in both groups; however there was no significant interaction ($p=.66$). For ASBC Group was significant [$F(1,1346)=7.21$, $p<.007$] in that the Escalators had higher scores than the non-escalators. There was also a main effect of Time [$F(1,728)=168.67$, $p<.0001$] with both groups showing decreased scores over time, starting at approximately 6 months. However the interaction was not significant ($p=.77$). For the CUDIT-R there was a significant interaction of Group by Time [$F(1,596)=8.77$, $p=.003$]. T-tests revealed that the Escalators had significantly higher scores relative to the Non-escalators at 5 years ($t=-12.11$; $p<.0001$), and that this group difference increased by 6 years ($t=-20.21$; $p<.0001$), since the Non-escalators' scores decreased ($p<.04$), while the Escalators' scores showed a non-significant increase ($p=.22$). With regard to PRC-Family rules, and for each of the three PRC measures on Decision-making, there was only a main effect of Time (all $P_s <.0001$), in that the two groups did not differ and showed the same pattern of decreasing scores from baseline to 24 months. For SNITS (problem behavior of social network members) a main effect of Group [$F(1,1347)=4.06$, $p=.04$] indicated greater scores for the Escalators relative to the Nonescalators overall, and a main effect of Time [$F(1,728)=11.28$, $p=.0008$] revealed that scores decreased with time in both groups. However there was no significant interaction ($p=.82$).

4. DISCUSSION

This study examined different longitudinal trajectories of marijuana use in adolescents, and compared Escalators to Non-escalators across multiple measurements. One important contribution that our findings add to the literature is the comparison between the escalating group and the low and medium non-escalating groups, since at baseline these three groups did not differ on several important variables including cigarette smoking and marijuana use, while over time they did start to diverged in their use patterns. Therefore it is important to better understand what contributed to the escalators significantly increasing their marijuana use over time, while the low and medium users did not escalate their use.

One of the main findings is that escalating marijuana use was accompanied by escalating cigarette smoking over time. While Escalators' cigarette use was similar to Non-users, Low users, and Medium users at baseline, at 6 years only the Escalators showed a significant increase in their smoking rates. Our results are in line with recent findings of a positive relationship between intensity of cigarette smoking and of marijuana use (46), supporting the view that escalating levels of tobacco smoking may potentially mediate the initiation of marijuana use (17). Further studying this relationship by following the longitudinal progression is of relevance because tobacco and marijuana co-use often leads to worse clinical outcome (47).

Additional key findings were that relative to Non-escalators the Escalators had higher novelty seeking, higher aggressive and anti-social behavior, and higher levels of support received from peers with problem behaviors. In line with previous findings (27) Escalators

had higher novelty seeking relative to Non-escalators. Notably our data show that this group difference persisted over time. Sensation-seeking is predictive of marijuana use in early adolescence (19), possibly because it leads to seeking novelty by means of impulsivity and risky actions (48). Novelty-seeking and impulsivity have also been associated with poor functioning of the lateral prefrontal cortex, a brain region involved in self-regulation, in young adult marijuana users (49). Furthermore, in both groups novelty-seeking scores decreased over time. There is evidence that sensation seeking sharply increases between ages 10 and 15, and then decreases slowly over the rest of adolescence (50). Therefore this decrease in novelty-seeking may be at least in part due to maturation processes.

Another important finding is that Escalators had higher aggressive and anti-social behavior relative to Non-escalators, and this group difference did not change over time. Marijuana use has been linked to multiple problem behaviors (10, 12) (13) and more specifically to anti-social behavior (51). One study found that individuals with “externalizing behaviors” during childhood and adolescence have increased risk of developing a cannabis use disorder (CUD) in young adulthood (52). Moreover, antisocial personality disorder was found to be associated with an increased risk for persistence of CUDs during a 3-year follow-up (53). However, we also found that both groups showed decreased scores in time, starting at approximately 6 months. Similarly, for social network support from peers who have problem behaviors we found significantly higher scores for the Escalators relative to the Non-escalators overall, and that these scores decreased similarly in both groups with time. While we do not have a clear-cut explanation for the decreasing effects over time, they may be related to maturational effects and better self-regulation with development, suggesting the importance of taking into account temporal aspects when examining the co-morbidity between marijuana use and externalizing behaviors. As would be expected, Escalators had also higher CUDIT scores at 5 and 6 years, as their marijuana use increased.

Further, we did not find any consistent or significant relationship over time between depression scores and escalating vs. non-escalating patterns. While previous reports indicate that depression may be an important factor in marijuana use initiation (54) our current findings seem to suggest that depressive symptoms may not play as much of a role in marijuana use escalation over time. It is also possible that we did not find significant group differences because we examined only depression symptoms, but did not use additional scales to measure negative affect or affect more generally. We also did not find striking differences between Escalators and Nonescalators on perceived stress. Although the Non-escalators had higher perceived stress scores than Escalators at baseline, these differences diminished over time.

Surprisingly, we did not find a relationship between parental control and escalation of marijuana use. Previous studies have found that parental monitoring in younger teens can have a protective effect on trying substances and negative peer influences (55) (10). However, our findings suggest that family rules may not have a direct impact specifically on escalation of marijuana use. Some of the monitoring and family rules may also be changing developmentally over time as teens become older, and this fact may have introduced variability in our longitudinal data. It is also possible that during late adolescence escalating

marijuana use is more mediated by peer influence than by parental control influence, as previous literature (10, 13) and our findings on the SNITS seem to suggest.

A strength of the present study was our ability to focus on prospective differences between Escalators and Non-escalators, two groups with similar levels of marijuana use at baseline, but who diverged over time in their use patterns. Despite this strength, not all of our psychosocial measures were assessed at each point across the longitudinal span (some only assessed through 24 months, whereas others assessed through the full 6 years), limiting perhaps some of our conclusions. Also, we examined marijuana use trajectories within an adolescent cohort oversampled for 'ever smoking' tobacco cigarettes, making it difficult to generalize to non-cigarette smokers in the same age range. It is possible that different patterns may be found in adolescent samples with a more normative distribution of risk behaviors. Finally, it will be important that future studies further examine how some of the psychosocial factors highlighted in our study may have different roles in the initiation vs. continuation of marijuana use over time.

5. CONCLUSIONS

In conclusion, the present findings provide new knowledge to better understand the psychosocial factors that differentiate Escalators from Non-escalators over adolescence and young adulthood. Our longitudinal findings on marijuana use expand several lines of previous longitudinal and non-longitudinal research that have found novelty seeking, aggressive and antisocial behavior, and problem behavior related to peer-context, to be related to substance use in adolescents. These factors must be thoroughly examined in clinical research in order to properly develop prevention and intervention programs for adolescents at risk for substance abuse.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- Marijuana (MJ) use is increasingly widespread among adolescents.
- We have limited knowledge on longitudinal trajectories of MJ use during adolescence.
- We examined adolescent longitudinal trajectories in MJ use in 1204 participants.
- We found differences on psychosocial measures in escalators vs non-escalators.

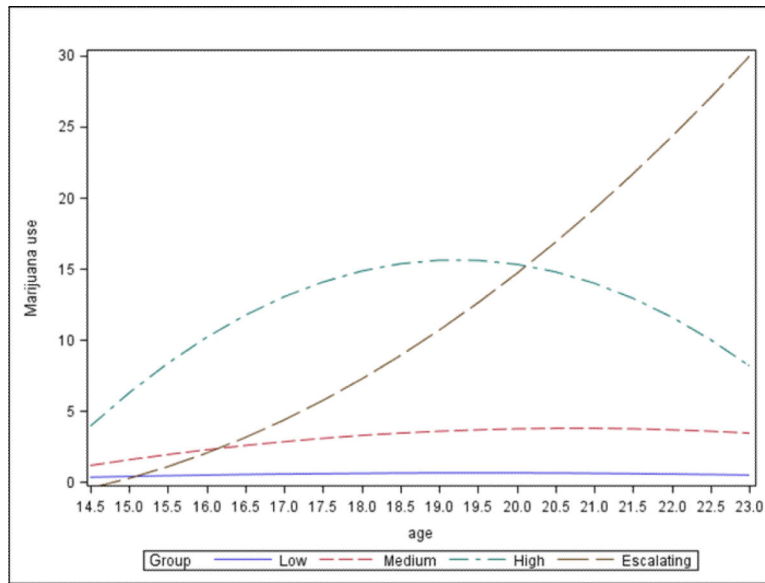


Figure 1. Illustration of estimated trend lines for the three classes of non-escalating users (i.e., low, medium and high groups) and one class of escalating users. “Marijuana use” is defined as follows: 0= zero time; 1=once a month or less; 3= more than once a month but less than once a week; 9=more than once a week but less than daily; 27= every day.

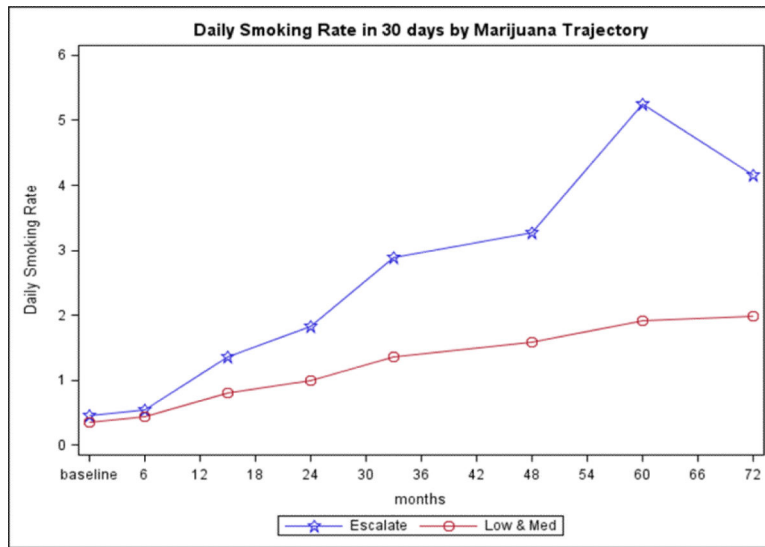


Figure 2. Daily cigarette smoking rate in 30 days, in Escalators and Non-escalators, from baseline to 72 months. Cigarette smoking rate is defined in terms of cigarettes per day.

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Table 1

Participants' characteristics at baseline and at 6 years.

	Never Users (n=129)	Non-Users (n=134)	Low Users (n=350)	Medium Users (n=282)	Escalating Users (n=100)	High Users (n=209)
BASELINE						
Age	15.52 (0.64)	15.75 (0.58)	15.64 (0.60)	15.63 (0.63)	15.62 (0.60)	15.61 (0.61)
Gender (% female)*	65%	67%	66%	57%	43%	38%
Ethnicity/Race						
Caucasian	53%	51%	58%	56%	58%	60%
Black	19%	12%	17%	16%	26%	15%
Hispanic	16%	19%	16%	20%	11%	17%
Other	12%	17%	9%	9%	5%	8%
Mother's Education*						
No more than HS	45%	38%	36%	29%	21%	34%
Some College	16%	22%	22%	23%	35%	17%
College degree or higher	39%	40%	42%	48%	44%	49%
Grade Point Average (GPA)*	3.97 (0.81)	3.75 (0.79)	3.79 (0.69)	3.72 (0.72)	3.65 (0.81)	3.52 (0.76)
Cigarette Smoking Rate (cigs per day)*	0.01 (0.06)	0.36 (1.37)	0.33 (1.63)	0.36 (1.2)	0.45 (1.00)	1.33 (3.2)
6 YEARS (72 months)						
Age	22.20 (0.83)	22.50 (0.80)	22.48 (0.88)	22.42 (0.82)	22.35 (0.79)	22.35 (0.79)
Gender (% female)*	66%	67%	70%	60%	43%	39%
Ethnicity/Race						
Caucasian	55%	54%	58%	55%	58%	60%
Black	18%	12%	17%	18%	26%	15%

	Never Users	Non-Users	Low Users	Medium Users	Escalating Users	High Users
BASELINE	(n=129)	(n=134)	(n=350)	(n=282)	(n=100)	(n=209)
Hispanic	14%	17%	15%	19%	11%	17%
Other	13%	17%	10%	8%	5%	8%
Highest Level of Education*						
Some HS, HS diploma, GED, vocational, or technical degree	16%	16%	18%	18%	19%	26%
Some college or 2-year degree	63%	60%	58%	56%	67%	63%
4-year degree	18%	24%	23%	26%	13%	11%
Graduate degree	3%	0%	1%	0%	1%	0%
Current Educational Status*						
Not in school	37%	36%	47%	49%	55%	53%
In HS, GED, vocational or technical program	3%	8%	2%	5%	2%	4%
In 2-year college	17%	19%	14%	12%	19%	17%
In 4-year college	36%	29%	34%	30%	22%	24%
In graduate school	7%	8%	3%	4%	2%	2%
Cigarette Smoking Rate (cigs per day)*	0.58 (2.54)	2.63 (5.19)	1.71 (3.87)	2.22 (4.29)	4.15 (5.12)	4.94 (5.95)

Note. GED=General Educational Development; HS=High School

Standard deviations are noted in parentheses.

* indicates significant at $p < .05$.

Table 2

Observed means and standard deviations of psychosocial measures at multiple assessment times for Non-escalators and Escalators.

	Non-Escalators (n 553)	Escalators (n 89)
AFFECT/STRESS		
<i>Center for Epidemiological Studies-Depression (CES-D)^T</i>		
Baseline	16.87 (9.88)	15.76 (8.49)
6 months	15.85 (9.86)	16.32 (9.61)
15 months	14.05 (9.12)	14.04 (8.49)
24 months	14.63 (9.29)	13.90 (9.34)
60 months	13.11 (9.63)	13.96 (11.00)
72 months	12.13 (9.25)	13.36 (9.55)
<i>Perceived Stress Scale (PSS)^{G×T}</i>		
Baseline	2.68 (0.73)	2.52 (0.74)
6 months	2.53 (0.76)	2.46 (0.78)
15 months	2.44 (0.78)	2.40 (0.84)
24 months	2.50 (0.76)	2.35 (0.77)
60 months	2.43 (0.74)	2.44 (.75)
72 months	2.39 (0.78)	2.46 (0.70)
TEMPERAMENT		
<i>Novelty-seeking^{G,T}</i>		
Baseline	3.47 (0.64)	3.66 (0.70)
6 months	3.45 (0.67)	3.51 (0.74)
15 months	3.39 (0.69)	3.54 (0.70)
RISK/PROBLEM BEHAVIOR		
<i>Adolescent Aggressive and Antisocial Behavior (ASBC)^{G,T}</i>		
Baseline	33.26 (6.95)	34.62 (7.77)
6 months	30.04 (5.86)	31.72 (7.20)
15 months	29.53 (5.63)	30.80 (5.73)
24 months	29.53 (5.62)	30.86 (6.67)
<i>Cannabis Use Disorders Identification Test-Revised (CUDIT-R)^{G×T}</i>		
60 months	4.53 (5.20)	14.18 (7.21)
72 months	3.88 (4.98)	15.34 (5.53)
PARENTAL MONITORING AND AUTHORITY		
<i>PRC-Family Rules^T</i>		
Baseline	2.89 (0.66)	2.91 (0.67)
6 months	2.76 (0.67)	2.75 (0.58)
15 months	2.57 (0.70)	2.51 (0.69)
24 months	2.42 (0.71)	2.36 (0.67)

	Non-Escalators (n = 553)	Escalators (n = 89)
<i>PRC-Decision Making (teen)^T</i>		
Baseline	0.54 (0.27)	0.52 (0.27)
6 months	0.58 (0.29)	0.59 (0.27)
15 months	0.64 (0.28)	0.60 (0.30)
24 months	0.66 (0.29)	0.69 (0.28)
<i>PRC-Decision Making (joint)^T</i>		
Baseline	0.29 (0.22)	0.31 (0.23)
6 months	0.28 (0.23)	0.28 (0.21)
15 months	0.24 (0.24)	0.26 (0.27)
24 months	0.25 (0.24)	0.23 (0.24)
<i>PRC-Decision Making (parent)^T</i>		
Baseline	0.17 (0.18)	0.17 (0.19)
6 months	0.15 (0.17)	0.14 (0.16)
15 months	0.12 (0.16)	0.14 (0.18)
24 months	0.08 (0.15)	0.08 (0.13)
PEERS		
<i>Social Network Inventory for Tobacco Smokers (SNITS)-Problem Behavior^{G, T}</i>		
Baseline	1.46 (1.10)	1.50 (1.13)
6 months	1.29 (0.95)	1.64 (1.08)
15 months	1.29 (0.96)	1.50 (0.93)
24 months	1.29 (0.93)	1.37 (1.08)

Note. “G” indicates a significant group effect ($p < .05$), “T” indicates a significant Time Effect ($p < .05$) and “G×T” Indicates a Group by Time interaction ($p < .05$). Standard deviations are noted in parentheses. n indicates sample size, which changes with wave.