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DEVELOPMENTAL TRAJECTORIES OF MARIJUANA USE FROM ADOLESCENCE TO ADULTHOOD: PERSONALITY AND SOCIAL ROLE OUTCOMES,[1,2]

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Summary

Longitudinal trajectories of marijuana use from adolescence into adulthood were examined for adverse life-course outcomes among African-Americans and Puerto Ricans. Data for marijuana use were analyzed at four points in time and on participants' personality attributes, work functioning, and partner relations in adulthood using growth mixture modeling. Each of the three marijuana-use trajectory groups (maturing-out, late-onset, and chronic marijuana-users) had greater adverse life-course outcomes than a non or low-use trajectory group. The chronic marijuana-use trajectory group was highly associated with criminal behavior and partners' marijuana use in adulthood. Treatment programs for marijuana use should also directly address common adverse life-course outcomes which users may already be experiencing.

Marijuana use at various stages of development has been associated with a number of adverse psychosocial outcomes (Hall, Degenhardt, & Lynskey, 2001). These outcomes have been reported in all areas of adult functioning, including psychological well-being (Hayatbakhsh, Najman, Jamrozik, Mamun, Alati, & Bor, 2007), work (Green & Ensminger, 2006; Ringel, Ellickson, & Collins, 2006; Fergusson & Boden, 2008) and relationships with partners (Green & Ensminger, 2006; Fergusson & Boden, 2008). There is growing evidence from epidemiologic and neuroscience literature that marijuana use, particularly chronic abuse, may have harmful effects. The focus of this research was to examine how specific trajectories of marijuana use are related to life-course outcomes in adulthood by studying two samples of randomly selected African-Americans and Puerto Ricans in a large urban area.

Researchers have identified a general pattern of marijuana use from initiation in middle to late adolescence (Gfroerer, Wu, & Penne, 2002) which includes a peak in late adolescence and young adulthood (Schulenberg, Merline, Johnston, O'Malley, Bachman, & Laetz, 2005) as well as a number of heterogeneous trajectories of use (e.g., Ellickson, Martino, & Collins, 2004). These trajectories are differentiated by such features as the age of initiation of use, the highest frequency of use, and the duration of that use. Although samples and methodology vary by study, some common substance use trajectories were found. These groups include the nonuser or stable low-user, early onset persistent or chronic high-user, developmentally limited or maturing-out user, and late-onset-increasing user (Jackson, Sher, & Schulenberg, 2008).

A few researchers have investigated ethnic differences among members in marijuana-use trajectories. Schulenberg, *et al.* (2005), in their study of young adults from ages 18 to 24 years, found few differences among African-American and Hispanic respondents assigned to each trajectory group. Ellickson, *et al.* (2004), who followed respondents from age 13 to 23 years, also identified similarities between distributions of African-American and Hispanic respondents within trajectory groups. Building on the findings of Schulenberg, *et al.* (2005) and Ellickson, *et al.* (2004), marijuana-use trajectories from adolescence to adulthood were studied here and included examination of ethnic differences in trajectory group membership.

Specific trajectories of marijuana use were related to adverse life-course outcomes in the domains of personality, work, and partner relationships. Family Interactional Theory is consonant with adolescent deviance decreasing prosocial bonds with family and work and interfering with successful functioning in adulthood (Brook, Brook, Gordon, Whiteman, & Cohen, 1990). Studies of trajectories of marijuana use with adult personality and behavioral outcomes showed, for example, that compared with nonuse trajectories, those involving chronic marijuana use were associated with increased likelihood of lowered life satisfaction (Ellickson, *et al.,* 2004), antisocial personality disorders, arrests (Flory, Lynam, Milich, Leukefeld, & Clayton, 2004), and aggression (Tucker, Ellickson, Orlando, Martino, & Klein, 2005). Trajectories involving late-onset marijuana use were also associated with similar outcomes in relation to nonuse trajectories (Ellickson, *et al.,* 2004; Flory, *et al.,* 2004; Brown, Flory, Lynam, Leukefeld, & Clayton, 2004; Tucker, *et al.*, 2005), as well as poor mental health (Ellickson, *et al.,* 2004; Tucker, *et al.*, 2005) and theft (Tucker, *et al.*, 2005).

From a life-course perspective and Family Interactional Theory, marijuana-use trajectories were hypothesized to be related to adult social roles, those of both worker and partner. The major mechanisms within this theory are social modeling, identification, and attachment. This research so far has indicated these mechanisms to be related to decrease in substance use (Marcus, Pahl, Ning, & Brook, 2007). Substance use then may be expected to be related to commitment to work and attachments to others (e.g., partners).

With regard to work roles and experience, researchers have reported that a chronic marijuana-use trajectory was associated with a greater likelihood of unemployment compared to the abstainer group (Schulenberg, *et al.,* 2005). Also, early high (chronic) and steady increaser (late-onset) marijuana-use trajectories were each associated with lower completed education (Ellickson, *et al.,* 2004; Tucker, *et al.*, 2005) and lower income (Ellickson, *et al.,* 2004) when compared with abstainer groups.

With regard to partner relationships, a chronic marijuana-use trajectory was associated with being a decreased likelihood of being married compared to the abstainer group (Schulenberg, *et al.,* 2005). Similarly, Tucker *et al.* (2005) found that a steady-increaser

(late-onset) marijuana-use trajectory was associated with a decreased likelihood of being married compared to the abstainer group.

Classification by trajectory of marijuana use was also likely to have a strong relationship with partner's marijuana use. The association of partner's marijuana use in adulthood with trajectories of marijuana use may occur as a consequence of selection (Grant, Heath, Bucholz, Madden, Agrawal, Statham, *et al.,* 2007) or socialization processes (Leonard & Homish, 2005). It appears partner's marijuana use has not been included in research on the outcomes of marijuana-use trajectories. However, researchers such as Leonard and Homish (2005), have found that marijuana-users, compared with nonusers were more likely to have a relationship with other marijuana-users.

The present sample of African-American and Hispanic respondents permits identification of trajectories of use within an understudied population and assessment of the impact of these trajectories on the lives of trajectory group members. Such knowledge is essential for public policy, targeting prevention and treatment. Further understanding of which group of users would be most likely to experience adverse outcomes and in which developmental periods marijuana-use trajectory groups escalate their use is constructive for assessing which users should be targeted for treatment programs and specifying the most effective timing for such programs.

The present research was undertaken to contribute to understanding trajectories of marijuana use and their relation to life outcomes in two ways. First, the participants' marijuana use was traced prospectively from early adolescence into adulthood. Second, longitudinal research that examines these relationships is limited for inner-city African-American and Hispanic participants.

Five primary hypotheses were tested: (1) There will be at least four trajectories corresponding to the four groups identified in prior trajectory research. (2) The chronic high-use trajectory will be associated with greater adverse life-course outcomes (i.e., in domains of personality or behavior, work, partner relationship, and partners' marijuana use) compared with a non or low-use trajectory. (3) The maturing-out use trajectory will be associated with greater adverse life-course outcomes than the non or low-use trajectory. (4) The late-onset trajectory will be associated with greater adverse life-course outcomes than the non or low-use trajectory. (5) The chronic high-users will have more adverse outcomes than the maturing-out users.

Method

Participants

Data were from a four-wave longitudinal study of African-American and Puerto Rican participants. At Time 4 (T4), 59% (*n*=498) of the participants were female, and 41 % (*n*=339) were male. Ethnically, 55% (*n*=460) self-identified as African-American, and 45 % (*n*=377) as Puerto Rican. Of the T4 participants, 45% (n=377) reported having a 12th grade education level or less, and 22% (n=184) were married and lived together at T4. The T4 median annual personal gross income was $15,001 to $22,500.

At Time 1 (T1 in 1990), all of the African-American and Puerto Rican students in Grades 7 to 10 (n=1332, 616 males, 716 females, mean age=14 yr., sd=1.3) were recruited from 11 schools serving the East Harlem area of New York City. Participating adolescents were given follow-up interviews when their mean ages were 19 yr. (T2, sd=1.5), 24 yr. (T3, sd=1.3), and 29 yr. (T4, sd=1.7).

The Institutional Review Boards of New York Medical College, the Mount Sinai School of Medicine, and the New York University School of Medicine approved the study's procedures for data collection. A Certificate of Confidentiality was obtained from the National Institute on Drug Abuse of the National Institutes of Health at each wave. At T1 and T2, written informed assent was obtained from all minors after the procedures were fully explained and passive consent procedures were followed for parents of minors. Informed consent was obtained for participants older than 18 years. At T3 and T4, informed consent was obtained from all participants. Additional information regarding methodology is available from previous reports (Brook, Brook, & Zhang, 2008).

Of the 837 participants at T4, 71% (n=594) provided data at all four times, and the remaining 29% (n=243) provided data at three of the four times. Chi-square and t tests were used to compare the 837 adults with data at T4 with the 495 who did not participate at T4. There were no significant mean differences at T1 on depressive mood (t=1.0) and delinquency (t=0.1).

Measures

Questions at T4 included demographic factors, personality attributes, criminal behaviors, drug use, work functioning, and partner relationships.

The respondents were asked about the frequency of their marijuana use at all four times, using response options of 1: Never, 2: A few times a year or less, 3: About once a month, 4: Several times a month, and 5: Once a week or more. A similar measure was used by Fergusson and Boden (2008).

Table 1 contains the demographic and psychosocial variables plus values for Cronbach alpha and their sources. The psychosocial variables in previous research were related to drug use and psychopathology (Brook, Whiteman, Czeisler, Shapiro, & Cohen, 1997; Crawford, Cohen, & Brook, 2001). Each psychosocial variable has been dichotomized so that its indicator is 1 when the participants' scores were at the 84th percentile or higher on the variable, and 0 otherwise to be consistent with our prior research (Brook, Stimmel, Zhang, & Brook, 2008).

There were 15 variables, with an average response rate of 99% for each of the variables. There were two missing values for the marijuana use variable at T4. The SAS MI procedure was used to deal with missing data; that is, Full Information Maximum Likelihood (FIML) imputation (Schaefer & Graham, 2002) was applied variable by variable.

Procedure

At T1, questionnaires were administered to all adolescents in their classrooms. At T2 and T3, the majority of the participants were interviewed in person, while some were interviewed over the telephone. At T4, 37% (n=310) of the participants were interviewed in person, 22% (n=184) were interviewed over the telephone and 41% (n=343) were mailed self-administered questionnaires. There were no significant differences at the .01 level or lower in the responses to any but one of the personality (e.g., physical depression), work (e.g., work achievement), and partner relations items (e.g., arguments), or on the marijuana trajectories for interview mode or any of the interactions of interview mode with sex and/or ethnicity. "Anxiety symptoms" was the only variable to differ significantly by mode of interview. Participants who completed the questionnaire by mail reported more anxiety symptoms.

Analysis

The SAS Traj procedure (Jones, Nagin, & Roeder, 2001; Jones & Nagin, 2007) was applied to explore the trajectories of participants' marijuana use over time using the censored normal distribution. A censored normal distribution has values restricted between the lower and upper limits as described in Jones et al. (2001). Specifically a value at the lower limit contributes the value of the normal cumulative distribution function (CDF) at the lower limit to the likelihood function. A value at the upper limit contributes one minus the CDF at the upper limit to the likelihood function. Intermediate values contribute the value of the normal probability density function to the likelihood function.

The Bayesian information criterion (BIC) was applied to evaluate J, the number of trajectory components for marijuana use. The Bayesian Information Criterion (BIC) is used for model selection among a class of parametric models with different numbers of parameters. It is computed as $BIC = -2\ln L + k \ln(n)$ where L is the maximum likelihood function for the estimated model, k is the number of free parameters to be estimated, and n is the sample size. The model having the maximum value of BIC was selected. We also examined the entropy measure as calculated in M-plus (Muthén, 1998–2004).

Trajectory group membership was assigned using modal posterior probability to compare sex, ethnicity, and T1 school using the chi-square test of independence. Sex or ethnic patterns were reported in the results. Nine of the 11 T1 schools had similar marijuana trajectories, but two of the smaller schools had different distributions on the trajectories. Modal posterior probability classification was applied to compare adult outcomes.

Logistic regression analyses were conducted to examine whether the trajectories of marijuana use compared with the reference trajectory group (i.e., non or low-users) were associated with the psychosocial indicators (variables) at T4 controlling for sex, ethnicity, and the two T1 schools noted above. Membership in the marijuana-use trajectories served as the independent variables, and the psychosocial indicators served as the dependent variables. Further, presence of depressive symptoms at T1 was used as a control variable to predict depressive symptoms and physical symptoms of depression at T4. Criminal behavior at T1 was used as a control variable to predict criminal behavior at T4. School achievement at T1 was used as a control variable in the analysis predicting variables in the work domain (T4). Since the remaining personality or behavioral variables, marital status, relations with partner and partners' marijuana use were not measured at T1, these could not be used as T1 control variables.

We predicted Y_i, the psychosocial indicator for Participant i, using as predictors X_{ij}, the indicator of the jth trajectory group of marijuana use for Participant i, and C_{ik}, the control variables specified above. The logistic regression model for comparing Trajectory Group j with the modal group was then $Y_i = \beta_0 + \sum_{j>1} \beta_j X_{ij} + \sum_k \gamma_k C_{ik} + \varepsilon_i$, where ε_i is the residual error for the ith participant under the model. The odds ratio for participants in Group j relative to the modal group was $e^{\hat{\beta}_j}$ where $\hat{\beta}_j$ is the estimated logistic regression coefficient (Agresti, 1996). These odds ratios are reported in Table 2. The odds ratio for the T1 control variable is noted. A second comparison was for odds ratios under the null hypothesis of no difference in between the j and j' ($j \neq j'$) trajectories of marijuana use within the model using the test statistic $X^2 = \dfrac{\left(\widehat{\beta}_j - \widehat{\beta}_{j'}\right)^2}{\text{var}\left(\widehat{\beta}_j - \widehat{\beta}_{j'}\right)}$. Under the null hypothesis, the test statistic has an asymptotic chi-square distribution with 1 df. We used Bonferroni's inequality to adjust for the three comparisons made. That is, the difference is said to be significant at the .05 level when

$X^2 > 5.736$, where $\Pr\{W < 5.736\} = 1 - \dfrac{0.05}{3}$ and W has a chi-square distribution with 1 df. For T4 outcomes with an odds ratio which differed significantly from the non or low-use group, each reported odds ratio was labeled using a superscript a or b. Estimated odds ratios in each row which were not significantly different were labeled by the same superscript or no superscript.

Some supplementary analyses were conducted; e.g., a logistic regression analysis using the chronic marijuana-use trajectory group which was compared with the maturing-out marijuana-use trajectory group. In these analyses, sex, ethnicity, the two differing T1 schools, and the T1 measures noted above were controlled.

Results

Mixture Modeling: Extracting Trajectories of Marijuana Use

Solutions were computed for 1 through 7 trajectories. The BIC and entropy measures for each trajectory solution were 1 (−5362), 2 (−4437, 0.93), 3 (−4283, 0.94), 4 (−4089, 0.96), 5 (−4152, 0.86), 6 (−4104, 0.99), and 7 (−4118, 0.99). Since the four-trajectory group model had the largest BIC and a local maximum of the entropy measure, we chose $J = 4$ trajectories for marijuana use. (See Figure 1.)

As shown in Figure 1, the four trajectory groups were labeled as follows. Group 1, the non or low marijuana-users, had mean values corresponding to not using marijuana at all or using marijuana a few times a year or less at all four waves of data collection (i.e., 1.08, 1.20, 1.23, and 1.11). Group 2, the maturing-out marijuana-users, had mean values corresponding to not using marijuana at all or using marijuana a few times a year or less at T1 (1.49), using more than several times a month at T2 (4.39), using from a few times a year or less to once a month at T3 (2.40), and not using marijuana at all or using marijuana a few times a year or less at T4 (1.26). Group 3, the late-onset marijuana-users, had mean values corresponding to not using marijuana at all or using marijuana a few times a year or less at T1 and T2 (1.24 and 1.63), using more than a few times a year at T3 (2.67), and using several times a month at T4 (4.05). Group 4, the chronic marijuana-users, had mean values corresponding to not using marijuana at all or using marijuana a few times a year or less at T1 (1.47), using more than once a month at T2 (3.67), and using more than several times a month at T3 and T4 (4.64 and 4.57). Estimated prevalences of the four trajectory groups were 71.8% non or low marijuana-users, 9.2% maturing-out marijuana-users, 9.4% late-onset marijuana-users, and 9.6% chronic marijuana-users. The non or low marijuana-users were used as the reference group. Each trajectory group had a similar distribution of ethnic groups (χ^2 (3) = 2.3; $p = .51$). Females were more likely to be non or low-users (66% female) and less likely to be marijuana-users, especially chronic users (31% female) (χ^2 (3) = 46.8; $p < .001$). (See Table 2.)

Odds ratios for comparisons of non or low-users with other trajectory groups

Table 2 presents the odds ratio for each marijuana-use trajectory group which was compared with the non or low marijuana-use trajectory group for each T4 psychosocial indicator. Membership in each of the marijuana-use trajectory groups was significantly associated with many of the psychosocial indicators. In the personality or behavior domain, membership in the chronic marijuana-use trajectory group was associated with an increased likelihood of experiencing anxiety symptoms and interpersonal difficulties. Membership in the late-onset and in the chronic marijuana-use trajectory groups were associated with an increased likelihood of experiencing T4 depressive symptoms after T1 depressive symptoms were controlled. Membership in the maturing-out marijuana-use trajectory group was correlated

with an increased likelihood of experiencing anxiety symptoms and having interpersonal difficulty. Membership in the maturing-out, the late-onset, and the chronic marijuana-use trajectory groups were associated very strongly with an increased likelihood of engaging in T4 criminal behavior after T1 criminal behavior was statistically controlled.

In the work domain, membership in the late-onset marijuana-use trajectory group increased the likelihood that participants were unemployed at T4 after controlling for T1 school achievement. Membership in the late-onset and in the chronic marijuana-use trajectory groups were associated with low work achievement at T4.

In the domain of marital status, membership in the late-onset and in the chronic marijuana-use trajectory groups were associated with a reduced likelihood of being married and living with a spouse.

In the domain of partner relationships, membership in the maturing-out and the chronic marijuana-use trajectory groups were associated with an increased likelihood of arguments with partners. Membership in the maturing-out marijuana-use trajectory group was correlated with low marital harmony. Membership in the maturing-out and membership in the late-onset marijuana-use trajectory groups were associated with low satisfaction with partners.

In the domain of partner's marijuana use, members of the maturing-out, the late-onset, and the chronic marijuana-use trajectory groups were all associated with an increased likelihood of having a partner who used marijuana.

Supplementary Analyses (data not shown)

In the personality/behavior domain, members of the chronic compared to the maturing-out marijuana-use trajectory group were more likely to have experienced anxiety symptoms and depressive symptoms, and engaged in criminal behavior.

In the work domain, membership in the chronic compared to the maturing-out marijuana-use trajectory group was associated with low work achievement.

In the domain of marital partner relations, members of the chronic compared with the maturing-out marijuana-use trajectory group scored higher on arguments with partner, and partner's marijuana use, and lower on being married and living with a spouse.

Differences in odds ratios

As shown in Table 2, the odds ratio for anxiety symptoms experienced by the chronic vs the non or low marijuana-use trajectory group was 2.3. The value of 2.3 was significantly greater than the odds ratio of 0.9 for the late-onset vs the non or low marijuana-use trajectory group ($p<0.05; \chi^2$ (1) = 5.06). For brevity, we report the p-values of the chi-square test only for significant differences. The odds ratio for criminal behavior of the chronic vs the non or low marijuana-use trajectory group (OR=7.5) was significantly greater than the odds ratio for the late-onset vs the non or low marijuana-use trajectory group (OR=3.0, χ^2 (1) = 7.29; $p<0.01$). The odds ratio for unemployment of the maturing-out vs the non or low marijuana-use trajectory group (OR=1.0) was significantly less than the odds ratio for the late-onset vs the non or low marijuana-use trajectory group (OR=2.4, χ^2 (1) = 4.47; $p<0.05$). The odds ratio for arguments with partner of the late-onset vs the non or low marijuana-use trajectory group (OR=1.9) was significantly less than the odds ratio for the chronic vs the non or low marijuana-use trajectory group (OR=4.4, χ^2 (1) = 5.02; $p<0.05$). The odds ratio for the partner's marijuana use of the chronic vs the non or low marijuana-use trajectory group (OR=15.0) was significantly greater than the odds ratio for the maturing vs the

non or low marijuana-use trajectory group (OR=3.0,χ^2 (1) = 18.87; p<0.001) and the late-onset vs the non or low marijuana-use trajectory group (OR=4.6,χ^2 (1) = 11.85; p<0.001).

Discussion

This longitudinal study is based on a non-random sample of African-Americans and Puerto Ricans in an Eastern US urban area.

Identification of Trajectories of Marijuana Use

With regard to other studies, Schulenberg, *et al.* (2005) and Ellickson, *et al.* (2004), using national representative samples, and Brown, *et al.* (2004), using an African-American sample, reported trajectories consistent with the chronic marijuana-use trajectory group in the present study. This is in accord with Schulenberg and colleagues' (2005) finding that there were no appreciable ethnic differences in membership in the chronic marijuana-use trajectory group among African-American and Hispanic respondents. In addition, Brown, *et al.* (2004) reported a trajectory corresponding to the late-onset trajectory group in the present study.

Associations Between Marijuana-Use Trajectories and Psychosocial Variables

Many of the specific trajectories of marijuana use (T1–T4) were associated with adverse life-course outcomes (T4) as shown in Table 2. Each of the trajectories of marijuana use was associated with both internalizing and externalizing problems, although the magnitude of the association was greater for externalizing problems. One externalizing variable, criminal behavior, was more highly related with each trajectory group of marijuana use in comparisons with the non or low marijuana-use trajectory group. This may be attributed to the relationship between the problem behaviors of substance abuse and "deviant behavior" identified in Problem Behavior Theory (Donovan & Jessor, 1985). Members of the chronic marijuana-use trajectory group were significantly more likely than members of the late-onset marijuana-use trajectory group (when outcomes for each group were compared to those for non or low-users) to engage in criminal behavior. Perhaps modeling or reinforcement of peers who display criminal behavior is involved here. Also, members of the chronic marijuana-use trajectory group may be more likely to have had exposure to criminal peers over a longer time than members of the late-onset marijuana-use trajectory group.

Marijuana-use trajectory group membership was also associated with an increased likelihood of experiencing internalizing symptoms of depression and anxiety. The self-medication hypothesis (Khantzian, 1997) suggests that the abuse of substances may serve to relieve symptoms of distress such as anxiety and depressive mood.

Of note, there were no statistically significant differences in the odds ratios between the maturing-out and the non or low marijuana-use trajectory groups on any factors assessed in the work domain; however the findings of the present study should be confirmed in future research. More specifically, if substance abusers reduce or stop marijuana use, their functioning in the work domain may be more similar to that of those individuals who abstain from using marijuana or who reported low use.

The chronic and late-onset marijuana-use trajectory groups had significantly different odds ratios from those of the non or low marijuana-use trajectory group on variables in the work domain (Ringel, *et al.*, 2006). One possible mechanism might be reduced motivation associated with marijuana use and labeled the amotivational syndrome (McGlothin & West, 1968). The syndrome involves apathy and a diminished ability to carry out complex, long-term plans (Ringel, *et al.*, 2006). Another mechanism proposed by Ringel, *et al.* is diminished cognitive functioning which limits ability to perform work-related tasks. There is

growing evidence that continued use of marijuana may lead to changes in the structure and function of the brain (Matochik, Eldreth, Cadet, & Bolla, 2005). In addition, Problem Behavior Theory (Jessor & Jessor, 1997) maintains that low achievement and marijuana use are two components of a more inclusive syndrome of problem behavior.

Trajectories of marijuana use from adolescence through adulthood were associated with participants' partner relationships in adulthood in that membership in either the chronic or the late-onset marijuana-use trajectory group reduced the likelihood of being married and living with one's spouse. This may be explained by the negative relations of illicit drug use with the timely assumption of adult roles (such as marriage) (Bachman, O'Malley, Schulenberg, Johnston, Bryant, & Merline, 2002). Divorce and separation were not similarly related to specific trajectories of marijuana use; possibly because power was not sufficient to assess the association of the trajectories of marijuana use with marital status (i.e., divorce, separation). Also, members of the maturing-out and chronic marijuana-use trajectory groups were more likely to argue with partners. Members of the maturing-out trajectory group were less likely to experience marital harmony. Members of the maturing-out and the late-onset trajectory groups were less likely to be satisfied with their partners.

Membership in each marijuana-use trajectory group was positively related to partner's marijuana use. This relationship was particularly strong for the chronic marijuana-use trajectory group. Marijuana-using individuals, particularly members of the chronic marijuana-use trajectory group, may select partners with similar substance abuse habits (Grant, *et al.*, 2007). Partners' marijuana use then would likely reinforce participants' marijuana use (Rhule-Louie & McMahon, 2007).

In consideration of potential clinical implications for the treatment of marijuana-users, adverse life-course outcomes for the chronic and the maturing-out marijuana-use trajectory groups were compared. The former group manifested more frequent symptoms of internal distress, greater difficulties in the work domain and more conflictual relationships with their partners. Thus our findings suggest that curtailing marijuana use, especially chronic marijuana use, through intervention may be beneficial to psychosocial functioning.

Limitations

Research assessing other psychosocial dimensions as well as genetic factors which may link trajectories of marijuana use to life-course outcomes seems a useful direction for future research. Present data are based on self-reports rather than on external measurements from official behavioral records such as police records or corroborating reports from partners. Given the descriptive nature of present data, no causal inferences are possible. For example, externalizing factors may predate the differences in criminal behavior between the nonuser group and the three marijuana-use trajectory groups. Furthermore, we were not able to control for conditions which often co-occur with marijuana use, such as the use of tobacco, alcohol, and other illicit drugs, in this study. Future research would benefit from an investigation of the relationships of these potential comorbid conditions to psychosocial outcomes like those examined here. Finally, some limitations are inherent to growth-mixture modeling. Nagin (2010) has cautioned that trajectories produced by growth-mixture modeling may allow an excessive amount of within group heterogeneity, resulting in identification of fewer trajectory groups than may actually exist. Jackson and Sher (2008) further cautioned that the use of different number of time points, different developmental periods, and particularly different measurements of the construct in question across trajectory studies can make it difficult to compare results from one study to those from another.

Despite these limitations, these analyses support and extend current literature in several ways. Unlike most research focused on one point in time, marijuana use over a span of 15 years was examined. Findings relating marijuana use from adolescence to adulthood to the prevalence of later adverse life outcomes are a major contribution. The three marijuana-use trajectory groups differed significantly from the non or low-use group in each psychosocial domain assessed.

Although there were some minor differences in the magnitude of the relations of specific marijuana-use trajectories with psychosocial outcomes, overall these trajectories were more similar than different in their associations with adverse life outcomes. This has important implications for the maturing-out marijuana-use trajectory group, showing that members of the maturing-out marijuana-use trajectory group are not exempt from adverse life-course outcomes in adulthood despite their decreased marijuana use. Prevention and treatment programs may, then, be of greater benefit during the early stages of marijuana use in childhood or adolescence.

The two psychosocial outcomes having the strongest relations with trajectories of marijuana use, criminal behavior and partners' marijuana use, were significantly positively associated with membership in each of the marijuana-use trajectory groups as compared with membership in the non or low-use group. The chronic marijuana-use trajectory group had the strongest association with these outcomes. As these outcomes may lead to further difficulties such as arrests and reinforcement of later marijuana use, it seems particularly important to target chronic users in treatment programs. Further, such treatment programs should directly address the adverse outcomes studied as well as other adverse life-course outcomes, e.g., depressive symptoms, which may already be experienced by adult users.

From a public health perspective, the present results are consistent with findings regarding the possible extent of adverse psychosocial consequences of cannabis use. Such consequences include, but are not limited to, increased risk of psychological disorders (Patton, Coffey, Carlin, Degenhardt, Lynskey, & Hall, 2002; Arseneault, Cannon, Witton, & Murray, 2004) and other illegal substance use (Fergusson, Boden, & Horwood, 2006). The findings document the long-term associations of chronic marijuana use with: 1) increased internalizing and externalizing problems and 2) decreased adequacy of role functioning, e.g., at work and in partner relationship in adulthood. Since members of this chronic marijuana-use trajectory group experienced the most adverse effects in each of the domains, continuing marijuana-users should receive attention and clinical intervention.

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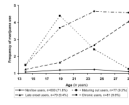
Figure 1.
Frequency of marijuana use by age for four derived trajectories. Frequency of marijuana use coded as 1: never, 2: a few times a year or less, 3: about once a month, 4: several times a month, 5: once a week or more.

Table 1

Psychosocial Measures: Sources and Cronbach Alpha

T4 Psychosocial Variable	Source	No. of Items	Sample Item	Response Range[b] (min, max)	Cronbach Alpha
Demographics					
Sex[a]	Standard	1	Are you (female or male)?	female (1), male (2)	n/a
Race/Ethnicity[a]	Standard	1	Which (race/ethnicity) best describes you?	African-American (1), Puerto Rican (2)	n/a
Personality/behaviors					
Anxiety symptoms	Derogatis (1994)	3	Over the last few years, how much were you bothered by feeling nervous or shaky inside?	not at all (0), extremely (4)	.78
Depressive symptoms	Derogatis (1994)	8	(How well does this describe you?) You sometimes feel unhappy, sad or depressed.	completely false (1), completely true (4)	.83
Physical symptoms of depression	Costello, Edelbrock, Kalas, Kessler, & Klaric (1982)	6	Over the last few years, how much were you bothered by loss of appetite?	not at all (0), extremely (4)	.78
Interpersonal difficulty	Derogatis (1994)	4	Over the last few years, how much were you bothered by feeling easily annoyed or irritated?	not at all (0), extremely (4)	.79
Criminal behavior	Gold (1966); Huizinga, Menard, & Elliott (1989)	9	How often in the last 5 years have you gotten in trouble with the police for something you did?	never (1), 5 or more times (5)	.63
Work					
Unemployment	Standard	1	In the past year, did you have a full time job?	yes (0), no (1)	n/a
Low work achievement	Original	3	How often have you received a good evaluation from your boss?	often (0), never (3)	.69
Low work performance	Wayne and Ferris (1990)	5	How would you rate your overall performance at work?	excellent (1), poor (5)	.85
Marital status					
Divorced or separated	Standard	1	Are you currently divorced or married, but separated?	no (0), yes (1)	n/a
Married and living together	Standard	1	Are you currently married and living together?	no (0), yes (1)	n/a
Relations with partner					
Arguments	Original	5	How often do the two of you argue or fight about things?	never (0), always (4)	.81
Low marital harmony	Spanier (1976)	7	How often do you and your partner talk with each other about everything?	all the time (0), never (4)	.92
Low satisfaction with partner	Spanier (1976)	4	How often you talk about breaking up with, separating from, or divorcing your partner?	never (0), all the time (5)	.76
Partner's marijuana use					

T4 Psychosocial Variable	Source	No. of Items	Sample Item	Response Range[b] (min, max)	Cronbach Alpha
Partner's marijuana use	Standard	1	Currently does your partner smoke marijuana?	yes (1), no (0)	n/a

[a]Items asked at T1

[b]These are the response options provided to the participants during data collection. The measures have been dichotomized for use in these analyses.

Table 2

Logistic Regression Analyses: Odds Ratios (and 95% Confidence Intervals) Comparing Marijuana-Use Trajectory Groups with Non or Low-Use Trajectory Group

T1–T4	Maturing-out vs Non or low-users		Late-onset vs Non or low-users		Chronic vs Non or low-users	
Measures at T4						
Personality/Behaviors						
Anxiety symptoms	1.6 ** a b	(0.9, 2.9)	0.9 a	(0.5, 1.8)	2.3 ** b	(1.3, 4.0)
Depressive symptoms *Note 4*	1.5 a	(0.9, 3.2)	2.3 ** a	(1.3, 4.4)	2.9 *** a	(1.7, 5.7)
Physical symptoms of depression *Note 4*	1.7	(0.9, 3.1)	1.6	(0.9, 3.0)	1.7	(0.9, 3.0)
Interpersonal difficulty	2.0 * a	(1.1, 3.4)	1.4 a	(0.8, 2.5)	1.9 * a	(1.1, 3.2)
Criminal Behavior *Note 5*	5.1 *** a b	(2.7, 9.7)	3.0 ** a	(1.5, 5.8)	7.5 *** b	(4.1, 13.5)
Work						
Unemployment *Note 6*	1.0 a	(0.5, 2.0)	2.4 ** b	(1.4, 4.3)	1.7 a b	(0.9, 3.1)
Low work achievement *Note 6*	1.4 a	(0.8, 2.5)	2.1 ** a	(1.2, 3.6)	2.3 ** a	(1.4, 3.9)
Low work performance *Note 6*	1.5	(0.9, 2.7)	1.5	(0.9, 2.6)	1.6	(0.9, 2.7)
Marital status						
Divorced or separated	1.8	(0.6, 4.9)	1.2	(0.3, 4.1)	0.4	(0.1, 2.9)
Married and living together	0.6 a	(0.3, 1.1)	0.3 ** a	(0.1, 0.6)	0.3 ** a	(0.1, 0.7)
Relations with partner						
Arguments	3.1 *** a b	(1.7, 5.4)	1.9 a	(0.9, 3.5)	4.4 *** b	(2.5, 7.6)
Low marital harmony	2.8 *** a	(1.6, 5.0)	1.3 a	(0.7, 2.6)	1.8 a	(0.9, 3.3)
Low satisfaction with partner	2.5 ** a	(1.4, 4.5)	2.2 ** a	(1.2, 3.9)	1.7 a	(0.9, 3.3)
Partner's marijuana use						
Partner's marijuana use	3.0 *** a	(1.7, 5.5)	4.6 *** a	(2.6, 8.0)	15.0 *** b	(8.5, 26.4)

*
$p<.05$,

**
$p<.01$,

***
$p<.001$

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1. Entries in each row with different superscripts are statistically different from one another.

2. Demographics for each trajectory group: the non or low marijuana-use group ($n = 600$, female = 397, African-American = 333), the maturing-out marijuana-use group ($n = 77$, female = 40, African-American = 37), the late-onset marijuana-use group ($n = 79$, female = 36, African-American = 47), and the chronic marijuana-use group ($n = 81$, female = 25, African-American = 43)

3. Sex, ethnicity, and the two dissimilar T1 schools were statistically controlled (Male and Puerto Rican were scored higher).

4. In the analyses examining T4 depressive symptoms and physical symptoms of depression by marijuana-use trajectories, T1 depressive symptoms was the control variable. The adjusted odds ratios for T1 depressive symptoms were 2.4 (P<.001) and 1.6 (P<.05), respectively.

5. In the analysis examining T4 criminality by marijuana trajectories, T1 criminality was the control variable; adjusted odds ratio 2.4 (P<.001).

6. In the analyses examining unemployment, low work achievement, and low work performance by marijuana-use trajectory groups, earlier T1 school achievement was the control variable. The adjusted odds ratios for these variables were 0.4 (P<.05), 0.5, and 0.9, respectively.