

Temperament Related to Early-Onset Substance Use: Test of A Developmental Model

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We tested a theoretical model of early-onset substance (tobacco, alcohol, and marijuana) use. A sample of 1,810 public school students was surveyed in sixth grade (*M* age 11.5 years) and seventh grade. Temperament dimensions were related to substance use, and structural modeling analyses showed indirect effects through self-control constructs. Good self-control had a path to higher academic competence and had direct effects to less peer use and less adolescent substance use; poor self-control had a path to more adolescent life events and more deviant peer affiliations. Academic competence and life events had indirect effects to adolescent substance use, through peer affiliations. Findings from self-report data were corroborated by independent teacher ratings. Effects were also noted for family variables and demographic characteristics. Implications of epigenetic theory for prevention research are discussed.

KEY WORDS: temperament; self-control; substance use; early onset; epigenetic theory.

INTRODUCTION

Early onset of substance use is known to have prognostic significance. Follow-back and follow-up studies have shown that substance use before the age of 13 years is predictive of substance abuse problems at later ages (Hawkins *et al.*, 1997; Kandel & Davies, 1992; Robins & Przybeck, 1985). Thus it is important to obtain a better understanding of the processes that act to either promote or deter early use. Theoretical models have suggested that temperament dimensions

may be particularly relevant for early onset (Tarter & Vanyukov, 1994; Zucker, 1994). Temperament is defined as simple characteristics that are early appearing, have some stability over time, and have a constitutional basis (Pedlow *et al.*, 1993; Rothbart & Ahadi, 1994; Rothbart *et al.*, 1994).⁶ Lifespan studies have shown that temperament measures in childhood are related to substance use at later ages (Cloninger *et al.*, 1988; Pulkkinen & Pitkänen, 1994). However, there has been little evidence available to test theoretical models of the relation between temperament and substance use, during the time when onset is actually occurring.

This research tested predictions derived from epigenetic models of behavioral development (Scarr, 1992; Tarter *et al.*, 1995). Epigenetic theory posits that

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⁶Temperament differs from personality in that temperament dimensions are early simple attributes that reflect the "style" of behavior, while adult personality characteristics are complex organized domains including elaborated content involving action tendencies, beliefs and attitudes, and orientations toward social relationships, added with cognitive and social maturation and experience. The linkage of these concepts is discussed in several places (Angleitner & Ostendorf, 1994; Molfese & Molfese, 2000; Rothbart & Ahadi, 1994).

behavior becomes increasingly complex over time with cognitive and social maturation, and that organization of behavior at one point in time influences organization at subsequent points in time (Cairns & Cairns, 1994; Rothbart & Ahadi, 1994). This perspective proposes that temperament will be related to patterns of adaptation and suggests that temperament characteristics may have indirect effects on early onset of tobacco and alcohol use because of relations to complex self-control ability, which is posited as a central factor in substance use liability (Miller & Brown, 1991; Sher & Trull, 1994). This theoretical model was tested with data from a representative sample of children beginning around 11 years of age, a time when rates of substance use are generally low (Johnston *et al.*, 1995). Structural modeling analyses tested the predictions that (a) simple temperament dimensions are related to more complex self-control abilities, and (b) self-control is related to exposure to proximal factors such as negative life events and deviant peer affiliations (Hawkins *et al.*, 1992; Wills, 1990). The following sections outline the basis for the predictions about protective and risk-promoting processes.

Temperament Dimensions

Temperament dimensions are simple characteristics that reflect the “style” of behavior (Buss & Plomin, 1984; Windle & Lerner, 1986). Several dimensions of temperament have suggestive linkages to substance use (Lerner & Vicary, 1984; Tarter, 1988) and a good record for replication across studies (Rothbart & Bates, 1998). Dimensions predicted to be positively correlated with substance use are *physical activity level*, the tendency to be physically active and to have difficulty sitting still, and *negative emotionality*, the tendency to become easily and intensely upset. Dimensions predicted to be inversely correlated with substance use are *task attentional orientation*, the ability to focus attention on a task and ignore distracting stimuli, and *positive emotionality*, the tendency to easily and frequently experience positive mood. Dimensions with an ambiguous theoretical status are *sociality*, the tendency to like being around people, and *rigidity* (vs. flexibility), the tendency to have difficulty adapting to change. Prior research has found complex effects for social dimensions (Tarter, 1988) and rigidity has been associated with the construct of shyness or inhibition, which has sometimes been suggested as a risk factor (Kellam *et al.*, 1980) and sometimes suggested as a protective factor (Kerr *et al.*, 1997).

Available evidence shows these dimensions to have some stability of core attributes over time (Pedlow *et al.*, 1993) and to have moderate heritability (Rothbart & Bates, 1998). It should be noted that the temperament dimensions discussed here are not construed as psychopathological characteristics; rather they are construed as attributes that are normally distributed in the population and make independent contributions to adjustment.

Temperament, Self-Control, and Substance Use

Epigenetic models posit that behavioral manifestations of temperament characteristics change as children acquire progressively more complex cognitive and social skills in response to maturational and environmental influences (Tarter *et al.*, 1995). For example, a high activity level would make it more difficult for a child to develop self-control skills because the stylistic characteristic of high activity is conducive to more off-task time and less positive relationships with socializing agents such as parents and teachers; conversely, the characteristic of focusing attention would be conducive to mastering cognitive self-regulation skills and temporal linking of behaviors and consequences (Barkley, 1997; Kochanska *et al.*, 2000; Rothbart & Ahadi, 1994). Developmental models suggest that such processes will be reflected in adolescence in more complex self-control abilities such as keeping promises and planning behavior, or being impatient and impulsive. This perspective predicts that temperament measures will be related to the more complex self-control abilities that occur with cognitive and social maturation. Two domains of self-regulation involving good self-control and poor self-control, respectively, have been noted as distinct domains that have somewhat different antecedents and consequences (Block & Block, 1980; Rothbart & Bates, 1998). The predictions derived are that task orientation and positive emotionality (and possibly sociability) will be related to good self-control ability, whereas activity level and negative emotionality (and possibly rigidity) will be related to poor self-control ability.

The theoretical model links self-control constructs to substance use by positing that self-control affects exposure to proximal factors (Wills *et al.*, 2000). A protective pathway is suggested through the relationship of good self-control to academic competence, which has been shown to be inversely related to adolescent substance use (Hawkins *et al.*, 1992; Wills *et al.*, 1992). A risk-promoting pathway for poor

self-control is suggested through relations to experiencing more negative life events and affiliating with substance-using peers, each of which has been consistently linked to substance use (Castro *et al.*, 1987; Chassin *et al.*, 1993; Wills *et al.*, 1992). Although some negative events may be outside the control of the adolescent, other events may be related to self-control because they involve planning and organization (e.g., completing school assignments, organizing social activities) or because they involve interpersonal behavior related to irritability and impulsiveness (e.g., talking back to teachers, being inconsiderate or hostile toward peers). Thus it was predicted that good self-control will be related to academic competence, and that poor self-control will be related to negative life events and deviant peer affiliations. The epigenetic model suggests that it is the complex self-control characteristics, rather than the simple temperament dimensions, that are involved in protection vs. vulnerability for substance use. Thus we further predicted that temperament dimensions would not have significant direct effects to substance use, but rather would have indirect effects through self-control ability.

The research was designed to investigate two other constructs that are implicated in adolescent substance use, risk-taking tendency and attitudinal tolerance for deviance (Jessor & Jessor, 1977). Previous research has suggested that deviance-prone attitudes represent a pathway that is somewhat independent of stress-coping factors (Wills *et al.*, 1996b), but relations of self-control to attitudinal constructs are not well studied. Risk-taking tendency has been suggested as a characteristic that has a predisposing role for substance use (Wills *et al.*, 1994; Zuckerman, 1994), but its relation to self-control and proximal risk factors is not well understood. These variables were included in the research and their roles were investigated, but without specific predictions other than that they would represent distinct pathways in the etiological process.

Present Study

In the present study, data were obtained at two time points from a multiethnic sample of participants from a metropolitan area, initially assessed around 11 years of age. The research included assessments of several temperament dimensions and multiple indicators for the constructs of good self-control and poor self-control. Measures of proximal factors for adolescent substance use (academic competence, negative life events, and affiliation with substance-using

peers) were obtained, and predictions about indirect effects to substance use were tested in structural equation modeling (MacKinnon, 1994; Wills & Cleary, 1999b).

The research design addressed several methodological issues from the literature on temperament and substance use. Measures of family characteristics were analyzed together with temperament dimensions, both to investigate their contributions to early substance use (cf. Brook *et al.*, 1990) and to control for predicted correlations of temperament dimensions with family variables (Rothbart & Ahadi, 1994; Windle, 1990). Because of issues raised about method variance (Rothbart & Bates, 1998), we obtained data on temperament and self-control from self-reports by participants and from teacher ratings; teacher ratings are an independent source of data, so observation of similar predictive effects for self-reports and teacher reports would rule out common-method variance as an interpretation of the findings. Demographic variables were included to investigate the relation of gender and ethnicity to predictors and outcomes (Bachman *et al.*, 1991; Brook, 1993) and analyses were performed to determine the replicability of the mediational findings and the longitudinal relations between constructs.

METHOD

Participants

The participants were students in two public school districts in a metropolitan area. Census data indicate that the communities the schools draw from are socioeconomically representative of the state population (U.S. Department of Commerce, 1992). At the initial assessment the students were in sixth grade (M age 11.53 years, SD 0.60) in a total of 18 elementary schools; at the seventh grade assessment (M age 12.63 years, SD 0.70) the students were in a total of six junior high schools. The sample was 51% female and 49% male. Self-reported ethnic background indicated 27% were African American, 23% Hispanic, 3% Asian American, 36% Caucasian, 5% mixed ethnicity (e.g., Black and Hispanic), and 7% other ethnicity. Data on family structure indicated 56% of participants were living with two biological parents, 34% were living with a single parent (primarily single mothers), and 10% were in a blended family (one biological parent and one stepparent). Data on parental education on a 1–6 scale indicated the mode was high

school graduate and the mean was 3.99 (SD 1.23), a level just above high school graduate.

Procedure

A self-report questionnaire was administered to students in classrooms by trained research staff using a standardized protocol. The questionnaire took approximately 40 min to administer. After giving standardized instructions to students, staff members circulated in the classroom to answer any individual questions about particular items. The sampling frame for the study was all English-speaking students in the school population. The survey was administered under confidential conditions, and a Certificate of Confidentiality protecting the data was obtained from the Public Health Service. Students were instructed that they should not write their name on the survey, and were assured their answers were strictly confidential and would not be shown to their parents or teachers. Methodological research has shown that when participants are assured of confidentiality, self-reports of substance use have good validity (Murray & Perry, 1987).

In the consent procedure, a notice was sent by direct mail to parents of all students in the grade. The notice informed parents about the purpose of the study, the nature of the measures, and the confidentiality of the data. A parent could have a child excluded from the data collection, if he/she wished, by phoning a designated administrator at the school or returning a stamped self-addressed postcard to the investigator. Students received a comparable written form at the time of survey administration; this notice provided information about the purpose and nature of the study, and informed the student that he/she could refuse or discontinue participation.

Surveys were initially administered in sixth grade in Spring 1994 and were administered a year later to the same school population in seventh grade. For the sixth grade assessment the sample size was 1,810 cases; the completion rate (number of surveys completed \div total enrollment from school class lists) was 94%, with nonparticipation occurring because of parental exclusion (1%), student refusal (1%), and unavailability or absenteeism (4%). For seventh grade the total sample size was 1,882 cases and the completion rate was 88%, with nonparticipation occurring because of parental exclusion (4%), student refusal (3%), or absenteeism (5%). The retention rate for study variables was approximately 90%.

Measures

Measures are described in the following sections. Unless otherwise noted, items were administered using a 5-point Likert response scale with anchor points *Not At All True for Me* and *Very True for Me*. Scale structure was checked with factor analysis (principal-factor method, varimax rotation) and internal consistency procedures (Cronbach alpha, reported for two assessments). All scales were constructed such that a higher score represents more of the named attribute. Because of length issues in surveying younger children, a few variables could not be included in the sixth grade survey but were included in the seventh grade survey.

Demographic Information

The questionnaire began with items about age, gender, and ethnicity (5 options, multiple responding allowed). An item on family composition asked what adult(s) the participant currently lived with (8 options, multiple responding allowed); this was recoded for analysis to three categories (single parent, blended family, or intact family). Items about parental education for father and mother, respectively, had a 1–6 response scale with anchor points Grade School and Post-College.

Temperament Dimensions

Temperament dimensions were assessed with an inventory comprising scales from the Revised Dimensions of Temperament Survey (DOTS-R, Windle & Lerner, 1986) and the Emotionality, Activity and Sociability Inventory (EAS, Buss & Plomin, 1984). A 6-item scale on task orientation (DOTS-R) had items about focusing on tasks and persisting till finished (Cronbach $\alpha = .72-.82$). A 5-item scale on positive emotionality (DOTS-R) had items about smiling frequently and generally being in a cheerful mood ($\alpha = .74-.83$). A 6-item scale on physical activity level (DOTS-R) had items about moving around frequently and being restless when having to sit still ($\alpha = .82-.83$). A 5-item scale on negative emotionality (EAS) had items about being easily frustrated and intensely upset ($\alpha = .74-.79$). A 4-item scale on sociability (EAS) had items about liking to be around people ($\alpha = .69-.72$). A 6-item scale on rigidity (DOTS-R) had items about having difficulty in adjusting to new people and situations ($\alpha = .78$).

Parent–Child Relationship

A 15-item inventory assessed supportive vs. conflictual aspects of the parent–child relationship (Barrera *et al.*, 1993; Wills *et al.*, 1992). Participants were instructed in answering the items to think about the one parent they talked to the most; this was done because of the prevalence of single-parent families anticipated in the sample. Measures were a 5-item scale for emotional support (e.g., “I can share my feelings with my parent,” $\alpha = .82-.85$) and a 7-item scale for instrumental support (e.g., “If I need help with my school work, I can ask my parent about it,” $\alpha = .69-.76$). The measure for parent–child conflict (3 items, $\alpha = .75-.78$) contained the items “I have a lot of arguments with my parent,” “I often feel my parent is giving me a ‘hard time’,” and “I feel my parent doesn’t understand me.”

Parental Substance Use

Questions about regular substance use (defined as weekly or more often) by parents included items for cigarette smoking, beer/wine use, and liquor (whiskey, scotch, or rum). Each item was coded on a 1–3 scale (No Parent Uses, One Parent Uses, and Two Parents Use). A 2-item scale for parental alcohol use had $\alpha = .66-.68$.

Good Self-Control

Good self-control was indexed with multiple indicators. The measure contained items on self-control in a variety of social and nonsocial situations. Items were drawn from previous measures of self-regulation and problem solving appropriate for children and adolescents (Kendall & Williams, 1982; Wills, 1986). Most items were introduced with the stem, “Here are some things people may say about themselves. Read each one and circle a number (from 1 to 5) to show if you think it’s true for you.” Factor analyses of data from several studies indicated a replicated subscale structure with indicators termed Soothability, Dependability, Planfulness, and Problem Solving (cf. Wills *et al.*, 1999). Overall reliability for the good self-control measure was $\alpha = .83-.87$.

Poor Self-Control

Poor self-control also was indexed with multiple indicators, drawn from previous measures on self-

regulation and impulsiveness (Eysenck & Eysenck, 1977; Kendall & Williams, 1982; Wills, 1986), and assessed poor ability to control emotions and behavior in everyday situations. A replicated subscale structure had subscales termed Impatience, Distractibility, Angerability, and Impulsiveness. Overall reliability for the poor self-control measure was $\alpha = .88-.92$.

Risk-Taking Tendency

A scale for risk-taking tendency used items drawn from the inventory of Eysenck and Eysenck (1977) as adapted for adolescents in previous research (Wills *et al.*, 1994). The scale contained items such as “I enjoy taking risks” and “I would enjoy fast driving.” The 6-item scale had $\alpha = .87$.

Tolerance for Deviance

A 10-item inventory on tolerance for deviance represents a core construct from problem behavior theory (Jessor & Jessor, 1977). The scale was administered with the stem “How wrong do you think it is” and contains examples of deviant acts (e.g., “Take things that don’t belong to you,” “Damage school property on purpose”). Responses were on a 1–4 scale with anchor points *Not At All Wrong* to *Very Wrong* (reflected in scoring). Reliability for the scale was $\alpha = .94$.

Perceived Competence

Scales from Harter’s Self-Perception Inventory for Adolescents indexed three domains of competence as perceived by the respondent (Harter, 1985). A scale of positive items on academic competence ($\alpha = .71-.72$) contains items about doing well in class and liking school. A scale on peer social competence ($\alpha = .67-.68$) contains items about feeling accepted by other students and having close friends. A scale on behavioral incompetence, containing predominantly negative items ($\alpha = .74-.75$), contains items about usually behaving appropriately versus doing things one is not supposed to.⁷

⁷Measures not included in the analysis were soothability, dropped from the good self-control construct because of potential overlap with temperament; peer competence, excluded from the models because it was uncorrelated with substance use; and behavioral competence, excluded because of extensive correlated errors with other constructs.

Negative Life Events

A 20-item checklist of negative life events was based on previous measures (Newcomb & Harlow, 1986; Wills *et al.*, 1992). The participant was asked to indicate whether each event had occurred during the previous year, using a dichotomous (Yes/No) response scale. The inventory included 11 events that could have occurred to a family member (e.g., "My father/mother was unemployed"); an index created for these items had $\alpha = .58-.62$. The inventory also included nine events that could have occurred directly to the adolescent him/herself (e.g., "I had a serious accident"); an index created for these items had $\alpha = .50-.51$. (An item concerning parent-child arguments was dropped to avoid overlap with the measure of parent-child conflict.)

Peers' Substance Use

Three items asked the participant whether any of his/her friends smoked cigarettes, drank beer/wine, or smoked marijuana. Responses were on 1-5 scales with response points None, One, Two, Three, and Four or More. A composite scale had $\alpha = .75-.83$.

Participant's Substance Use

Substance use by the participant was measured with items that asked about the typical frequency of his/her cigarette, alcohol, and marijuana use. Three items were introduced to participants with the stem: "How often do you smoke cigarettes/drink alcohol/smoke marijuana?" Responses were on 1-6 scales with scale points *Never Used*, *Tried Once-Twice*, *Used Four-Five Times*, *Usually Use a Few Times a Month*, *Usually Use a Few Times a Week*, and *Usually Use Every Day*. A fourth item asked the participant whether in the last month he/she had had three or more drinks on one occasion; response points were *No*, *Happened Once*, and *Happened More than Once*. The indices of cigarette, alcohol, and marijuana use were intercorrelated, consistent with methodological research (Hays *et al.*, 1987; Needle *et al.*, 1989); α was .60 for sixth grade and .78 for seventh grade.

Teacher Ratings

Teachers provided ratings of temperament and self-control on the same items completed by the

participants, worded for a third-party format. The measures were done by the teacher in the class where the surveys were distributed, and were completed around the time when the student questionnaire was administered. Teachers were instructed to rate items as they observed them in the school setting. The teacher reports were completed outside of school hours, teachers were compensated for doing the ratings, and these data were obtained with 95-97% completion. Reports were obtained for six dimensions of temperament ($\alpha = .93-.98$) and on 7-item scales for good self-control ($\alpha = .95$) and poor self-control ($\alpha = .93$). Teacher ratings were matched to individual student data through ID codes. Teachers did not know what students said about themselves on the self-report questionnaire, hence the teacher reports represent an independent source of data. Because most students changed schools between sixth grade and seventh grade, teacher ratings in the two assessments were done by essentially different groups of teachers.

RESULTS

Prevalence rates for the substance use measures, including indices of lifetime and recent (monthly, weekly, daily) use, are presented in Table 1. There was a detectable amount of early use; for example, in sixth grade 6% of the sample had smoked cigarettes four times or more often. There was a considerable increase in prevalence for all substances from sixth grade to seventh grade. The prevalences and the age-related increase are generally consistent with other data for this age range (Johnston *et al.*, 1995), though rates of marijuana use tend to be lower. Early onset was defined for sixth grade as the proportion of participants who had used two substances both at least 4-5 times, and for seventh grade as the proportion who had used two substances at least 4-5 times and had some experience with marijuana or heavy drinking.

Table 1. Prevalence (%) for Three Substance Use Indices, for Two Grades

Usage	Index/Grade					
	Cigarettes		Alcohol		Marijuana	
	6th	7th	6th	7th	6th	7th
Never	78%	60%	59%	47%	98%	90%
1-2 times	16	21	33	33	1	5
4-5 times	4	10	6	15	<1	3
Monthly	1	4	2	4	<1	1
Weekly	1	2	<1	1	<1	<1
Daily	<1	3	<1	<1	<1	<1

This prevalence was 5% for sixth grade and 12% for seventh grade.

The substance use indices were intercorrelated and the correlations increased with age. Correlations among indices for adolescents' tobacco, alcohol, and marijuana use were mostly in the range from .30 to .50. Similar intercorrelations were found among indices of friends' tobacco, alcohol, and marijuana use. These intercorrelations are consistent with other data (Hays *et al.*, 1987), and indices of tobacco, alcohol, and marijuana use were combined for analysis in a composite score (cf. Needle *et al.*, 1989; Newcomb & Bentler, 1988).

Descriptive Statistics and Correlations

Descriptive statistics for the study variables indicated that distributions for the temperament dimensions were normal for the most part; distributions for positive emotionality and sociability were shifted somewhat toward higher levels. Distributions for the self-control variables showed a similar pattern, with participants tending to endorse somewhat higher levels of good self-control and lower levels of poor self-control, but skewness values were in the low end of the range. Moderate skewness was noted for the peer substance use and adolescent substance use variables, for which most participants endorsed lower values (i.e., nonuse or minimal use); for these measures, skewness values were in the range from 0.8 to 2.5. The pattern of distributions for temperament and self-control variables was similar for the self-report and teacher-report data.

Correlations of temperament and self-control variables with participants' substance use are presented in Table 2. The predictions for temperament

were generally confirmed: activity level and negative emotionality were positively correlated with substance use; task orientation and positive emotionality were inversely correlated with substance use; and the correlation of sociability with substance use was nonsignificant (cf. Tarter, 1988). Good self-control was inversely related to substance use and poor self-control was positively related to substance use, both as predicted. These results were replicated across assessments and were generally consistent across sources. The exception was positive emotionality, for which self-reports were significant but teacher reports were nonsignificant. Thus results supported the predictions, and the fact that quite similar results were observed for self-reports and teacher ratings indicates the findings are not attributable to method variance.⁸

Relations of the study variables to gender and ethnicity were examined in analyses of variance including main-effect terms for gender and ethnicity (Black vs. Hispanic or White and Hispanic vs. Black or White) together with the Gender \times Ethnicity interaction terms. Results for the two-way interactions were within the chance range, so Table 3 presents findings for main-effect models. Focusing on the strongest and most consistent findings, for temperament, boys scored higher on task orientation, activity level, and rigidity, whereas girls scored higher on sociability and negative emotionality. Boys also scored higher on poor self-control, risk taking tendency, and negative life events. Effects for ethnicity indicated Blacks scored higher on activity level and negative emotionality, and Blacks and Hispanics scored lower on parental support relative to Whites. Both minority groups experienced more negative life events, including family-related events and adolescent events, and there was a tendency for both minority groups to report more poor self-control but no differences in good self-control. Hispanics reported lower levels of perceived academic competence, and Blacks reported lower levels of substance use. Because of these effects, subsequent analyses were performed with demographic controls.

Table 2. Correlation of Temperament and Self-Control Measures with Substance Use Score, for Self-Report Data and Teacher-Report Data, for Two Assessments

Variable	6th grade		7th grade	
	Self	Teacher	Self	Teacher
Task orientation	-.12****	-.14****	-.16****	-.19****
Positive emotionality	-.14****	-.04	-.15****	-.05
Sociability	-.01	-.02	-.04	.06*
Activity	.17****	.16****	.16****	.15****
Negative emotionality	.18****	.12****	.20****	.15****
Rigidity	—	—	.08**	.13****
Good self-control	-.27***	-.18****	-.27****	-.20****
Poor self-control	.32****	.14****	.37****	.20****

Note. *N* for correlations is approximately 1,800 cases.

* $p < .05$. ** $p < .01$. *** $p < .001$. **** $p < .0001$.

⁸The correlation of self-reports and teacher reports in sixth grade was .14 for protective temperament dimensions, .25 for difficult temperament dimensions, .17 for good self-control, and .35 for poor self-control. Comparable correlations for seventh grade were .14, .18, .12, and .26. These data are consistent with other studies (Achenbach *et al.*, 1987). Accordingly, the self-report and teacher-report data were analyzed separately.

Table 3. Means and Anova Results for Relations of Gender and Ethnicity to Study Variables, for Two Assessments

Variable	Female			Male			<i>F</i>		
	B	H	W	B	H	W	Gender	Ethn. 1	Ethn. 2
<i>6th-grade data</i>									
Temperament									
Task orient.	18.97	18.66	18.48	19.06	19.21	19.79	8.3**	0.2	0.4
Pos. emotion.	21.09	20.82	21.27	20.18	20.43	20.82	8.2**	2.7	2.6
Sociability	17.36	17.76	17.45	16.90	17.34	17.46	2.4	3.1	0.4
Activity	19.02	17.13	16.50	19.19	18.49	17.82	8.6**	26.1****	2.6
Neg. emotion.	17.01	15.97	15.15	16.14	15.62	14.89	3.8*	31.1****	6.6**
Family variables									
Par. support	45.40	45.28	46.48	44.45	45.12	46.76	0.30	12.4****	8.2**
Par. conflict	6.69	6.76	6.60	6.70	6.34	6.70	0.2	0.1	0.2
Fam. events	12.84	13.00	11.76	12.79	12.97	11.77	0.0	82.8****	102.2****
Par. smoking	1.75	1.61	1.60	1.74	1.74	1.70	3.4	4.3*	0.2
Par. alcohol	2.85	2.74	2.69	2.86	3.03	2.80	5.1*	3.0	3.8*
Self-control									
Good control	49.96	50.56	49.16	48.17	48.92	48.95	6.9**	0.00	1.5
Poor control	35.53	33.78	30.67	36.66	36.21	32.85	8.6**	37.1****	19.0****
Proximal factors									
Acad. comp.	11.02	9.82	10.89	11.14	10.03	11.13	1.7	0.23	3.1****
Adol. events	11.08	10.89	10.49	11.48	11.42	10.78	23.3****	45.9****	26.5****
Peer sub. use	4.60	4.85	4.35	5.05	4.73	4.28	0.4	13.7***	11.1***
Substance use									
Part. sub. use	3.71	3.88	3.83	3.89	3.88	3.99	3.2	1.9	0.1
<i>7th-grade data</i>									
Temperament dimensions									
Task orient.	18.12	16.99	17.67	18.86	18.66	19.76	31.4****	0.4	7.6**
Pos. emotion.	21.12	20.16	20.94	19.96	20.30	20.05	8.3**	0.1	1.2
Sociability	17.06	17.01	17.51	16.66	16.62	16.59	13.0***	0.9	1.4
Activity	17.26	16.06	15.58	18.06	16.75	16.53	5.9*	14.7****	0.8
Neg. emotion.	15.46	14.85	14.04	15.02	13.90	13.96	3.8*	15.8****	1.6
Rigidity	14.09	14.45	12.60	15.21	15.13	13.51	12.0***	24.9****	31.7****
Family variables									
Par. support	43.39	42.38	44.75	43.21	44.19	45.18	2.7	9.1**	10.4***
Par. conflict	7.18	7.28	7.27	7.03	6.41	6.94	7.0**	0.0	1.5
Fam. events	12.35	12.58	11.67	12.52	12.40	11.61	0.1	50.4****	61.8****
Par. smoking	1.75	1.63	1.66	1.70	1.64	1.70	0.0	1.0	0.7
Par. alcohol	2.79	2.69	2.89	2.81	2.85	2.83	0.1	0.7	2.0
Self-control and related variables									
Good control	51.52	50.54	48.88	49.31	49.56	49.65	2.0	3.3	1.5
Poor control	56.19	54.35	51.79	59.18	58.74	57.09	22.0****	8.4**	3.6
Risk taking	12.47	13.46	13.66	15.93	15.31	16.41	67.9****	4.7*	2.6
Tol. deviance	19.64	20.30	18.76	22.21	22.63	19.69	11.9***	6.2**	11.4***
Proximal factors									
Acad. comp.	10.86	9.52	10.53	10.91	10.35	10.98	9.8***	0.6	22.3****
Adol. events	11.08	11.13	10.91	11.46	11.24	11.06	6.4**	7.8**	4.4*
Peer sub. use	7.12	7.46	6.67	6.49	6.52	6.30	10.2***	1.6	4.4*
Substance use									
Part. sub. use	5.70	5.94	5.91	5.63	5.82	6.64	1.3	14.0****	7.8**

Note. Orient.: orientation; pos.: positive; emotion.: emotionality; neg.: negative; par.: parental; fam.: family; acad.: academic; comp.: competence; adol.: adolescent; sub.: substance; part.: participant; tol.: tolerance.

* $p < .05$. ** $p < .01$. *** $p < .001$. **** $p < .0001$.

Table 4. Correlations for Study Variables, for Two Assessments

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
<i>6th grade</i>																			
1. Task orientation	—																		
2. Pos. emotion.	.27	—																	
3. Sociability	.18	.40	—																
4. Activity	.01	.04	.11	—															
5. Neg. emotion.	-.09	-.17	-.05	.42	—														
6. Parent support	.28	.41	.25	-.11	-.23	—													
7. Parent conflict	-.06	-.19	-.05	.22	.38	-.46	—												
8. Family events	-.03	-.08	-.01	.21	.29	-.17	.20	—											
9. Parent smoking	-.04	-.03	.03	.12	.12	-.07	.08	.21	—										
10. Parent alcohol	-.06	-.07	.02	.18	.16	-.22	.20	.26	.28	—									
11. Good control	.53	.49	.35	-.21	-.29	.63	-.33	-.14	-.07	-.20	—								
12. Poor control	-.11	-.18	-.03	.52	.64	-.32	.46	.37	.18	.28	-.42	—							
13. Acad. comp.	.28	.31	.21	-.12	-.20	.34	-.17	-.15	-.09	-.14	.54	-.31	—						
14. Adol. events	-.05	-.14	-.04	.29	.34	-.26	.26	.41	.16	.21	-.30	.55	-.23	—					
15. Peer sub. use	-.11	-.15	.01	.28	.33	-.24	.23	.30	.26	.29	-.33	.44	-.18	.40	—				
16. Part. sub. use	-.17	-.20	-.02	.24	.26	-.31	.31	.22	.23	.34	-.45	.43	-.24	.38	.79	—			
<i>7th grade</i>																			
1. Task orientation	—																		
2. Pos. emotion.	.31	—																	
3. Sociability	.17	.46	—																
4. Activity	.02	.09	.05	—															
5. Neg. emotion.	-.15	-.20	-.11	.36	—														
6. Rigidity	.12	-.02	-.03	.37	.40	—													
7. Parent support	.36	.42	.28	-.11	-.29	-.08	—												
8. Parent conflict	-.16	-.18	-.08	.25	.43	.22	-.56	—											
9. Family events	-.11	-.09	-.04	.17	.23	.21	-.24	.27	—										
10. Parent smoking	-.04	-.05	-.01	.11	.12	.07	-.08	.13	.23	—									
11. Parent alcohol	-.09	-.08	-.05	.14	.19	.14	-.23	.24	.31	.34	—								
12. Good control	.59	.45	.25	-.20	-.30	.02	.56	-.35	-.19	-.07	-.21	—							
13. Poor control	-.19	-.11	.01	.57	.64	.48	-.34	.48	.37	.15	.27	-.50	—						
14. Risk taking	-.08	-.09	.06	.33	.27	.15	-.24	.32	.19	.12	.20	-.34	.64	—					
15. Tol. deviance	-.14	-.19	-.07	.12	.12	.11	-.21	.12	.15	.10	.10	-.30	.28	.23	—				
16. Acad. comp.	.39	.35	.20	-.10	-.23	-.08	.44	-.24	-.15	-.09	-.13	.55	-.35	-.16	-.18	—			
17. Adol. events	-.16	-.15	-.04	.24	.32	.21	-.31	.32	.46	.17	.24	-.30	.52	.35	.15	-.26	—		
18. Peer sub. use	-.17	-.14	.06	.20	.25	.10	-.29	.31	.31	.29	.30	-.34	.45	.38	.27	-.28	.40	—	
19. Part. sub. use	-.21	-.16	-.01	.20	.22	.11	-.30	.33	.28	.31	.39	-.37	.45	.40	.25	-.29	.41	.74	—

Note. Pos.: positive; emotion.: emotionality; neg.: negative; acad.: academic; comp.: competence; adol.: adolescent; comp.: competence; sub.: substance; part.: participant; tol.: tolerance.

Structural Modeling Analysis

Initial confirmatory analyses performed with Mplus (Muthén & Muthén, 1998) verified that the measurement model was satisfactory and provided the construct correlations, which are presented in Table 4.⁹ To test the theoretical model of early onset,

a structural modeling analysis was conducted with temperament dimensions and family variables specified together as exogenous variables, thus controlling for any correlation of temperament with the parent-child relationship or parental substance use; family life events was specified as exogenous because it could not plausibly be a consequence of adolescent's self-control. Indices for gender, ethnicity, family structure, and parental education were also included as exogenous variables, to control for any correlations of

⁹Confirmatory analyses were performed in MPlus (Muthén & Muthén, 1998) with the indicators for peer substance use and participant substance use specified as categorical, using Weighted Least Squares estimation with robust standard errors (WLSMV). The confirmatory model for sixth grade data with three correlated errors had chi-square (93, N = 1,668) = 472.20; the confirmatory model for seventh grade data with seven correlated errors had

chi-square (127, N = 1,733) = 737.96. WLSMV estimation does not provide usual fit indexes such as the Root Mean Square Error of Approximation; degrees of freedom are computed using an algorithm given in Muthén and Muthén (1998), Appendix 4.

temperament and family variables with demographics. Parental support was specified as a latent construct measured by emotional support and instrumental support, and parental alcohol use was specified as a latent construct measured by indicators of beer/wine drinking and liquor drinking. The other exogenous constructs were manifest variables, each measured by a single indicator.

The structural model was specified with the hypothesized mediators of temperament effects as the first level of endogenous variables. Good self-control and poor self-control were specified at this level (with risk-taking tendency and tolerance for deviance, in seventh grade), with covariances of their residual terms.¹⁰ Academic competence, adolescent life events, and peer substance use were specified subsequent to these, with regression effects specified. The criterion was a latent construct for participant's substance use. Good self-control was specified as a latent construct measured by indicators of dependability, planning, and problem solving, and poor self-control was a latent construct measured by indicators of impatience, distractibility, and angerability (and impulsiveness in seventh grade). Peer substance use was a latent construct measured by indicators of friends' cigarette use, beer/wine use, and marijuana use. Participant's substance use was specified as a latent construct measured by cigarette smoking, alcohol use, and marijuana use. The other endogenous constructs were manifest variables, each measured by a single indicator. The same basic model was analysed for sixth-grade data and seventh-grade data, in order to test for replicability of effects.

Because of the inclusion of categorical variables and skewed measures, the models were estimated in Mplus using the weighted least squares method with robust standard errors (Muthén & Muthén, 1998; West, Finch, & Curran, 1995). The structural models were initially estimated with a set of paths predicted from theory and prior research (cf. MacCallum *et al.*, 1992); for example the initial model for sixth grade data was specified with 12 paths. Aside from demographic effects, additional structural coefficients were included if they had modification indices > 10 (corresponding to $p < .001$);

¹⁰A nested analysis for the self-control indicators compared the fit indices for a 2-factor model (with constructs for good self-control and poor self-control, and their covariance) with a 1-factor model (having one construct for self-control). For sixth grade data the difference chi-square (1 *df*) was 729.18, and for seventh grade data the difference chi-square (1 *df*) was 1,201.26. Thus the specification of two constructs for self-control is most appropriate.

correlated error terms were included if they had modification indices > 20 ($p < .0001$). The final models are presented in Fig. 1 and Fig. 2. The covariances of exogenous variables (included in the models but omitted from the figures) are included in Table 4; measurement model parameters and residual covariances are presented in Table 5. The structural model for sixth grade data with six correlated error terms had reasonable fit to the data, chi-square (109, $N = 1,668$) = 412.31, and the model for seventh grade data with 10 correlated errors also had reasonable fit, chi-square (158, $N = 1,733$) = 777.83. (Degrees of freedom were computed with an algorithm given in Muthén & Muthén, 1998, Appendix 4.) Squared multiple correlations for the endogenous constructs indicated the exogenous variables generally accounted for 30–60% of the variance in the mediators; the exception was tolerance for deviance, for which only 8% of the variance was predicted by temperament and family variables. Together the variables in the model accounted for 68% of the variance in participant's substance use at each assessment.

Effects for Temperament and Self-Control

Results for the temperament dimensions were consistent with prediction and were replicated across assessments. The findings discussed here are all independent effects and are significant at $p < .0001$ unless otherwise noted. Task orientation and positive emotionality had paths to good self-control, whereas activity level and negative emotionality had paths to poor self-control. This establishes the first part of the theoretical model, which posits basic relations of temperament and self-control. Temperament dimensions had some other effects, for example with activity level having paths to risk taking and tolerance for deviance. In the seventh grade model there were direct effects to academic competence, with positive emotionality related to higher academic competence and rigidity related to lower academic competence; this may reflect the effects of emotional arousal for concentration on tasks, but could also derive from interpersonal processes, with emotional tone affecting the quality of interpersonal relationships in school settings (Rothbart & Ahadi, 1994). Thus the relations of temperament dimensions to substance use were primarily but not exclusively through self-control.¹¹

¹¹Results for sociability were erratic (cf. Tarter, 1988). In the sixth grade model sociability had a path to good self-control, but in seventh grade data it had paths to more poor control and more

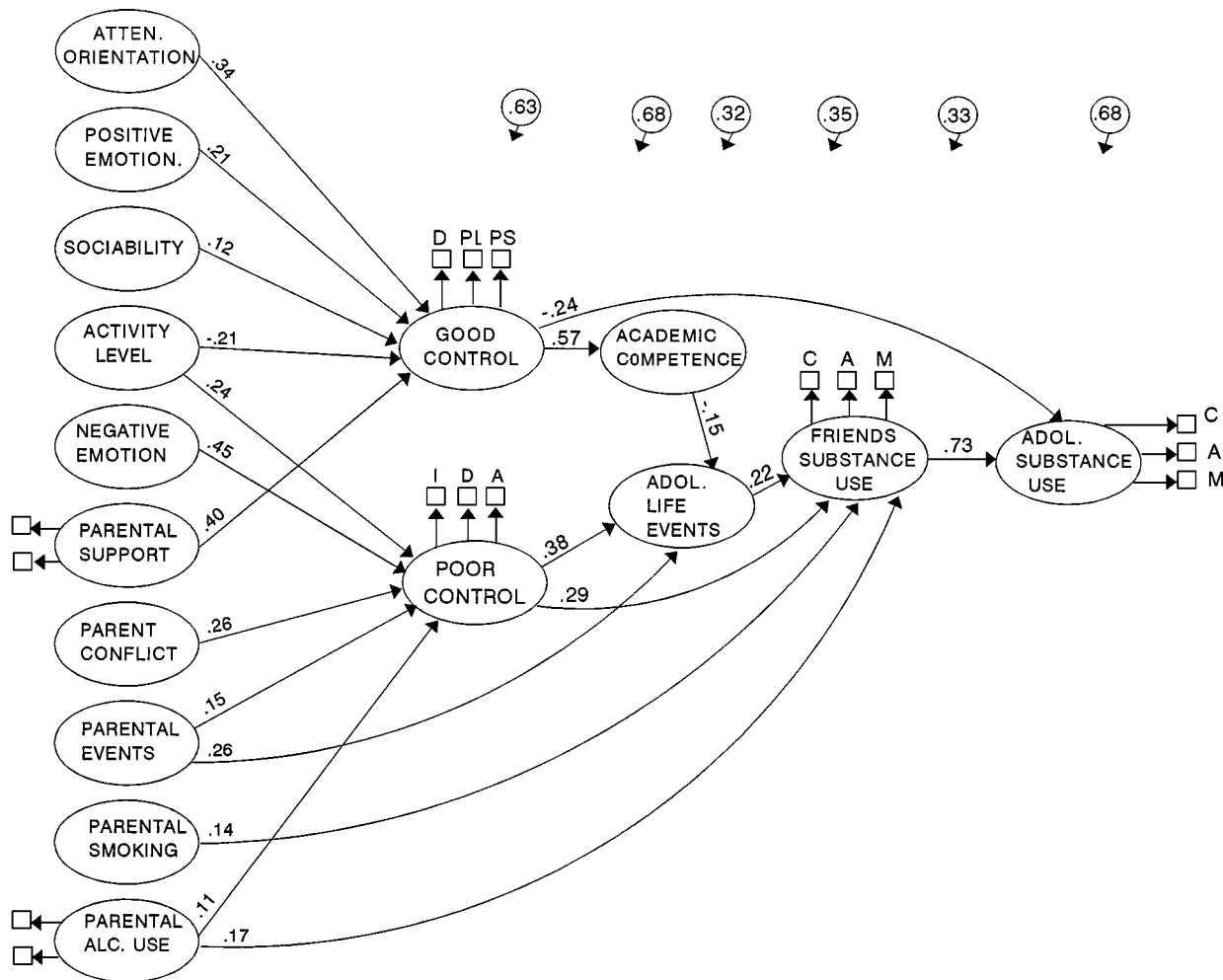


Fig. 1. Structural model for temperament dimensions and family variables, self-control constructs, and proximal factors in relation to child substance use, for sixth grade data. Values are standardized coefficients; all coefficients are significant at $p < .001$. Single-headed arrows indicate path coefficients, curved double-headed arrows indicate covariances. Values in circles at top of figure are squared multiple correlations, the variance accounted for in a given construct by prior variables. Demographic variables were included in the model but are not represented in the figure; for results, see text. For measurement model parameters, residual covariances, and covariances of exogenous variables, see Tables 4 and 5. Abbreviations for good self-control indicators are D: dependability, PL: planning, PS: problem solving; for poor self-control, indicators are I: impatience, D: distractibility, A: angerability. For friend and child substance use constructs, C: cigarettes, A: alcohol, M: marijuana. Emotion.: emotionality; alc.: alcohol; adol.: adolescent.

The relations of self-control constructs to proximal factors were consistent with prediction in most respects. Good self-control had a path to academic competence, and poor self-control had a path to adolescent life events. In addition there was a direct

effect from good self-control to fewer deviant peer affiliations (sixth grade only) and to less substance use (both assessments), and a direct effect from poor self-control to more deviant peer affiliations (sixth grade only). Thus the predicted role of self-control for exposure to proximal factors was generally supported.

risk taking tendency, and these were suppression effects. Results for rigidity were apparently paradoxical, showing a path to more good self-control ($p < .001$) and a path to more poor self-control, but this accords with suggestions that inhibition may be related to inhibitory aspects of self-control but may also be related to higher levels of emotional arousal (Windle, 1994, 1995; Newman & Wallace, 1993).

The final prediction was that temperament dimensions would have no direct effects to substance use when self-control and other factors are considered. This prediction was supported, as an analysis with direct effects included in the model (from temperament to substance use) indicated these were

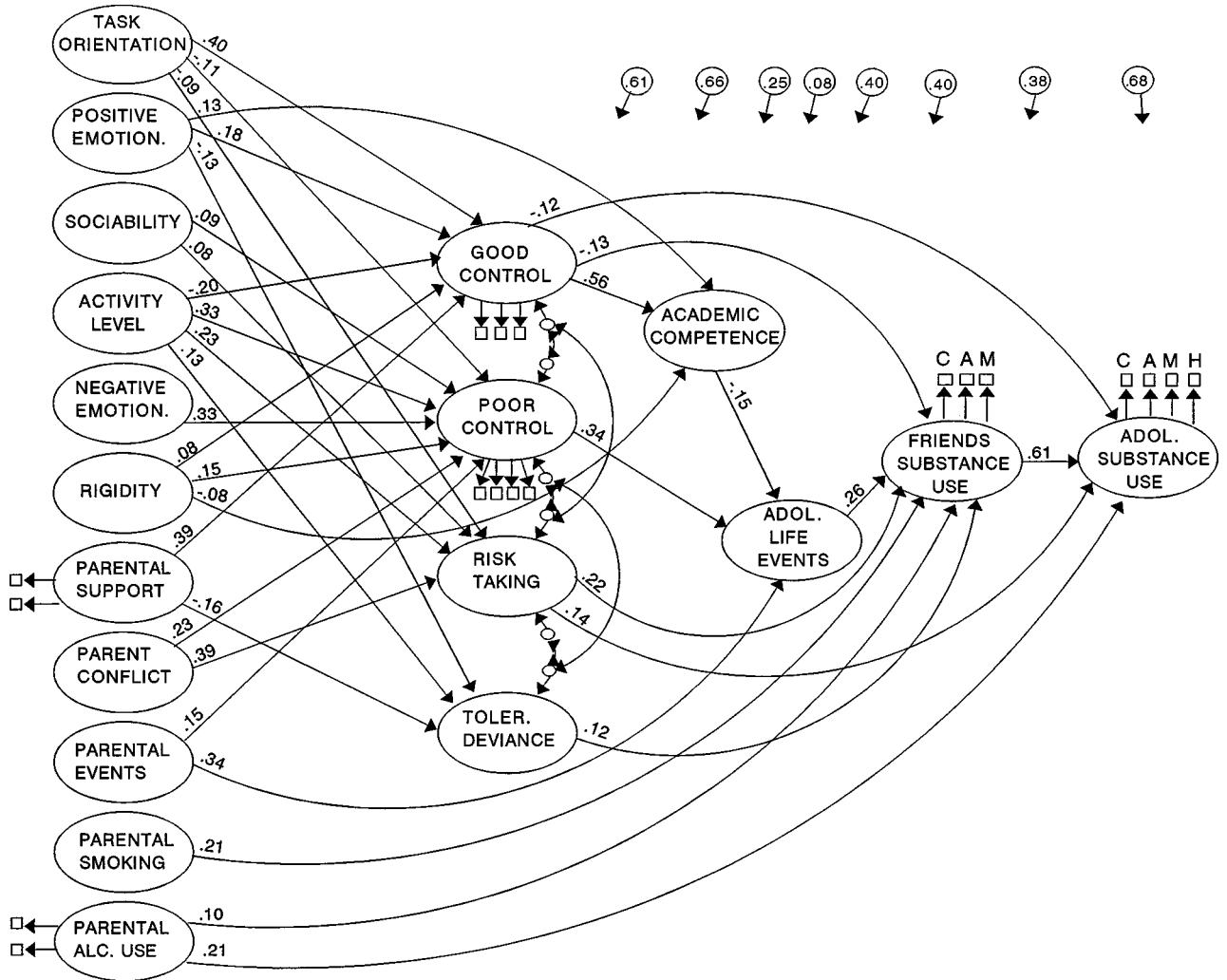


Fig. 2. Structural model for temperament dimensions and family variables, self-control constructs, and proximal factors in relation to adolescent substance use, for seventh grade data. For statistical and graphical conventions, see caption for Fig. 1. For measurement model parameters, residual covariances, and covariances of exogenous variables, see Tables 4 and 5. Demographic variables were included in the model but are not represented in the figure; for results, see text. Indicators for good self-control are dependability, attention control, and problem solving; indicators for poor self-control are impatience, distractibility, angerability, and impulsiveness. Indicators for friend and adolescent substance use constructs are cigarette smoking, alcohol use, marijuana use, and heavy drinking. Toler.: tolerance; for other abbreviations, see caption for Fig. 1.

all nonsignificant. This is consistent with the prediction of a process involving indirect effects for temperament. Computation of total indirect effects for temperament indicated these were all significant with the exception of one dimension.¹²

¹²Total indirect effects for temperament showed in sixth grade the indirect effects were significant ($p < .0001$ unless otherwise noted) and inverse for task orientation ($t = 5.71$), positive emotionality ($t = 4.58$), and sociability ($t = 3.59$, $p < .001$), and were positive for activity level ($t = 8.20$) and negative emotionality

Effects for Related Variables and Proximal Factors

Effects for related variables were consistent with the theoretical structures behind them. Risk taking had a direct effect to deviant peer affiliations,

($t = 8.32$). Total indirect effects for seventh grade were inverse for task orientation ($t = 7.69$) and positive emotionality ($t = 5.76$), and were positive for activity level ($t = 9.93$), negative emotionality ($t = 5.88$), and sociability ($t = 4.52$); the indirect effect for rigidity was inverse and marginal ($t = 2.06$, $p < .05$).

Table 5. Standardized Values for Model Parameters, for Two Assessments

Construct/indicator	Measurement model loadings		1.	2.	3.	4.
	6th grade loading	7th grade loading				
Parental support						
Emotional	.80	.87				
Instrumental	.83	.78				
Parental alcohol use						
Beer/wine	.71	.73				
Liquor	.70	.66				
Good self-control						
Dependability	.59	.64				
Planning	.53	.72				
Problem solving	.71	.72				
Poor self-control						
Impatience	.59	.55				
Distractibility	.70	.72				
Angerability	.80	.74				
Impulsiveness	na	.82				
Peer substance use						
Cigarettes	.90	.88				
Alcohol	.80	.89				
Marijuana	.80	.87				
Participant substance use						
Cigarette smoking	.88	.80				
Alcohol use	.65	.79				
Marijuana use	.75	.81				
Heavy drinking	na	.88				
<hr/>						
			1.	2.	3.	4.
<i>Covariances of residual terms</i>						
1. Good control			—	-.14	na	na
2. Poor control			-.21	—	na	na
3. Risk taking			-.16	.29	—	na
4. Tol. deviance			-.11	.18	.15	—

Note. Values for sixth grade are above diagonal, values for seventh grade are below diagonal. na: measure not available in this assessment.

probably reflecting a tendency of individuals oriented toward risky experiences to seek out like-minded companions (Scarr & McCartney, 1983); a direct effect to substance use may represent a tendency to engage in different kinds of risky behaviors (Maggs *et al.*, 1995). The path from tolerance for deviance to peer affiliations is predicted in problem behavior theory in terms of a relation between the attitudinal system and the peer social system (Jessor & Jessor, 1977).

Effects for the proximal factors were consistent with previous research but included a mixture of direct and indirect effects. Academic competence had a path to fewer adolescent life events

(cf. Wills *et al.*, 1992) but had no other effects in the model, so its relationship to substance use was an indirect one. Adolescent life events had a positive path to deviant peer affiliations (cf. Castro *et al.*, 1987) but no significant direct effect to substance use with robust standard errors, so that the relation of life events to substance use was also an indirect one. The path to deviant peer affiliations probably reflects a tendency of adolescents experiencing many negative events to become demoralized and alienated from conventional institutions, and to prefer companionship with similarly alienated peers (Newcomb & Harlow, 1986). Affiliation with substance-using peers had a strong path to adolescent substance use, supporting its hypothesized role as a proximal factor (cf. Curran *et al.*, 1997; Wills & Cleary, 1999a). It should be noted that this path was already a substantial one at the age of 11 years.

Effects for Family Variables

The family variables had a number of independent effects, representing both direct and indirect pathways to substance use. Parental supportiveness had paths to more good self-control, less tolerance for deviance, and fewer negative life events, consistent with theoretical work about the role of the family in development of self-regulation (Brody *et al.*, 1996; Rothbart & Ahadi, 1994; Wills *et al.*, 1996). Paths from parent-child conflict to poor self-control and risk-taking tendency may reflect disengagement from family and conventional values (Blackson *et al.*, 1996; Patterson *et al.*, 1989). Paths from family life events to poor self-control and adolescent life events could indicate a provoking effect of family stress on children's events and could also reflect some shared characteristics of parents and children (Conger *et al.*, 1992; Rutter *et al.*, 1997).

Results for parental smoking and alcohol use showed several significant effects (cf. Hawkins *et al.*, 1992; Petraitis *et al.*, 1995), including both direct and indirect effects. There were indirect effects for parental smoking and parental alcohol use, represented by pathways from parental use to higher levels of peer use ($p < .001$). There was also a direct effect from parental alcohol use to adolescent use, which could represent availability or shared physiological vulnerability (Sher, 1991; Windle, 1999). Note that parental substance use was correlated with a less supportive and more conflictual family environment,

Table 6. Standardized Regression Coefficients for Prospective Analyses for Paths in Model

Path	β	t
Distal factors to self-control		
Protective temperament 6 → Good control 7	.07	2.62**
Sociability 6 → Good control 7	.02	0.52
Activity level → Good control 7	-.09	3.61***
Parent support 6 → Good control 7	.09	3.53***
Difficult temperament 6 → Poor control 7		
Parent conflict 6 → Poor control 7	.08	3.50***
Family events 6 → Poor control 7	.07	2.90**
Parent alcohol 6 → Poor control 7	.05	2.40**
Paths to intermediate factors		
Good control 6 → Acad. competence 7	.11	4.20****
Poor control 6 → Adol. events 7	.18	6.35****
Acad. competence 6 → Adol. events 7	-.08	3.34***
Family events 6 → Adol. events 7	.13	4.92**** (direct effect)
Paths to proximal factors		
Parent smoking 6 → Friends' use 7	.05	2.30* (direct effect)
Parent alcohol 6 → Friends' use 7	.06	2.56** (direct effect)
Poor control 6 → Friends' use 7	.14	5.54**** (direct effect)
Adol. events 6 → Friends' use 7	.13	5.31****
Good control 6 → Substance use 7	-.07	2.83** (direct effect)
Friends' use 6 → Substance use 7	.21	7.76****

Note. Tabled values are standardized regression coefficients from prospective regression models including a grade 7 criterion with a grade 6 predictor variable and the grade 6 value for the criterion variable. Protective temperament: task orientation + positive emotionality; difficult temperament: activity level + negative emotionality.

* $p < .05$. ** $p < .01$. *** $p < .001$. **** $p < .0001$.

but the effects for parental use are independent of these correlations.¹³

Longitudinal Effects

To test the longitudinal status for the paths in the structural model, prospective multiple regression analyses were performed with seventh grade outcomes and sixth grade covariates. For example, an analysis was performed with seventh grade good self-control as the criterion and with good self-control and protective temperament from sixth grade (task

orientation + positive emotionality) as the predictors; for another example, an analysis had seventh grade adolescent life events as the criterion, with poor self-control and life events from sixth grade as the predictors. Such analyses determine whether a given variable is related to change over time in a variable specified subsequent to it in the model. Results are presented in Table 6.

The prospective analyses confirmed the relationships in the structural model in 17 of 18 tests. Considering the central theoretical paths, temperament dimensions were related to change in self-control, and self-control was related to change in academic competence and adolescent life events. (The one non-significant effect was for the temperament dimension of sociability.) Academic competence was related to change in adolescent life events, life events was related to change in peer substance use, and peer substance use was related to change in adolescent substance use. In addition, family variables and parental substance use indices demonstrated significant relationships to change in self-control and other constructs. Thus the predictive relationships outlined in epigenetic theories (Tarter *et al.*, 1995; Wills *et al.*, 2000) were supported in longitudinal analyses.

¹³Demographic effects were that male gender had paths to more poor self-control and more risk-taking, and had direct effects to more adolescent life events and less peer substance use. African American and Hispanic ethnicity each had a path to more good self-control and a direct effect to less child/adolescent substance use, and Hispanic ethnicity had a direct effect to less academic competence. Single-parent family had a path to more tolerance for deviance ($p < .05$) and a direct effect to more peer substance use. Parental education had a path to less poor self-control and direct effects to more academic competence and less peer substance use. Because of some convergence problems with categorical dummy variables, demographics were analyzed in models estimated with the maximum likelihood method.

DISCUSSION

This research was conducted to test a theoretical model of the relation of temperament to early substance use. The analyses were based on data from a large and diverse sample of children and adolescents, and data from 11 years of age indicated a non-trivial prevalence of tobacco and alcohol use. Findings generally supported the theoretical model that generated the predictions, results were corroborated by an independent source of evidence, and findings were replicated across assessments. There were significant risk-promoting effects for activity level and negative emotionality, and protective effects for task orientation and positive emotionality (cf. Rothbart & Ahadi, 1994; Tarter *et al.*, 1995). There were predicted relations of temperament dimensions to self-control constructs, and significant effects from self-control constructs to proximal risk and protective factors. Thus this research indicates that early onset of substance use occurs in an appreciable proportion of the population and that developmental models provide a useful approach for understanding early onset.

The findings suggest a reason for the prognostic significance of early onset: It is grounded in a context of temperament and self-control characteristics, which are known to have some stability over time (cf. Shoda *et al.*, 1990; Pedlow *et al.*, 1993). This suggests a reason for why early onset predicts outcomes over substantial time periods (Christie *et al.*, 1988; Hawkins *et al.*, 1997; Pulkkinen & Pitkänen, 1994; Zucker, 1994).

It should be noted that the contributions of family variables to substance use etiology were also important ones. For example, parental supportiveness showed significant contributions to good self-control and less deviance prone attitudes. Conversely, conflict between parents and children was a significant contributor to risk taking tendency and poor self-control. Interpretation of these effects, like those for parental substance use, should recognize that they may reflect several different kinds of processes; modeling and social learning processes may be represented to some extent (Petraitis *et al.*, 1995) and shared vulnerabilities of children and parents may also be involved (Rutter *et al.*, 1997). Further research using various research designs is desirable to clarify the processes through which family variables contribute to coping and adjustment of children and adolescents (Garmezy, 1993; Tarter *et al.*, 1995; Wills *et al.*, 1996a).

Findings on demographic variables provided some replication of previous findings on parental

education (cf. Adler *et al.*, 1994; Wills *et al.*, 1995) and ethnicity (e.g., Bachman *et al.*, 1991; Vaccaro & Wills, 1998; Vega *et al.*, 1993). However, the results clarified that some of these are indirect effects, through self-control and peer affiliations, whereas others are direct effects. These findings have implications for theory on the risk and protective effects of ethnicity (Brook, 1993; Vega *et al.*, 1998).

Temperament Characteristics and Self-Control

This research tested a structural model of the relation between temperament and substance use, and found no evidence for direct effects. The data actually indicate three different types of indirect-effect processes in temperament-substance use relationships. One process is represented in the pathways from temperament to self-control; the theoretical basis for this has been explicated previously and represents a pathway primarily through a self-regulation mechanism. A second process derives from the fact that temperament dimensions are correlated with the quality of the parent-child relationship, and parental factors are then related through their own pathways to substance use; this affects likelihood of substance use through an essentially social mechanism (Moffitt, 1993; Rothbart & Ahadi, 1994; Windle, 1990). A third type of process derives from the fact that risk and protective dimensions are relatively uncorrelated within individuals, so that elevation in one risk-promoting attribute could be offset by elevation in a protective attribute (cf. Eisenberg *et al.*, 2000; Wills *et al.*, 1998). Thus in this perspective, substance use arises from a "chain of failures" (Moffitt, 1993) based on a child's temperament profile, social relationships, and self-control abilities that may either promote adjustment or detract from it.

Our theoretical model proposed that self-control would predict exposure to proximal factors for substance use. The results were consistent with this prediction: self-control constructs were related to academic competence, negative life events, and deviant peer affiliations. These findings link the self-control model with established risk and protective factors for adolescent substance use (Hawkins *et al.*, 1992; Petraitis *et al.*, 1995). The one nonpredicted result was a direct effect from good self-control to less adolescent substance use. This path has not been found in studies with older adolescents, where a direct effect from good self-control to fewer deviant peer affiliations is found (cf. Wills *et al.*, 1999). The direct effect for good self-control in the present study may be

a consequence of general cautiousness at early ages, whereas a direct effect for shaping decisions about companions may be more prominent at later ages (Rutter *et al.*, 1997).

The findings for proximal factors provided evidence for several types of effects (cf. Hawkins *et al.*, 1992). The inverse path from academic competence to negative life events was significant but smaller in magnitude than the positive path from poor self-control, probably reflecting a relation to more academically-related events whereas effects of poor self-control can be involved in many types of adolescent events. The results found for academic involvement could underestimate its effects, as this construct may be related to other types of protective factors such as resistance efficacy (Wills *et al.*, 1989) or perceived vulnerability to harmful effects of substances (Bachman *et al.*, 1988). The path from adolescent life events to peer affiliations may involve feelings of alienation and rejection, such that stressed adolescents differentially associate with peers who are themselves alienated and inclined to deviant behaviors (cf. Castro *et al.*, 1987; Newcomb & Harlow, 1986).

Because epigenetic theory posits relations of constructs over time, we performed prospective analyses to test the longitudinal relationships outlined in the model. These analyses supported the postulated relations for temperament dimensions and for self-control, showing constructs at one point in the model related prospectively to change in constructs at subsequent points in the model. These findings strengthen support for the conceptual validity and the methodological appropriateness of the developmental model that generated the predictions.

Methodological Issues

This study tested whether effects for temperament and self-control would be observed for an independent source of evidence. The teacher ratings provided general corroboration of effects observed for self-report data, indicating that method variance is not a tenable explanation for these findings. This is noteworthy from a methodological standpoint because the participants were rated by different groups of teachers at the two assessments. The sole exception was for the temperament dimension of positive emotionality, for which self-reports were significant but teacher reports showed mostly nonsignificant correlations. This may reflect a previously noted tendency for teachers to be less accurate in perceiving internal states (Achenbach

et al., 1987). It would be desirable to corroborate self-reports with data from additional sources (e.g., parents, peers) on dimensions such as parent-child relationships and peer affiliations. Such efforts will need consideration of the ability of different sources to access situations where the attribute can be reliably observed, and the relative accuracy of different sources would seem a useful topic for further research.

Some aspects of the study could be noted as possible limitations. The measures of self-control, although based on multiple indicators, did not include some facets that have been delineated in recent research, including time perspective and delay of gratification (Barkley, 1997; Newman & Wallace, 1993; Zimbardo & Boyd, 1999). Assessment of self-control constructs with other methods, including neuropsychological assessment and performance measures, may provide additional information on effects of self-control. For the structural models, we note that reciprocal relations and moderation effects between model constructs are possible in principle and need to be investigated with appropriate analytic approaches (cf. Curran *et al.*, 1997; Wills & Cleary, 1999a). The present research was designed to investigate the relation of self-control constructs to variables from a coping-competence paradigm, and relations to other types of constructs, such as peer social perceptions or perceived vulnerability to harmful effects of substances, would be desirable to investigate. Finally, the present research assessed contributions of temperament and self-control to substance use at early ages, and contributions at later ages could be studied.

Implications for Prevention Research

The findings have several implications for prevention programs. From the perspective of etiology, the findings show that early use is predicted by contributions from multiple domains of variables. Various temperament dimensions show independent contributions to self-control, and parent-child relationships and parental substance use represent other domains of predictors for self-control and other factors. Although theoretical papers have postulated these kinds of multiple contributions (e.g., Zucker, 1994), the present findings demonstrate the extent to which early onset is related to different types of variables. This reinforces suggestions about the need for multimodal approaches to prevention that consider family variables, individual self-control characteristics, and environmental factors (Sussman & Johnson, 1996).

The results indicated that the effects of dispositional characteristics are not direct ones. Rather, effects of temperament occur through their relationship to self-control. This concept opens new avenues for prevention, not only because self-control indices may be targeted for intervention in different settings but also because other constructs (e.g., academic competence) may be amenable to modification through various approaches. We also note that there is an appreciable level of early-onset substance use and the predictive characteristics that produce early onset seem, to a considerable extent, to be in place by the age of 11 years. These findings argue for the importance of early interventions designed to address risk and protective factors before onset occurs (Ialongo *et al.*, 1999; Reid *et al.*, 1999; Wynn *et al.*, 2000).

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