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Behavioral and Emotional Regulation and Adolescent Substance Use Problems: A Test of Moderation Effects in a Dual-Process Model

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Abstract

In a structural model, we tested how relations of predictors to level of adolescent substance use (tobacco, alcohol, marijuana), and to substance-related impaired-control and behavior problems, are moderated by good self-control and poor regulation in behavioral and emotional domains. The participants were a sample of 1,116 public high-school students. In a multiple-group analysis for good self-control, the paths from negative life events to substance use level and from level to behavior problems were lower among persons scoring higher on good behavioral self-control. In a multiple-group analysis for poor regulation, the paths from negative life events to level and from peer substance use to level were greater among persons scoring higher on poor behavioral (but not emotional) regulation; an inverse path from academic competence to level was greater among persons scoring higher on both aspects of poor regulation. Paths from level to impaired-control and behavior problems were greater among persons scoring higher on both poor behavioral and poor emotional regulation. Theoretical implications for the basis of moderation effects are discussed.

Keywords

substance use; adolescents; self-regulation; substance use problems; moderation

This research examined how behavioral and emotional aspects of self-regulation are related to adolescent substance use and substance-related problems. Indices of good self-control, such as decision making and future time perspective, are found to be inversely related to frequency of tobacco and alcohol use in clinical and general-population samples (Audrain-McGovern et al., 2006; Aytacilar, Tarter, Korisci, & Lu, 1999; Zimbardo & Boyd, 1999).

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Indices of poor regulation (e.g., impulsiveness, affective lability) are positively related to substance use among both adolescents and adults (Bickel, Odum, & Madden, 1999; Petry, Bickel, & Arnett, 1998; Simons, Oliver, Gaher, Ebel, & Brummels, 2005). This literature includes studies showing self-regulation measures related to progression across stages of smoking (Novak & Clayton, 2001) and escalation in level of substance use over time (Brody & Ge, 2001; Wills & Stoolmiller, 2002).

Studies have also shown linkages of self-regulation measures to substance-related problems. With adolescents, Wills, Sandy, and Shinar (1999) showed that measures for good self-control and poor regulation were associated in opposite directions with substance-related behavior problems (e.g., fighting while drinking) and impaired-control problems (e.g., difficulty controlling intake). Patock-Peckham, Cheon, Balhorn, and Nagoshi (2001) showed with a sample of college students that a composite measure representing good self-control was inversely related to an index of alcohol-related problems based on problems with impaired control; these findings were subsequently replicated, in opposite direction, with a scale for impulsiveness (Patock-Peckham & Morgan-Lopez, 2006). Simons et al. (2009) showed in a college sample that impulsiveness and affective lability were related to alcohol abuse and dependence problems, with results showing indirect effects through paths to level of use as well as direct effects to problems.

Previous research on self-regulation has focused on main effects but recent studies have demonstrated moderation effects. In the present research we tested for moderation by examining how pathways from predictor variables to level and problems differed as a function of self-regulation attributes. Also, prior research has focused on behavioral aspects of self-regulation but emotional aspects may also be important (Khantzian, 1990; Southam-Gerow & Kendall, 2002). Thus we assessed both aspects and examined their relations to level and problems in the context of a dual-process model. The following sections outline the dual-process approach to conceptualizing self-regulation and the method we used for testing moderation effects.

Behavioral and Emotional Regulation and Dual-Process Models

Self-regulation variables include two domains. In the behavioral domain, *good behavioral self-control* involves attributes such as the tendency to plan ahead, consider alternatives before acting, and link behaviors and consequences over time (Carver & Scheier, 2000; Miller & Brown, 1991). These attributes are theoretically interrelated (e.g., Barkley, 1997) and empirically they load together on a construct of good self-control, which is related to protective factors for substance use such as academic competence (e.g., Wills et al., 1999, 2001). *Poor behavioral regulation* is based on attributes such as being impatient or distractible, having difficulty in delaying gratification, and being easily frustrated. These indicators load together and this construct (also termed impulsiveness or disinhibition) is related to higher levels of risk factors for substance use, including negative life events and affiliation with deviance-prone peers (Wills et al., 2001, 2004). The existence of two domains of constructs is consistent with the propositions of dual-process theories. These suggest that there are two processing systems, both related to health outcomes but with different modes of operation (Gerrard et al., 2008; Hoffman, Friese, & Strack, 2009; Lieberman, 2007). Structural modeling analyses have shown that good behavioral self-control and poor behavioral regulation are statistically distinct and have somewhat different pathways to substance use (e.g., Dvorak & Simons, 2009; Wills & Ainette, 2009).

In the emotional domain, the construct of *good emotional self-control* involves the ability to reduce excessive arousal and deal with negative emotions such as sadness or anger (Cole, Michel, & Teti, 1994). To some extent the strategies required for controlling emotions are believed to involve cognitive effort through focusing or shifting attention, monitoring level

of arousal, and using active cognitive strategies to minimize unpleasant stimuli (Rothbart, Derryberry, & Evans, 2000; Southam-Gerow & Kendall, 2002). Hence emotional self-control should theoretically be correlated with behavioral self-control and empirically this is found to be the case in adolescence (Wills et al., 2006). The attributes underlying *poor emotional regulation*, such as difficulty recovering from interpersonal provocation or tendency to ruminate about sad experiences, probably originate from different processes such as emotional reactivity and difficulty inhibiting negative thoughts (Derryberry & Rothbart, 1997; Gilliom et al., 2002). The available data indicate scores for good emotional self-control and poor emotional regulation are inversely but only moderately related (Wills et al., 2006), as is the case for behavioral aspects.

This approach for conceptualizing self-regulation has linkages to dual-process theoretical accounts of addictive behaviors. Bickel et al. (2007) have discussed evidence for drug dependence as deriving from an interaction between two competing neural systems. One system, which they label “reflective,” is indexed by attributes such as planning to achieve goals and considering future consequences of present activities, analogous to what we have termed good self-control. The other system, labeled “impulsive,” is based on brain regions that react to emotion- and reward-oriented stimuli and is indexed by attributes such as impulsiveness and a present orientation in which future rewards are strongly discounted; this concept is analogous to what we have termed poor regulation. Bickel et al. suggest that addictive behavior results when the influence of the reflective system is undermined by an overactive impulsive system.

A related model by Steinberg (2007) has also posited two brain networks. A cognitive-control network involves functions such as planning and forethought, similar to measures we use for good self-control. A socioemotional network involves reward-oriented functions, is sensitive to social and emotional stimuli, and is especially activated when persons are emotionally aroused and/or with peers. Steinberg (2007) has argued that the socioemotional network, similar to our concept of poor behavioral/emotional regulation, influences risk-taking in interaction with the cognitive-control network. On the basis of these propositions, we hypothesized that adolescent substance use would be related to an interaction of good self-control and poor regulation.

Moderation Effects for Self-Regulation

Recent research has demonstrated moderation effects of self-regulation. A study by Wills, Ainette, Stoolmiller, Gibbons, and Shinar (2008) with younger adolescents showed there was less impact of life events on 1-year growth in substance use among persons scoring higher on good self-control. A study by Gardner, Dishion, and Connell (2008) with older adolescents showed that a composite of temperament measures similar to good self-control (inhibition, attention, and persistence) reduced the impact of peer deviance on externalizing behavior assessed 1 year later.

There is still relatively little knowledge about how self-regulation variables act as moderators. It has been suggested that forethought could help persons prepare to deal with potentially troublesome situations and problem solving could provide alternative solutions to problems that arise. Emotional self-regulation could help dampen arousal in problem situations, whereas rumination about negative events would maintain tension after the event has occurred. However, there is still little evidence on how either aspect of self-regulation operates to produce moderation. Research by Wills, Sandy, and Yaeger (2002) showed that measures similar to self-regulation altered relations between substance use level and substance-related problems, but the measures used in the studies were focused on behavioral aspects. Simons et al. (2009) found in a college sample that measures based on impulsivity and affective lability increased the relation between alcohol level and problems, but this

study did not have a measure of good self-control. Thus there is a need for research that includes both types of self-regulation constructs and tests how good self-control or poor regulation moderate effects of variables that are known predictors of adolescent substance use, such as negative life events and affiliation with peer substance users.

Present Research Design and Hypotheses

In the present research we measured behavioral and emotional aspects of good self-control and poor regulation. Testing of the hypotheses was based on a structural model including the four self-regulation measures as predictors of mediating variables (academic competence, negative life events, and deviant peer affiliations) which were related to level of adolescent substance use; in turn, level was specified as a predictor of substance-related behavior problems and impaired-control problems (Stacy & Newcomb, 1999). While the cross-sectional data do not resolve issues about temporal direction of effects, this analysis tests a model that can be falsified, for example if the self-regulation variables are not related in the predicted manner to the mediators.

We predicted (a) that substance use would be related to an interaction between good self-control and poor regulation (Bickel et al., 2007; Steinberg et al., 2007). To clarify how moderation occurs we established a structural model of predictor-criterion relations, expecting on the basis of previous research that self-regulation variables would have indirect effects on substance use problems through the mediators. Multiple-group analyses then determined how paths in this model differed as a function of self-regulation attributes. Positing that moderation could occur at two places in the model, we predicted (b) that self-regulation variables will moderate paths from proximal factors to substance use level, altering the effect of life events and peer deviance on level of use (though we did not make specific predictions about behavioral and emotional aspects) and (c) that self-regulation variables will alter paths from substance use level to problems (Simons et al., 2009; Wills et al., 2002). The analyses included variables likely to be associated with self-regulation and substance use, including gender and parental education.

Method

Participants

The participants were students in four public high schools in the New York metropolitan area; 51% were 10th graders and 49% were 11th graders. The sample ($N = 1,307$) was 52% female and 48% male; the mean age was 16.0 years ($SD 0.7$). Ethnic distribution was 4% African American, 6% Asian-American, 66% Caucasian, 17% Hispanic, 3% other ethnicity, and 6% multiple ethnicity. For family structure, 18% of the participants were with a single parent, 6% were in a blended family (one biological parent and one stepparent), and 76% were with two biological parents. On a 1–6 scale, the mean for father=s education was 4.5 ($SD 1.4$), similar for mother=s education, indicating that almost all the parents had at least some college education.

Procedure

Data were obtained through a self-report questionnaire administered to students in classrooms by research staff using a standardized procedure. The research was reviewed and approved by the Institutional Review Board at Albert Einstein College of Medicine. The survey, designed for a 40-minute class period, was administered under anonymous conditions: students were instructed not to write their name on the questionnaire and were assured that their answers were anonymous and would not be known to anyone. In studies where participants are assured of confidentiality, self-reports of substance use have good validity (e.g., Patrick et al., 1994).

Students participated under a consent procedure in which parents were sent, by direct mail, a notice that informed them about the purpose of the research and the nature of the measures. A parent could have his/her child excluded from the research, if he/she wished, through returning a postcard to the investigator or contacting a designated administrator at the school. Students were similarly informed about the purpose and nature of the research prior to questionnaire administration and signed an assent form if they wished to participate; they were instructed that they could refuse or discontinue participation at any time. From an eligible population of 1,477 students based on class lists, the parental exclusion rate was 2%, the student refusal rate was 3%, and the student absenteeism rate was 7%, so the overall completion rate was 88%.

Measures

Measures are described in the following sections. Scale structure was determined with factor analysis (principal components, varimax rotation) and internal consistency analysis (Cronbach's alpha) and low-loading items were dropped from scales as appropriate. All scales were scored such that a higher score indicates more of the quantity named in the scale label.

Demographics—The participant was asked about his/her age, gender, and ethnicity (5 options, multiple responding allowed). An item on family structure asked what adult(s) he/she was currently living with (8 options, multiple responding allowed); this was recoded for analysis to three levels (single parent, blended family, or intact two-parent family). Items on six-point scales asked about level of education for father and mother and had anchor points Grade School and Post-college Education (masters/doctoral degree or other professional education).

Good behavioral self-control—The self-control measures were based on items obtained from several sources (Chen et al., 2004; Eysenck & Eysenck, 1978; Kendall & Wilcox, 1979; Simons & Carey, 2002; Zimbardo & Boyd, 1999). In each case, responses were on 5-point Likert scales with anchor points Not at All True for Me and Very True for Me. Scoring was based on previous analyses of measurement structure, which have consistently indicated separate factors for good behavioral control and poor behavioral regulation (Wills et al., 2001, 2004, 2007), and also for good emotional self-control and poor emotional regulation (Wills et al., 2006). Good behavioral self-control was assessed with four scales, which had individual α s of .59–.86. A 6-item scale for planfulness had items such as “I like to plan things ahead of time” and “I like to concentrate on one thing at a time.” A 5-item scale for future time perspective had items such as “Thinking about the future is pleasant for me” and “I complete assignments on time by making steady progress.” A 6-item scale for problem solving had items such as “When I have a problem ... I get as much information as I can” and “I think about the choices before I do anything.” A 5-item scale on delay of gratification has items such as “I can do boring work if I think it will pay off later on” and “I can say No to a good time when I know there is work to do first.” These were combined in a composite score for good behavioral self-control ($\alpha = .85$).

Poor behavioral regulation—Poor behavioral regulation was assessed with three scales derived from the same sources, which had individual α s of .73–.83. A 6-item scale on distractibility had items such as “I am easily distracted from my school work” and “I like to switch from one thing to another.” A 4-item scale on impulsiveness had items such as “I often do things without stopping to think” and “I often get involved in things I later wish I could get out of.” A 3-item scale on immediate gratification had items such as “It's difficult for me when I have to wait my turn for a long time” and “I tend to spend my money as soon

as I get it.” These scales were combined in a composite score for poor behavioral regulation ($\alpha = .73$).

Good emotional self-control—Good emotional self-control was assessed with three scales, (from Kendall & Wilcox, 1979; Zeman et al., 2001), which had individual α s of .80–.92. A 6-item scale for soothability had items such as “I can easily calm down when I am excited or wound up” and “If I get upset or distressed, I can recover quickly.” A 5-item scale for sadness management had items such as “When I am feeling sad or down ... I can control my sadness and carry on with things” and “I do something totally different until I feel better.” A 4-item scale for anger management had items such as “When I am angry or upset ... I stay calm and keep my cool” and “I try to deal calmly with what is making me mad.” These scales were combined in a composite score for good emotional self-control ($\alpha = .69$).

Poor emotional regulation—Poor emotional regulation was assessed with three scales derived from the same sources and from Simons and Carey (2002), which had individual α s of .86–.89. A 5-item scale on affective lability had items such as “My moods change a lot from day to day” and “One minute I can be OK and the next minute I can be tense and nervous.” A 6-item scale on angerability had items such as “When I have a problem ... I take it out on someone else” and “I blame and criticize other people.” A 3-item scale on anger rumination had items such as “I often find myself thinking about things that have made me angry” and “When people do something to make me angry, I don’t forget about it.” A 3-item scale on sadness rumination had items such as “I often get sad thinking about things that have happened in the past” and “I often find myself thinking about things that have made me sad.” These scales were combined in a composite score for poor emotional regulation ($\alpha = .83$).

Academic involvement—Academic orientation was assessed with an 8-item scale (from Wills et al., 2006) that assessed involvement in school and academic performance. The scale had items such as “In general, I like school a lot” and “Doing well in school is important to me” ($\alpha = .78$).

Negative life events—In a 20-item checklist of negative events, the participant was asked to indicate (No/Yes) whether or not a given event had occurred during the previous year (Wills et al., 2001). The checklist included an 11-item index on family life events, those that occurred to a family member and were unlikely to have been caused by the adolescent him/herself (e.g., “My father/mother: had a serious illness/lost his/her job/had a serious accident/had problems with money”); for analysis two items on parental separation/divorce were dropped to avoid overlap with the family-structure controls. The checklist also had a 9-item index on adolescent life events, those that occurred directly to the adolescent and could have been caused by the adolescent him/herself (e.g., “I had a serious accident,” “I broke up with a girl/boy friend,” “I got in trouble with the police,” “I got disciplined or suspended in school”). These were indexes rather than psychometric scales so internal consistency was not computed.

Friends=substance use—Peer substance use was assessed with the lead-in statement “Here are some simple questions about your friends.” Items asked the participant “Do any of your friends smoke cigarettes/drink beer or wine/smoke marijuana.” Responses were on 5-point scales with anchor points None of My Friends and More Than Three of My Friends. The items were correlated and a 3-item composite score for peer substance use had $\alpha = .78$.

Adolescent’s substance use level—Level of substance use was assessed with four items. Three items were introduced with the stem: “Which of the following is most true for

you about smoking cigarettes/using alcohol (beer, wine, or liquor)/using marijuana?" Responses were on 7-point scales (e.g., "I have never smoked cigarettes" to "I smoke cigarettes every day"). An item on heavy drinking asked the participant whether in the last month he/she had five or more drinks at one sitting (in about 2 hours); response points were No, Happened Once, Happened Twice, and Happened More than Twice. The items were correlated and a 4-item score for overall adolescent substance use had $\alpha = .84$. (Reports for 30- and 14-day substance use were also obtained; results for these were similar and the overall substance use score had a better match with the time frame for the substance problem measures, so we used that variable.)

Adolescent substance use problems—An inventory for substance use problems was based on previous measures for adolescents (Smith, McCarthy, & Goldman, 1995; White & Labouvie, 1989). Items were introduced with the stem, "Here are some things that could happen to people in connection with smoking, alcohol, or other drug use. During the past 12 months, have you experienced any of these things?" Responses were on 4-point scales (Never Happened to Happened Three or More Times). On the basis of factor analysis the inventory was scored for a scale on impaired-control problems, which had items such as "Used more alcohol or drugs than you intended," and "You tried to cut down on smoking or alcohol use but couldn't cut down much" (7 items, $\alpha = .92$). A scale on substance-related behavior problems had items such as "Got in trouble with the police because of alcohol or drugs," "Got in trouble for smoking, alcohol, or drug use at school," "Friends avoided you because of smoking or alcohol use," and "Broke up with a boy friend/girl friend because of smoking or alcohol use" (6 items, $\alpha = .96$).

Results

Prevalence rates for the substance use measures are presented in Table 1. In general the rates are comparable to data from other samples. For example, the rate for ever use of cigarettes as computed for 10th graders in the present sample was 33%, comparable to the rate of 32% reported for 10th graders in 2008 in the Monitoring the Future (MF) survey (Johnson, O'Malley, Bachman, & Schulenberg, 2009). Data for ever use of marijuana were also comparable to MF (36% vs. 30%). However, rates for overall use of alcohol were considerably higher compared to MF data, with the rate for ever use being 83% compared with 58% in MF. This comparison suggests that some experience with alcohol use was normative in this population. Heavy drinking was not rare either but comparison of the 14-day rates (19% in the present sample vs. 16% in MF) indicates that the present sample was similar in this respect.

Descriptive statistics are presented in Table 2. For the most part the measures of self-regulation were normally distributed. Skewness values were close to zero for measures of good self-control; measures of poor regulation tended to be shifted toward lower values but skewness values were still low. Distributions for the mediators had relatively low skewness and the composite score for substance use had only moderate skew. Descriptive statistics for the two problem measures were computed, as in the analyses that follow, only for participants who had a nonzero level of substance use (because abstainers logically are not at risk for substance use problems). Descriptives for the problem measures indicated there was moderate skewness for impaired-control problems and more skewness for substance-related behavior problems.

Test of Hypotheses

For testing the hypotheses we used a three-phase approach. First we tested for the interaction of self-regulation domains predicted by the concept of competing systems. Second, we

established pathways from predictors to substance use level and problems in a structural equation model. Third, we tested how pathways in this model were moderated by self-regulation variables.

For the first test, the hypothesized interaction between self-regulation systems (Bickel et al., 2008; Steinberg, 2007) was tested in multiple regression analysis. With a score for substance use level or problems as the criterion, main-effect terms for good self-control and poor regulation were entered together with their cross-product. For all analyses, the analytic sample was restricted to persons who had some experience with substance use ($N = 1,116$).¹ To control for any correlations with demographics, the analytic model included binary indices for gender and ethnicity (Caucasian vs. noncaucasian), two indices for family structure (single parent vs. blended or intact and blended vs. single or intact); and a score for parental education (sum of father=s and mother=s education). We used a criterion of $p < .01$ for interpretation. For substance use level as criterion, the interaction term for good behavioral self-control X poor behavioral regulation had $t = -3.15$ ($p = .002$) while the interaction term for good emotional self-control X poor emotional regulation had $t = -2.09$, $p = .04$. Results were graphed by computing estimated values of substance use at $M \pm 1$ SD on the predictor variables. Graphic results (Fig. 1A) indicated the interaction for behavioral variables had the predicted form. The effect of poor behavioral regulation on substance use was less for persons with a higher level of good behavioral self-control; in fact the effect of poor regulation on substance use level was almost completely eliminated at a higher level of good self-control. The effect for emotional regulation (Fig. 1B) was similar in form but was smaller in magnitude and not significant by our criterion.

For substance use problems as the criterion, the interaction of good behavioral self-control X poor behavioral regulation had $t = -3.15$ ($p = .002$) for impaired-control problems (Fig. 2A) and had $t = -3.54$ ($p < .001$) for behavior problems (Fig. 2B); graphs indicated the effect of poor regulation was reduced at a higher level of good behavioral self-control. An analysis for the emotional domain showed the interaction of good emotional self-control X poor emotional regulation had $t = -2.09$ ($p = .04$) for impaired-control problems (Fig. 2C) and had $t = -3.92$ ($p < .0001$) for behavior problems (Fig. 2D). The form of the interactions was consistent with prediction: The effect of poor emotional regulation on problems was less at a higher level of good emotional self-control.² Thus the hypothesized moderation effect was observed, both for level of substance use and with respect to number of substance-related problems.

Mediation Analysis

An overall moderation effect being demonstrated, it is necessary to determine the pathways from predictors to criterion variables in order to study where the moderation by the self-regulation variables occurs. Accordingly we specified a structural equation model of pathways from predictor variables to substance use level and problems. The data were analyzed in Mplus version 5 with maximum likelihood estimation (Muthen & Muthen, 2005) using the EM algorithm for missing data. A preliminary model with correlations among the model variables had good fit, with χ^2 (13 df, $N = 1,116$) = 24.43, Comparative Fit

¹There were interactions for cigarettes, marijuana, and heavy drinking, but not for overall alcohol use so we used a three-item substance use score for the analyses. Analyses for cases with one point on the substance use scale ($N = 1,116$), two points ($N = 960$), or three points ($N = 839$) on the scale showed quite similar results and we used the first subsample for maximal power.

²Tests for crossed interactions indicated for substance use level, good behavioral SC $\times$ poor emotional regulation, $t = -3.26$, $p < .001$; good emotional SC $\times$ poor behavioral regulation, $t = -2.11$, $p = .04$. For impaired-control problems, good behavioral SC $\times$ poor emotional, $t = -3.03$ ($p < .01$), good emotional SC $\times$ poor behavioral, $t = -1.34$, *ns*. For behavior problems, good behavioral SC $\times$ poor emotional, $t = -5.37$ ($p < .001$), good emotional SC $\times$ poor behavioral, $t = -3.83$, $p < .001$. We think this noteworthy because the correlations of the predictors for the crossed interactions ($r = -.29$ in each case) were lower yet the results supported a similar conclusion.

Index (CFI) = .99, and Root Mean Square Error of Approximation (RMSEA) = .028, Confidence Interval (CI) = .009–.045. Correlations are presented in Table 3. The demographic variables were not strongly correlated with self-regulation or substance use, but some correlations were noted and justified including these as covariates. With regard to self-regulation measures, the inverse correlations between good self-control and poor regulation were higher than in previous studies, where they are mostly in the range from $-.20$ to $-.40$ (Wills et al., 2001, 2004, 2007; Wills, Isasi, Ainette, & Chen, 2009). However, the positive correlations between behavioral and emotional aspects were lower than in a previous study (Wills, Ainette, et al., 2006). The self-regulation measures had substantial correlations with the hypothesized mediators, and the mediators were substantially correlated with substance use level. Thus the patterning of correlations was consistent with the postulated model of relations between self-regulation measures, mediators, and criterion variables. Substance use level was related to both of the problem measures, with a higher correlation for impaired-control problems than for substance-related behavior problems.

The structural model was specified with the four self-regulation variables as exogenous (i.e., not predicted by any prior construct in the model) and correlations of the self-regulation variables with demographic variables were included in the model. Variables hypothesized to mediate the relation of self-regulation with substance use (academic competence, negative life events, and affiliation with peer substance users) were specified as intermediate constructs, with covariances of their residual terms. Substance use level was regressed on the three hypothesized mediators, and the two substance-related problem measures (specified with a covariance of their residual terms) were regressed on substance use level. Composite scores for the four assessments of self-regulation were analyzed as manifest variables, because the higher construct correlations for self-regulation variables that occur with latent constructs would reduce the ability to detect unique effects. The subscales in the composite scores were substantially correlated (the mean intercorrelation was .46) and the various subscales correlated at similar levels with the substance use score. Other constructs in the model were also analyzed as manifest variables.

We estimated an initial model with all paths from the exogenous variables (including demographics) to the intermediate variables (three mediators and substance use level) plus two paths from level to the criterion constructs of substance-related problems. From this initial model, nonsignificant paths were dropped and paths with $p < .01$ were retained. This model had reasonable fit, with χ^2 (57 *df*, $N = 1,116$) of 174.92, CFI of .97, and RMSEA of .043 (CI .036–.050). Modification indices indicated that adding four direct effects from poor regulation to problems would improve the fit of the model, so these paths were included. The final structural model had good fit, with χ^2 (53 *df*, $N = 1,116$) of 108.46, CFI of .98, and RMSEA of .031 (CI .023–.039). This main-effect model is presented in Figure 3 with standardized coefficients. (The model was also analyzed with robust estimates of standard errors and none of the conclusions was different.) The residual correlations of endogenous variables, included in the model but excluded from the figure for graphical simplicity, for academic competence were $-.12$ with life events and $-.03$ with peer affiliations, and the residual correlation of life events with peer affiliations was .20. The residual correlation of impaired-control problems with substance-related behavior problems was .39. The prior variables in the model accounted for 10% to 40% of the variance in the mediators, and prior variables accounted for 30% of the variance in level of substance use. Together with mediators and direct effects, the variables in the model accounted for 52% of the variance in control problems and 21% of the variance in behavior problems.

The results indicated unique effects (all $p < .01$) for three of the self-regulation measures. Good behavioral self-control had a positive path to academic competence and an inverse path to affiliation with peer users. Poor behavioral regulation had paths to negative life

events and peer user affiliations. Poor emotional regulation had an inverse path to academic competence and a positive path to life events. Good emotional regulation had no significant unique effects. Results for intermediate variables indicated that academic competence had an inverse path to level of substance use whereas life events and peer user affiliations had positive paths to level. Substance use level had a larger path to impaired-control problems ($\beta = .67$) than to behavior problems ($\beta = .36$), a pattern consistent with other studies (Stacy & Newcomb, 1999; Wills et al., 2002). Direct effects from poor regulation to substance use problems were not predicted but were significant for both poor behavioral and poor emotional regulation, net of their relations to the mediators.³

Results for demographic variables (included in the model but excluded from the figure for graphical simplicity) indicated male gender was related to lower academic involvement ($\beta = -.09, p < .001$) and more substance use ($\beta = .08, p < .01$). White race was related to more affiliation with peers who used substances ($\beta = .14, p < .0001$) and more substance use ($\beta = .08, p < .01$). Single-parent family structure was related to more negative life events ($\beta = .16, p < .0001$) as was blended family structure ($\beta = .07, p < .01$). Parental education was related to more academic involvement ($\beta = .10, p < .001$), fewer negative life events ($\beta = -.17, p < .0001$) and substance-using friends ($\beta = -.10, p < .01$), and had a direct effect to behavior problems ($\beta = -.09, p < .01$).

We evaluated the indirect effects of self-regulation variables on problem measures in Mplus. For impaired-control problems the critical ratio (CR) for the total indirect effect (indirect effect/standard error, analogous to a *t* test) was as follows: -7.89 ($p < .0001$) for good behavioral control, 5.17 ($p < .0001$) for poor behavioral control, and 6.43 ($p < .0001$) for poor emotional control. The specific indirect effects (self-regulation variable $\rightarrow$ mediator variable $\rightarrow$ substance use level $\rightarrow$ substance use problems, two each for good behavioral, poor behavioral, and poor emotional) were all significant at $p < .0001$. For substance-related behavior problems the CRs for the total indirect effects were as follows: -6.93 ($p < .0001$) for good behavioral control, 4.88 ($p < .0001$) for poor behavioral control, and 5.88 ($p < .0001$) for poor emotional control. The specific indirect effects (same pathways as above) were all significant at $p < .0001$ except the path from poor behavioral regulation through negative life events and level to behavior problems ($CR = 3.63, p < .001$). Thus the mediation pathways through academic competence, life events, and peer affiliations, and their respective paths to substance use level, were all statistically significant.

Moderation Analysis

Having determined pathways from predictors to criterion variables in a multivariate model, the question now examined is, Where in this model does the moderation occur? In Figure 3, moderation could occur by self-regulation systems directly moderating each others=effects on mediators (i.e., immediate effects), through altering paths from mediators to level of substance use (i.e., intermediate effects) and/or through altering paths from level to problems (i.e., downstream effects). To determine the locus of moderation, multiple-group analyses were performed. Subgroups were formed based on a median split of a self-regulation measure, and the paths in the model in Figure 3 were computed for subgroups that were low vs. high on the self-regulation subgrouping. Analyses were conducted for subgroupings based on good behavioral or emotional self-control and on poor behavioral or emotional regulation; it should be noted that these tests were not totally independent because the self-regulation variables were correlated.

³Based on confirmatory analyses we analyzed a similar model with latent constructs for good behavioral self-control (4 indicators), good emotional self-control (3 indicators), poor behavioral regulation (3 indicators), and poor emotional regulation (4 indicators). This model had comparable fit and structural results were essentially the same as those reported here although correlations among the constructs tended to be higher and paths to mediators to be larger.

We first analyzed the model in both subgroups simultaneously with all parameters freely estimated (termed the base model). Equality constraints were then imposed on three sets of paths: the paths from self-regulation variables to mediators, the paths from mediators to substance use level, and the paths from level to problems. In each case the chi-square difference from the base model was obtained to determine whether the coefficients differed significantly across groups, using a criterion of $p < .01$ for the set test. In the following presentation we focus on intermediate and downstream effects because that is where the moderation was observed to occur.⁴ The base model subgrouped on good behavioral self-control (with 545 cases in the low group and 524 cases in the high group) is presented in Fig. 4A with nonstandardized coefficients. The base model had relatively good fit, with χ^2 (108 df) = 170.36, CFI of .98, and RMSEA of .033. For this model the set test for paths from mediators to substance use level was significant, difference chi-square (3 df) = 18.01, $p < .0001$, as was the set test for the paths from level to problems, difference chi-square (2 df) = 13.15, $p < .001$. Given significant set tests, we tested constraints with 1 df for each of the individual paths. Results (Fig. 4A) showed that paths from mediators to level were consistently lower in the subgroup that was higher on good control, but the path from negative life events to substance use level was the only individual path that differed significantly across the subgroups ($p < .01$). The path from level to behavior problems differed significantly across subgroups ($p < .001$) but the path from level to impaired-control problems did not.

In the multiple-group analysis subgrouped on good emotional self-control there were 538 cases in the low group and 528 cases in the high group. The base model (Fig. 4B) had good fit, with chi-square (108 df) = 170.46, CFI = .98, and RMSEA = .033. In contrast to results for good behavioral self-control, this analysis showed no significant moderation. The set test for paths from mediators to level had difference chi-square (3 df) = 1.19, *ns*, and the set test for paths from level to problems had difference chi-square (2 df) = 1.26, also nonsignificant. Because the set tests were nonsignificant we did not perform tests for any of the individual paths in this model.

In the multiple-group analysis subgrouped on poor behavioral regulation there were 568 cases in the low group and 518 cases in the high group. The base model (Fig. 5A) had good fit, with χ^2 (108 df) = 155.28, CFI = .98, and RMSEA = .028. The set test for paths from mediators to substance use level was significant, difference chi-square (3 df) = 26.00 $p < .0001$, as was the set test for the paths from level to problems, difference chi-square (2 df) = 20.06, $p < .0001$. Tests of individual paths indicated that all three paths from mediators to level differed across groups (Fig. 4A). The risk-promoting effect of negative life events ($p < .01$) and peer user affiliations ($p < .05$) was larger in the subgroup higher on poor regulation, and the protective effect of academic competence also was greater for this subgroup ($p < .01$). For substance use problems, the path from level to impaired-control problems was significantly greater for the subgroup higher on poor behavioral regulation ($p < .01$) as was the path from level to behavior problems ($p < .0001$).

The multiple-group analysis subgrouped on poor emotional regulation had 544 cases in the low subgroup and 532 cases in the high subgroup. The base model (Fig. 5B) had good fit, with chi-square (108 df) = 163.74, CFI = .98, and RMSEA = .031. The set test for path from mediators to level was marginally significant, difference chi-square (3 df) = 10.09, $p = .02$; the set test for paths from level to problems was significant, difference chi-square (2 df) =

⁴Set tests for paths from self-regulation measures to mediators were nonsignificant, difference chi-squares 1.09 and 0.40 with 2 df for Figs. 4A and B (*ns*), and 9.73 and 3.58 with 4 df for Figs. 5A and B ($p = .04$ and *ns*). Set tests for direct effects from poor regulation to problems, subgrouped on good self-control, had difference chi-square (4 df) of 10.02 ($p = .04$) and 8.54 ($p = .07$) for behavioral and emotional variables, respectively. None met our criteria for interpretation.

28.84, $p < .0001$. Tests of the individual paths (Fig. 5B) indicated that for mediators only the path from academic competence to level differed ($p < .05$) across subgroups. The paths from level to problems were both significantly larger ($p < .0001$) in the subgroup higher on poor emotional regulation.

Discussion

The purpose of this research was to examine how relations of behavioral and emotional aspects of self-regulation to substance use level and problems are moderated in the context of a dual-process approach. Bivariate analyses showed a predicted interaction between self-regulation systems, with the effect of poor regulation on substance use being lower among persons who scored higher on good self-control. To clarify the locus of moderation we analyzed a structural model of pathways from predictors to outcomes; this model showed unique effects to mediators for three of the self-regulation variables. Multiple-group analyses provided detailed information about the locus of the moderation in this model, showing that moderation by self-regulation variables occurred for effects of mediators on substance use level and for effects of level on substance use problems. Buffering effects were found for good behavioral self-control, and vulnerability effects were noted for poor behavioral and emotional regulation.

Although there has been considerable research showing a relation between impulsiveness and substance abuse (Lejuez et al., 2010; Perry & Carroll, 2008; Verdejo-Garcia, Lawrence, & Clark, 2008), there has been less attention to pathways through which this occurs and possible moderation of self-regulation systems. The findings of the present study showed a significant interaction between good self-control and poor regulation in prediction of adolescent substance use, consistent with the conception of substance use as the result of an interaction between two competing systems (Bickel et al., 2007; Steinberg et al., 2007; Volkow, Wang, Fowler, & Telang, 2008; Wills & Dishion, 2004). A detailed analysis of the way moderation occurred showed that this did not represent a process in which the two systems directly moderated each others=immediate effects. Rather, moderation occurred through a mixture of intermediate and downstream effects, which occurred at several sites in the multivariate model. These included moderation of relations of risk factors (negative life events, peer substance use) to level of substance use, and moderation of the relation of level to substance-related impaired-control and behavior problems. For the protective factor of academic competence, we found moderation such that academic competence had a stronger (inverse) path to substance use level at higher levels of poor behavioral and emotional regulation. The observed moderation effects should be considered for further development of dual-process models, considering not only the nature of the reflective and impulsive systems (Lieberman, 2007; Hoffman et al., 2009) but also the way in which their effects are translated into behavioral outcomes (Gerrard et al., 2008; Wills & Ainette, 2009).

In general the results in this study were stronger for behavioral variables than for emotional variables, but the differences do not represent a sharp distinction. Good behavioral self-control and poor behavioral regulation each had significant main effects in the structural model whereas good emotional self-control showed no significant main effects. However, poor emotional regulation did have several main effects in the structural model. Neither do we see a sharp distinction in moderation effects. Behavioral variables are clearly important in regard to moderating the effect of negative life events and peer affiliations on level of substance use and for moderating the effect of level on substance-related behavior problems, where one would expect behavioral processes (e.g., problem solving, delay of gratification) to be important. However, although one might think academic competence would be related strictly to behavioral variables, poor emotional regulation was inversely related to academic involvement as a main effect (replicating a finding from Wills et al., 2006), and poor

emotional regulation showed moderation effects at two sites in the multiple-group analyses. Thus emotional aspects of self-regulation are clearly important, both for intermediate variables and for proximal outcomes.

Moderation for the effect of substance use level on problems has been found in previous research (Simons et al., 2009; Wills et al., 2002) but the present study demonstrated somewhat different moderation effects for good self-control and poor regulation. Good behavioral self-control moderated only the path from substance use level to behavioral problems, while poor behavioral regulation moderated both types of paths from level to problems. We suggest that the findings considered together may reflect two types of process. Altering the impact of mediators (e.g., reducing the impact of negative events or peer use) may represent a more general process in which social transactions across a range of contexts (e.g., teachers, parents, and peers) differ as a function of the individual's self-regulation characteristics. Altering the impact of substance use level on problems may occur more in the context of specific situations related to substance use (e.g., with small groups of peers or with larger groups at parties and social events), where behavioral and emotional self-regulation characteristics shape the way in which persons use substances and the way they behave when under the influence of intoxicants. This suggests considering how self-regulation moderates outcomes in both task-oriented and social contexts.

In this study, good emotional self-control had no unique effects in the structural model and had no significant moderation effects, but we do not think this means it is unimportant. Emotional self-control did have significant zero-order correlations with mediator and criterion variables (Table 3) but these were slightly lower than the correlations for behavioral self-control, and in the multivariate model the unique effects went to the behavioral measure. Note that the criterion correlations for emotional self-control tended to be higher in a previous study (Wills, 2006); this included younger students and was composed largely of minority-group youth, whereas the present sample were older adolescents who were predominantly Caucasian, so the findings may be attributable in part to sample differences. There may be populations or outcomes where good emotional self-control is more or less important and we think this is a topic for further investigation. Emotional self-control should be investigated for unique effects at different ages (e.g., may be more relevant for younger adolescents) and for different populations (e.g., may be particularly important for persons who live in highly stressful environments).

Some limitations to the study should be considered. The sample was older adolescents in school districts where parental education and income were above average for the state; thus it would be desirable to replicate the results in different types of settings. The measures for good self-control and poor regulation were correlated more highly than in previous studies (Wills et al., 2006; Wills et al., 2009), and tests of these measures in other samples would be useful. The study was cross-sectional and does not resolve issues about temporal relations of variables, for example possible reciprocal relations between academic performance and substance use. Finally, the problem measures asked about a range of consequences associated with substance use but were not designed to produce diagnostic indices. Further research may investigate how self-regulation variables are related to diagnostic indices for substance abuse and dependence.

Approaches to Conceptualizing Poor Regulation

Some parallels can be noted between the present dual-process approach and alternative models that have aimed to distinguish different aspects of poor regulation. A model formulated by Dawe and Loxton (2004) has postulated two different aspects of impulsive behavior: a tendency to act rashly and without regard for the consequences, which they term *rash impulsiveness*, and a tendency to experience a strong attraction for rewards, termed

reward sensitivity. Empirically it has been found that the two dimensions factor separately and each has unique effects in relation to substance use and other problem behaviors (Dawe & Loxton, 2004; De Wit & Richards, 2004; Franken & Muris, 2006; Lejuez et al., 2010; Loxton, Nguyen, Casey, & Dawe, 2008). Research based on the concept of a reward deficiency underlying vulnerability to various addictive behaviors (Blum, Cull, Braverman, & Comings, 1996) has additionally posited that risk is elevated among individuals who have a deficit in rewarding experiences, with corresponding low positive affect, because of constitutional or environmental factors (Bowirrat & Oser-Berman, 2005; Yacubian & Büchel, 2009). These postulates have received support in human research on substance use (Mohr, Brannan, Mohr, Armeli, & Tennen, 2008; Volkow, Fowler, & Wang, 2004; Wills, Sandy, Shinar, & Yaeger, 1999; Wills, Vaccaro, & McNamara, 1992). Recent studies with animal models have also suggested that reward deficiency processes may operate to influence the probability of initiating use and becoming dependent on substances (Belin, Mar, Dalley, Robbins, & Everitt, 2008; Dalley et al., 2007; Perry, Larson, German, Madden, & Carroll, 2005). The dimension of rash impulsiveness is similar to the variable of poor behavioral regulation that we have assessed, but the dimension of reward sensitivity was not measured in the present research and neurological models of addiction (Bickel et al., 2007; Steinberg, 2007) have not distinguished these two aspects in detail. Further research with measures of rash impulsiveness and reward sensitivity would be useful for studying their pathways to substance use and other outcomes.

Another approach is based on work by Whiteside and Lynam (2001), who analyzed a set of personality measures and suggested there are several dimensions of impulsivity that are only modestly correlated. The variables studied were sensation seeking (excitement seeking and risk taking); impulsive behavior occurring under emotional arousal, which was termed “urgency;” and two scores for (lack of) persistence and (lack of) forethought. (These investigators used low scores on measures of planfulness and persistence as indices of impulsivity.) Studies have shown that subscales from the Whiteside and Lynam (2001) inventory are correlated with a variety of problem behaviors including substance use, antisocial behavior, and pathological gambling (Fischer & Smith, 2008; Miller, Flory, Lynam, & Leukefeld, 2003) as has been found for other measures of impulsivity (Verdejo-Garcia et al., 2008; Yacubian & Büchel, 2009). This work is related to the measures used in the present research in that scales based on planfulness and persistence in problem solving (i.e., good behavioral self-control) are only moderately related to measures of poor regulation and predict substance use through somewhat different pathways, net of risk-taking tendency (e.g., Wills et al., 2001, 2006).

Cyders et al. (2007) subsequently distinguished two aspects of urgency, which are substantially correlated and load together as facets of a common construct in a higher-order model; these are termed Negative Urgency (rash behavior that occurs in times of negative mood) and Positive Urgency (rash behavior that occurs in times of positive mood). These measures are correlated with substance use and other problem behaviors (e.g., Cyders et al., 2007; Zapolski, Cyders, & Smith, 2009). The measures for positive and negative urgency may be analogous to the scales of poor behavioral/emotional regulation used in the present research although they are framed in a somewhat different way. The theme of current research with urgency measures has been to test whether they make unique contributions to outcomes net of other scales in the inventory. These results have been somewhat inconsistent; for example in multivariate analyses negative urgency had a significant unique contribution for drinking in Cyders et al. (2007) but positive urgency had the only unique contribution to drug use in Zapolski et al. (2009); this may be a consequence of the scales=intercorrelation ($r = .67$ in Zapolski et al., 2009). Research with experience sampling designs, which should be most relevant for urgency theory because it assesses positive and negative emotions and daily situations, has also produced some results that were not

consistent with prediction. In a study by Simons, Dvorak, Batien, and Wray (2010) with college students, between-subjects analyses showed positive urgency was not correlated with positive affect, and within-day analyses showed positive urgency was inversely (not positively) related to daily alcohol intoxication while negative urgency was unrelated to either intoxication or dependence symptoms. The latter result contrasts with findings from experience sampling research showing poor behavioral control associated with increased negative consequences (Neal & Carey, 2007; Simons et al., 2005). Further studies are needed to determine how urgency scales are correlated with other measures of good self-control and poor regulation, what their pathways are to outcomes (e.g., why are high-impulsive persons more likely to end up in certain kinds of situations), and how results on positive urgency link with research showing positive mood to be a protective factor for drinking (e.g., Mohr et al., 2008) while negative affect is a robust predictor of substance use and abuse (Cheetham, Allen, Yücel, & Lubman, 2010).⁵

How Do Moderation Effects Occur

The moderation effects found in the present research are partially consistent with the conceptual framework outlined in the Introduction. The fact that the path from life events to substance use level was reduced in the subgroup higher on behavioral self-control suggests persons in this group are more resourceful and flexible in dealing with negative occurrences. Similarly, the fact that the path from level to behavior problems was lower is consistent with a behavioral mechanism, with persons higher on good self-control being more able to manage their behavior in substance-related situations and avoid inappropriate or reckless behavior that would get them in trouble with external agencies such as police or school officials. However, the findings did not support the proposition that good self-control is connected with a better ability to deal with peer pressure. While bivariate interactions have been found in other studies, the present multivariate analyses did not show evidence of reduced paths from peer use to substance use level among persons scoring higher on behavioral self-control; instead results showed this path was larger for persons scoring higher on poor regulation. This suggests attention to measuring both domains of self-regulation and studying how poor behavioral and emotional regulation is related to behavior in crucial social interactions (Sussman, McCuller & Dent, 2003).

The results for poor regulation indicated somewhat different effects for behavioral and emotional aspects. Poor behavioral regulation moderated all the pathways in the model so is clearly an important aspect of regulation. A higher level of poor emotional regulation increased paths from level to both types of substance use problems but showed only one moderation effect on paths from mediators to level of substance use. It should be noted, however, that both aspects of poor regulation moderated paths to impaired-control problems as well as to substance-related behavior problems, suggesting that these make it difficult to control intake as well as behavior. This could reflect more physiological sensitivity to drug effects as well as more negative mood and emotional lability, which would make persons susceptible to adverse effects of drug use (Baker et al., 2004; Simons & Carey, 2002). It may be that the task-related aspects of poor behavioral regulation (e.g., impatience, distractibility) have implications for dealing with life problems in several areas (i.e., academics, peer relationships), whereas poor emotional regulation is most relevant for proximal contexts in which substances are being used. The direct effects from poor regulation to problems need replication but may reflect a process in which these variables affect outcomes independently of intoxication (Simons et al., 2009). Further research is

⁵It should be noted that college student drinking is often associated with group social occasions or celebratory occasions and positive mood may be positively related to daily drinking (Simons et al., 2010), but even in such studies it may function as a buffering agent (Mohr et al., 2008) or interact with other variables such as distress tolerance (Simons et al., 2005).

needed on how behavioral and emotional aspects of self-regulation relate to behavior in different social contexts (e.g., peers vs. adults) and for different types of problems (e.g., task problems vs. interpersonal problems).

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References

- Audrain-McGovern J, Rodriguez D, Tercyak KP, Nenner G, Moss HB. The impact of self-control indices on peer smoking and adolescent smoking progression. *Journal of Pediatric Psychology*. 2006; 21:139–151. [PubMed: 16467314]
- Aytaclar S, Tarter RE, Korisci L, Lu S. Association between hyperactivity and executive cognitive functioning in childhood and substance use in early adolescence. *Journal of the American Academy of Child and Adolescent Psychiatry*. 1999; 38:172–178. [PubMed: 9951216]
- Baker TB, Piper M, McCarthy D, Majeskie M, Fiore M. Addiction motivation reformulated: An affective processing model. *Psychological Review*. 2004; 111:33–51. [PubMed: 14756584]
- Barkley RA. Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological Bulletin*. 1997; 121:65–94. [PubMed: 9000892]
- Belin D, Mar AC, Dalley JW, Robbins TW, Everitt BJ. High impulsivity predicts the switch to compulsive cocaine-taking. *Science*. 2008; 320:1352–1355. [PubMed: 18535246]
- Bickel WK, Miller ML, Yi R, Kowal BP, Lindquist DM, Pitcock JA. Behavioral and neuroeconomics of drug addiction: Competing neural systems and temporal discounting processes. *Drug and Alcohol Dependence*. 2007; 90(S1):S85–S91. [PubMed: 17101239]
- Bickel WK, Odum AL, Madden GJ. Impulsivity and cigarette smoking: Delay discounting in smokers and ex-smokers. *Psychopharmacology*. 1999; 146:447–454. [PubMed: 10550495]
- Blum K, Cull JG, Braverman ER, Comings DE. Reward deficiency syndrome: A basis for addictive, impulsive, and compulsive disorders. *American Scientist*. 1996; 84:132–145.
- Bowirrat A, Oscar-Berman M. Relation between dopaminergic neurotransmission, alcoholism, and reward deficiency syndrome. *American Journal of Medical Genetics Part B (Neuropsychiatric Genetics)*. 2005; 132B:29–37.
- Brody G, Ge X. Linking parenting and self-regulation to functioning and alcohol use in early adolescence. *Journal of Family Psychology*. 2001; 15:82–94.
- Carver, CS.; Scheier, MF. On the structure of behavioral self-regulation. In: Boekaerts, M.; Pintrich, PR.; Zeidner, M., editors. *Handbook of self-regulation*. San Diego: Academic Press; 2000. p. 41–84.
- Cheetham A, Allen NB, Yücel M, Lubman DI. The role of affective dysregulation in drug addiction. *Clinical Psychology Review*. 2010; 30:621–634. [PubMed: 20546986]
- Chen K, Sheth AJ, Elliott DK, Yaeger A. Prevalence and correlates of past-year substance use, abuse, and dependence in a community sample of high school students. *Addictive Behaviors*. 2004; 29:413–423. [PubMed: 14732431]
- Colder CR, Chassin LM. Affectivity and impulsivity: Temperamental risk for alcohol involvement. *Psychology of Addictive Behaviors*. 1997; 11:83–97.
- Cole PM, Michel MK, Teti LO. The development of emotion regulation and dysregulation. *Monographs of the Society for Research in Child Development*. 1994; 59:73–100. [PubMed: 7984169]
- Cyders MS, Smith GT, Spillane NS, Fischer S, Annus AM, Peterson C. Development of a measure of positive urgency. *Psychological Assessment*. 2007; 19:107–118. [PubMed: 17371126]
- Dalley JW, et al. Nucleus accumbens D2/3 receptors predict trait impulsivity and cocaine reinforcement. *Science*. 2007; 315:1267–1270. [PubMed: 17332411]

- Dawe S, Loxton NJ. The role of impulsivity in the development of substance use and eating disorders. *Neuroscience and Biobehavioral Reviews*. 2004; 28:43–351.
- Derryberry D, Rothbart MK. Reactive and effortful processes in the operation of temperament. *Development and Psychopathology*. 1997; 9:633–652. [PubMed: 9448999]
- DeWit, H.; Richards, JB. Dual determinants of drug abuse in humans: Reward and impulsivity. In: Bevens, RA.; Bardo, MT., editors. *Motivational factors in the etiology of drug abuse*. Volume 50 of the Nebraska Symposium on Motivation. Lincoln, NE: University of Nebraska Press; 2004. p. 19-55.
- Dvorak RD, Simons JS. Moderation of resource depletion in the self-control strength model: Differing effects of two modes of self-control. *Personality and Social Psychology Bulletin*. 2009; 35:572–583. [PubMed: 19193603]
- Eysenck SBG, Eysenck HJ. Impulsiveness and venturesomeness: personality description. *Psychological Reports*. 1978; 43:1247–1255. [PubMed: 746091]
- Fischer S, Smith GT. Binge eating, problem drinking, and pathological gambling: Linking behavior to shared traits. *Personality and Individual Differences*. 2008; 44:789–800.
- Gardner T, Dishion T, Connell A. Adolescent self-regulation as resilience within the deviant peer context. *Journal of Abnormal Child Psychology*. 2008; 36:273–284. [PubMed: 17899361]
- Gerrard M, Gibbons FX, Houlihan AE, Stock ML, Pomery EA. A dual-process approach to health risk decision making. *Developmental Review*. 2008; 28:29–61.
- Gilliom M, Shaw DS, Beck JE, Schonberg MA, Lukon LL. Anger regulation in disadvantaged preschool boys. *Developmental Psychology*. 2002. 2002; 38:222–235.
- Franken H, Muris P. Gray=s impulsivity dimension: A distinction between Reward Sensitivity and Rash Impulsiveness. *Personality and Individual Differences*. 2006; 40:1337–1347.
- Hoffman W, Friese M, Strack F. Impulse and self-control from a dual-systems perspective. *Perspectives on Psychological Science*. 2009; 4:162–175.
- Johnson, LD.; O=Malley, PM.; Bachman, JG.; Schulenberg, JE. *Secondary school students*. Vol. 1. Bethesda, MD: National Institute on Drug Abuse; 2009. Monitoring the Future national survey results on drug use, 1975–2008. NIH Publication No. 09–7402
- Kendall PC, Wilcox LE. Self-control in children: Development of a rating scale. *Journal of Consulting and Clinical Psychology*. 1979; 47:1020–1029. [PubMed: 512157]
- Khantzian, EJ. Self-regulation and self-medication factors in alcoholism and the addictions. In: Galanter, M., editor. *Recent developments in alcoholism*. Vol. 8. New York: Plenum Press; 1990. p. 255-271.
- Lejeuz CW, Magidson JF, Mitchell SH, Sinha R, Stevens MC, de Wit H. Behavioral and biological indicators of impulsivity in the development of alcohol use, problems, and disorders. *Alcoholism: Clinical and Experimental Research*. 2010; 34:1334–1345.
- Lieberman, MD. The X- and C-systems: The neural basis of automatic and controlled social cognition. In: Harmon-Jones, E.; Winkelman, P., editors. *Integrating biological and psychological explanations of social behavior*. New York: Guilford; 2007. p. 290-315.
- Loxton NJ, Nguyen D, Casey L, Dawe S. Reward drive, rash impulsivity, and punishment sensitivity in gamblers. *Personality and Individual Differences*. 2008; 45:167–173.
- Miller J, Flory K, Lynam D, Leukefeld C. A test of the four-factor model of impulsivity-related traits. *Personality and Individual Differences*. 2003; 34:1403–1418.
- Miller, WR.; Brown, JM. Self-regulation as a conceptual basis for the prevention of addictive behaviors. In: Heather, N.; Miller, WR.; Greeley, J., editors. *Self-control and the addictive behaviors*. Sydney, Australia: Maxwell Macmillan; 1991. p. 3-79.
- Mohr C, Brannan D, Mohr J, Armeli S, Tennen H. Evidence for positive mood buffering in college drinkers. *Personality and Social Psychology Bulletin*. 2008; 34:1249–1259. [PubMed: 18550862]
- Muthén, L.; Muthén, B. *Mplus User's Guide*. Los Angeles, CA: Author; 1998.
- Neal DJ, Carey KB. Association between alcohol intoxication and alcohol related problems: An event-level analysis. *Psychology of Addictive Behaviors*. 2007; 21:194–204. [PubMed: 17563139]
- Novak SP, Clayton RR. Influence of school environment and self-regulation on transitions between stages of cigarette smoking. *Health Psychology*. 2001; 20:196–207. [PubMed: 11403217]

- Patock-Peckham JA, Cheong JW, Balhorn ME, Nagoshi CT. A model of parenting styles, self-regulation, perceived drinking control, and alcohol use and problems. *Alcoholism: Experimental and Clinical Research*. 2001; 25:1284–1292.
- Patock-Peckham JA, Morgan-Lopez A. Links between parenting styles, impulse control, and college drinking outcomes. *Psychology of Addictive Behaviors*. 2006; 20:117–125. [PubMed: 16784353]
- Patrick DL, Cheadle A, Thompson D, Diehr P, Koepsell T, Kinne S. The validity of self-reported smoking. *American Journal of Public Health*. 1994; 84:1086–1093. [PubMed: 8017530]
- Perry JL, Carroll ME. The role of impulsive behavior in drug abuse. *Psychopharmacology*. 2008; 200:1–26. [PubMed: 18600315]
- Perry JL, Larson EB, German JP, Maden GJ, Carroll ME. Impulsivity (delay discounting) as a predictor of acquisition of IV cocaine self-administration in female rats. *Psychopharmacology*. 2005; 178:193–201. [PubMed: 15338104]
- Petry NM, Bickel WK, Arnett M. Shortened time horizons and insensitivity to future consequences in opioid-dependent individuals. *Addiction*. 1998; 93:729–738. [PubMed: 9692271]
- Rothbart MK, Ahadi SE, Evans DE. Temperament and personality: Origins and outcomes. *Journal of Personality and Social Psychology*. 2000; 78:122–135. [PubMed: 10653510]
- Simons JS, Carey KB. Risk and vulnerability for marijuana use problems: The role of affect dysregulation. *Psychology of Addictive Behaviors*. 2002; 16:72–75. [PubMed: 11934090]
- Simons JS, Carey KB, Wills TA. Alcohol abuse and dependence symptoms: A model of common and specific etiology. *Psychology of Addictive Behaviors*. 2009; 23:415–427. [PubMed: 19769426]
- Simons JS, Dvorak RD, Batien BD, Wray TB. Event-level associations between affect, alcohol intoxication, and acute dependence symptoms: Effects of urgency, self-control, and drinking experience. *Addictive Behaviors*. 2010; 35:1045–1053. [PubMed: 20685044]
- Simons JS, Oliver M, Gaher R, Ebel G, Brummels P. Methamphetamine and alcohol abuse: Associations with impulsivity. *Addictive Behaviors*. 2005; 30:1370–1381. [PubMed: 16022933]
- Simons JS, Gaher RM, Oliver MNI, Bush JA, Palmer MA. An experience sampling study of associations between affect and alcohol use and problems among college students. *Journal of Studies on Alcohol*. 2005; 66:459–469. [PubMed: 16240553]
- Smith GT, McCarthy DM, Goldman MS. Drinking and alcohol-related problems among early adolescents. *Journal of Studies on Alcohol*. 1995; 56:383–394. [PubMed: 7674672]
- Southam-Gerow MA, Kendall PC. Emotional regulation and understanding: Implications for child psychopathology. *Clinical Psychology Review*. 2002; 22:189–222. [PubMed: 11806019]
- Stacy AW, Newcomb MD. Adolescent drug use and adult drug problems in women. *Experimental and Clinical Psychopharmacology*. 1999; 7:160–173. [PubMed: 10340156]
- Steinberg L. Risk taking in adolescence: New perspectives from brain and behavioral science. *Current Directions in Psychological Science*. 2007; 16:55–59.
- Sussman S, McCuller WJ, Dent CW. The association of social self-control with drug use among high-risk youth. *Addictive Behaviors*. 2003; 28:1159–1166. [PubMed: 12834658]
- Verdejo-Garcia A, Lawrence AJ, Clark L. Impulsivity as a vulnerability marker for substance use disorders: Review of findings from high-risk research, problem gamblers, and genetic association studies. *Neuroscience and Biobehavioral Reviews*. 2008; 32:777–810. [PubMed: 18295884]
- Volkow ND, Fowler JS, Wang GJ. The addicted brain viewed in light of imaging studies: Brain circuits and treatment strategies. *Neuropharmacology*. 2004; 47:3–13. [PubMed: 15464121]
- Volkow ND, Wang GJ, Fowler JS, Teland F. Overlapping neuronal circuits in addiction and obesity: Evidence of systems pathology. *Philosophical Transactions of the Royal Society B*. 2008; 363:3191–3200.
- White HR, Labouvie EW. Towards the assessment of adolescent problem drinking. *Journal of Studies on Alcohol*. 1989; 50:30–37. [PubMed: 2927120]
- Whiteside SP, Lynam DR. Using a structural model of personality to understand impulsivity. *Personality and Individual Differences*. 2001; 30:669–689.
- Wills, TA.; Ainette, MG. Temperament, self-control, and adolescent substance use: A two-factor model of etiological processes. In: Scheier, LM., editor. *Handbook of drug use etiology*. Washington, DC: American Psychological Association; 2009. p. 127–146.

- Wills TA, Ainette MG, Stoolmiller M, Gibbons FX, Shinar O. Good self-control as a buffering agent for adolescent substance use. *Psychology of Addictive Behaviors*. 2008; 22:459–471. [PubMed: 19071971]
- Wills TA, Cleary S, Filer M, Shinar O, Mariani J, Spera K. Temperament and self-control related to early-onset substance use. *Prevention Science*. 2001; 2:145–163. [PubMed: 11678291]
- Wills TA, Dishion T. Temperament and adolescent substance use: An analysis of emerging self-control. *Journal of Clinical Child and Adolescent Psychology*. 2004; 33:69–81. [PubMed: 15028542]
- Wills TA, Isasi CR, Ainette MG, Chen KW. A two-factor model for the measurement of self-control constructs. Manuscript submitted for publication. 2009
- Wills TA, Murry V, Brody G, Gibbons FX, Gerrard M, Walker C, Ainette M. Ethnic pride, self-control, and protective/risk factors. *Health Psychology*. 2007; 26:50–59. [PubMed: 17209697]
- Wills TA, Resko J, Ainette M, Mendoza D. The role of parent and peer support in adolescent substance use. *Psychology of Addictive Behaviors*. 2004; 18:122–134. [PubMed: 15238054]
- Wills TA, Sandy JM, Shinar O. Cloninger's constructs related to substance use level and problems in late adolescence: A mediational model based on self-control and coping motives. *Experimental and Clinical Psychopharmacology*. 1999; 7:122–134. [PubMed: 10340152]
- Wills TA, Sandy JM, Shinar O, Yaeger A. Contributions of positive and negative affect to adolescent substance use. *Psychology of Addictive Behaviors*. 1999; 13:327–338.
- Wills TA, Sandy JM, Yaeger A. Moderators of the relation between substance use level and problems. *Journal of Abnormal Psychology*. 2002; 111:3–21. [PubMed: 11866177]
- Wills TA, Stoolmiller M. The role of self-control in escalation of substance use: A time-varying analysis. *Journal of Consulting and Clinical Psychology*. 2002; 70:986–997. [PubMed: 12182282]
- Wills TA, Vaccaro D, McNamara G. The role of life events and competence in adolescent substance use. *American Journal of Community Psychology*. 1992; 20:349–374. [PubMed: 1415032]
- Wills TA, Walker C, Mendoza D, Ainette MG. Behavioral and emotional self-control: Relations to substance use in samples of middle- and high-school students. *Psychology of Addictive Behaviors*. 2006; 20:265–278. [PubMed: 16938064]
- Yacubian J, Büchel C. Genetic basis of individual differences in reward processing and the links to addictive behavior and social cognition. *Neuroscience*. 2009; 164:55–71. [PubMed: 19446009]
- Zapolsky TCB, Cyders MA, Smith GT. Positive urgency predicts illegal drug use and risky sexual behavior. *Psychology of Addictive Behaviors*. 2009; 23:348–354. [PubMed: 19586152]
- Zeman J, Shipman K, Penza-Clyve S. Development and validation of the Children's Sadness Management scale. *Journal of Nonverbal Behavior*. 2001; 25:187–205.
- Zimbardo PG, Boyd JN. Time perspective: A valid, reliable individual-differences metric. *Journal of Personality and Social Psychology*. 1999; 77:1271–1288.

Figure 1.

Interactions for self-regulation variables, substance use level as criterion. Shown are estimated values of substance use for cases at $M \pm 1 SD$ on good self-control and poor regulation. (A) Good behavioral self-control X poor behavioral regulation; (B) Good emotional self-control X poor emotional regulation.

Figure 2. Interactions for self-regulation variables, impaired-control problems and behavior problems as criteria. Shown are estimated values of substance use for cases at $M \pm 1 SD$ on the respective predictors. (A, B) Interactions for good behavioral self-control X poor behavioral regulation; (C, D) Interactions for good emotional self-control X poor emotional regulation.

Figure 3.

Structural model for relation of self-regulation variables to mediator and criterion variables ($N = 1,116$). Values are standardized coefficients; all coefficients are significant at $p < .01$. Straight arrows represent path effects; curved arrows indicate covariances. For covariances of exogenous variables (included in the model but excluded from the figure) see Table 4; for residual correlations of endogenous variables see text. Circles at top of figure show squared multiple correlations, the variance accounted for in a construct by all variables to the left of it in the model.

Figure 4.

Paths in base models for multiple-group analyses of good self-control. Values are nonstandardized coefficients (SE in parentheses). 4A: Analysis for subgroups of low behavioral self-control (above line) and high behavioral self-control (below line). 4B: Analysis for subgroups of low emotional self-control (above line) and high emotional self-control (below line). * indicates individual coefficients for subgroups are significantly different ($p < .05$); ** indicates coefficients for subgroups differ ($p < .01$); *** indicates coefficients for subgroups differ ($p < .001$); **** indicates coefficients for subgroups differ ($p < .0001$).

Figure 5.

Paths in base models for multiple-group analyses of poor regulation. Values are nonstandardized coefficients (SE in parentheses). 5A: Analysis for subgroups low on poor behavioral regulation (above line) and high on poor behavioral regulation (below line). 5B: Analysis for subgroups of low on poor emotional regulation (above line) and high on poor emotional regulation (below line). For graphical conventions, see Figure 4 caption.

Table 1

Prevalence Rates (%) for Overall and Recent Substance Use, for Four Indices

Frequency	Overall-use indices		
	Smoking	Alcohol	Marijuana
Never	64%	14%	58%
1–2 times	12	16	9
3–4 times	7	14	8
Few times/yr	8	25	9
Few times/mo	3	26	9
Few times/wk	2	5	5
Every day	3	<1	3
			Heavy drinking past month
			None
			Once
			Twice
			3–3 times
			19

Note: Analysis for total sample, $N = 1,307$.

Table 2

Descriptive Statistics for Study Variables

Variable	Range	<i>M</i>	<i>SD</i>	<i>Skew</i>
<u>Good behavioral self-control</u>				
Planfulness	6–30	20.45	3.93	−0.21
Future perspective	5–25	15.41	4.08	0.03
Problem solving	6–30	20.21	4.91	−0.27
Delay gratification	5–25	15.64	3.84	−0.03
<u>Poor behavioral regulation</u>				
Distractibility	6–30	16.36	5.45	0.20
Impulsiveness	4–20	10.52	3.68	0.41
Immediate gratification	3–15	7.02	3.07	0.75
Present orientation	5–25	11.58	3.84	0.57
<u>Good emotional self-control</u>				
Soothability	6–30	16.38	4.90	0.25
Sadness management	5–25	15.41	4.05	−0.02
Anger management	4–20	12.49	4.00	−0.04
<u>Poor emotional regulation</u>				
Affective lability	5–25	11.57	4.91	0.77
Angerability	6–30	12.74	5.04	0.99
Anger rumination	3–15	7.85	3.18	0.41
Sadness rumination	3–15	8.70	3.10	0.22
<u>Mediator variables</u>				
Academic involvement	8–40	29.69	5.01	−0.49
Academic alienation	8–40	15.54	4.53	0.80
Negative life events	0–18	4.47	2.88	0.67
Friends substance use	0–12	8.20	3.97	−0.77
<u>Criterion variables</u>				
Overall substance use	0–20	5.61	4.96	0.83
Sub. problems--control	0–21	2.97	4.23	1.79
Sub. problems--behavior	0–12	0.53	1.39	3.94

Note: *N* for descriptives = 1,307 except for the problems measures, *N* = 1,116.

Table 3

Correlations of Study Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Gender (0F, 1 M)	---														
2. Race (0 NonW, 1 White)	.00	---													
3. Single (0 non, 1 Single)	-.01	-.24	---												
4. Blended (0 non, 1 Blend)	-.03	-.12	-.12	---											
5. Parental Education	.04	.56	-.20	-.11	---										
6. Good behavioral SC	-.06	.04	-.08	-.02	.10	---									
7. Good emotional SC	.15	.10	-.02	-.03	.12	.31	---								
8. Poor behavioral regulation	-.04	-.02	.05	.06	-.05	-.56	-.29	---							
9. Poor emotional regulation	-.14	-.01	.05	.04	-.07	-.29	-.46	.59	---						
10. Academic competence	-.09	.08	-.12	-.02	.16	.61	.26	-.42	-.30	---					
11. Negative life events	-.10	-.19	.23	.09	-.23	-.27	-.24	.40	.47	-.32	---				
12. Peer substance use	.04	.07	.04	.01	-.04	-.26	-.10	.25	.16	-.20	.27	---			
13. Substance use level	.10	.07	.10	.04	-.05	-.31	-.12	.26	.20	-.31	.29	.48	---		
14. Sub. problems--control	.03	.03	.06	.04	-.06	-.29	-.16	.31	.28	-.30	.34	.39	.71	---	
15. Sub. problems--behavior	.02	-.04	.04	.01	-.12	-.23	-.13	.25	.24	-.25	.31	.22	.42	.56	---

Note: N for analysis = 1,116. SC = self-control; sub. = substance. FS = family structure. Approximate significance levels are $r > .10$, $p < .001$; $r > .12$, $p < .0001$.