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J Res Adolesc. Author manuscript; available in PMC 2015 March 01.

Published in final edited form as:
J Res Adolesc. 2014 March 1; 24(1): 117–130. doi:10.1111/jora.12030.

Influences on Boys' Marijuana Use in High School: A Two-Part Random Intercept Growth Model

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Abstract

This study examined differences in predictors of marijuana use versus quantity of marijuana use across the high school years, using annual assessments from the Oregon Youth Study (OYS) and a two-part model for semicontinuous data. The OYS is a community sample of at-risk boys followed from age 10 years. In order to capture dynamic prediction effects, change scores of predictors, as well as baseline scores, were included. Baseline predictors predominantly showed associations with the intercepts but not with the slopes of growth models. Change scores for parental monitoring, peer substance use, and antisocial behavior and deviant associations were associated with both parts of the model. Findings highlight the importance of looking at marijuana use compared to quantity of marijuana use.

Keywords

marijuana; growth; antisocial behavior

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Marijuana has long been the most commonly used illicit drug in the U.S. (Substance Abuse and Mental Health Services Administration, 2010) and in recent years has shown increases in prevalence among students in Grades 8, 10, and 12 (Johnston, O'Malley, Bachman, & Schulenberg, 2010). The Monitoring the Future Study found that in 2009 only 17% of students in Grade 8 had tried marijuana (Johnston, et al., 2010), but by Grade 12, the proportion had increased over 2.5 times to 44%. Along with the increasing numbers of youth who transition to marijuana use, there is growth in the quantity of use among users (Johnston, et al., 2010). Further cause for concern regarding adolescent marijuana use is that there is evidence of lasting negative effects of use on the developing adolescent brain (Arseneault, Cannon, Witton, & Murray, 2004; Bossong & Niesink, 2010), such that more

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use is associated with greater risk for mental illness (Moore et al., 2007). Finally, there is evidence of negative socioeconomic consequences in early adulthood of adolescent marijuana use (Broman, 2009). Thus, there is both increasing prevalence of marijuana use among adolescents and increasing evidence of the negative consequences of such use. Therefore, a better understanding of factors related to the onset and escalation of marijuana use across adolescence is of critical importance and will inform the development of preventive interventions.

The current study uses a theoretical approach based in a Dynamic Developmental Systems (DDS) framework (Capaldi, Shortt, & Kim, 2005) that focuses on the interactions between developmental history associated with general risk for problems (including marijuana use) – particularly as indicated by conduct problem behaviors – and outcome-specific risk, mainly from proximal social influences (e.g., parental and peer substance use) in the etiology and course of risk behaviors (Capaldi, Stoolmiller, Kim, & Yoerger, 2009). A similar theoretical approach has been taken by others to examining the emergence of substance use problems (J. O. Lee et al., 2011). By using such a framework to guide the selection of predictors of both use versus nonuse and quantity of marijuana use, and by including repeated measures of marijuana use outcomes for an at-risk sample of boys (in the Oregon Youth Study; OYS), the present study makes a novel contribution to the substance use literature. In the current study, the hypothesized general developmental risk pathway predictors included parental monitoring and boys' depressive symptoms, antisocial behavior, and deviant peer associations; whereas the more proximal and specific social influence pathway factors were parent marijuana use and peer substance use.

The value of the study is further increased by examining the effects on the marijuana use outcomes of *changes* across adolescence in these social influences within a two-part semicontinuous growth model. Within the context of the growth model, this identifies how changes in predictors directly influence both use and quantity of use without the need for additional growth models for the predictors. This method allows for conducting several key tests simultaneously for the predictors, and thus makes a novel contribution to understanding adolescent marijuana use. Specifically, we tested whether key predictors of marijuana use were more associated with the intercepts and growth in use versus nonuse of marijuana compared with the quantity of marijuana used. We also tested the difference between associations of static baseline predictors and change score versions across time points of those same predictors. This approach, which we have previously used to examine prediction to growth in alcohol use (Capaldi, et al., 2009), addresses the dynamic nature of the associations that general and outcome-specific risk factors have with marijuana use and quantity of use. In addition, the study makes a substantial contribution over prior studies with the OYS data set that have included examination of peer and family factors associated with substance use in midadolescence (Dishion, Capaldi, Spracklen, & Li, 1995); prediction to age of onset of use through age 16 years only, involving time-invariant predictors (Dishion, Capaldi, & Yoerger, 1999); and examination of reciprocal associations between observed social interactions with a friend and substance use from early adolescence to young adulthood (Dishion & Owen, 2002).

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Characteristics of Marijuana Use at Adolescence

There have been numerous studies of the associations of both general and outcome-specific risk factors with a range of marijuana outcomes (use, frequency, latent classes). However, few studies have adequately modeled key distributional characteristics of marijuana use in adolescence – namely the typically skewed nature of the distribution of quantity of marijuana used and, in particular, that many individuals are nonusers. Relatedly, the notion that different predictor pathways may apply to use versus nonuse in comparison to quantity of use among users has generally not been well addressed, even though it is well established that different factors should influence the onset and occurrence versus the maintenance or escalation of youth substance use. The two-part random intercepts model (Olsen & Schafer, 2001) addresses these issues by permitting simultaneous prediction to (a) use versus nonuse and (b) to quantity of use given any use. This approach has been used in numerous studies to examine the etiology and growth in alcohol use at adolescence (Blozis, Feldman, & Conger, 2007; Brown, Catalano, Fleming, Haggerty, & Abbott, 2005; Capaldi, et al., 2009). Prior studies that have used the two-part models of marijuana use have focused on either the program effects of an intervention (Brown, et al., 2005; Dembo, Wareham, Greenbaum, Childs, & Schmeidler, 2009) or on ethnic differences in growth (C. Lee, Mun, White, & Simon, 2010). This study is the first, to our knowledge, to use general and outcome-specific risk factors to predict to growth in both marijuana use and quantity of use in the high school years.

General Risk Factors for Marijuana Use

Youth antisocial behavior and association with deviant peers are strongly predictive of a cluster of problem behaviors in adolescence, including marijuana use (Dishion, et al., 1999; Tarter, Kirisci, Ridenour, & Vanyukov, 2008), and thus represent a general risk pathway to such problem outcomes. Specifically, Flory, Lynam, Milich, Leukefeld, and Clayton (2004) showed that adolescents with symptoms of conduct disorder were more likely to be in either of the marijuana use groups they identified as opposed to the nonuser group. Windle and Wiesner (2004) also found that initial levels of delinquent behaviors were significantly lower for nonusers than for all classes of users they identified based on growth patterns. Several studies also document that associations with deviant peers increases risk for later substance use (Dishion, et al., 1995; Kirisci, Mezzich, Reynolds, Tarter, & Aytaclar, 2009), and marijuana use specifically (Mauricio et al., 2009). Antisocial behavior and deviant peer association are highly associated in adolescence (Dishion & Patterson, 2006) and intimately associated with the general risk developmental pathway; therefore, in the current study, they were combined in the prediction models.

A second general pathway risk factor included in the model is depressive symptoms. There is mixed and often contradictory evidence for an association between depressive symptoms and marijuana use for adolescents (Degenhardt, Hall, & Lynskey, 2003). Effects of depressive symptoms on later marijuana use would be expected based on the self-medication hypothesis, which posits that substances may be used to alleviate negative affect or to provide some positive stimulation in the context of anhedonia (Khantzian, 1997). Though Degenhardt and colleagues did not find support for the self-medication hypothesis, others have. Windle and Wiesner (2004) found significant relations between depressive symptoms

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and marijuana use growth patterns in adolescence. Fleming, Mason, Mazza, Abbott, and Catalano (2008) found similar results for a main effect on using marijuana. It is thus important to examine this association in a further study, at the same time controlling for associated risk factors (e.g., antisocial behavior).

Poor parental monitoring is a well-established risk factor for a wide range of problem behaviors at adolescence, including delinquency, sexual risk behavior (Capaldi, Crosby, & Stoolmiller, 1996), and substance use (Bahr, Hoffmann, & Yang, 2005); thus, good parental monitoring (involving parental or other adult supervision and knowledge of the youth's activities) is an important family protective factor for problem behaviors in adolescence (Dishion & McMahon, 1998; Snyder, 2002). A link between low parental monitoring and marijuana use has been identified (Lac & Crano, 2009; Martins, Storr, Alexandre, & Chilcoat, 2008), which suggests parental monitoring could have a protective effect. It is thus hypothesized that, in the multivariate two-part model, parental monitoring will relate to lower marijuana use, particularly given that it is an illicit drug.

Outcome-Specific Risk Factors for Marijuana Use

A key aspect of the DDS model of the etiology of substance use is to examine the contribution of outcome-specific risk in the context of the contribution of general risk factors, and parental and peer substance use are hypothesized to be the most important outcome-specific risk factors for marijuana use in adolescence. The influence of parental substance use on their children's substance use is well documented (Bailey, Hill, Oesterle, & Hawkins, 2006; Li, Pentz, & Chou, 2002; Reinherz, Giaconia, Hauf, Wasserman, & Paradis, 2000) and likely involves multiple mechanisms, including shared genetic risk, modeling, and increased access to substances. We are concerned here with the specific influence of parent marijuana use, which has also been reported to directly influence adolescent marijuana use (Kandel, Griesler, Lee, Davies, & Schaffran, 2001).

Association with peers who use illicit substances (including alcohol and tobacco for minors) is a more specific peer influence on marijuana use than is deviant peer association in general. Perceived peer use of marijuana has been found to predict use of marijuana (Creemers et al., 2010; D'Amico & McCarthy, 2006), as has smoking tobacco with peers (Duncan, Tildesley, Duncan, & Hops, 1995; Kiesner, Poulin, & Dishion, 2010). To help clarify the role of peer substance use versus general deviance (antisocial behavior and deviant peer association combined), both risk factors were included in the model.

Issues in Prediction to Quantity of Use

The etiology of levels and changes in *quantity* of marijuana use is much less clear than that of use versus nonuse for adolescents; as studies generally do not distinguish between these concepts, they are often confounded. Yet understanding the etiology of higher levels of use versus occasional use at adolescence is critically important from a prevention standpoint, because adolescents who use more marijuana are more likely to have impairment and long-term problems (Arseneault, et al., 2004; Bossong & Niesink, 2010; Moore, et al., 2007). The use of the two-part growth model in the current study will help clarify the role of the

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theoretical predictors in both use and growth in quantity of use of marijuana across the high school years.

Change in Risk Across the High School Years

The use of change scores (from one assessment to the next) of risk factors is an underutilized approach to studying dynamic associations within growth models (Brook, Whiteman, Finch, Morojele, & Cohen, 2000). This approach accounts for the fact that the predictors are changing with development but is a manageable approach for a multivariate prediction model (versus, for example, trying to examine multiple simultaneous growth curve models). Prediction from change scores provides stronger evidence of a likely causal association than use of predictors from one time point, and it also provides evidence of strength of associations at particular developmental stages (in the current case, across high school). This may be particularly informative for the design of prevention programs.

Hypotheses of the Current Study

Our theorized model is presented in Figure 1. We expected that all of the baseline scores of risk factors would significantly predict the intercepts of both parts of the model, namely use versus nonuse of marijuana and quantity of use. We also expected that the association between the change scores and the outcomes would be significant across time. Given that the predicted direct associations between the change scores and the outcomes across time were expected to be relatively strong, particularly for prediction from changes in peer substance use, we considered it unlikely that the Grade 8–9 predictors would be significantly associated with the slopes of either parts of the model (hence the dashed lines in the model).

Method

Sample

Schools in neighborhoods with higher incidences of juvenile delinquency were identified in a medium-sized metropolitan area (Eugene–Springfield, Oregon). Boys in Grade 4 (ages 9–10 years) of those schools were invited to participate in the study with their families (the study did not include girls). The recruitment rate was 74.4% (N = 206), and retention was at least 97% at each wave through the senior year of high school (Capaldi, Chamberlain, Fetrow, & Wilson, 1997). The sample size of boys was 202 (98%) in Grade 8 and 201 (98%) in Grade 12. The sample was predominantly White (90%), and 75% were of lower socioeconomic status. At Grade 8, family composition included intact parents (38%), single parent (19%), stepparent (29%), and multiple parental transitions (14%). The proportion of single-parent families was between 14% and 17% through Grade 12. Parents living with the youth were invited to participate at each wave. At Grade 8, 191 mothers and 140 fathers participated, and at Grade 12, 188 mothers and 128 fathers participated. Both parents participated in 53% to 64% of the families, and at least one parent participated in 95% to 99% of the families across the period.

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Procedure

The OYS involved yearly data collection with alternating major (Grades 4, 6, 8, 10, and 12) and minor waves. In line with the theoretical framework of DDS, the major assessments were multimethod and multiagent involving predictors and outcome measures (Capaldi, et al., 1997). This allowed for a more ecological examination of participants behavior, using key natural raters (Kellam, Rebok, Mayer, Ialongo, & Kalodner, 1994) in their lives as well as self- reports and avoided the issues of common method bias (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Minor waves were more limited in scope and focused mainly on the dependent variables, including measures of marijuana use. The data in the current study were taken from Wave 5 (ages 13–14 years, Grade 8) through Wave 9 (ages 17–18 years, Grade 12) over a period of 5 years, with the dependent variables taken from Wave 6 to Wave 9. Parents (and OYS men as adults) provided informed consent and all procedures were approved by the IRB of the Oregon Social Learning Center. Participants were compensated for their time at each assessment wave. Family members were reimbursed at a rate of approximately $10 per hour for their participation in each of the assessment protocols.

Interviews and questionnaires—The parent (or parents) and adolescent boys were interviewed separately. The interviews lasted 45 minutes to 1 hour each. The boys were asked questions concerning problem behavior and substance use, and the interviewers completed a ratings checklist after each interview.

Schools—Teachers completed questionnaires rating the study boys on academic, emotional, and behavioral adaptations to school, using the Teacher Report Form (TRF) (Achenbach, 1991).

Measures

Dependent variable—Marijuana use was coded on the basis of any reported use in the past year. The quantity of marijuana usage was calculated using a formula based on the reported number of times participants smoked marijuana in the last year. Two questions were asked of each participant, “How many times have you used marijuana in the last year?” and “When using marijuana, how much do you usually use?” Participants gave an estimated number of times used in the last year. For how much they usually use, they had four options: answered that they share a joint, have one joint, have two joint, or gave an amount themselves. With the assumption that an average joint of marijuana was equal to one gram (World Health Organization, 1997), the multiplication of these variables gives an estimate in grams of marijuana of the amount of marijuana used in the last year. Given that the two-part analysis assumes normality in the second part (i.e., quantity of marijuana use), the variable was log transformed after subtracting a constant to minimize skewness.

Independent variables—The risk factors or independent variables were initially assessed at Grade 8 (ages 13–14 years) for all factors except antisocial behavior and deviant peer associations and depressive symptoms, which were available at Grade 9, and these scores were used to predict the intercept and slope of marijuana use and quantity of use across high school (see Table 1 for more information). The general strategy for building predictor

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constructs for this study has been described by Capaldi and Patterson (1989) and Patterson, Reid, and Dishion (1992). Several potential indicators were developed for each construct and combined as follows:

a. The internal consistency of the a priori items associated with each scale or indicator was established using criteria of an alpha of at least .6 (Cronbach, 1951) and an item-total correlation of .2 ($p < .05$).

b. The convergent validity of the indicators for a construct was examined within a principal component factor analysis. Items with factor loadings for the one-factor solution of at least .3 were retained.

c. The indicator scores were standardized to ensure equal weight and aggregated by taking the mean of the scales for the final score.

Four of the predictors were coded so that a higher score represented a more problematic behavior or situation, with only parental monitoring scored so that a high score involved stronger monitoring.

The correlation matrix for the predictor variables – namely parent marijuana use, peer substance use, participant's antisocial behavior and deviant associations, depressive symptoms, and parental monitoring – is shown in Table 2. Although significantly associated, the independent variables were not so strongly associated as to cause concern of multicollinearity.

Youth antisocial behavior and deviant association—Scales for youth antisocial behavior were created from three sources: parents, teachers, and the interviewer. None of the items pertained to substance use or illegal behavior directly related to substance use (e.g., selling drugs). Parent questions came from two questionnaires, Child Behavior Check List (CBC-L) (Achenbach & Edelbrock, 1983) and Peers Questionnaire (Oregon Social Learning Center, 1982–2012), with 15 questions from the externalizing scale of the CBCL and 1 question from the Peers Questionnaire. The scores from the mother and father were checked separately for construct validity and then combined. Teachers also filled out two questionnaires, the TRF (Achenbach, 1991) and the Teachers Peers Social Skills Questionnaire [TPRSK] (Dishion & Capaldi, 1985; Walker & McConnell, 1988), with 19 items from the TRF and 1 item from the TPRSK. A final item was the interviewer ratings from the Youth Interview. Cronbach's alpha for all of these indicators was .74.

Deviant peer association was assessed by two parent questionnaires (CBC-L and Peers Questionnaire), with one item from the CBC-L and two items from the Peers Questionnaire. Like the measure of antisocial behavior, the construct was validated for each parent then combined. Teacher reports from two questionnaires were also included (TRF and TPRSK), with one item from TRF and three items from the TPRSK. The final indicator of the construct came from youth report in an interview and questionnaire (Describing Friends Questionnaire), with 10 items from the interview and 5 questions from the questionnaire. Cronbach's alpha for the indicators was .76. The antisocial behavior and deviant peer association constructs were highly associated ($r = .78$, $p < .001$) and were standardized and combined to avoid problems of multicollinearity in the final analysis.

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Youth depressive symptoms—A single indictor involving the youth's self-report of 20 items regarding depressive symptoms (CES-D, Radloff, 1977) was used. Cronbach's alpha for the scale was .86.

Parental monitoring—The parental monitoring measure was created from the Parent Interview, parent interviewer ratings, Youth Interview, and youth interviewer ratings. Mothers were asked 12 questions and fathers 15 questions that were separately validated and then combined. These were combined with interviewer rating items regarding monitoring by the mother and father. In a similar fashion, the boy answered nine questions about parental monitoring in the interview, and the interviewer answered one question about the boy. Cronbach's alpha for the indicators was .75.

Frequency of parent marijuana use—Parental reports from the Substance Use Questionnaire were used. Following Capaldi et al. (2009), parent marijuana frequency was a standardized average across the two parents. The correlation of the two indicators was .88 ($p < .001$).

Peer substance use—A total of 10 items from the Youth Interview, with an additional 3 questions that both parents answered in the Parent Interview, were used to assess peer substance use. Cronbach's alpha for the indicators was .90.

Multiple Imputation in Stata

To utilize the full sample, multiple imputation was used to obtain 20 datasets of sample size of 204 with full information on the predictors. Two participants had no data on the outcome and were excluded. A total sample size of 176 out of 204 would have resulted from using only the available information on covariates, losing about 14% of the sample. Although each variable was only missing – at most, 11 observations (5%) and, on average, 5 missing observations (2%) – the combined missingness over time resulted in the 14% loss of the sample. The multiple imputation was run with all of the variables in the model, as well as a series of demographic variables that were related to the missingness of outcome and increased prediction of the covariates (Engels & Diehr, 2003). The outcome was returned to the original state of missingness for the modeling as missing data on the outcome was modeled using full information maximum likelihood (FIML).

Analytic Plan

The data on marijuana use for the high school years of the sample were analyzed using a single semicontinuous two-part analysis in Mplus using the maximum likelihood with robust standard errors (MLR) estimator to handle better the missing data in the second part of the model (Olsen & Schafer, 2001). This analysis addresses two different aspects of marijuana usage (see Figure 1) by two parallel growth models that are estimated simultaneously with change scores on the outcomes. The use of change scores allows the predictors to have a time-varying effect on the outcomes, in a fashion that allows for the development and changes in behavior of the participants, peers, and parents to influence the outcomes. The first is a binary growth model for use versus nonuse of marijuana, and the second is a growth model of quantity used, with not using marijuana considered missing in the second

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part. The two-part analysis allows for analysis of continuous data with a preponderance of zeros, in a similar fashion to a zero-inflated Poisson model for discrete data. Given that multiple imputation, a two-part growth model, and the MLR estimator were used for missing data, no fit statistics beyond an *R*-squared are available for the model from Mplus (Muthén & Muthén, 1998–2010). However, given the common lack of fit statistics for growth models in the literature, we consider that the use of *R*-squared is adequate in this case.

The model was estimated with a simple linear slope and random intercepts only for both parts of the model. The use of a linear slope is due to the fact that only four time points were available for high school in our sample. The residuals for the continuous part of the model were held constant across time for parsimony, and the intercept of the growth model in Part 1 and the outcome variables in Part 2 were fixed at 0 for identification purposes. The intercept and slope of both parts of the model were regressed on the five baseline (either Grade 8 or 9) predictors.

Regarding prediction from change scores, the dependent variables of both parts (i.e., use and quantity of use of marijuana) at the last three time points were simultaneously regressed on the change scores between assessments for each predictor, thus allowing for a much stronger test of the association of the predictors to the marijuana outcomes across this period of rapid growth in both marijuana use versus nonuse and quantity of use. For parsimony, the effect of the change score across time points was held constant, which results in a single parameter estimate for the link between the change scores and each of the two dependent variables. Two of the predictors, antisocial behavior and deviant associations and depressive symptoms, were assessed in all 4 years of high school; thus, change scores from Grades 9 to 10, 10 to 11, and 11 to 12 were calculated as predictors. For the remaining variables, change scores from Grades 8 to 10 were used to predict the dependent variables at Grades 10 and 11, and change scores from Grades 10 to 12 were used to predict the dependent variables at Grade 12. This design, although complex, made the best use of the multiple assessments to test the hypotheses regarding prediction to growth.

Results

Prevalence and Quantity of Marijuana Use

Shown in Table 3 are prevalence rates for the prior 12-month period and the *N* by grade for first marijuana use, any marijuana use, and also average quantity of use [untransformed with test of normality for the transformed variable (D'agostino, Belanger, & D'Agostino Jr, 1990)], with zero use (i.e., nonusers) excluded for the latter score. Just over 20% of the sample indicated some marijuana use before high school, with 17% using in Grade 9, increasing to 35% by Grade 12. Similarly, the quantity of marijuana used increased substantially over time, with a particularly large jump from Grade 9 to Grade 10 (more than three times the Grade 9 average). In preparation for analysis, the quantity of marijuana use was log transformed to minimize skew, and all waves of the variable showed nonsignificant *p*-values for a test of non-normality.

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Part 1: Prediction to Use versus Nonuse

The analytic model contained two separate but parallel growth models that had identical prediction models associated with them (see Table 4 and 5). Part 1 (first main column in Table 4) was the predicted growth in the probability of smoking marijuana. The intercept of the use of marijuana (i.e., higher probability of use at Grade 9) was predicted by the general risk predictor of boy's antisocial behavior and deviant associations and the outcome-specific risk predictors of parent marijuana use and peer substance use. As shown in Table 4 (intercept of latent slope), the slope of use indicated a significant increase across time in the probability of marijuana use. None of the variables assessed at Grade 8 or 9 significantly predicted the slope of use. However, as shown in Table 4 (change score prediction), relative increases in peer substance use were associated with an increased probability of marijuana use; whereas relative increases in parental monitoring were associated with a decreased probability of use.

Part 2: Prediction to Quantity of Use

The second part of the growth model (second main column of Table 4) concerned predictors of the quantity of marijuana used by the youth who used in a given year. The intercept of quantity of use at Grade 9 was predicted by Grades 8 and 9 depressive symptoms and peer substance use; both were associated with increased quantities of use. The intercept of the quantity of use was not itself significant, but the slope parameter was significant, showing a trend toward increased quantity of use over time. Depressive symptoms were significantly negatively associated with the slope, possibly indicating some recovery from the initially higher levels of quantity of use at ages 14–15 years associated with depressive symptoms. The effects of the change scores on the quantity of marijuana used indicated that relative increases between assessments in the boy's antisocial behavior and deviant associations, and in peer substance use each significantly predicted increased quantity of use.

Random Effects and *R*-Squared

The intercepts of both parts of the model were significantly associated (see Table 5), and both intercepts had significant residual variance and the quantity of marijuana used had significant residual variance. As fit statistics are not available for the model, we estimated the *R*-squared values for the outcomes and the two random intercepts (see Table 5). The binary use outcome had *R*-squared values that ranged from .77 at Grade 9 to .65 at Grade 12. The continuous (i.e., quantity of use) outcome had *R*-squared values that ranged from .68 at Grade 9 to .65 at Grade 11. The random intercept of Part 1 of the model had an *R*-square value of .68; whereas the random intercept of Part 2 of the model had an *R*-square value of . 54. Although other model fit indices were not available for this analysis, the high *R*-squared values show the predictive power of the model.

Discussion

The present study partitioned two important aspects of marijuana use that typically have been confounded in studies of adolescence and examined prediction from change in the predictors across the high school years, as well a prediction from the same variables assessed at Grade 8 or Grade 9. Examining change scores as predictors is a very valuable

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approach when examining growth of a behavior, especially of behaviors showing such marked growth as marijuana use and quantity of use in the high school years. The approach yielded fine-grained results in predicting intercepts and growth in both the use and quantity of use of marijuana for a sample of boys who lived in higher delinquency neighborhoods as children. Although both general risk factors and marijuana-specific social influence from key developmental interactants (parents and peers) were associated with marijuana use and quantity of use across adolescence, there were substantial differences in the predictors for use versus nonuse and quantity of use. Suggesting that the conflation in most studies between the use versus nonuse of marijuana and the quantity of use of marijuana is problematic, and that variables of such a skewed nature as marijuana use would benefit from the use of a two-part semicontinuous model.

All of the Grade 8 and 9 predictors, except parental monitoring, were associated with either the initial intercept of use (i.e., probability of use versus nonuse) or with the intercept of quantity of use, and peer substance use predicted both. The fact that only peer substance use predicted the initial status of both parts of the model was unexpected but not without precedent. Given that 63% of seniors in the Monitoring the Future Study reported that they never smoked marijuana alone and 47% said they smoked with one or two other people most of the time or always (Bachman, Johnston, & O'Malley, 2011), it is less surprising that peer substance use was the most consistent predictor of both use and quantity of use. In addition, across the latent intercept, latent slope, and change score predictions to the outcomes, the predictors showed more significant associations with marijuana use (Part 1 of the model) then quantity of marijuana use (Part 2), suggesting that more research is needed regarding prediction of the quantity of marijuana use after controlling for use versus nonuse. Neither of the parent variables was found to be significantly associated with Part 2 of the model in any way, raising the likelihood of mediation effects with the potentially more proximal predictors.

Even with the outcome-specific risk factors in the model, the general developmental risk pathway factor of boys' antisocial behavior and deviant associations was predictive of both marijuana use in the first year of high school and of increases in quantity of use over time (change scores). The strong (though not significant) standardized association for antisocial behavior and deviant peer association with the slopes of both parts of the model suggest an even stronger influence that would need to be replicated with a larger sample. Thus, such problem behaviors and associations are a key risk factor for marijuana use in high school. This is consistent with findings of previous studies (Flory, et al., 2004; Tarter, et al., 2008). Marijuana use is illegal in both adolescence and adulthood, compared with the use of alcohol and tobacco, which are only illegal in adolescence and therefore a somewhat milder form of delinquent behavior (i.e., a status offense) than is marijuana use. Thus, initiation of marijuana use and growth in use and quantity across the high school years are particularly strongly associated with these indicators of problem behavior and delinquency at adolescence.

Parental monitoring, which is arguably the strongest external protective factor overall against problem behavior in adolescence, was as expected protective against marijuana use, with increases in parental monitoring between time points predictive of lower probability of

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use. Parental monitoring, however, was only marginally protective of use at Grade 9 (the intercept). However, as the model was multivariate, the association between baseline parental monitoring and Grade 9 marijuana use may have been accounted for by parent and peer substance use. These findings add to the body of work indicating the importance of parental monitoring in protecting adolescents from engaging in problem and health-risking behaviors (Dekovi, 1999), including substance use (Windle & Wiesner, 2004). The role that parents may play in monitoring has been questioned, with some researchers arguing that this behavior is entirely driven by youth disclosure (Kerr & Stattin, 2003). However, the weight of evidence suggests that monitoring is an interactional process between the parent and youth that is built around a history of parental positive involvement in the youth's life (Brody, 2003; Capaldi, 2003).

Prior evidence for the association of depressive symptoms with marijuana use at adolescence has been mixed. Whereas this predictor was not associated with use versus nonuse in the current study, it was associated with the intercept (positively) and slope (negatively) of quantity of marijuana use. Thus, evidence was consistent with the hypothesis that adolescents experiencing depressive symptoms may use marijuana to alleviate or self-medicate those symptoms, but that they do so less over the course of high school. This is particularly interesting in that the study only involved male youth, and depressive symptoms are generally considered to be more problematic for girls than for boys. Confidence in these findings is strengthened by the fact that antisocial behavior was included in the model, because depressive symptoms consistently show a low-to-moderate association with antisocial behavior (Capaldi, 1992), and antisocial behavior is associated with marijuana use.

Findings regarding the outcome-specific predictor of parent marijuana use were surprisingly weak – only being associated with use versus nonuse at Grade 9. The outcome-specific predictor of peer substance use, however, was very strongly predictive of both marijuana use and quantity of use. Overall, it appears, as suggested in prior studies, that in mid to late adolescence the influence of peers' marijuana use is much stronger than is the influence of parental use (Flay et al., 1994). Furthermore, whereas peer marijuana use is likely to be growing substantially across the high school years, use by parents is likely to be flat or diminishing. Thus, it was not unexpected that parent use would show the hypothesized effects to the intercept of use but not to growth in quantity.

Given the strength of each of the predictors, the substantial difference between the associations for each model is confirmation of the importance of considering illegal substance use in adolescence in a two-part model, when possible. The study design was a significant advance over prior research in a number of respects – particularly with the examination of growth in both the probability of marijuana use and quantity of use over a critical developmental period, the high school years – along with the examination of a theoretically driven and comprehensive prediction model, including both general developmental risk pathway and substance specific predictors and effects.

The study has some limitations. First, the sample was predominantly White and included male adolescents only. The extent to which these findings would generalize to other ethnic

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groups and to girls requires testing. Second, reports of frequency of peer marijuana use were limited to reports by the adolescent. Third, predictors were not all assessed every year; therefore, some of the change-score predictors spanned more than 1 year. Fourth, fit statistics are not available for two-part growth models other then *R*-squared. Finally, the sample size was relatively modest for the models tested. Strengths of the study included the use of multimethod, multiagent measures and the repeated measurements of the dependent (and independent) variables across the period, both of which enhance reliability of these variables and the use of a two-part semicontinuous model to account for the heavily skewed nature of the data.

This study shows the important role that antisocial behavior and deviant associations play for male adolescents in initiation and growth in use of marijuana and the importance of parental monitoring in protecting youth from such growth in use. A major finding was the importance of peer substance use as a dynamic predictor of marijuana use across the high school years. The differences between predictors of initiation and quantity of marijuana use and the dynamic nature of the association of peer substance use, parental monitoring, and antisocial behavior and deviant peer association with marijuana use would have been missed in a simpler model, as they have been in the literature to date. Taken all together, these findings indicate the importance of addressing these risk factors for male youth from at-risk backgrounds in prevention programs (Brown, et al., 2005; Spaeth, Weichold, Silbereisen, & Wiesner, 2010).

Acknowledgments

The project described was supported by awards from National Institutes of Health, U.S. Public Health Service (NIH) to Dr. Capaldi: Award Number 1R01AA018669 (Understanding Alcohol Use over Time in Early Mid-Adulthood for At-Risk Men) from the National Institute on Alcohol Abuse and Alcoholism (NIAAA); R01 DA 015485 (Adjustment Problems and Substance Use in Three Generations) from the National Institute of Drug Abuse (NIDA); and HD 46364 (Risk for Dysfunctional Relationships in Young Adults) from the National Institute of Child Health and Development (NICHD). The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH, NIDA, NIAAA, or NICHD. We thank Jane Wilson and the data collection staff for their commitment to high-quality data and Sally Schwader and David Kerr for editorial assistance.

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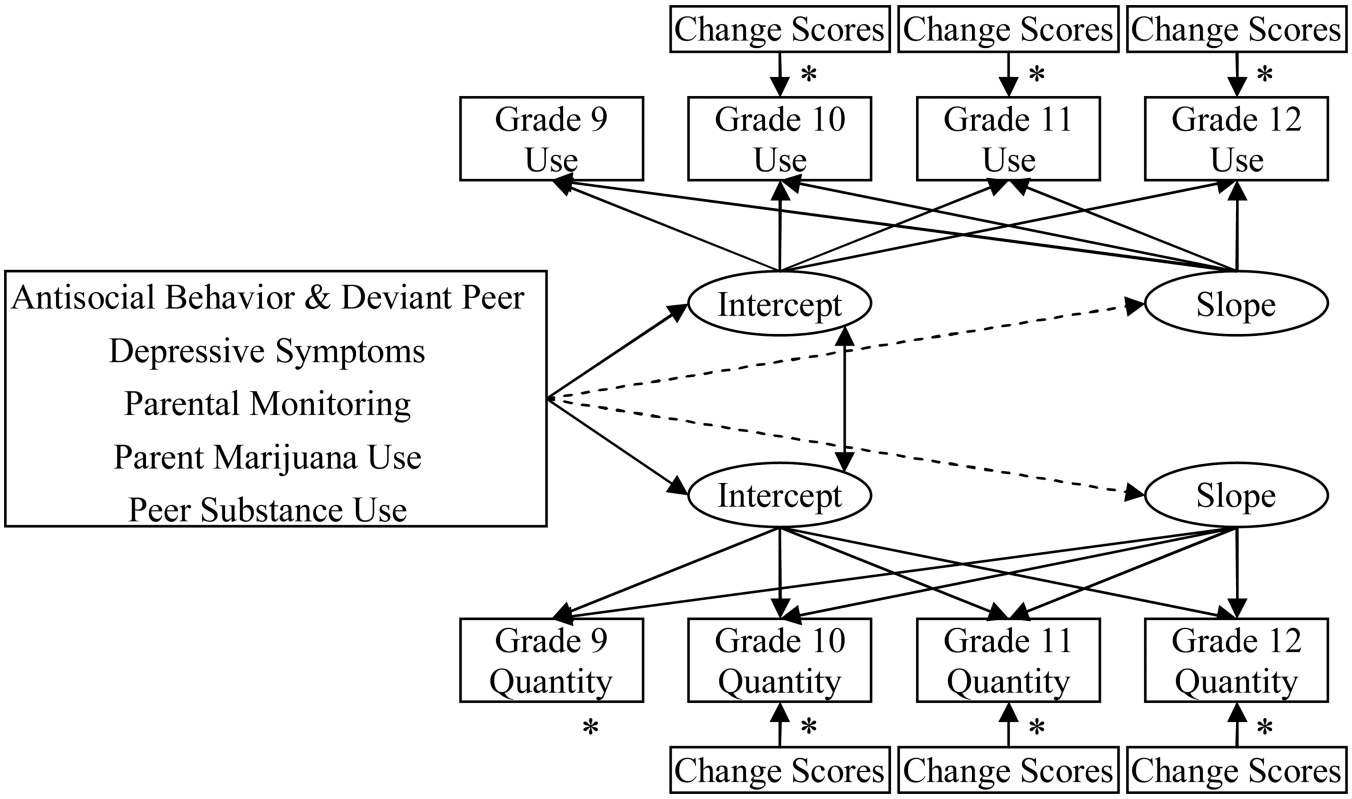

Figure 1. Two-part semicontinuous model of marijuana growth

Note: For parsimony, the residuals for the intercepts and repeated measures are not shown. *The association between change scores and the outcome where held constant across time for each predictor as were the residuals for the outcomes on continuous portion of the model.

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Table 1

Representative Measures of Predictors From Grade 10

Construct	Assessment instrument	Respondent	Number of items	Sample item	Cronbach's alpha	Pearson corr.
Antisocial behavior					0.74	
	CBC-L, overt	M,F	7,7	Disobedient at home.	.82, .74	0.65
	CBC-L, covert	M, F	8,8	Destroys others things.	.84, .87	0.73
	Peers q'naire	M, F	1, 1	How often does your son get in conflicts with other kids around the home?		0.24
	CBC-L, overt	Teacher	11	Cruelty, bullying, meanness to others.	0.93	
	CBC-L, covert	Teacher	8	Lying or cheating.	0.86	
	TPRSK	Teacher	1	How often does he exert negative influence on his friends?		
	Interview, ratings	Interviewer	1	How likely is it that this boy will have future trouble with the police?		
Deviant peer association					0.76	
	CBC-L + peers q'naire	M,F	1+2, 1+2	Hangs out with kids who get in trouble.	.83, .84	0.71
	CBC-L + TPRSK	Teacher	1+3	Does this student associate with kids involved in stealing or vandalism?	0.92	
	Interview + describing friends q'naire	Youth	10+5	During the past year, how many of your friends stole something worth < $5?	0.86	
Antisocial behavior + deviant peers						0.78
Depressive symptoms						
	CESD-D	Youth	20	During the past week, I felt sad.	0.86	
Parent monitoring					0.75	
	Interview, parent monitoring	M,F	12, 15	On the average, how many hrs per week is your son alone or with siblings only?	.82, .79	0.73
	Interview, impressions	Interviewer	1, 1	This parent seemed to monitor the child carefully.		0.77
	Interview	Youth	9	Your parents let you go any place you please without asking.	0.79	
	Interview, impressions	Interviewer	1	This boy seems to be well supervised by his parents.		
Parent marijuana use						
	Substance use q'naire	M,F	1, 1	How often do you smoke pot or hash?		0.88
Peer substance use					0.9	
	Interview	Youth	10	How often do your friends drink?	0.84	
	Interview	M, F	3,3	Son hangs out with kids who smoke?	.88, .87	

Note: M stands for Mother, F stands for Father.

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Table 2

Correlation Matrix of Predictor Variables With Baseline Outcome

	A	B	C	D	E	F	G
A. Use versus nonuse	1						
B. Quantity of use†	NA	1					
C. Antisocial behavior & deviant peer	0.44***	0.19	1				
D. Depressive symptoms	0.16*	0.21	0.29***	1			
E. Parental monitoring	−0.40***	−0.17	−0.46***	−0.14	1		
F. Parent marijuana use	0.30***	0.20	0.18*	−0.07	−0.25***	1	
G. Peer substance use	0.41***	0.35*	0.52***	0.23***	−0 44***	0.21**	1

†All who did not use are set to missing.

*$p < .05$.

**$p < .01$.

***$p < .001$.

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Table 3

Use and Quantity of Use From Grade 9 to Grade 12

		First recorded use[a]		Any recorded use		Average quantity use[b]		
N	**Grade**	***% N***	**Count**	***% N***	**Count**	***M***	***SD***	***P***
201	9	5%	11	17%	34	52.74	143.03	0.159
199	10	6%	12	20%	39	171.40	452.49	0.212
202	11	8%	17	28%	57	176.06	476.78	0.108
201	12	10%	21	35%	70	150.88	530.81	0.440

[a] A total of 20.32% of the sample reported first use before high school.

[b] Quantity of use in grams.

[c] Quantity of use is log transformed to minimize skew.

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Table 4

Two-Part Semicontinuous Growth Model for Marijuana Use: Fixed Effects

	Part 1: Use versus nonuse			Part 2: Quantity of use		
	B	***S.E.***	***β***	***B***	***S.E.***	***β***
Prediction to latent intercept						
Intercept of latent intercept	0	NA		−0.76	0.46	
Antisocial behavior and deviant peers	1.32**	0.43	0.39	0.51	0.34	0.23
Depressive symptoms	0.29	0.39	0.09	0.60*	0.25	0.27
Parental monitoring	−0.60	0.36	−0.18	−0.21	0.24	−0.09
Parent marijuana use	0.60*	0.28	0.18	0.25	0.23	0.11
Peer substance use	1.09**	0.34	0.32	0.86**	0.32	0.38
Prediction to latent slope						
Intercept of latent slope	0.86***	0.15		0.73***	0.14	
Antisocial behavior and deviant peers	−0.30	0.16	−0.55	0.19	0.13	0.54
Depressive symptoms	−0.09	0.15	−0.17	−0.33**	0.11	−0.92
Parental monitoring	0.12	0.16	0.22	0.03	0.08	0.08
Parent marijuana use	0.03	0.12	0.06	−0.11	0.08	−0.32
Peer substance use	−0.20	0.15	−0.38	−0.12	0.13	−0.34
Change score prediction to outcome						
Antisocial behavior and deviant peers	0.06	0.20	0.01	0.56***	0.16	0.15
Depressive symptoms	−0.17	0.16	−0.05	0.11	0.15	0.04
Parental monitoring	−0.57**	0.18	−0.16	−0.10	0.15	−0.04
Parent marijuana use	0.12	0.16	0.03	−0.21	0.14	−0.06
Peer substance use	0.89***	0.25	0.23	0.64**	0.21	0.20

Note: The intercepts of the outcome for Part 2 and the intercept of the intercept of Part 1 are fixed to 0.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

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Table 5

Two-Part Semicontinuous Growth Model for Marijuana Use: Random Effects

	B	S.E.
Correlations		
Pt. 1 Intercept with pt. 2 intercept	0.41*	0.20
Residual variance		
Quantity of use	2.41***	0.39
Pt. 1 intercept	3.58***	1.12
Pt. 2 intercept	2.36***	0.48
R-Square		
Use grade 9	0.77***	0.05
Use grade 10	0.73***	0.05
Use grade 11	0.68***	0.06
Use grade 12	0.65***	0.06
Quantity of use grade 9	0.68***	0.06
Quantity of use grade 10	0.66***	0.05
Quantity of use grade 11	0.65***	0.05
Quantity of use grade 12	0.66***	0.06
Pt. 1 intercept	0.68***	0.07
Pt. 2 intercept	0.54***	0.10

* $p < .05$.

** $p < .01$.

*** $p < .001$.