Sensation Seeking and Drug Use by Adolescents and Their Friends: Models for Marijuana and Alcohol*

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ABSTRACT. *Objective:* To investigate the prospective influence of individual adolescents' sensation seeking tendency and the sensation seeking tendency of named peers on the use of alcohol and marijuana, controlling for a variety of interpersonal and attitudinal risk and protective factors. *Method:* Data were collected from a cohort of adolescents (N = 428; 60% female) at three points in time, starting in the eighth grade. Respondents provided information about sensation seeking, the positivity of family relations, attitudes toward alcohol and drug use, perceptions of their friends' use of alcohol and marijuana, perceptions of influence by their friends to use alcohol and marijuana, and their own use of alcohol and marijuana. In addition, they named up to three peers, whose sensation seeking and use data were integrated with respondents' data to allow for tests of hypotheses about peer clustering and substance use. *Results:* Structural equation modeling analyses revealed direct effects of peers' sensation seeking on adolescents' own use of both marijuana and alcohol 2 years later. An unexpected finding was that the individual's own sensation seeking had indirect (not direct) effects on drug use 2 years later. *Conclusions:* These findings indicate the potential importance of sensation seeking as a characteristic on which adolescent peers cluster. Furthermore, the findings indicate that, beyond the influence of a variety of other risk factors, peer sensation seeking contributes to adolescents' substance use. (*J. Stud. Alcohol* **60:** 622-631, 1999)

THIS ARTICLE grows out of research addressing means of identifying a substantial portion of young people presumably at high risk of becoming drug users—adolescents and young adults with a high need for stimulation—and addressing their needs in prosocial ways. Sensation seeking, a personality trait involving preferences for novel, unusual, or risky situations (Zuckerman, 1979, 1983, 1994) has consistently been linked with drug and alcohol use among teenagers (Bates et al., 1994; Earleywine and Finn, 1991; Forsyth and Hundleby, 1987; Newcomb and McGee, 1989). In earlier studies, we found that up to 80% of adolescent users of specific drugs were high sensation seekers (Donohew et al., 1990).

Here, we report on the second phase of a two-part study of etiologic associations among need for sensation, peer group networks and drug use of adolescents. The first part (Donohew et al., unpublished manuscript) described the relationships between sensation seeking and peer networks. This second part reports the results of a structural equation modeling analysis of the associations among sensation seeking, friends' sensation seeking and the use of alcohol and marijuana. Data were collected from a cohort at three points in time, starting in eighth grade; additionally, a network analysis of adolescents' and friends' data was conducted prior to development of the models.

We propose that sensation seeking, an individual level intrapersonal trait, and social influences are complementary rather than contradictory explanations of adolescent drug use and that both peer network factors and sensation seeking influence the likelihood of use. It is plausible that individuals with high sensation seeking needs will tend to have similar interests and be members of the same peer group. It is also plausible that both social and individual forces are operating in a two-way casual fashion—in effect "causing" each other, in a reinforcing relationship.

Additionally, we suggest that high levels of sensation seeking positively influence the future likelihood of associating with drug-using peer groups; i.e., high sensation seekers will tend to select friends who engage in similar behaviors. Further, we suggest that high levels of sensation seeking are positively related to prodrug attitudes and susceptibility to peer influence to use alcohol or drugs which, in turn, predict use.

Sensation seeking and drug use

One of the risk factors underlying alcohol and drug use, as well as other risk behaviors, is sensation seeking (Zuckerman, 1979, 1983, 1987a,b, 1994). Our earlier research find-

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ings are consistent with those from other studies indicating that individuals with a high need for sensation begin using drugs at an earlier age and are more likely than low sensation seekers to become regular users (Bates et al., 1994; Kilpatrick et al., 1976; Pedersen, 1991; Schwarz et al., 1978; Segal et al., 1980; Zuckerman, 1979, 1983, 1994).

The research also indicates that individual differences in need for sensation and, to a lesser extent, in prior drug use, play a major role in responses to drug abuse prevention messages, with more powerful messages required for attracting and holding the attention of high sensation seekers. Responses include exposure preferences, physiological responses, and changes in attitude and behavioral intentions (Donohew et al., 1990, 1994; Lorch et al., 1994; Palmgreen et al., 1995).

Need for sensation, which has been found to be associated with preferences for novel, complex, and ambiguous stimuli (Zuckerman, 1979), has been measured both as a personality trait (Pearson, 1970, 1971; Zuckerman, 1978, 1983, 1987b; Zuckerman et al., 1964) and as part of a more general activation theory of information exposure (Donohew et al., 1980, 1988; Everett and Palmgreen, 1995).

According to Zuckerman, sensation seeking increases during adolescence then levels off in the mid- to late 20s. Changes or stability in sensation-seeking needs have recently been linked to changes in substance use patterns. For example, Bates and colleagues (1994) report that, over time, relative increases in sensation seeking are associated with increases in adolescent substance use. Decreases in need for sensation appear to curb increases in substance use but do not necessarily lead to reductions in use.

Two factors appear to underlie the consistent association between sensation seeking and adolescent drug and alcohol use (Segal et al., 1980). The risk or illegality associated with substance use provides one source of stimulation for the high sensation seeking adolescent. Furthermore, sensation seekers obtain direct neurological stimulation from the substance itself. Indeed, both novelty seeking and stimulant drug self-administration in animals may involve a common dopamine system in the brain (Bardo and Mueller, 1991; Bardo et al., 1989). Recent research connects the D4 dopamine receptor gene with novelty seeking (Benjamin et al., 1996; Cloninger et al., 1996; Ebstein et al., 1996). Presumably, if novelty-seeking and drug-seeking behaviors in humans activate a similar neurological system, novel or high sensation stimulation may function as substitutes for drug use (Bardo and Mueller, 1991; Bardo et al., 1996).

Peer influence

Although biological and psychological factors are considered to be risk factors for substance use, one of the most consistent findings is the effect of peer influence on substance use. Several studies have pointed to the influence of social network variables and psychosocial variables upon subsequent adolescent drug use (Kandel, 1985; Kandel et al., 1986; Kaplan et al., 1987). Adolescent drug use most often occurs in a peer context (Oetting and Beauvais, 1986; Oetting et al., 1991). Adoption of drug use occurs in a context where friends support and model drug use as well as make drugs available (Oetting and Beauvais, 1986). Oetting and Beauvais (1987) also claim that the dominant variable in adolescent drug use is the selection of peers with whom the individual chooses to associate, with the most important peers constituting a peer cluster. Peer cluster theory describes the association between peer relationships and drug use as direct, with drug use serving to shape group behavior and maintain group identity. However, the influence of the peer group does not necessarily reflect the concept of peer pressure as commonly understood (Oetting et al., 1991). Peer cluster theory suggests that all members of the peer group mutually affect each other. That is, all members agree on decisions and behaviors such as encouraging or discouraging substance use (Oetting and Beauvais, 1987). Thus, each member of the peer group is as much a persuader as he or she is persuaded.

Many have questioned why and how adolescents begin to affiliate with drug-using peers. Indeed, several factors may be operating in this process. Socialization characteristics related not only to peers but also to family, religion, schools, and the community may influence adolescent substance use (Oetting et al., 1991). Elliott et al. (1985) tested a model of marijuana and other illicit drug use, using as predictor variables the amount of time spent with family, amount of time spent on academic concerns, commitment to conventional school norms, and association with delinquent peers. Although the variables pertaining to family and school influenced the individual's likelihood of associating with deviant peers, only the association with such peers had direct effects on illicit drug use. Additionally, Massey and Krohn (1986) reported that commitment to school and belief in conventional norms were inversely related to the likelihood of affiliating with peers who smoke cigarettes. Cattarello (unpublished doctoral dissertation) found that the probability of associating with marijuana-using peers was affected by attachment to family, commitment to school, and marijuana-specific beliefs.

An important issue to consider here concerns the temporal ordering of peer affiliation and drug use. Does one choose peers and then begin to use drugs, or does one first use drugs and then select peers who engage in similar behaviors? Or, as we propose, do individual and social factors mutually influence each other?

Bauman and Ennett (1994) suggest that the role of peer influence is exaggerated when one fails to acknowledge factors other than influence per se. For example, both selection and projection may account for the strong correlation

between one's own drug use and the drug use of peers. Selection refers to the role of substance use in the formation of friendships; e.g., drug users may seek out other users as friends, while nonusers tend to affiliate with other nonusers. Projection occurs when persons attribute, or project, their behavior onto that of their friends. Neither selection nor projection proposes that friendship causes drug use (Bauman and Ennett, 1994).

Recent studies have attempted to simultaneously model both individual and peer group variables in order to determine their contributions to adolescent drug use. For example, Webb et al. (1993) examined the relationships among intrapersonal risk factors such as sensation seeking and tolerance of deviance; alcohol expectancies; and interpersonal factors of peer influence and perceived peer use of alcohol. Intrapersonal risk factors, a construct consisting of sensation seeking and tolerance to deviance loadings, exhibited both direct and indirect effects on alcohol use. Both intrapersonal and social factors indirectly influenced use through their influence on alcohol expectancies. Social risk factors did not directly affect use. Expectancies appeared to mediate the effect of both social and intrapersonal risks on use; however, intrapersonal risks also operated independently of expectancies. Dielman et al. (1993) reported that susceptibility to peer pressure as well as peer use and approval of use had the strongest direct effects on adolescent use and misuse of alcohol. Several studies report that peer factors influence adolescent alcohol and drug use (Kandel, 1985); however, other analyses have suggested that adolescents who use drugs will seek out peers who use drugs (Kandel, 1978). Because more than one etiological pathway exists for adolescent drug and alcohol use, we attempted to simultaneously model both individual and peer-group variables in order to determine their contributions to adolescent drug use.

Method

Participants

Eligible participants were a subsample of the initial cohort assessed in a large-scale evaluation of a primary prevention program in the Fayette County, Kentucky, school system beginning in the 6th grade (Clayton et al., 1996). Initially, participants were deemed eligible for the present analysis if, at either the 8th-, 9th-, or 10th-grade assessment, they named a peer who also participated in the study at that assessment. This criterion yielded a sample of 510 adolescents.[1] Careful scrutiny of the data revealed four recurring missing data patterns that could not be overcome using available imputation or modeling strategies. Dropping participants who evinced one of these patterns yielded an analysis sample of 428 (60% female) participants. Details regarding the handling of missing data are presented in the Results section.

Measures

Sensation seeking. From Form V of Zuckerman's (1978) Sensation Seeking Scale (SSS), 24 items were used to measure general sensation seeking of participants and their named peers.[2] Responses to individual items could range from 1 (disagree) to 5 (agree), and a total score was computed by averaging over the 24 items. Internal consistency of the measure was .78.

Peer sensation seeking. This was measured using the same 24-item scale for three of the respondent's peers. On the survey, respondents were asked to name three peers with whom they interacted most often. Respondent nomination of specific peers provides a more accurate representation of peer behavior than does estimation of the behavior of "generalized" others (Rice, 1993). If the nominated peers completed a questionnaire, their sensation seeking scores were matched to the respondent's data across the three time periods (Donohew et al., unpublished manuscript). For a small number of cases, the second- and/or third-named peers did not have complete data to create a measure of peer sensation seeking. For those cases, the score for the first-named peer was used as the peer sensation seeking score. Otherwise, the two or three peer sensation seeking scores were averaged.

Positive family relations. Seven items were used to assess the positivity of participants' family relations. Items queried respondents regarding how often they got along with their mother, got along with their father, had fun with parents, were happy at home, got attention at home, were understood by parents, and felt close to the family. Responses could range from 1 (never) to 5 (most of the time); the mean of responses to the seven items served as our measure of positive family relations.

Attitudes toward alcohol and drugs. Four items assessed *drug attitudes.* These are: "It is OK to try drugs once or twice just to see what they are like"; "It is OK for people to use drugs if drugs make them feel better"; "There is nothing wrong with using most drugs"; and "Drugs help you have more fun." *Alcohol attitudes* were measured by agreement or disagreement with the statement: "It is okay to buy alcohol." All attitude variables had a response range from 1 (disagree strongly) to 5 (agree strongly).

Perceptions of friends' use. Two items queried participants regarding the proportion of their friends who use alcohol and marijuana. Response options were *none, 1 or 2, some, most,* and *all.*

Perceived influence to use alcohol and marijuana. Susceptibility to peer influence was measured by items that asked whether the respondent would "smoke marijuana if asked" and "drink alcohol if offered some." Responses for these variables ranged from 1 (definitely not) to 5 (definitely would).

Alcohol and marijuana use. In two items, participants and peers were asked how many times they used alcohol and

marijuana during the past year. Responses could range from 1 (none) to 7 (40 or more times).

Procedure

Participants completed the questionnaire, from which the present measures were drawn, at school near the end of their 8th-, 9th- and 10th-grade years. A passive consent procedure was used, and approximately 1% of students were not granted parental permission. Trained data collectors emphasized confidentiality by demonstrating the separation of identifying information from questionnaire responses. Participants typically completed the questionnaire in about 45 minutes. Participants who had difficulty reading the questionnaire were either interviewed or permitted to mail in the questionnaire after completing it. Named peers' scores on sensation seeking, alcohol use, and drug use were merged with participants' data records to permit tests of hypotheses regarding peer influence.

Results

Handling of missing data

Of the 510 participants in the sample, 389 (76%) provided useable data on every variable at every occasion. The prevalence of missing data for every variable at each assessment is presented below. Note that, with the exception of data from peers, missing data for individual variables range from 0 to 2% of the sample and, for the most part, are less than 1% of the sample.

Among the 121 participants with incomplete data, three systematic patterns involving the peer measures accounted for most of the missing data. There were 30 participants missing only peer data in the 8th grade, an additional 30 participants were missing only peer data in the 9th grade, and 15 participants were missing only peer data in the 10th grade. An additional seven participants were missing peer data for two of the three assessments. Because these subsamples numbered fewer than the number of variables ($k = 39$), we were unable to use a multigroup structural equation model as a means of keeping them in the analysis sample (Muthén et al., 1987) and these 82 participants were not included in the analyses. Analysis of the missing data patterns revealed that missing data on any of the peer variables were not associated with alcohol or marijuana use, and missing data on peer variables at one assessment were not associated with missing data on peer variables at the other assessments.

For the remaining 39 participants with incomplete data, missing data were infrequent and widely scattered. In order to keep these participants in the analysis sample we used a regression imputation strategy to replace missing values with predicted ones. Missing values were imputed by regressing each variable on which there were missing values on the remaining 38 variables and on the gender of the participant.[3] Multiple *R*s for these equations ranged from .50 to .85 (mean = .73). After imputation, the analysis sample included 428 participants (84% of the full sample).

Zero-order associations

Correlations among all the variables as well as means and standard deviations are displayed in Table 1. Note that sensation seeking and family relations were very stable across the period of the study. With the exception of marijuana use, the remaining variables were moderately stable over time. Marijuana use was stable between 9th and 10th grades, but was unstable from 8th to 9th and 8th to 10th grades.

Correlations between actual peer alcohol and marijuana use and participants' perceptions of their friends' use were modest. At the 8th-grade assessment, peer alcohol and marijuana use were modestly correlated with perceptions of alcohol and marijuana use. At each assessment, participant and peer sensation seeking were modestly correlated. The correlation between alcohol and marijuana use increased substantially from year to year. Within wave, alcohol use was most strongly associated with perceived peer influence to use alcohol, attitudes toward drug use, perceived alcohol use by friends, and sensation seeking; by 10th grade, actual peer alcohol use is among the strongest correlates of alcohol use. Marijuana use, within wave, was most strongly associated with perceived marijuana use by friends, attitudes toward drug use and peer marijuana use (9th and 10th grades); by 10th grade, peer sensation seeking was among the strongest correlates of marijuana use.

Model specification

Thirteen variables were included at each of three waves: 8th, 9th and 10th grade. The variables (with the prevalence of missing data for each wave) follow: sensation seeking (0, 0, 0); positive family relations (<1, <1, 0); attitude toward alcohol use (<1, <1, 0); attitude toward drug use (<1, <1, 0); peer sensation seeking (7, 8, 4); perceived alcohol use by friends (1, 0, <1); perceived marijuana use by friends (2, 1, <1); peer alcohol use (7, 8, 4); peer marijuana use (7, 8, 4); perceived peer influence to use alcohol (<1, <1, <1); perceived peer influence to use marijuana (<1, <1, 0); alcohol use—past year (<1, <1, <1); marijuana use—past year (<1, <1, 0). Values are percentages of a total *N* of 510. Actual *n*'s ranged from 470 to 510 with a mean of 501. As is typical, the exogenous variables (8th-grade assessment) were permitted to covary. Within wave, disturbances associated with endogenous variables (9th- and 10th-grade assessments) were permitted to covary. In the initial model specification, only lag1 effects were estimated (i.e., paths from 8th-grade variables to 10th-grade variables are

TABLE 1. Correlations and descriptive statistics for variables in the structural equation model

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
8th Grade Assessment																			
1. Sen. sk.																			
2. Pos. fam.	.34																		
3. Alc. att.	−.30	−.25																	
4. Drug att.	−.38	−.32	.64																
5. Pr. sen. sk.	.29	.13	−.23	−.19															
6. Fr. alc. use	.25	.28	−.20	−.18	.11														
7. Fr. mj use	.17	.20	−.18	−.23	.09	.62													
8. Pr. alc. use	.21	.11	−.18	−.08	.35	.26	.28												
9. Pr. mj use	.07	.07	−.09	−.12	.11	.26	.33	.45											
10. Alc. infl.	.47	.41	−.55	−.53	.24	.32	.21	.20	.07										
11. Mj infl.	.27	.34	−.51	−.57	.14	.18	.24	.10	.23	.51									
12. Alc. use	.35	.28	−.41	−.32	.16	.28	.22	.25	.06	.60	.29								
13. Mj use	.05	.12	−.19	−.18	.01	.14	.25	.19	.21	.14	.27	.20							
9th Grade Assessment																			
14. Sen. sk.	**.72**	.25	−.18	−.27	.20	.11	.08	.12	−.01	.33	.17	.29	.04						
15. Pos. fam.	.28	**.68**	−.16	−.25	.07	.21	.19	.08	.02	.25	.20	.23	.09	.28					
16. Alc. att.	−.33	−.23	**.31**	.39	−.18	−.14	−.19	−.15	−.08	−.42	−.31	−.34	−.07	−.41	−.31				
17. Drug att.	−.31	−.21	.37	**.59**	−.18	−.12	−.19	−.11	−.10	−.38	−.44	−.21	−.13	−.34	−.32	.66			
18. Pr. sen. sk.	.31	.06	−.13	−.16	**.37**	.03	−.06	.10	−.08	.23	.10	.19	−.02	.30	.10	−.24	−.23		
19. Fr. alc. use	.27	.22	−.14	−.23	.07	**.40**	.33	.11	.06	.27	.26	.26	.10	.29	.29	−.37	−.36	.07	
20. Fr. mj use	.24	.17	−.25	−.27	.11	.31	**.40**	.21	.21	.29	.32	.26	.21	.25	.24	−.32	−.41	.04	.57
21. Pr. alc. use	.16	−.02	−.16	−.11	.21	.14	.13	**.30**	.14	.18	.11	.19	.08	.15	.06	−.18	−.22	.36	.20
22. Pr. mj use	.19	.06	−.09	−.14	.14	.06	.12	.26	**.24**	.16	.15	.18	.20	.15	.09	−.15	−.20	.24	.07
23. Alc. infl.	.38	.30	−.31	−.35	.15	.14	.20	.20	.04	**.57**	.27	.41	.10	.42	.37	−.61	−.47	.19	.35
24. Mj infl.	.24	.21	−.21	−.38	.13	.10	.24	.09	.07	.27	**.41**	.14	.16	.26	.30	−.38	−.58	.17	.34
25. Alc. use	.30	.15	−.34	−.29	.21	.14	.16	.27	.09	.45	.28	**.47**	.17	.39	.23	−.63	−.47	.22	.39
26. Mj use	.17	.13	−.24	−.30	.14	.07	.12	.20	.12	.22	.32	.21	**.27**	.23	.16	−.34	−.49	.16	.27
10th Grade Assessment																			
27. Sen. sk.	**.63**	.18	−.17	−.21	.19	.08	.06	.09	.00	.27	.17	.21	.00	**.73**	.17	−.25	−.22	.29	.12
28. Pos. fam.	.22	**.61**	−.15	−.23	.11	.17	.10	.11	.05	.24	.23	.18	.16	.23	**.69**	−.26	−.22	.05	.23
29. Alc. att.	−.29	−.17	**.25**	.28	−.15	−.14	−.13	−.12	−.07	−.33	−.23	−.26	−.04	−.33	−.16	**.51**	.36	−.19	−.26
30. Drug att.	−.32	−.13	.23	**.37**	−.22	−.07	−.14	−.12	−.12	−.28	−.29	−.21	−.05	−.35	−.20	.50	**.54**	−.23	−.22
31. Pr. sen. sk.	.21	.09	−.16	−.11	**.30**	.01	−.08	.05	−.09	.18	.06	.15	−.03	.23	.06	−.15	−.10	**.34**	−.04
32. Fr. alc. use	.26	.19	−.10	−.13	.11	**.41**	−.08	.05	−.09	.18	.06	.15	.07	.26	.20	−.28	−.21	.08	**.54**
33. Fr. mj use	.30	.20	−.23	−.27	.20	.34	**.33**	.27	.20	.30	.31	.29	.14	.32	.21	−.35	−.36	.17	.48
34. Pr. alc. use	.22	.05	−.19	−.16	.27	.06	.08	**.23**	.05	.23	.16	.21	.01	.22	.06	−.26	−.17	.25	.10
35. Pr. mj use	.15	.05	−.18	−.18	.23	.02	.08	.21	**.12**	.18	.19	.26	.07	.16	.09	−.26	−.21	.23	.05
36. Alc. infl.	.35	.27	−.25	−.29	.18	.20	.28	.20	.12	**.44**	.19	.33	.14	.36	.28	−.44	−.33	.16	.29
37. Mj infl.	.38	.20	−.27	−.40	.19	.07	.18	.12	.15	.34	**.36**	.23	.16	.37	.20	−.43	−.47	.19	.27
38. Alc. use	.31	.22	−.29	−.28	.17	.18	.21	.24	.08	.43	.24	**.44**	.09	.37	.23	−.49	−.38	.16	.35
39. Mj use	.27	.11	−.28	−.28	.22	−.01	.10	.24	.11	.32	.28	.30	**.16**	.31	.12	−.41	−.42	.25	.24
Mean	3.02	1.85	4.73	4.74	3.04	1.50	1.33	1.59	1.09	2.01	1.24	1.50	1.04	3.14	2.00	4.36	4.60	3.15	1.90
SD	.51	.91	.71	.49	.40	.75	.66	.86	.46	1.24	.73	.93	.28	.51	.97	1.09	.71	.42	1.00

constrained to zero). As such, the fit of the initial model was tested on 169 degrees of freedom.

Model fit

We used three criteria, all based on maximum likelihood estimation, to evaluate model fit. The SCALED χ^2 (Satorra and Bentler, 1988) is a corrected form of the standard χ^2 variate used to evaluate the omnibus fit of structural equation models. SCALED χ^2, which corrects for the ill effects of nonnormality on the standard χ^2 variate, appears to be the optimal test statistic for evaluating optimal fit of structural equation models at this time (Hu et al., 1992). Mardia's (1970) test of multivariate kurtosis (normalized estimate = 137.02) revealed that the present data were not multivariate normal. We also consulted the comparative fit index (CFI; Bentler, 1990), a normed index that reflects the improvement in fit of a proposed model over the null, or independence, model; values of CFI greater than .90, in most instances, reflect good fit. Finally, we used the root mean square error of approximation (RMSEA; Steiger, 1990) to evaluate the fit of our models. RMSEA is bounded by zero, a value it will take when a model exactly reproduces a set of observed data. Browne and Cudeck (1993) propose .05 as a value indicative of close fit, .08 as indicative of marginal fit and .10 as indicative of poor fit of a model taking into account degrees of freedom of the model.

Estimation of our initial model produced promising fit statistics (SCALED $\chi^2 = 284.98$, 169 df, $n = 428$, $p < .001$, CFI = .97, RMSEA = .05). Follow-up multivariate Lagrange multiplier tests revealed 14 nonzero lag2 paths. Freeing those paths produced a model with excellent fit to the data (SCALED $\chi^2 = 151.61$, 155 df, $n = 428$, $p = .56$, CFI = 1.00, RMSEA = .02). The 95% confidence interval on RMSEA ranged from 0 to .032, further underscoring the

TABLE 1. (cont.)

Variable	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
8th Grade Assessment																				
1. Sen. sk.																				
2. Pos. fam.																				
3. Alc. att.																				
4. Drug att.																				
5. Pr. sen. sk.																				
6. Fr. alc. use																				
7. Fr. mj use																				
8. Pr. alc. use																				
9. Pr. mj use																				
10. Alc. infl.																				
11. Mj infl.																				
12. Alc. use																				
13. Mj use																				
9th Grade Assessment																				
14. Sen. sk.																				
15. Pos. fam.																				
16. Alc. att.																				
17. Drug att.																				
18. Pr. sen. sk.																				
19. Fr. alc. use																				
20. Fr. mj use																				
21. Pr. alc. use	.20																			
22. Pr. mj use	.18	.49																		
23. Alc. infl.	.33	.22	.21																	
24. Mj infl.	.48	.21	.24	.49																
25. Alc. use	.38	.28	.19	.64	.38															
26. Mj use	.48	.28	.43	.29	.56	.43														
10th Grade Assessment																				
27. Sen. sk.	.16	.12	.14	.30	.17	.28	.18													
28. Pos. fam.	.24	−.02	.09	.29	.24	.18	.14	.16												
29. Alc. att.	−.35	−.20	−.13	−.53	−.30	−.42	−.21	−.35	−.25											
30. Drug att.	−.33	−.20	−.19	−.47	−.40	−.41	−.27	−.36	−.25	.76										
31. Pr. sen. sk.	−.01	.09	.04	.11	.01	.18	.05	.27	.08	−.19	−.18									
32. Fr. alc. use	.37	.24	.12	.33	.20	.33	.22	.26	.20	−.37	−.29	.09								
33. Fr. mj use	**.53**	.29	.23	.36	.34	.42	.34	.33	.22	−.45	−.48	.21	.66							
34. Pr. alc. use	.19	**.29**	.27	.34	.18	.34	.14	.27	.11	−.36	−.33	.40	.25	.32						
35. Pr. mj use	.24	.20	**.28**	.21	.21	.33	.28	.22	.15	−.27	−.32	.29	.15	.38	.57					
36. Alc. infl.	.25	.20	.19	**.63**	.30	.44	.21	.35	.32	−.56	−.52	.12	.39	.44	.28	.25				
37. Mj infl.	.36	.23	.30	.45	**.50**	.40	.38	.42	.26	−.57	−.72	.12	.32	.55	.34	.34	.54			
38. Alc. use	.38	.28	.22	.60	.37	**.63**	.34	.37	.22	−.58	−.50	.22	.45	.55	.42	.39	.62	.53		
39. Mj use	.39	.24	.33	.37	.45	.51	**.58**	.30	.11	−.41	−.53	.16	.26	.53	.31	.44	.38	.64	.61	
Mean	1.44	2.07	1.18	2.51	1.37	1.95	1.12	3.29	2.03	4.12	4.39	3.28	2.28	1.86	2.68	1.46	2.67	1.69	2.53	1.42
SD	.78	1.27	.69	1.38	.95	1.49	.62	.60	.97	1.29	.93	.47	1.07	1.01	1.59	1.16	1.38	1.22	1.88	1.24

Notes: Sen. sk. = participant sensation seeking; Pos. fam. = positive family relations; Alc. att. = attitude toward alcohol use; Drug att. = attitude toward drug use; Pr. sen. sk. = mean sensation-seeking score of named peers; Fr. alc. use = perceived alcohol use by friends; Fr. mj use = perceived marijuana use by friends; Pr. alc. use = mean alcohol use by named peers; Pr. mj use = mean marijuana use by named peers; Alc. infl. = perceived influence by friends to use alcohol; Mj infl. = perceived influence by friends to use marijuana; Alc. use = alcohol use during past year; Mj use = marijuana use during past year. All correlations are based on $n = 428$. Coefficients in bold type face are test-retest correlations. Coefficients ≤.08 are significant at $p < .05$.

good fit of the adjusted model. The χ^2-difference test was nonsignificant ($\chi^2 = 133.37$, 14 df, $n = 428$, $p < .001$), indicating a highly significant reduction in the SCALED χ^2 as a result of freeing the lag2 parameters.

Parameter estimates

Completely standardized maximum likelihood estimates of path coefficients are displayed in Table 2. Statistical tests of parameters were based on robust standard errors (Bentler and Dijkstra, 1985), which correct for nonnormality. In the first row under each variable name are the path coefficients for effects of 8th-grade variables on 9th-grade variables. In the second row are coefficients for 9th- to 10th-grade effects. For some variables, the modified model included lag2 paths from 8th-grade variables to 10th-grade variables. In those instances, a third row includes those path coefficients. To provide orientation, coefficients for autoregressive paths are in bold typeface.

The importance of particular variables as predictors is made clear as one reviews the table. Sensation seeking most strongly predicted the sensation seeking level of named peers, particularly for 9th graders. Sensation seeking also predicted attitudes toward alcohol and drug use as well as perceived influence to use alcohol and marijuana. Interestingly, sensation seeking, in the context of the remaining variables, failed to predict alcohol or marijuana use. Peer sensation seeking was not a prominent predictor, but it did

TABLE 2. Completely standardized maximum likelihood estimates of path coefficients in full structural model

Outcome (lag)	1	2	3	4	5	6	7	8	9	10	11	12	13	R^2
1. Sensation seeking														
8th→9th	**.73**‡	.02	.06	−.03	.00	−.07	−.00	−.01	−.04	−.02	−.01	.08	.01	.54
9th→10th	**.60**‡	−.02	.07	.01	.07	−.11†	.02	−.01	.00	.02	−.03	.04	.05	.57[a]
8th→10th	**.21**‡													
2. Positive family relations														
8th→9th	.07	**.67**‡	.03	−.09	−.04	−.01	.07	.03	−.05	−.11*	−.05	.07	.00	.48
9th→10th	.01	**.50**‡	−.09	.06	−.01	−.00	.12*	−.08*	.06	−.01	.03	−.02	−.05	.54[a]
8th→10th		**.25**‡					−.10†						.09†	
3. Attitude toward alcohol use														
8th→9th	−.11*	−.02	**−.03**	.19*	−.04	.09	−.10	−.04	−.00	−.18*	−.05	−.12	.05	.25
9th→10th	−.08	.10*	**.29**‡	−.01	−.04	.05	−.22‡	−.06	.02	−.34‡	.02	.04	.06	.38
4. Attitude toward drug use														
8th→9th	−.08	.03	−.08	**.49**‡	−.04	.06	−.08	−.05	.03	−.07	−.15*	.03	.00	.38
9th→10th	−.11†	.05	.12	**.33**‡	−.07	.10*	−.15†	−.02	−.04	−.20‡	−.06	−.04	.12	.40[a]
8th→10th										−.10†				
5. Peer sensation seeking														
8th→9th	.21‡	−.09	.07	−.05	**.32**‡	.04	−.14†	.00	−.10	.06	.03	.08	.00	.23
9th→10th	.14*	.03	.00	−.01	**.26**‡	−.13*	−.00	−.02	−.05	−.01	−.08	.13*	.00	.18[a]
8th→10th					**.13**†									
6. Perceived alcohol use by friends														
8th→9th	.13*	.01	.13	−.08	−.03	**.28**‡	.12*	.02	−.10	−.02	.17*	.11	−.01	.24
9th→10th	.08	−.01	−.03	.08	−.03	**.36**‡	−.04	.10*	−.01	.13*	−.07	.03	.07	.38[a]
8th→10th						**.21**‡								
7. Perceived marijuana use by friends														
8th→9th	.09	−.04	−.02	−.04	−.01	.04	**.26**‡	.05	.04	.03	.14	.08	.05	.25
9th→10th	.09*	−.02	.00	−.03	.03	.15†	**.28**‡	.07	.06	.04	.01	.12	.01	.42[a]
8th→10th						.16‡								
8. Peer alcohol use														
8th→9th	.05	−.15†	−.03	.01	.10	.05	.00	**.21**‡	.00	.05	.04	.08	.01	.14
9th→10th	.05	−.07	−.05	.06	.12†	−.12*	.14*	**.12**	.15*	.17†	.01	.18*	−.14	.23
9. Peer marijuana use														
8th→9th	.12	−.05	.10	−.06	.04	−.11	−.02	.14	**.15**	.03	.03	.09	.13	.14
9th→10th	−.01	−.00	−.11	.04	.13†	−.19*	.19†	−.01	**.17***	−.10	.04	.22†	.03	.22[a]
8th→10th												.10		
10. Perceived peer influence to use alcohol														
8th→9th	.12†	.08	.04	−.07	−.05	−.19†	.17†	.11*	−.05	**.47**‡	−.06	.07	−.02	.38
9th→10th	.10*	.03	−.05	.01	.01	.03	−.05	.03	.03	**.53**‡	−.06	.01	.03	.44[a]
8th→10th							.16‡							
11. Perceived peer influence to use marijuana														
8th→9th	.09	.03	.14	−.23‡	.03	−.12*	.20†	.05	−.08	.04	**.28**‡	−.04	.04	.25
9th→10th	.15‡	−.06	−.11	−.07	−.01	−.03	.10	.01	.14†	.09	**.24**‡	.05	−.02	.40[a]
8th→10th				.08*										
12. Alcohol use (past year)														
8th→9th	.08	−.07	−.04	−.02	.06	−.09	.05	.13*	−.02	.19†	.05	**.28**‡	.04	.31
9th→10th	.07	−.03	−.06	.04	−.05	.01	.09	.08	.03	.25‡	.04	**.30**‡	.01	.50[a]
8th→10th												**.11**†		
13. Marijuana use (past year)														
8th→9th	.03	−.02	.04	−.18*	.04	−.03	−.03	.15*	−.04	−.04	.19†	.07	**.18**	.19
9th→10th	.06	−.06	−.08	−.00	.09	−.02	.11	−.03	.10	−.03	.10	.25‡	**.31**‡	.47[a]
8th→10th						−.09†								

Note: Coefficients in bold are for autoregressive paths.
[a] R^2 is for equation that also includes 8th→10th path(s).
†$p < .05$; ‡$p < .01$; ‡$p < .001$; statistical tests based on robust standard errors.

predict (as might be expected) peer alcohol and marijuana use and, at a marginally significant level ($p = .06$), respondent marijuana use in the 10th grade. Peer alcohol use predicted perceived use of alcohol by friends, perceived peer influence to use alcohol and alcohol and marijuana use in the 9th grade. Peer marijuana use predicted only peer alcohol use and perceived peer influence to use marijuana in the 10th grade. Participants' alcohol use predicted peer alcohol use, peer marijuana use, and peer sensation seeking in the 10th grade; marijuana use was not a significant predictor of variables in the model. Perceived influence by peers to use alcohol was a consistent predictor of other variables in the model, influencing family relations, attitudes toward alcohol use, attitudes toward drug use, peer alcohol use, and alcohol use in

both the 9th and 10th grades. Perceived influence by peers to use marijuana was less important as a predictor, though it was the strongest predictor of 9th-grade marijuana use.

Looking across rows in the final two sections of the table reveals the strength of the model at predicting alcohol and marijuana use during the past year. Looking to the end of those rows, it is clear the prediction of 10th-grade use was substantially better than prediction of 9th-grade use. The 10th-grade R^2s for marijuana reveal that variables in the model are significant predictors of substance use. Ninth-grade alcohol use was predicted by peer alcohol use, perceived peer influence to use alcohol, and alcohol use at the previous assessment. Tenth-grade alcohol use was predicted by perceived influence by peers to use alcohol as well as alcohol use at each of the previous two assessments. Marijuana use in the 9th grade was predicted by attitude toward drug use, peer alcohol use and perceived peer influence to use marijuana. Marijuana use in the 10th grade was predicted by peer sensation seeking, alcohol use, and marijuana use at the previous year's assessment.

Discussion

The purpose of this study was to examine the influence of individual and peer variables on later alcohol and marijuana use. Previous studies have suggested causal relationships between sensation seeking and drug use and between peer influence and drug use; the findings in this study suggest that the actual process of using drugs and alcohol involves both sensation seeking and peer network factors.

Among the findings of this study having greater theoretical significance are those indicating an indirect route from individual sensation seeking through peers to drug and alcohol use. In other words, the intrapersonal trait of sensation seeking did not exert a direct effect on drug use but instead appeared to exert its influence *indirectly,* with adolescents picking persons of similar sensation seeking levels and the sensation seeking level of these peers tending to influence peer alcohol and marijuana use. This finding, coupled with the finding that participants' sensation seeking predicted sensation seeking level of named peers, indicates that sensation seeking plays a role in the formation of peer clusters (Oetting and Beauvais, 1986, 1987), possibly through mutual attraction to activities involving novelty and risk. This is further reinforced by the finding that attitudes toward two risky activities, alcohol and drug use, were directly related to sensation seeking. Sensation seeking was also related to perceptions about the amount of influence peers would have on individuals' own use of alcohol and drugs.

Perceived influence by peers to use alcohol was a predictor of attitudes toward alcohol and drug use in the 9th and 10th grades; however, perceived influence by peers on use of marijuana only predicted individual marijuana use in 9th grade. *Actual* use of alcohol by participants and by peers also predicted some of the perceptions and future use by participants and peers. Marijuana use by participants was not a significant predictor, however, and marijuana use by peers predicted only peer alcohol use and perceived peer influence on marijuana use in 10th grade.

A noteworthy set of findings concerns the actual versus perceived use of alcohol and marijuana by peers and the effects of those two variables on alcohol and marijuana use. The correlations between perceptions of friends' alcohol and marijuana use and friends' reports of their own alcohol and marijuana use were consistently weak across the period of the study. Neither measure was a strong predictor of respondents' alcohol and marijuana use; however, named peers' reports of alcohol use at the 8th-grade assessment predicted respondents' alcohol use the following year, and named peers' reports of marijuana use at the 8th-grade assessment predicted respondents' marijuana use the following year. This pattern of findings raises questions regarding adolescents' ability to accurately predict their friends' drug and alcohol use and the degree to which perceived versus actual use by friends affects own use.

A proper evaluation of the pattern of associations highlighted by the structural equation model requires consideration of the strategy by which the associations were estimated. Because of the size of our model—13 variables measured at three occasions—we were not able to model latent variables and, thereby, control for measurement error. Thus, although the reliability of our measures is within typical range, the path coefficients are attenuated to varying degrees as a result of measurement error. Also, between-wave effects were estimated after controlling for the effect of the variable on itself across waves. For instance, the effect of peer sensation seeking at Time 1 on marijuana use at Time 2 was evaluated controlling for the effect of Time 1 marijuana use. Although this is an appropriate and rigorous test of prospective associations, it works against large path coefficients. Finally, we felt it appropriate to evaluate the focal associations controlling for a variety of risk and protective factors not directly relevant to our analysis. In so doing, we provided strong tests of our hypotheses by requiring that any effects *add* to effects that might be attributed to other plausible predictors. In short, the seemingly modest path coefficients, where significant, are impressive when considered in light of the means by which they were estimated.

In conclusion, given that higher sensation seekers search for novel and exciting situations, perhaps the selection of friends is, in itself, a sensation-seeking activity. Prevention efforts might be improved by taking into account both individual and peer network variables, especially given the potential sources of stimulation that friends may be able to provide.

Notes

1. Extensive statistical comparisons of the 510 eligible participants and the 1,430 members of the initial cohort who provided data on multiple occasions revealed no practically significant differences. Comparisons on 30

variables potentially relevant to the processes under investigation yielded 17 statistically significant differences ($p < .05$), largely attributable to the high power of the between-group t tests. In terms of practical significance, the average effect size (Pearson's r) across the statistically significant comparisons was .08. The two effect sizes that exceeded $r = .10$ were, "How well are you doing in school?" ($r = .13$ favoring participants not in the present sample); and gender ($\phi = .15$ favoring females in the present sample).

2. Because of the length of the evaluation survey, it was not feasible to include the full 40-item Sensation Seeking Scale. The 24 items retained in the survey were selected for their suitability for adolescents and represented the four content areas of the Sensation Seeking Scale. Empirical comparisons between the 24-item scale and Form V of the Sensation Seeking Scale have supported the integrity of the brief measure; the correlations among subscales and between the scale and outcomes are highly similar, and the correlations between corresponding subscales as well as the full scale are 1.0 when corrected for attenuation (Lynam, 1997).
3. For comparison purposes we also used Rubin's (1987) sampling/importance resampling (SIR) algorithm to impute missing values (available as a SAS macro at the Prevention Science and Methodology Group website: http://yates.coph.usf.edu/research/psmg/Sirnorm/sirnorm.html). Results were indistinguishable from those reported here.

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