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How Academic Achievement, Attitudes, and Behaviors Relate to the Course of Substance Use During Adolescence: A 6-Year, Multiwave National Longitudinal Study

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Self-report data regarding alcohol, cigarette, and marijuana use were collected biennially from ages 14 to 20 in a nationally representative panel sample of adolescents ($N = 1,897$) from the Monitoring the Future study. Growth curve analyses were performed using hierarchical linear modeling to consider psychosocial background, motivation and school attitudes, and parental and peer influences at age 14 as predictors of concurrent substance use and change in substance use. Results indicated that school misbehavior and peer encouragement of misbehavior were positively associated with substance use at age 14 and with increased use over time; school bonding, school interest, school effort, academic achievement, and parental help with school were negatively associated. The protective effects of positive school attitudes and perceptions of high status connected to academics were stronger for low-achieving compared with high-achieving youth. Implications for a developmental perspective on substance use etiology and prevention are discussed.

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Adolescents who have difficulty in some arenas of their life are likely to have difficulty in other arenas (Dryfoos, 1990; Gottfredson & Hirschi, 1994; Jessor & Jessor, 1977). Based on decades of research, negative school experiences are known risk factors for substance use (Hawkins, Catalano, & Miller, 1992; Petraitis, Flay, & Miller, 1995). In particular, students with negative school experiences (including low academic achievement, low motivation, truancy, or acting out in the classroom) are more likely than those with more positive school experiences to use alcohol, cigarettes, and marijuana (e.g., Bachman, Johnston, & O'Malley, 1981; Bryant, Schulenberg, Bachman, O'Malley, & Johnston, 2000; Bryant & Zimmerman, 2002; Diem, McKay, & Jamieson, 1994; Smith & Fogg, 1978). Adolescence is the time when substance use typically begins and then escalates (Johnston, O'Malley, & Bachman, 2002), and patterns of behavior related to both academic difficulties and substance use are likely to be established over the course of adolescence, setting the stage for subsequent other problem behaviors and multiple health risks.

Despite the extensive literature on substance use and academic failure, many important gaps remain. In general, a fuller understanding of the impact of academic experiences on adolescent substance use requires a more in-depth consideration of which academic factors are most important (and for whom) and how these factors relate to both concurrent substance use and, particularly, to increased use over time. In the present study, we addressed three gaps in the literature, including the lack of empirical emphasis on (a) diverse indications of academic success and failure, including motivation and school attitudes as well as students' perceptions of the academic beliefs of parents and peers; (b) change in substance use over multiple time points during adolescence; and (c) population-based variations across gender, ethnicity, and achievement level. Using our conceptual model, we examined adolescents' academic psychosocial background, motivational system, and perceptions of parents and peers as they relate to the course of substance use from age 14 to age 20 in a nationally representative sample, focusing on similarities and differences as a function of gender, ethnicity, and eighth-grade achievement level.

From a human ecological perspective, adolescents' problem behaviors and attitudes are linked across multiple developmental contexts including family, school, and peer settings (Brofenbrenner, 1979). Jessor and Jessor's (1977) problem behavior theory suggests that such school-related behaviors as acting out or skipping classes are likely to be related to problem behaviors in other contexts such as using substances or other delinquent acts. When students are not behaviorally or psychologically engaged in the classroom, they tend to cut class, fail to complete their

schoolwork, and otherwise misbehave (Brophy, 1996; Steinberg, 1996). This misbehavior may transfer to other settings and provide adolescents with more opportunities to use substances. Beyond connections among behaviors, Jessor and Jessor's theory also highlights how demographics, motivation and belief structures, and students' perceptions of their peer and family environments provide linkages among problem behaviors, creating a web of beliefs and behaviors that extends across contexts. By focusing only on academic and substance use problem behaviors, we may overlook adolescents' academic beliefs and perceptions of their environment.

Figure 1 illustrates the conceptual model for the present study. The key concepts are drawn from Jessor and Jessor's (1977) problem behavior theory, including school problem behaviors, motivation and school beliefs, perceived environment, and demographics. As shown in Figure 1, academic beliefs and behaviors and demographics are expected to be directly related to concurrent adolescent substance use as well as to changes in substance use over time. Ethnicity, gender, and perceptions of one's ability are associated both with how adolescents negotiate developmental transitions and also with adolescents' decision-making across contexts (Crockett, 1997; Maccoby, 1995; McLoyd, 1998; Wigfield, 1994); thus, one would expect these factors to moderate the extent to which experiences and beliefs affect the course of change in substance use. In the

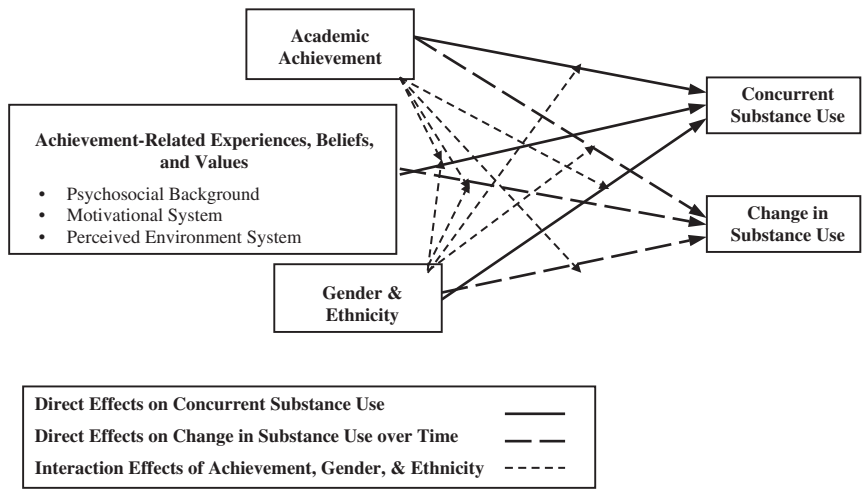

FIGURE 1 Conceptual model of achievement and achievement-related effects on substance use during adolescence.

current model, we also examined how the direct effects of adolescents' psychosocial background, motivational system, and perceived environment system on concurrent substance use and change in use over time are moderated by adolescents' achievement level and gender and ethnicity (see lighter dotted lines in Figure 1).

The model includes direct effects of academic achievement on concurrent substance use and change in use over time, but not the direct effects of substance use on achievement variables. This decision was based on previous research indicating that academic achievement and other academic variables (particularly grades) are stable during adolescence (Bryant et al., 2000; Mounts & Steinberg, 1995; Osborne, 1997), that academic difficulties typically occur before substance use initiation, and that over time academic variables such as grades and school misbehavior are more predictive of substance use than vice versa (Bryant et al., 2000). To some extent, especially during high school, it is likely that adolescents' academic beliefs and behaviors are reciprocally related to their beliefs and behaviors regarding substance use. Nonetheless, it appears that the preponderance of the influence works from academic variables to substance use (Bryant et al., 2000; Schulenberg, Bachman, O'Malley, & Johnston, 1994). Thus, the focus of the current article is on the impact of adolescents' academic beliefs and behavior on concurrent substance use and change in use over time. Such an analysis may help to clarify the role that academics may play in preventing substance use increases over time. The following sections summarize the research literature and expectations for the current research based on the direct and interaction effects on adolescents' substance use presented in Figure 1.

Academic Achievement

Many theories explaining substance use during adolescence, such as family interaction theory (Brook, Whiteman, & Gordon, 1983), the social development model (Hawkins & Weis, 1985), and problem behavior theory (Jessor & Jessor, 1977), have associated adolescents' academic achievement and skills with substance use (Petraitis et al., 1995). In empirical studies, school failure has been well documented as a risk factor for problem behaviors in general (Dryfoos, 1990) and for substance use specifically (Bachman et al., 1981; Eccles, Lord, Roeser, Barber, & Jozefowicz, 1997; Hawkins et al., 1992; Schulenberg et al., 1994; Smith & Fogg, 1978). Relatively few studies, in comparison, have associated adolescents' achievement levels with change in substance use over time (for exceptions, see Bryant et al., 2000; Bryant & Zimmerman, 2002; Luthar

& Cushing, 1997). Consistent with previous research, we expect that adolescents who report low academic achievement will report higher concurrent use of substances and, to a lesser extent, increased substance use over time. Some studies revealed links between academic achievement and change in substance use over time (e.g., Bryant et al., 2000; Luthar & Cushing, 1997) whereas others have not (e.g., Bryant & Zimmerman, 2002).

The direct effects of achievement on substance use may be moderated by demographic factors. Previous studies have indicated that males and Whites have higher rates of substance use compared with their adolescent counterparts (Johnston et al., 2002) and that there are demographic differences related to school failure as a risk factor for substance use. Research suggests that White adolescents may be more vulnerable than African American adolescents to the impact of school-related risk factors on substance use (Wallace & Muroff, 2002). In general, girls report higher grades than boys (Frome & Eccles, 1998), and low achievement seems to affect girls more negatively than boys. Girls with low levels of academic achievement are more at risk than boys with low levels of academic achievement for psychological distress and low academic self-concept (Frome & Eccles, 1998; Pomerantz, Altermatt, & Saxon, 2002), suggesting that school failure may put girls at more risk than boys for problem behaviors such as substance use. Thus, in the current research we expected that low academic achievement would be a stronger risk factor for substance use for White adolescents than for ethnic minority adolescents and for girls than for boys.

Psychosocial Background

Problem behaviors such as psychological distress and a propensity to act out and misbehave are likely to co-occur during adolescence (Jessor & Jessor, 1977). A number of studies have linked truancy and psychological distress with adolescent substance use and abuse (Dryfoos, 1990; Hawkins et al., 1992; Newcomb & Bentler, 1989; Newcomb et al., 2002). Relatively few studies, in comparison, have associated negative school behaviors and psychological distress with change in substance use over time (for exceptions, see Bryant et al., 2000; Bryant & Zimmerman, 2002; Luthar & Cushing, 1997; Orlando, Ellickson, & Jinnett, 2001; Scheier, Botvin, Griffin, & Diaz, 2000; Wills, Sandy, & Yaeger, 2002). Based on the findings from these studies, we expected to find stronger positive associations between school misbehavior and concurrent substance use, weaker positive associations between loneliness and concurrent substance use, and

weaker positive associations between these two factors and change in substance use over time.

Demographic and achievement differences may moderate the links between psychosocial background and substance use. For example, with respect to achievement differences and distress, research suggests that the impact of self-esteem on substance use varies by achievement level (Eccles et al., 1997). Regarding ethnicity and academic behaviors, research on urban adolescents indicates that truancy is a risk factor for some substances for African American adolescents and for other substances for White adolescents (Bryant & Zimmerman, 2002). Concerning gender differences, females tend to report less school misbehavior and more psychological distress than males, and truancy and problem behavior in general appear to be less predictive of increased substance use for females (Brunswick & Messeri, 1984; Bryant et al., 2000; Bryant & Zimmerman, 2002; Ge, Conger, & Elder, 2001; Windle, 1990); thus, we expected to find these same differences in the current national study. Research on urban adolescents also suggests that psychological distress as a risk factor for substance use varies by both ethnicity and gender, although findings are not always consistent: School stress has been identified as a risk factor for concurrent substance use for females but not for males (Brunswick & Messeri, 1984); for males but not for females (Bryant & Zimmerman, 2002); and for White, suburban females (not males) but not for urban males or females who were predominantly African American or Hispanic (Way, Stauber, Nakkula, & London, 1994). The present study allowed us to consider these mixed findings regarding gender and ethnic differences as well as achievement level differences in a nationally representative sample.

Motivation and School Attitudes

Consistent with problem behavior theory, adolescents' beliefs about school and their academic expectations appear to be related to problem behaviors (Dryfoos, 1990; Hawkins et al., 1992), although, as we mentioned earlier, there are some gaps in the research linking measures of motivation and school attitudes to adolescents' involvement in substance use. Youth with high levels of achievement motivation and positive attitudes who report that they like and are interested in school and have high self-perceptions of academic competence and academic values are less likely to engage in substance use (Brook, Whiteman, Gordon, & Cohen, 1986; Bryant & Zimmerman, 2002; Hawkins & Weis, 1985; Roeser, Eccles, & Freedman-Doan, 1999; Scheier & Botvin, 1998;

Smith & Fogg, 1978; Voelkl & Frone, 2000). Having high academic goals, such as planning to graduate from college, is a protective factor associated with less substance use among adolescents (Bachman et al., 1981; Schulenberg et al., 1994). As is true for research on adolescents' school behaviors, the research examining school beliefs and change in substance use over the course of adolescence is limited. Adolescents' school beliefs and motivation—including their perceptions of school importance, value of school experiences, academic self-efficacy, school bonding, and college plans—appear to be strongly associated with concurrent substance use, but evidence is mixed about whether they are strongly associated with change in substance use during high school (Bryant et al., 2000; Bryant & Zimmerman, 2002). In the current study, we expected to find links between motivation and concurrent substance use, and we considered the mixed previous findings regarding change in substance use, as well.

Some research suggests that positive attitudes toward academics are particularly protective against substance use for high-achieving students compared with low-achieving students, indicating an interactive effect of achievement (as included in Figure 1; Evans & Skager, 1992). It is likely that it is the combination of high achievement, high motivation, and positive attitudes that protects against increases in substance use over time (Bryant & Zimmerman, 2002). Generally, girls' academic self-perceptions are lower than boys' self-perceptions, even though girls' reports of achievement are higher (Frome & Eccles, 1998; Pomerantz et al., 2002); therefore, gender differences may exist in the association between motivational beliefs and substance use, as well. Positive school attitudes as protective factors against substance use may be less important for African American or other minority adolescents (Bryant & Zimmerman, 2002). Examining these interactive effects in a nationally representative sample should help us to understand their meaning—we expected that measures of achievement motivation would have greater association with substance use for high-achieving youth, females, and White students than for their peers.

Perceived Environment: Peer and Family Influences

Adolescents who have positive attitudes toward school and whose parents and peers support their education are less likely to use substances than are youth from less education-oriented environments. In general, when parents are aware of and monitor their adolescents' daily activities, adolescents are less likely to engage in problem behavior (Hawkins et al., 1992; Pilgrim, Schulenberg, O'Malley, Bachman, & Johnston, 2003); a key

aspect of parental monitoring is knowledge of and involvement with adolescents' schoolwork (Adalbjarnardottir & Hafsteinsson, 2001; Chen, Greenberger, Lester, Dong, & Guo, 1998; Kerr & Stattin, 2000). Compared with nonusers' parents, parents of adolescents who use substances monitor their schoolwork less and have fewer rules about how they spend their time (Coombs & Paulson, 1988). Some research suggests that although adolescents' perceptions of their families are important for educational outcomes, perceptions of peers (peers' substance use, in particular) may be more strongly associated with substance use outcomes (Kandel & Andrews, 1987; Mounts & Steinberg, 1995; Steinberg, 1996). Considerable research has shown that adolescents who use cigarettes, alcohol, and marijuana are more likely to have friends who also use substances (Hawkins et al., 1992), reflecting both selection and socialization effects (e.g., Kandel & Andrews, 1987; Newcomb & Bentler, 1989; Schulenberg et al., 1999). Adolescents who perceive that their friends use substances and skip school are more likely to use substances and misbehave in school than students who perceive that fewer of their friends are involved in deviant behaviors (Bryant & Zimmerman, 2002; Fuligni, Eccles, Barber, & Clements, 2001). A positive network of friends who model and encourage positive behaviors can provide a shield against risks for students who may be having trouble in school (Brown, Dolcini, & Leventhal, 1997).

Regarding the relationship between adolescents' perceptions of parents and peers and change in adolescents' substance use over time, recent findings based on growth modeling analyses indicate that adolescents who perceive that peers and parents are using fewer substances and that their parents monitor their activities are less likely to increase their own substance use over time (Barnes, Reifman, Farrell, & Dintcheff, 2000; Curran, 2000; Curran, Stice, & Chassin, 1997; Wills, Sandy, Yaeger, & Shinar, 2001). Much less is known about how adolescents' perceptions of parental and peer attitudes and behaviors regarding academics are associated with change in substance use over time. In the current research, we expect, given previous findings, that adolescents' perceptions of peer disapproval of misbehavior and approval of academic success will have stronger negative effects on adolescent substance use and change in use over time than adolescents' perceptions of parents' school help.

Research involving an urban sample of youth provides suggestions regarding the interaction effects of academic achievement and demographics on perceived environment. The perception that friends believe doing well in school is important may be particularly protective against using alcohol and other substances for low-achieving students compared with those who are doing better academically, and for African American

adolescents compared with White adolescents (Bryant & Zimmerman, 2002). In addition, the social support from friends may be a more important protective factor against substance use for girls than for boys (Bryant & Zimmerman, 2002). Finally, research suggests that the negative effects of peer pressure and the positive effects of parental monitoring on adolescent substance use may be stronger for females than for males (Farrell & White, 1998; Webb, Bray, Getz, & Adams, 2002). Research on a nationally representative sample should help to clarify whether these differences generalize beyond urban samples of adolescents—we expected that peer effects would be stronger for low-achieving and female adolescents, and that parent effects would also be stronger for females than for males.

Overview

The main focus of this study was on links between youths' academic experiences and their substance use over the course of adolescence. In particular, we examined how academic experiences, attitudes, and perceptions are related to changes in substance use in a nationally representative panel of students followed from age 14 to age 20. The study addressed the gaps in the existing research by linking motivation to substance use, considering change in substance use over time, and including a close examination of achievement and demographic differences in a nationally representative sample of adolescents. We sought to describe and explain how initial levels of substance use and intraindividual changes in substance use are predicted by interindividual factors (psychosocial, motivation, and perceived environmental variables) in the total sample and as a function of ethnicity, gender, and level of academic achievement. Growth curve analysis using hierarchical linear modeling (HLM) is an advantageous strategy for examining this multilevel model in which interindividual factors are included to predict differences among individuals in their initial levels of substance use and rates of change in use over time.

METHOD

This study used data from the Monitoring the Future project, an ongoing study of adolescents and young adults (Johnston et al., 2002). The project has surveyed nationally representative samples of 12th-grade students (from the 48 contiguous United States) each year since 1975, using questionnaires administered in classrooms. In 1991, the project was

expanded to include 8th- and 10th-grade students. Of the approximately 37,000 eighth-graders surveyed in 1991 and 1992, 2,000 individuals were selected in each cohort for follow-up surveys by mail. Participants were surveyed in school in eighth grade and then surveyed by mail biennially for three additional time points (i.e., average ages 16, 18, and 20). Not all students were 14 in eighth grade; thus, age was included as a predictor in the models.

Sample

The final panel sample used for the analyses included 1,897 students from two cohorts (1991 and 1992) of nationally representative samples. (Corrective weights were used to adjust for the oversampling of individuals estimated to be at high risk for school dropout in the panels so that the samples best represent the original national samples.)

The original sample included 4,000 eighth-grade participants. There are two forms of the questionnaire; based on within-classroom random assignment, approximately half of the students completed one form ($n = 1,975$) and half completed the other form ($n = 2,025$). Only students who completed the first form were included in the present sample because the variables of interest were only on this form.

Students were White (64.5%), African American (11.3%), Latino (9.1%), or other minorities (15.1%). The sample is 51.8% female. On average, participants reported that either their mother's or their father's highest level of schooling was ''some college.'' Most youth came from two-parent households (78.4%).

Because of the requirements of HLM, it is necessary to exclude respondents who are missing data on any of the predictors; incomplete data are permitted for dependent variables, although information is required for at least one time point (see Table 1 for sample sizes for dependent variables at each time point). Of the 1,975 respondents, 78 were missing data on gender or ethnicity, and 661 were missing data on one or more of the other eighth-grade predictors. (For numbers for each of the predictors, see Table 2. Note that loneliness, peer support for misbehavior, and status of academic success had sizeable missing data—these items were on the last page of the questionnaire.) Rather than excluding a sizable portion of the sample for the present HLM analyses, we imputed missing data for all of the predictor variables except for gender and ethnicity. Multiple imputation (MI) techniques provide methods for handling missing data where m values are imputed for each missing variable to complete the data (Rubin, 1987). In following standard procedures, MI

TABLE 1
Means, Standard Deviations, and Skewness of Adolescents' Monthly Substance Use From Age 14 to Age 20

	Age			
Substance	*14*	*16*	*18*	*20*
Cigarettes				
M	1.31	1.48	1.79	1.97
SD	0.83	1.04	1.35	1.47
Skewness	3.44	2.38	1.69	1.44
Kurtosis	13.95	5.34	1.87	0.98
N	1,861	1,531	1,234	1,198
Alcohol				
M	1.46	1.61	1.96	2.38
SD	0.95	1.07	1.35	1.51
Skewness	2.67	2.15	1.53	1.02
Kurtosis	8.03	4.88	1.81	0.25
N	1,780	1,485	1,217	1,178
Marijuana				
M	1.08	1.28	1.53	1.61
SD	0.45	0.92	1.32	1.40
Skewness	6.94	3.80	2.78	2.50
Kurtosis	54.80	14.80	7.02	5.40
N	1,875	1,544	1,227	1,192

Note. Responses ranged from 1 to 7.

was performed for the predictor variables using multiple linear regression plus a random component to produce the imputed values (missing value analysis in SPSS 10.0 was used). Predictor variables used in the estimation process included all of the eighth-grade data for each participant. Five ($m = 5$) imputed data sets were generated; the value of $m = 5$ was chosen to yield estimates that were approximately 95% efficient (Rubin, 1987; Schafer & Graham, 2002).[1] Separate HLM analyses were performed using all five of the imputed data sets, and the HLM results represent the effect sizes averaged across the five sets of estimates. We excluded students who were missing gender or ethnicity information, bringing the final sample to 1,897 students (weighted *N*; unweighted $N = 1{,}891$). *T* tests on all variables

[1] According to Rubin (1987), the efficiency of an estimate based on m imputations (compared with an infinite number) is $(1+\lambda/m)^{-1}$, where λ is the rate of missing data. When $\lambda = .25$ and $m = 5$, efficiency is 95%.

TABLE 2
Means and Standard Deviations of Interindividual Variables Measured at Eighth Grade (Age 14)[a]

Measures	*M*	*SD*	*N*	*Range*	*Skew*	*Kurtosis*	*No. of Items*	*Alpha*
Demographics								
Age	13.57	0.74	1,895	12–18	0.30	0.66	1	
Parental education	4.22	1.29	1,787	1–6	− 0.24	− 0.95	1	
Psychosocial background								
Academic achievement	5.72	2.27	1,858	1–9	− 0.36	− 0.77	1	
School misbehavior	− 0.02	0.71	1,848	− .5–4.4	2.54	8.28	4	0.66
Loneliness	2.56	1.25	1,572	1–5	0.38	-0.93	2	0.72
Motivation and school attitudes								
School interest	3.06	1.00	1,872	1–5	− 0.19	− 0.32	1	
Perceived school difficulty	2.66	1.01	1,892	1–5	0.36	− 0.27	1	
Effort	4.20	0.91	1,887	1–5	− 1.01	0.50	1	
School bonding	3.08	0.97	1,889	1–5	− 0.26	− 0.37	2	0.77
College plans	3.37	0.83	1,842	1–4	− 1.30	1.04	1	
Perceived environment								
Parental school support	3.00	0.91	1,810	1–4	− 0.64	− 0.61	2	0.64
Peer support for misbehavior	2.75	0.75	1,483	1–5	0.18	0.07	3	0.51
Status of academic success	3.38	1.34	1,437	1–5	− 0.31	− 1.13	2	0.83

[a] Before data were standardized and imputed.

revealed that adolescents who were eliminated from the analyses because of missing gender and ethnicity data ($n = 78$; 3.9%) reported lower grades at age 14 than adolescents who were included in the analyses ($n = 1{,}897$); no other significant differences were found.

Measures

Two levels are included in growth curve models. Level 1 represents repeated measures that vary within the individual over time—in this case, substance use. Level 2 represents factors that vary between individuals—in this case, eighth-grade predictor variables that include demographic, psychosocial background, motivation, and contextual factors.

Level 1—Intraindividual change. Means, standard deviations, and skewness information for Level 1 substance use variables from age 14 to age 20 are presented in Table 1. These measures, which have been used

in national panel studies for decades, have adequate psychometric properties (O'Malley, Bachman, & Johnston, 1983).

Cigarette use. In each survey, respondents reported how frequently they smoked cigarettes during the past 30 days; item responses ranged from 1 to 7 (1 = not at all, 2 = less than 1 cigarette per day, 3 = 1–5 cigarettes per day, 4 = about 1/2 pack per day, 5 = about 1 pack per day, 6 = about 1 1/2 packs per day, 7 = 2 or more packs per day).

Alcohol use. Respondents also reported how many occasions (if any) they had alcoholic beverages to drink during the past 30 days. Item responses ranged from 1 to 7 (1 = 0, 2 = 1–2, 3 = 3–5, 4 = 6–9, 5 = 10–19, 6 = 20–39, 7 = 40+occasions).

Marijuana use. Respondents reported how many occasions (if any) they used marijuana or hashish during the last 30 days; item responses ranged from 1 to 7. (Possible responses are the same as for alcohol use earlier.)

Adolescents' monthly substance use was measured every survey year (ages 14, 16, 18, and 20). At age 14, among adolescents with valid data, 17.4% of the respondents reported that cigarette use, 26.7% reported alcohol use, and 4.1% reported marijuana use during the previous month. These measures, which have been used in national panel studies for decades, have adequate psychometric properties (O'Malley, Bachman, & Johnston, 1983).

Level 2—Interindividual factors. Means, standard deviations, and scale information for Level 2 (individual) psychosocial background, motivation factors, school attitudes, and perceived environment variables are reported in Table 2. All variables were measured at eighth grade.

Ethnicity, gender, and age. Students reported their gender, a description of their ethnicity, and their age in years. Possible ethnicity responses were Native American or American Indian, Black or African American, Mexican American or Chicano, Cuban American, Puerto Rican American, Other Latin American, Oriental or Asian American, White or Caucasian, or other. Groups used in the analyses included White (comparison group), African American, Latino, and other (because of the relatively small subsamples, all of the other minority students were included in the other minority group for the analyses). Students reported how old they were on their last birthday: 1 = 11 years old or less, 2 = 12 years old, 3 = 13 years old, 4 = 14 years old, 5 = 15 years old, 6 = 16 years old, 7 = 17 years old, 8 = 18 years old or more; responses were recoded to represent years of age.

Parental education. Participants reported the highest completed level of schooling of their father and of their mother separately, and the higher of the two was used in the analyses. Possible responses

included: 1 = completed grade school or less, 2 = some high school, 3 = completed high school, 4 = some college, 5 = completed college, 6 = graduate or professional school after college, 7 = don't know or does not apply (categorized as missing data).

Academic achievement. Academic achievement was measured by a single item—youths' self-report of their average grade during the previous year: 1 = D and 9 = A.

School misbehavior. This composite consisted of a mean of students' standardized reports of school suspensions in their lifetime (3-point scale), days of school skipped (7-point scale), and classes skipped (6-point scale) during the previous 4 weeks, as well as reports of how often in the past year respondents were sent to the office or had to stay after school because they misbehaved (5-point scale; four items, Cronbach's alpha = 0.66; Bryant et al., 2000).

Loneliness. Students reported on a 5-point scale how much they agreed or disagreed with two statements about loneliness (i.e., ''A lot of times I feel lonely, I often feel left out of things''; Cronbach's alpha = .72; Schulenberg, Wadsworth, O'Malley, Bachman, & Johnston, 1996).

School interest. Students reported on a 5-point scale how often over the previous year they found their course work interesting (one item).

Perceived school difficulty. Students reported on a 5-point scale how often over the previous year they found their schoolwork too hard to understand (one item).

Effort. Students reported on a 5-point scale how often over the previous year they tried to do their best work in school (one item).

School bonding. Respondents indicated on a 5-point scale how much they enjoyed, and how much they hated (reverse coded), being in school during the previous year (two items, Cronbach's alpha = 0.77; Bryant et al., 2000).

College plans. Students reported on a 4-point scale how likely it is they will graduate from college (four-year program; one item).

Parental school support. Respondents reported on a 4-point scale how often their parents (or stepparents or guardians) check on whether they have done their homework and provide help with their homework when it is needed (two items, Cronbach alpha = 0.83).

Peer support for school misbehavior. This was a composite of adolescents' report of how they think most of the students in their classes would feel if they (the respondents) cheated on a test or intentionally did things to make the teacher angry (two items: 1 = they would like it very much, 5 = they would dislike it very much; reversed coded) and how often they find that their friends encourage them to do things that their teachers would not like (one item: 1 = never, 5 = almost always; total of three items, Cronbach alpha = 0.51; Schulenberg et al., 1996).

Status of academic success at school. Respondents reported how important good grades and college plans are for being looked up to or having high status at school (1 = no importance, 5 = very great importance; two items, Cronbach's alpha = .83).

Data Analytic Approach

In HLM growth curve models, intraindividual factors (Level 1 factors) are the occasions of measurement (Time 1, Time 2, etc.) nested within individuals; interindividual factors (Level 2) are demographic, psychosocial, motivational, and family and peers variables (Bryk & Raudenbush, 2002). At Level 1 in the current research, adolescent substance use was included at ages 14, 16, 18, and 20 in addition to a linear component with initial use at age 14 (eighth grade) as the intercept. At the interindividual level (Level 2), demographic, psychosocial background, motivational, and family and peer factors were entered to explain differences in adolescents' substance use at age 14 (concurrent use), and rates of intraindividual linear and quadratic change in substance use from ages 14 to 20. The linear factor describes the linear growth in substance use, and the quadratic factor describes acceleration in the rates of change. The growth models were estimated separately for cigarettes, alcohol, and marijuana using full ML estimation in HLM. In the final set of analyses, interaction effects of ethnicity, gender, and achievement level were examined. The interaction models were estimated using full ML estimation including *z*-scored predictors for noncategorical variables; consistent with standard practice in the literature, all dummy variables (gender and ethnicity) were recoded (–1,1), and interaction terms were created where each predictor was multiplied in turn by ethnic minority status, then gender (e.g., African American students = 1, Whites = –1; females = 1, males = –1), and achievement status at age 14 (standardized age 14 academic achievement; Aiken & West, 1991). Omnibus tests were performed to reduce the probability of Type I errors. Details regarding the analyses are presented in the Appendix.

RESULTS

Unconditional Model (Average Growth Models)

Results from the unconditional growth model for cigarettes, alcohol, and marijuana are presented in Table 3 (described in Equations A1–A4 in the

TABLE 3
Linear Model of Growth in Substance Use (Unconditional Model)

	Fixed Effect	*Coefficient*	*SE*	*t ratio*	*df*	*p value*
Cigarettes	Mean age 14 status	1.338	.019	70.13	1,877	.000
	Mean linear growth	0.150	.017	8.63	1,877	.000
	Mean quadratic growth	− 0.001	.003	− 0.22	1,877	.824
Alcohol	Mean age 14 status	1.473	.023	65.13	1,851	.000
	Mean linear growth	0.087	.021	4.12	1,851	.000
	Mean quadratic growth	0.012	.004	3.44	1,851	.001
Marijuana	Mean age 14 status	1.072	.013	80.23	1,882	.000
	Mean linear growth	0.164	.019	8.65	1,882	.000
	Mean quadratic growth	− 0.008	.003	− 2.71	1,882	.007
	Random Effect	*Variance Component*		$\chi 2$	*df*	*p value*
Cigarettes	Age 14 status	.140		1555.56	1,200	.000
	Linear growth	.094		1382.08	1,200	.000
	Quadratic growth	.001		1235.41	1,200	.233
	Level 1 error	.544				
Alcohol	Age 14 status	.099		1356.90	1,165	.000
	Linear growth	.092		1194.46	1,165	.268
	Quadratic growth	.003		1316.83	1,165	.001
	Level 1 error	.830				
Marijuana	Age 14 status	.001		800.05	1,206	> .500
	Linear growth	.288		2573.22	1,206	.000
	Quadratic growth	.007		2704.36	1,206	.000
	Level 1 error	.345				
Reliability of OLS Regression Coefficient Estimates						
Cigarettes	Age 14 status	.220				
	Linear growth	.203				
	Quadratic growth	.107				
Alcohol	Age 14 status	.116				
	Linear growth	.139				
	Quadratic growth	.175				
Marijuana	Age 14 status	.003				
	Linear growth	.522				
	Quadratic growth	.490				

Appendix). The results from the unconditional model indicated a significant linear increase for all three substances and a significant quadratic effect in rates for alcohol and marijuana use (see the mean

growth rates and mean acceleration in the fixed effects portion of Table 3). The significant linear effect for all three substances was positive, indicating that adolescents, in general, increased their use over time; the significant quadratic effect for alcohol was positive, indicating an acceleration in the rate of increase over time; and the significant quadratic effect for marijuana was negative, indicating a deceleration in the rate of increase over time. The random effects portion of Table 3 indicates that adolescents differed significantly in their initial (age 14) levels of cigarette and alcohol use ($p < .0001$), that the rates of linear increases in cigarette and marijuana use differed significantly across individuals, and that acceleration in rates of alcohol use and deceleration in rates of marijuana use differed across individuals. Although 4.1% of the adolescents reported some use of marijuana at age 14 (and the mean was significantly different from zero as indicated in the top portion of Table 3), there was no significant variation ($p > .50$) in the means on the 7-point scale. The reliabilities for estimating the intercepts and slopes were acceptable, though not very high, especially for the marijuana use intercept (whereas the reliabilities for estimating the linear and quadratic change rates of marijuana use were high). Reliabilities are typically lower when there is less observed variance in the outcome across the sample (Bryk & Raudenbush, 2002).

We considered the homogeneity of Level 1 variance, an assumption in HLM, across the time points by modeling time as a predictor of the common variance σ^2 (Bryk & Raudenbush, 2002; see the Appendix). We found that time was not a predictor of Level 1 variance for alcohol use ($p = .86$); time was related to Level 1 variance in cigarette use ($p < .01$), where planned contrasts revealed that the variance at the third and second time points was less than the variance at the first time point ($p < .001$); and time was related to Level 1 variance in marijuana use ($p < .001$), where planned contrasts revealed that variance increased significantly at every time point except between the third and fourth time points ($p < .001$).

Explaining Substance Use Differences

In the models of age 14 status and linear and quadratic change in substance use, the intercepts (substance use at age 14) and slopes (substance use linear and quadratic change rates) become outcomes. The effect sizes associated with these results are presented in Table 4 (results are based on averages across the $m = 5$ imputed data

TABLE 4
Effect Sizes From Final Hierarchical Linear Models of Monthly Cigarette, Alcohol, and Marijuana Use Including Age 14 Status and Rates of Growth From Ages 14 to 20

Fixed Effect	*Cigarette Use*	*Alcohol Use*	*Marijuana Use*
	Mean Age 14 Status[a]		
Demographics			
Age	0.28**	0.27*	
Female	0.40***	0.32*	
African American	−0.97***	−0.74***	
Latino	−0.48**	0.29	
Other minority	−0.08	−0.21	
Parental education	−0.14	0.04	
Psychosocial background			
Academic achievement	−0.26**	−0.14	
School misbehavior	1.32***	1.81***	
Loneliness	−0.06	−0.26*	
Motivation and school attitudes			
School interest	0.04	−0.30*	
School difficulty	0.13	−0.11	
Effort	−0.22*	−0.27	
School bonding	−0.35**	−0.13	
College plans	−0.38***	−0.28*	
Perceived environment			
Parents' school help	−0.02	−0.37**	
Peer misbehavior	0.26*	0.36**	
Status of academic success	−0.03	−0.19	
	Mean Linear Growth[b]		
Demographics			
Age	−0.07		0.00
Female	−0.06		0.17*
African American	−0.39***		−0.20
Latino	−0.44***		0.00
Other minority	−0.12		−0.22*
Parental education	−0.05		0.04
Psychosocial background			
Academic achievement	−0.33***		−0.25***
School misbehavior	−0.06		0.31***
Loneliness	0.03		−0.15*
Motivation and school attitudes			
School interest	−0.03		−0.07
School difficulty	−0.08		−0.17*
Effort	0.00		−0.12
School bonding	0.02		0.03
College plans	0.08		−0.09

TABLE 4
(*Continued*)

Fixed Effect	*Cigarette Use*	*Alcohol Use*	*Marijuana Use*
Perceived environment			
Parents' school help	0.04		− 0.08
Peer misbehavior	− 0.01		0.17*
Status of academic success	− 0.03		− 0.09
	Mean Quadratic Growth[b]		
Demographics			
Age		− 0.01	− 0.02
Female		− 0.28***	− 0.27***
African American		− 0.22**	0.11
Latino		− 0.11	− 0.05
Other minority		− 0.05	0.25*
Parental education		0.04	0.00
Psychosocial background			
Academic achievement		0.02	0.20*
School misbehavior		− 0.11*	− 0.22**
Loneliness		− 0.08	0.12
Motivation and school attitudes			
School interest		− 0.01	0.10
School difficulty		0.04	0.14
Effort		− 0.06	0.08
School bonding		0.06	− 0.05
College plans		0.21***	0.14
Perceived environment			
Parents' school help		0.05	0.08
Peer misbehavior		− 0.01	− 0.11
Status of academic success		0.02	0.03

[a] For dichotomous predictors (i.e., gender and ethnicity), $ES = \beta/\sqrt{T_{00}}$, where β is the coefficient from the specified hierarchical linear modeling (HLM) model (see Equation A5) and T_{00} is the variance in initial status (r_{0i} in Equation A2) from the unconditional model (see Table 3). For the remaining continuous predictors, $ES = 2 * \beta * S_x/\sqrt{T_{00}}$, where β is the coefficient from the specified HLM model, S_x is the standard deviation of the predictor (which is 1 as the variables were standardized), and T_{00} is the variance in initial status from the unconditional model.

[b] For dichotomous predictors, $ES = \beta/\sqrt{T_{11}}$, where β is the coefficient from the specified HLM model (see Equations A6 and A7) and T_{11} (T_{22} for acceleration) is the variance in growth rates (r_{1i} in Equation A3 and r_{2i} in Equation A4 for acceleration) from the unconditional model (see Table 3). For the continuous predictors, $ES = 2 * \beta * S_x/\sqrt{T_{11}}$, where β is the coefficient from the specified HLM model, S_x is the standard deviation of the predictor (again, this is 1), and T_{11} is the variance in linear (T_{22} in quadratic) growth rates from the unconditional model. (See Equation 13 in Raudenbush & Liu, 2001.)

*$p < .05$.
**$p < .01$.
***$p < .001$.

sets).[2] (Note that because there was no significant variance in the marijuana use intercept, alcohol use linear growth, and cigarette use quadratic growth, the corresponding columns in Table 4 are blank.) Effect sizes were calculated using the variances in initial statuses and growth rates from the unconditional models (Raudenbush & Liu, 2001) from Table 3 (see Table 4 for details). Using the conventional guidelines suggested by Cohen (1977), small effects are defined at 0.1, medium effects are defined at 0.3, and large effects are defined at 0.5; however, Rosenthal, Roshow, and Rubin (2000) warned against strict interpretation of these definitions.

Cigarette use. Based on the model including all eighth-grade predictors, and as indicated in the first column of Table 4, eighth-grade (age 14) cigarette use was higher for females than for males, and higher for White students than for African American and Latino students. In terms of psychosocial background, eighth-grade cigarette use was higher for students who reported lower academic achievement and higher school misbehavior than their counterparts; likewise, regarding motivation and school attitudes, cigarette use was higher for students who reported lower levels of effort, school bonding, and college plans compared with their counterparts. In terms of perceived environment, eighth-grade cigarette use was higher among students who perceived that their peers would support their school misbehavior than those who did not.

In regard to predicting variation in change in cigarette use over time, the linear increase in cigarette use from age 14 to age 20 was greater for Whites than for African Americans and Latinos, and was greater for those with lower eighth-grade academic achievement.

Alcohol use. Based on the model including all eighth-grade predictors, eighth-grade (age 14) alcohol use was higher for females than for males, and higher for White students than for African American students (see Table 4). Students who reported higher levels of school misbehavior and lower levels of loneliness reported higher concurrent eighth-grade alcohol use. In terms of motivation and school attitudes, adolescents who reported lower levels of school interest and college plans reported higher concurrent alcohol use in eighth grade compared with

[2] Because the substance use was not normally distributed (see skewness and kurtosis in Table 1), and because the measure of substance use in this study was not an equal unit scale, multiple approaches were used to examine whether results were robust to assumption violations. Results were similar when HLM analyses were performed where the substance use variables were treated as ordinal (distances between the seven categories of use were permitted different thresholds) and count data (using an overdispersed Poisson distribution). Details regarding these analyses are available from the first author.

their counterparts. Regarding the perceived environment, students who reported that their peers supported misbehavior and that they received less school help from parents were more likely to report concurrent eighth-grade alcohol use.

In terms of quadratic growth, females' rates of increase in alcohol use showed less acceleration from age 14 to age 20 compared with males, and African American adolescents' rates of increase in alcohol use also showed less acceleration over this period compared with White students. With regard to psychosocial background, for adolescents who reported more school misbehavior, their rates of increase in alcohol use showed less acceleration from age 14 to age 20 compared with adolescents who reported less school misbehavior. At age 14, adolescents who reported high school misbehavior were already using more alcohol than adolescents who reported low misbehavior; therefore, their trajectory starts off much higher and has a slower rate of increase. In contrast, adolescents who reported higher[3] college plans reported less alcohol use at age 14, but their alcohol use rates accelerated quickly from age 14 to age 20 compared with youth with lower college plans (see Figure 2). As Figure 2 indicates, adolescents with college plans at age 14 actually were using more alcohol by age 20 than their peers without college plans (it is likely that most of these students were at age 20 in college where alcohol use is common; e.g., see O'Malley & Johnston, 2002; Schulenberg et al., 1994).

Marijuana use. The data in Table 4 indicate that, for linear growth in the model including all eighth-grade predictors, females increased their marijuana use more than males, and other minority students (not African Americans or Latinos) increased their marijuana use less than White students. In terms of psychosocial background, students who reported higher levels of school misbehavior and lower levels of academic achievement and loneliness increased their marijuana use more than their counterparts. Adolescents who reported higher levels of school difficulty in eighth grade increased their marijuana use less than those who reported lower levels of school difficulty. In addition, adolescents who reported that more friends condoned misbehavior in eighth grade increased their marijuana use more than those who reported that their friends condoned misbehavior less.

The quadratic results for marijuana use indicated that females decelerated their rates of increase in marijuana use more than did males during this period. Compared with White students, other minority

[3] When "high" and "low" are used in the figures, they refer to 1 *SD* above or below the mean.

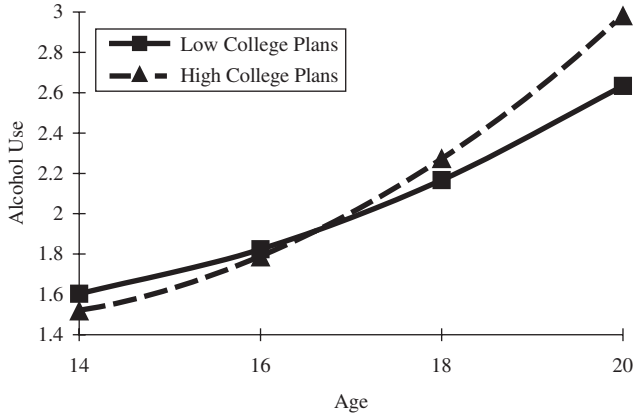

FIGURE 2 Monthly alcohol use from age 14 to age 20 for adolescents reporting low and high college plans at age 14. Figure includes controls for all other variables in the model.

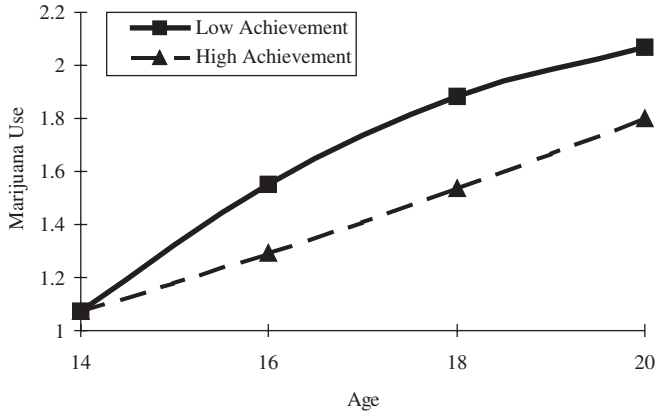

FIGURE 3 Monthly marijuana use from age 14 to age 20 for adolescents reporting low and high achievement at age 14. Figure includes controls for all other variables in the model.

students increased their use less yet accelerated their use more from age 14 to age 20. In addition, low-achieving students increased their marijuana use more than did high-achieving students, but their marijuana use rate had more deceleration from age 14 to age 20 compared with high achievers (see Figure 3). The findings for high-misbehaving students mirrored those for low achievers: High-misbehaving students increased their use more

than did low-misbehaving students; however, their use decelerated more than that of low-misbehaving students during this period.

Interaction Effects of Ethnicity, Gender, and Achievement Level

In the substance use models with interaction terms, all of the ethnicity (African American–White, Latino–White, other minority–White), gender (female–male), and achievement level (high–low) interactions for each of the predictor variables (psychosocial background, motivation, and perceived environment factors) were included in a single model. Because these models included 73 predictors to model both substance use at age 14 and rates of linear and quadratic change in substance use, the possibility of making a Type I error was high. Thus, an omnibus test was performed for the set of interactions as a whole for the intercept and each of the slopes across each of the substances (with p set at .05); in addition, only individual effects significant at the $p < .01$ level were considered. The omnibus test for all interactions (the null hypothesis was that no interactions exist) was significant for the cigarette use intercept, $\chi^2(57) = 111.37$, $p < .0001$, and for the linear slope, $\chi^2(57) = 76.73$, $p < .05$; was significant for the alcohol use intercept, $\chi^2(57) = 90.86$, $p < .01$, and quadratic term, $\chi^2(57) = 79.51$, $p < .05$; and was significant for the marijuana use linear slope, $\chi^2(57) = 79.70$, $p < .05$, but not for the marijuana use quadratic term, $\chi^2(57) = 73.95$, $p = .065$.

For the cigarette use intercept (monthly cigarette use at age 14), two interactions were significant at the $p < .01$ level. As reported earlier, eighth-grade school misbehavior was a risk factor for concurrent cigarette use, but the significant interaction revealed that it was more of a risk factor for Whites than for African American students ($p < .001$). In addition, a gender interaction revealed that high-achieving females use more cigarettes than males in general and than low-achieving males ($p < .01$). A Gender × Achievement interaction was also found for the linear slope, where low-achieving girls use fewer cigarettes in eighth grade but increase their use much more than boys or high-achieving girls over time ($p < .01$; similar to the quadratic effect described next for alcohol use and shown in Figure 4). An Achievement × School Misbehavior interaction revealed that having high grades was protective only for students with low school misbehavior; adolescents reporting high levels of misbehavior did not differ in their marijuana use by achievement level ($p < .01$; similar to the quadratic effect described next for alcohol use and shown in Figure 5).

For the alcohol use intercept, two achievement interactions were found: High levels of school bonding and college plans were actually risk factors

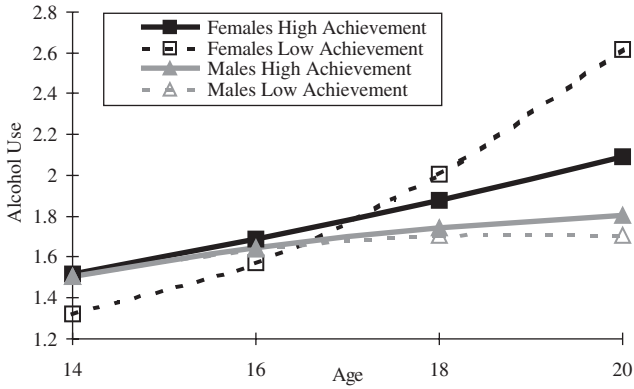

FIGURE 4 Gender × Achievement interaction on quadratic growth (acceleration) in alcohol use from age 14 to age 20. Figure includes controls for all other variables in the model.

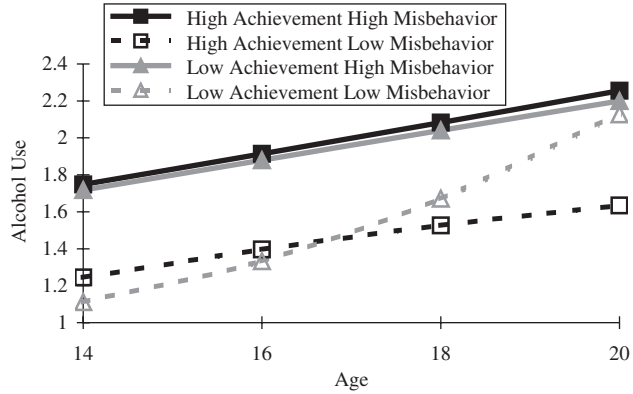

FIGURE 5 Achievement × School Misbehavior interaction on quadratic growth (acceleration) in alcohol use from age 14 to age 20. Figure includes controls for all other variables in the model.

for adolescents who reported high grades but were more protective for those who reported low grades ($p < .01$). For the acceleration in alcohol use from ages 14 to 20 (quadratic term), ethnicity and achievement interactions were found. As noted previously, college plans at eighth grade were associated with an acceleration in the rate of increase in alcohol use; however, this risk factor held for White students but not for the other minority group of adolescents ($p < .01$). Although we found that females in

general showed less acceleration in the increase in their alcohol use over time compared with males, the significant Gender × Achievement Group interaction revealed that this was not true for females with low academic achievement (grade point average) at eighth grade; indeed, this group of females was found to accelerate the most in their rate of alcohol use increase compared with males and other females ($p < .001$; see Figure 4). Furthermore, although low school misbehavior at eighth grade was associated with an acceleration in the rate of increase in alcohol use over time (because of the associated relatively low intercept), this was true only for students with low academic achievement ($p < .01$; see Figure 5).

Regarding the linear slope of marijuana use, we found two interactions. Although perceived school difficulty at eighth grade was an overall risk factor for increased marijuana use over time, it was more so for other minority students than for White students ($p < .01$). Second, although females tended to have greater increases in marijuana use over time (compared with males), this was a particular tendency of females who reported at eighth grade that they put higher effort into their schoolwork ($p < .01$). These results suggest that for females, putting effort into doing their best work in school could be stressful, or it could be that both using marijuana and reporting increased effort to do good work in school is associated with social desirability for females.

DISCUSSION

Key challenges for advancing our understanding of difficulties during adolescence concern how various domains of young peoples' lives interrelate concurrently, how risk and protective factors unfold over time, and how key formative experiences vary in their impact as a function of demographic characteristics (Hawkins et al., 1992; Jessor, 1992; Mounts & Steinberg, 1995; Schulenberg, Maggs, Steinman, & Zucker, 2001). Our purpose in this study was to advance the understanding in these areas by addressing three specific gaps in the literature: the lack of empirical emphasis on (a) diverse indications of academic success and failure, including motivation and school attitudes as well as students' perceptions of the academic beliefs of parents and peers; (b) change in substance use over multiple time points during adolescence; and (c) population-based variations across gender, ethnicity, and achievement level.

This study provides new and needed evidence that school-related factors beyond low academic achievement contribute to both concurrent substance use and changes in substance use over time. As expected from problem behavior theory, high levels of reported school misbehavior and

low levels of academic achievement early in adolescence were associated with high concurrent cigarette use and increased cigarette and marijuana use over time. These findings build on problem behavior theory in their attention to the relation between problem behaviors rather than clustering problem behaviors together (Jessor & Jessor, 1977). The study also provides some support for including motivation and school attitudes in current models regarding academics and substance use (e.g., Hawkins & Weis, 1985; Voelkl & Frone, 2000). When adolescents reported higher levels of school interest, school effort, school bonding, and college plans, they were less likely to report concurrent cigarette and alcohol use. We found evidence that Jessor and Jessor's (1977) perceived environment factors likely play a part in the link between academic difficulties and substance use. Adolescents' perceptions of their parents' provision of school help and their peers' attitudes regarding misbehavior were associated with concurrent substance use and change in use over time. This helps to show that the perceived environment includes school behaviors as well the substance use values and behaviors of parents and peers, whose effects on adolescent substance use have been well documented.

Although these results do not establish causal connections among these expanded academic factors and substance use, they provide strong support for models of problem behavior and of substance use prevention that include consideration of adolescents' academic beliefs and behaviors. Accounting for these different behavioral, motivational, and perceived environment factors related to school may help us tap into the low school engagement that Brophy (1996) and Steinberg (1996) have suggested indicates a lack of structure in adolescents' lives. Adolescents with a combination of negative school experiences and negative attitudes may miss out on formative academic experiences in the classroom and, instead, may affiliate with other delinquent peers and skip school. This lack of structure and exposure to delinquent peers is likely to permeate multiple contexts of development and be associated with increased substance use and problem behavior (Jessor & Jessor, 1977; Larson, 2000).

We expand on previous research regarding academics and substance use by providing information about how the different academic factors were associated with change in substance use from early to late adolescence. Notably, the patterns of change in substance use from age 14 to age 20 varied depending on the type of substance, yet similarities could be identified in terms of predictors of change. Adolescents who reported higher grades in early adolescence were less likely to increase their cigarette and marijuana use over time. The study provided little support, however, for the motivation variables as predictors of change in

substance use over the course of adolescence. This suggests that the protective effects of enhanced achievement motivation and positive school attitudes early in adolescence do not provide added value at the end of and beyond high school, beyond their possible indirect contribution via early educational success. The context of substance use is altered during these latter years, when more of the adolescents who were high achievers in early adolescence may be using substances—particularly alcohol and, to a lesser extent, marijuana. It may be that early experiences of achievement and high levels of motivation are protective factors against increased cigarette use over time but not as protective against alcohol and marijuana use. Well-adjusted and motivated young adolescents may be less inclined to initiate alcohol and marijuana use early but have the potential to increase their alcohol and marijuana use at a faster rate during the transition to the college years (Schulenberg & Maggs, 2002). Entering college, for many adolescents, is associated with major developmental transitions regarding social relationships with peers, contexts of social interaction, and self-regulation and self-perceptions, all of which could also be associated with alcohol use (Bachman, Wadsworth, O'Malley, Johnston, & Schulenberg, 1997; Maggs, 1997; Schulenberg & Maggs, 2002).

In the nationally representative sample used here we found that the results were generally, but not entirely, robust with respect to adolescents' gender, ethnicity, or achievement level. The close attention to context, however, emphasized by Steinberg, Darling, and Fletcher (1995), adds depth to our understanding of the links between academics and substance use and may provide information for more context-specific prevention models. Some evidence indicated that school misbehavior was a risk factor for concurrent cigarette use more for Whites than for African American students, suggesting that school misbehavior and cigarette use may have stronger associations in terms of problem behavior for White youth, or that the contexts of use may be different for African American and White adolescents (Bryant & Zimmerman, 2002; Wallace & Muroff, 2002). We also found that the protective effects of school attitudes vary by achievement level, supporting some previous limited evidence (Bryant & Zimmerman, 2002). College plans and bonding to school were more protective in terms of concurrent alcohol use for adolescents reporting low grades and more of a risk factor, even at eighth grade, for concurrent alcohol use for students with higher grades. For youth who are having difficulty in school, bonding to school and having plans for college may compensate for the increased risk due to their school difficulties. In terms of the high achievers, Evans and Skager's (1992) work also suggests that academically successful substance users have high educational aspirations during early adolescence. The gender differences indicated that

low-achieving girls, in particular, those who have difficulty in school, may be at risk for increased cigarette, alcohol, and marijuana use over time. This suggests that low-achieving girls may cope differently with school stresses or difficulties or have different social supports or peer groups compared with boys or high-achieving girls. Replicating some of the subgroup findings from urban samples in the national sample, as well as identifying additional subgroup differences, helps to validate the inclusion and examination of contextual factors in models of substance use etiology and prevention.

Similar to the findings regarding concurrent substance use, the results regarding change in substance use were largely the same across ethnicity, gender, and achievement level. The interactions regarding acceleration in the alcohol use slope provide additional information vis-à-vis varying levels of risk for alcohol use increases, particularly for low-achieving students. Low-achieving females and low-achieving adolescents who reported low school misbehavior also reported lower levels of alcohol at the first wave, but both groups were more likely to increase their alcohol use at faster rates over time. Together, these results suggest that although low achievement may not be a salient marker for risky concurrent alcohol use among young adolescents, it may indicate heightened risk for alcohol use increases over time for females and for students who do not exhibit other school problem behaviors. The ethnicity interactions brought to light the fact that the risk for accelerated future alcohol use associated with having high college plans discussed previously may not apply to students from some ethnic minority groups (not African Americans or Latinos). Indeed, having difficulty with school and low college plans are risk factors for these other ethnic minority students for faster substance use increases over time.

Strengths and Limitations

Several strengths and limitations—including issues related to generalizability, measurement, and longitudinal designs and methods—need to be recognized in the current research. In the understanding of developmental phenomena, large-scale longitudinal survey research can help provide a needed emphasis on populations and important subgroups. The current study involves a nationally representative sample of adolescents from the United States, permitting conclusions to be generalizable across this population and defined subgroups; furthermore, youth are followed over multiple time points, permitting the consideration of trajectories of substance use. The conclusions, however, must be considered in light of missing data and attrition, a limitation ubiquitous to large-scale long-

itudinal studies. Youth who were missing substance use data at the last time point were more likely to use substances earlier, resulting in less variation in the outcome variables. Thus, the effects of predictors may, in fact, be underestimated. In addition, the same model was used for the missing data imputation as in the HLM data analysis. Although this is standard procedure, using different multiple imputation models (for example, using additional variables to predict missing values, but not using those variables in the analysis) could conceivably strengthen the HLM results and better meet the assumption of multiple imputation that data are missing at random (Schafer & Graham, 2002).

Though extensive in scope, the study is limited to some degree by the measurement of the predictors and of substance use. All of the measures are based on adolescents' self-report and some are based on single-item measurement. Including more reliable measures and additional information from peers, parents, and teachers regarding the nature of adolescents' experiences in peer, home, and school contexts would help us understand school and substance use connections. Collecting substance use data more frequently (rather than at 2-year intervals) would also help provide a more accurate representation of substance use among youth during adolescence.

Although we considered predictors of change in substance use over time, we did not consider issues of causality or reciprocal effects. Many aspects of adolescents' academic trajectories, including beliefs and behaviors, have been established before eighth grade and may have already contributed to and been affected by adolescents' behaviors and beliefs about substance use before the study began. Nonetheless, we were able to consider correlates of change in substance use over the course of adolescence with some suggestions as to how these may be related to adolescents' academic experiences and beliefs.

As suggested earlier, a major strength of the study is the longitudinal design covering middle to late adolescence when extensive change in substance use tends to occur. This research could be extended by examining how change in, in addition to the static influences of, academic experiences and beliefs relates to change in substance use over time. For example, Hawkins, Guo, Hill, Battin-Pearson, and Abbott (2001) showed how school bonding (which we found to be one of the more powerful predictors of concurrent, but not change in, substance use) changes over the course of adolescence, and it would be beneficial to see how these various ''moving targets'' work together. Our study helps set the stage for such future efforts by covering an extensive range of academic factors and showing how these factors relate to substance use among adolescents in the United States.

Implications

The results indicate that multiple dimensions of adolescents' academic experiences, more than just school failure, relate to substance use and change in substance use over time. Prevention implications from Hawkins et al.'s (1992) review of the literature on risk and protective factors for substance use included promoting academic achievement and commitment to school. The findings presented here underscore those efforts and further suggest that school misbehavior is a key risk for substance use, and multiple dimensions of motivation and school support from parents and peers are additional protective factors that may help promote positive youth outcomes. The current findings expand on current research by considering models of substance use change over time and draw attention to the fact that risk factors for change in use over time may not be the same as risk factors for concurrent use, particularly during times of multiple developmental transitions (Schulenberg et al., 2001). Developmentally appropriate interventions that target the needs of the different age levels and groups may help youth negotiate transitions to high school or college and avoid health risks (Schulenberg & Maggs, 2002). Preparing youth before they make transitions can buffer them against social and academic stressors they may face in the new school environments. Targeting the school behavior and attitudes of adolescents and the contexts of peers and family will also contribute to healthy outcomes for adolescents and the reduction of problem behaviors. School-based substance use prevention programs that have multiple targets and multiple points of intervention are most likely to be effective (Botvin, 1996). The results support the enrichment of education, the improvement of achievement (e.g., increased grades, graduation rates), and reduction of school misbehavior and truancy as desirable outcomes of prevention programs in schools.

Our results suggest that some risk and protective factors differ in their salience depending on the substance, on whether we refer to concurrent use or changes over time, and on the background characteristics of the adolescents. The challenge, then, for researchers, prevention scientists, and those interested in promoting healthy outcomes for youth is how to design programs that best target these risk and protective factors for vulnerable young people at developmentally appropriate times.

APPENDIX

Details regarding the hierarchical models are described as follows.

Models of Intraindividual Change (Level 1)

In the intraindividual change or Level 1 model, occasions of measurement are nested within the individual. The following equation specifies the growth model within students:

$$Y_{ti} = \pi_{0i} + \pi_{1i}a_{ti} + \pi_{2i}a_{ti}^2 + e_{ti} \quad \text{(A1)}$$

where Y_{ti} is the observed status (substance use) at time t for individual i; π_{0i} is the intercept (initial status at age 14) or the substance use of individual i at $a_{ti} = 0$; π_{1i} is the yearly rate of change in substance use for individual i from age 14 to age 20; a_{ti} is the linear term where 0 is age 14, 2 is age 16, 4 is age 18, and 6 is age 20 (the same time interval is used for all individuals); π_{2i} is the rate of acceleration in the change (or the curvature of the change); and $a_{ti}{}^2$ is the quadratic term, which is the linear term squared. Errors are represented by e_{ti} with common variance σ^2; the assumption of homogeneity of this variance at Level 1 (across the time points) is described in the Results section.

Interindividual Models (Level 2)

The first step in a growth curve model is to estimate a Level 1 (intraindividual) model that is unconditional at Level 2 to examine whether there are significant linear and quadratic increases in substance use across all students (fixed effects), and whether students differ in their initial status (π_{0i}) and their rates of change (π_{1i}, π_{2i}; random effects). These unconditional models were estimated using full maximum likelihood (ML) estimation in HLM for each of the substances (cigarettes, alcohol, and marijuana) separately. In the interindividual level, or Level 2, model, the growth parameters (π_{0i}, π_{1i}, π_{2i}) become outcomes modeled as a function of student characteristics. In the unconditional model, no individual-level predictors were included. That is,

$$\pi_{0i} = \beta_{0\,0} + r_{0i} \quad \text{(A2)}$$

$$\pi_{1i} = \beta_{1\,0} + r_{1i} \quad \text{(A3)}$$

$$\pi_{2i} = \beta_{2\,0} + r_{2i} \quad \text{(A4)}$$

where significant βs indicate that initial substance use ($\beta_{0\,0}$) and linear ($\beta_{1\,0}$) and quadratic ($\beta_{2\,0}$) increases in use are significantly greater than zero. Significant between-student variance in r_{0i}, r_{1i}, and r_{2i}, the errors at the individual level, indicates that students differ significantly in their initial status and rates of change.

Individual-level predictors were introduced into the Level 2 models in the next step, which was estimated using full ML estimation in HLM, to model the significant variance in the intercepts (initial status at age 14) and linear and quadratic slopes (rates of change and acceleration or deceleration in rates of change between ages 14 and 20):

$$\begin{aligned}\pi_{0i} = {} & \beta_{0\,0} + \beta_{0\,1}(\text{Female}) + \beta_{0\,2}(\text{African American}) + \beta_{0\,3}(\text{Latino}) \\ & + \beta_{0\,4}(\text{Other Minority}) + \beta_{0\,5}(\text{Parental Education}) \\ & + \beta_{0\,6}(\text{Academic Achievement}) + \beta_{0\,7}(\text{School Misbehavior}) \\ & + \beta_{0\,8}(\text{Loneliness}) + \beta_{0\,9}(\text{School Interest}) \\ & + \beta_{0\,13}(\text{College Plans}) + \beta_{0\,14}(\text{Parents' School Help}) \\ & + \beta_{0\,15}(\text{Peer Misbehavior}) \\ & + \beta_{0\,16}(\text{Status of Academic Success}) + r_{0i}\end{aligned} \tag{A5}$$

$$\begin{aligned}\pi_{1i} = {} & \beta_{1\,0} + \beta_{1\,1}(\text{Female}) + \ldots + \beta_{1\,16}(\text{Status of Academic Success}) \\ & + r_{1i}\end{aligned} \tag{A6}$$

$$\begin{aligned}\pi_{2i} = {} & \beta_{2\,0} + \beta_{2\,1}(\text{Female}) + \ldots + \beta_{2\,16}(\text{Status of Academic Success}) \\ & + r_{2i}\end{aligned} \tag{A7}$$

where the βs in Equation A5 represent the individual effects on initial (age 14) rates of substance use (cigarettes, alcohol, or marijuana use) and the βs in Equations A6 and A7 (the patterns are the same as in Equation A5) represent the individual effects on linear and quadratic rates of change in substance use.

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