A Dual-Process Model of Early Substance Use: Tests in Two Diverse Populations of Adolescents

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Objective: We tested a dual-process model based on behavioral and emotional regulation constructs, which posits that good self-control and poor regulation make independent contributions and have different types of pathways to outcomes. The utility of the model for predicting substance use was tested in two diverse populations of younger adolescents. *Method:* A survey was administered in classrooms to middle-school students in Westchester County, New York ($N = 601$) and Honolulu, Hawaii ($N = 881$). The New York sample was 8% African American, 5% Asian American, 47% Caucasian, 31% Hispanic, and 9% other ethnicity. The Hawaii sample was 21% Asian American, 8% Caucasian, 26% Native Hawaiian/Pacific Islander, 34% Filipino, and 10% other ethnicity. Structural equation modeling analyses tested pathways from the four regulation variables through six hypothesized mediators to a criterion construct of substance use (tobacco, alcohol, and marijuana). *Results:* Results were replicated across samples and were consistent with prediction. Unique contributions were found for good self-control and poor regulation, including both behavioral and emotional aspects. Good self-control had an inverse effect on substance use primarily through relations to higher levels of protective factors (e.g., academic competence). Poor regulation independently had a risk-promoting effect on substance use through relations to higher levels of risk factors (e.g., negative life events). *Conclusions:* Two field studies showed the dual-process model is robust across different populations. Substance prevention programs should consider approaches for enhancing good self-control as well as procedures for reducing poor regulation and minimizing its impact. Extensions to health behaviors including dietary intake and physical activity are discussed.

Keywords: substance use, adolescents, self-control, dual-process theory, mediation

Supplemental materials: http://dx.doi.org/10.1037/a0027634.supp

Adolescent onset of cigarette smoking and other substance use is a topic of continuing concern to health psychology, both because of the ultimate linkage of these behaviors to heart disease and cancer in adulthood and because early onset (before 14 years of age) is prognostic for problems at later ages (e.g., Breslau, Fenn, & Peterson, 1993; Hawkins et al., 1997; Tarter et al., 1999). These include behavioral problems, such as fighting or reckless driving,

and substance-related problems such as tobacco dependence and difficulty in quitting. Approaches to health behavior based on rational evaluation of risks and benefits have had some successes in application to public health programs. However, smoking remains a public health issue (Johnston, O'Malley, Bachman, & Schulenberg, 2009; Schroeder & Warner, 2010) and new theoretical perspectives may help to inform prevention programs. Here we outline a dual-process model of early substance use and test the model in two different populations of adolescents so as to determine the robustness of this theoretical approach.

From an origin in attitude research (Chaiken & Trope, 1999), the implications of dual-process theory for health behavior research are now being explored (Gibbons et al., 2009; Hofmann, Friese, & Strack, 2009; Wills & Ainette, 2010). This approach posits that two distinct systems are involved in processing information and responding to situations. A controlled approach is based on conscious processing of information and consideration of risks; this approach is systematic but takes time and requires cognitive effort. The other approach is more spontaneous and less conscious, relatively fast, and based on heuristics and mental images rather than conscious reflection. In various disciplines the two domains have been given terms such as X and C (reflexive and reflective) systems (Lieberman, 2007); impulse and reflection

(Hofmann et al., 2009); or reason and reaction (Gibbons et al., 2009).[1] The present research program originated in studies on the effects of temperament and self-control in early adolescence (Wills & Dishion, 2004) where the two domains are termed *good self-control* and *poor regulation*.

Dual-Process Research With Adolescents

The constructs of good self-control and poor regulation represent two domains of processes that are inversely related but only moderately correlated. Good self-control is a set of correlated abilities involving a tendency to acquire and evaluate information, think ahead about situations, and achieve goals through a focus on completing tasks. It is similar to what has been termed "planfulness" in adults (Rutter et al., 1997) or "effortful control" in children (Rothbart, Ahadi, & Evans, 2000) and is not the same thing as IQ (Tarter et al., 1999; Wills, Ainette, Mendoza, Gibbons, & Brody, 2007). It is grounded in early temperament dimensions such as attentional control (Wills, Sandy, & Yaeger, 2000) but by adolescence it has become considerably more complex.[2] Poor regulation involves a set of characteristics that also are correlated: A tendency to be impatient and act without thinking, to like to switch tasks, and to be easily irritated or frustrated; this is similar to what has been termed "disinhibition" or "rash impulsivity" (Iacono, Carlson, Taylor, Elkins, & McGue, 1999; Loxton, Nguyen, Casey, & Dawe, 2008; Perry & Carroll, 2008). Poor regulation is grounded in temperament attributes such as activity level and irritability (Eisenberg, Fabes, Guthrie, & Reiser, 2000; Wills et al., 2001), but by adolescence it comes to involve a broader repertoire of reactions as situations become more complex.

Direct Measurement of Two Domains

This research program has proceeded with three linked goals. One has been assessing the two domains of regulation with multiple indicators. It is assumed that a construct such as good self-control may be based on simple characteristics such as attention and working memory (Barkley, 1997; Rothbart et al., 2000), but by adolescence, it has increased in complexity with cognitive and social maturation, and the construct is probably not well represented by a single indicator. Thus several scales derived from social and personality psychology have been tested for their role in assessing the underlying constructs. For good self-control these include planning and problem solving (Rosenbaum, 1990; Wills, McNamara, Vaccaro, & Hirky, 1996), time perspective (Zimbardo & Boyd, 1999), and delay of gratification (Mischel, Shoda, & Rodriguez, 1989). For poor regulation these include indicators such as impatience, impulsiveness, and distractibility (Eysenck & Eysenck, 1978; Kendall & Wilcox, 1979). The indicators are intercorrelated as predicted by Barkley's (1997) formulation, and confirmatory analyses have established an empirical measurement structure in which indicators load on the predicted constructs (e.g., Wills, Murry, et al., 2007; Wills, Walker, Mendoza, & Ainette, 2006). Across studies, the average construct correlation for good self-control and poor regulation is about $r = -.30$, which is consistent with the proposition that they are two distinct systems (Bickel et al., 2007; Wills & Dishion, 2004).

Testing Pathways to Outcomes

A second theme in our research on the dual-process model is delineating *how* the two systems are related to health behavior

outcomes. Given the many known predictors of adolescent substance use (Petraitis, Flay, & Miller, 1995), it seems unlikely that either of the processes leads directly to complex behavioral outcomes (Zucker, 1994). Thus we have used a multiple-mediator framework for understanding how regulation constructs are related to outcomes, positing that there are indirect pathways from regulation to adolescent substance use and that these involve a range of variables. Because self-regulation has generalized effects, we posit that the pathways to substance use include developed competencies (e.g., academic competence), patterns of life stress, and cognitive factors such as the perceived risk of substance use. Theoretical models of adolescent substance use generally view affiliation with peers who smoke or drink as the proximal factor for use (e.g., Hoffmann, Sussman, Unger, & Valente, 2006) hence we construe peer affiliations as a final pathway through which prior variables may operate. Within this theoretical framework we use structural equation modeling to test whether the effects of regulation constructs are mediated through various indirect pathways, or whether good self-control or poor regulation have direct effects to substance use. This approach is readily falsifiable if the regulation constructs are unrelated to the mediators in the predicted manner and/or the mediators are unrelated to the outcomes.

Including Emotional Aspects

The third theme in the research is including emotional as well as behavioral aspects of regulation. It has been suggested that theories have underestimated the role of emotion for health behaviors (e.g., Slovic, 2003). To address this conceptual gap, measures of emotional regulation derived from several theoretical positions (Calkins, 1994; Khantzian, 1990; Southam-Gerow & Kendall, 2002) have been included in recent research. Consistent with the dual-process framework, we include measures for good self-control of sadness and anger (Zeman, Shipman, & Penza-Clyve, 2001) as well as measures for poor emotional regulation such as "angerability" and affective lability (Simons & Carey, 2002). Though a prior study showed behavioral and emotional aspects of regulation are substantially correlated (Wills et al., 2006), we retain a distinction so as to test for unique effects.

Selection of Mediators and Covariates

Three variables tested as mediators were selected because they had plausible relations to regulation characteristics and substance use and were likely to represent different types of pathways than developed competencies, life stressors, or perceived risk. Tolerance for deviance is an attitudinal construct from problem behavior theory (Jessor &

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[1] Personality models have used terms such as *impulse* and *constraint* or *analytic-rational* and *intuitive-experiential* systems (Carver, 2005). Models from addictive-behavior research have proposed different neurological substrates for the systems (Bickel et al., 2007; Steinberg, 2007).

[2] The development of self-regulation characteristics is theoretically complex. An attribute such as good self-control develops from early temperamental characteristics in continuing interaction with the parenting the child receives and, possibly, the larger social environment in which he or she lives (Rothbart & Rueda, 2005; Wills, Sandy, & Yaeger, 2000). A full discussion of developmental aspects of self-regulation is, however, beyond the scope of the present paper.

Jessor, 1977) that has been related to adolescent substance use and has effects that are relatively independent from either good self-control or poor regulation, though it may be correlated with impulsiveness (e.g., Wills et al., 2001). The construct of prototype (mental image of a typical same-age substance user) is derived from social-cognitive models of problem behavior (Gibbons, Gerrard, & Lane, 2003). This perceptual variable may be a predisposing factor for substance use but is not the same type of construct as either affective or attitudinal variables. Perceived consensus (the perceived prevalence of tobacco and alcohol use in the population of age peers) has shown a relation to adolescent substance use in addition to actual peer behavior and attitudes about substance use (Graham, Marks & Hanson, 1991). For covariates, parent-child relationship variables (support and conflict) were selected because they are substantially correlated with children's regulation attributes, parental support being correlated with good self-control and parent-child conflict being correlated with poor regulation (e.g., Wills et al., 2001, 2007a, 2007b). Because of these correlations, it is crucial in any analysis to include parental support and conflict as covariates so that observed effects for individual regulation attributes cannot be attributed to relationship characteristics.

In the present research, we tested this theoretical model in research conducted with samples of adolescents from two different populations (Westchester, New York and Honolulu, Hawaii), using a structural modeling approach in which all the variables are tested in a single analysis. The dual-process formulation predicts that good self-control and poor regulation will make independent contributions to substance use. A subsidiary prediction is that behavioral and emotional aspects of regulation will have unique effects. Good self-control is predicted to be positively related to outcomes that require effort and persistence, particularly academic performance. Because of more in-depth processing of information, we also predicted a positive relation to perceived risk from substance use. Poor regulation is hypothesized to conduce toward less anticipation of problem situations and less desirable means of dealing with them, hence we predicted a positive relation to life events. Assuming a prior history of rejection in relationships with more conventional peers, we also predicted a positive relation to tolerance for deviance and perceiving more favorable prototypes of substance users. Overall, our theoretical approach hypothesizes indirect relations of regulation constructs to substance use through intermediate variables, rather than direct effects on substance use.

Method

Using similar methods in samples that differed in ethnic and socioeconomic characteristics, we obtained measures for hypothesized mediators together with a detailed assessment of regulation constructs. The following sections describe the procedures and measures.

Participants

Study 1. The participants were 601 students from three public middle schools in the New York metropolitan area (53% in 7th grade, 47% in 8th grade). The schools were in largely suburban areas where household income (mean $98,403) was above average for the state. The sample was 55% female and the mean age was 12.8 years (SD 0.7). Regarding ethnicity, the sample was 8%

African American, 5% Asian American, 47% Caucasian, 31% Hispanic, 6% multiple ethnicity, and 3% other ethnicity. Regarding family structure, 21% of the participants were living with a single parent, 7% were in a blended family (one biological parent and one stepparent), 68% were with two biological parents, and 3% were in an extended family (two parents plus one or more adult relatives). Parental education measured on a 1–6 scale had M = 4.5 (SD 1.4), a mean level close to college graduate.

Study 2. The participants were 881 students in 8th grade in four public middle schools in an area of Honolulu, Hawaii where household income (mean $50,010) was at or below average for the state. The sample was 55% female and the mean age was 13.5 years (SD 0.6). Regarding ethnicity, the sample was 7% African American, 21% Asian American (Chinese, Japanese, or Korean), 8% Caucasian, 3% Hispanic, 18% Native Hawaiian, 34% Filipino, and 8% Samoan/Tongan. Regarding family structure, 24% of participants were living with a single parent, 9% were in a stepparent family, 48% were with two biological parents, and 19% were in an extended family. Parental education had M = 3.9 (SD 1.2), indicating 1–2 years education beyond high school.

Procedure

A self-report questionnaire was administered to students in classrooms by trained research staff. The survey took one class period (approximately 40 minutes) and was administered under anonymous conditions. Initial instructions emphasized anonymity and stated that the student should not write his or her name on the survey. After obtaining student assent and giving instructions to participating students, staff members remained in the classroom to answer any individual questions about particular items. In conditions where participants are assured of confidentiality, self-reports of substance use have good validity (e.g., Patrick et al., 1994).

Study 1. The procedure was reviewed by the Institutional Review Boards at Albert Einstein College of Medicine (Bronx, NY) and Student Assistance Services (Tarrytown, NY). 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 a student excluded from the research, if he or she wished, through returning a postcard to the investigator or contacting a designated administrator at the school. Prior to survey administration, eligible students were similarly informed about the research and were instructed that they could refuse or discontinue participation; students who wished to participate signed an assent form. From a population of 678 students, 3% were excluded by parents, 3% declined participation, and 5% were absent on the survey day. The completion rate (the ratio of usable questionnaires to total class enrollment from school lists) was 89%.

Study 2. The procedure was reviewed by the institutional review boards for the University of Hawaii and the Hawaii Department of Education. A consent form was sent home through the school to parents. This informed the parent about the purpose and nature of the research and asked the parent to check yes or no to indicate whether his or her child would be allowed to participate in the research. Prior to survey administration, students with an affirmatively signed parental form were informed about the purpose and nature of the research and instructed that participation was voluntary; students who wished to participate signed an assent form. From a population of 1,381 students, parental forms were not returned for 24%, 8% of the stu-

dents were excluded by parents, 1% declined participation, and 5% were absent on the survey day. A total of 881 surveys were obtained and the completion rate was 64%, comparable to studies where similar procedures are employed (e.g., Fosados et al., 2007; Unger, Hamilton, & Sussman, 2004).

Measures

Most of the measures have been used in previous studies, but scale structure was verified with factor analysis and internal consistency analysis. Unless noted otherwise, responses were on 5-point Likert scales with anchor points *Not at all true for me* and *Very true for me*. Measures were scored so that a higher score indicates more of the attribute named in the variable label. Measures were identical for the two studies, with a few additions in Study 2 that are noted. The demographic and regulation measures are described in detail; the mediators are summarized.

Basic demographics. The basic demographic items asked the participant about his or her age and gender. An item on family structure asked "What adults do you live with right now?" Nine response alternatives were provided and the student was told to check one or more. Items on education for parents were on 6-point scales with anchor points *grade school* and *postcollege*.

Ethnicity. In Study 1 the respondent was asked "Would you say you are:" and was presented with four ethnicity options (African American, Hispanic, Asian American, White) with the instruction "Check one or more" plus an Other write-in option. With similar instructions in Study 2, the nine main ethnicity options were: African American, Chinese, Hispanic, Native Hawaiian, Filipino, Japanese, Korean, Samoan or Tongan, and Caucasian; an Other response was also provided with a write-in option. A coding procedure was employed for multiple ethnicity.[3]

Good behavioral self-control. Scales were derived from previous inventories (Kendall & Wilcox, 1979; Wills et al., 1996; Zimbardo & Boyd, 1999). A complete description of items in all scales is available at http://dx.doi.org/10.1037/a0027634.supp. A composite score was based on a 4-item subscale on planning, a 4-item subscale on concentration and persistence, and a 6-item subscale on problem solving. In Study 2, a scale was added for future time perspective. Composite-score alphas were .80 and .81 for Study 1 and Study 2, respectively.

Good emotional self-control. Measures were derived from Kendall and Wilcox (1979) and an inventory for emotional regulation developed by Zeman et al. (2001). A composite score was based on 4-item subscales for sadness control and anger control. In Study 2, a 5-item scale on emotional soothability was added. Composite-score alphas were .72 and .76.

Poor behavioral regulation. Measures were derived from the noted sources plus inventories on impulsiveness and delay of gratification (Chen et al., 2004; Eysenck & Eysenck, 1978). A composite score was based on a 5-item subscale on distractibility, a 6-item subscale on impulsiveness, and a 5-item subscale on present orientation. In Study 2, a 5-item subscale was added for immediate gratification. Composite-score alphas were .71 and .74.

Poor emotional regulation. Measures were derived from the noted sources plus a scale on affective lability (Simons & Carey, 2002). A composite score was based on a 6-item subscale on angerability, a 5-item scale on affective lability, a 3-item scale on

sadness rumination, and a 3-item scale on anger rumination. Composite-score alphas were .74 and .72.

Parental and mediator variables. Six mediating variables were included to test for pathways from regulation constructs to peer use and adolescent use. They tapped developed competencies, constructs from stress-coping and problem-behavior theory, and three constructs derived from social–cognitive theory. These are summarized in Table 1 together with the parental covariates.

Friends substance use. Affiliation with peers who used substances was indexed with a 3-item inventory. The items asked, "How many of your friends smoke cigarettes/drink alcohol/smoke marijuana?" Responses were on 5-point scales (*None of my friends–More than three of my friends*). The items were intercorrelated and alphas for a composite score were .85 and .87.

Adolescent substance use. 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 0–6 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 or she had three or more drinks at one sitting (in about 2 hours); responses were on a 0–3 scale (*Never, Once, Twice, More than Twice*). The items were intercorrelated and a 4-item composite score had alphas of .84 and .80 for the two studies, respectively.

Results

Descriptive Statistics and Construct Correlations

Prevalence rates of substance use are presented in Table 2. Rates of regular use were generally low, consistent with the young age of the participants (Johnston et al., 2009). The patterning of use was similar in the two samples, with rates being highest for alcohol use and lowest for marijuana. Descriptive statistics for the study variables are included in Table 3. Distributions for the good self-control and poor-regulation measures were close to normal. Some of the mediators had larger skewness values, in the range from 1.3 to 1.7; peer substance use and adolescent substance use tended to have moderate skew (range from 1.9 to 3.3).

Confirmatory models analyzed in Mplus (Muthén & Muthén, 2005) were specified with manifest variables, excepting a latent construct for adolescent substance use, measured by four indicators.[4] The measurement model was satisfactory, with consistently high loadings of indicators on the adolescent substance use construct. The confirmatory models had good fit, with Comparative Fit Index (CFI) = .98 for both studies. Construct correlations, presented in Table 3, were similar across the two samples. The

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[3] From the set of 10 options, 58% of participants checked only one ethnicity and 42% checked two or more options. For cases with multiple ethnicities a coding procedure with hierarchical override rules was employed (cf. Glanz, Maskarinec, & Carlin, 2005; Kaholokula, Grandinetti, Nacapoy, & Chang, 2008).

[4] Initial confirmatory analyses established that the measurement model for the regulation constructs was appropriate, and nested tests showed that the 4-factor model had better fit than a 2-factor or 1-factor model. The analyses used manifest variables for the regulation constructs so as to have a case:parameters ratio over 5:1 (Chou & Bentler, 1995) and increase the probability of detecting unique effects.

Table 1
Summary of Measures For Parental Covariates and Mediator Variables

Construct	Source	Response scale	Items	Cronbach α Study 1	Cronbach α Study 2
Parental emotional/instrumental support	Wills et al., 2001	1–5 Lik	11	.89	.92
Parent–adolescent conflict	Wills et al., 2001	1–5 Lik	3	.85	.83
Academic competence	Bryant, Schulenberg, O'Malley, Bachman, & Johnston, 2003	1–5 Lik	8	.83	.81
Negative life events[A]	Wills et al., 2002	No/Yes	20	n.a.	n.a.
Tolerance for deviance	Jessor & Jessor, 1977	1–5 Mor	10	.94	.93
Prototypes of adolescent substance users	Gibbons et al., 2003	1–5 Adj	15	.88	.91
Perceived consensus for substance use	Graham et al., 1991	0–100	3	.86	.85
Cognitive risk (perceived harm and vulnerability)	Gerrard, Gibbons, & Gano, 2003	1–5 Prob	9	.83 .87	.86 (harm) .89 (vuln)

Note. Lik = Likert scale (*Not at all true for me–Very true for me*); Mor = morality scale (*Not at all wrong–Very wrong*); Adj = adjective description scale (*Not at all X–Very X*); Prob = probability scale (*Not at all likely to occur–Very likely to occur*).
[A] This was a checklist, so internal consistency was not computed. Two items on family changes were dropped from analysis to avoid overlap with the family structure measures.

correlation of good self-control and poor regulation measures was moderate (across studies, mean $r = -.31$) while the correlation of behavioral and emotional measures was higher (mean $r = .57$). The good self-control measures tended to be positively correlated with protective factors (e.g., academic competence) whereas measures for poor regulation were positively correlated with risk factors (e.g., life events). The hypothesized mediators were substantially correlated with peer substance use, and peer use was strongly correlated with adolescent substance use, supporting its posited role as a proximal factor.

Structural Equation Modeling Analysis

To test pathways from the dual-process constructs to substance use we specified a structural equation model with the four regulation measures as exogenous (i.e., not predicted by any prior construct in the model) together with covariates of parental support and conflict, family structure (three binary contrast variables), ethnicity (two–three binary contrast variables), and parental education. The six hypothesized mediators were specified as endogenous (i.e., could be predicted by prior constructs in the model) with covariances of their residual terms. Friend substance use was specified with paths from the mediators and a path to adolescent substance use.

Tests of the same structural model were conducted with data from the New York and Hawaii samples. Initial models included all paths from exogenous variables to mediators and all paths from mediators to peer use. Analyses were conducted using robust standard errors (Muthén & Muthén, 2005) so as to adjust for any skewness in the variables. Nonsignificant paths were dropped from the initial models. In both studies, a direct effect from poor behavioral regulation to peer substance use was added on the basis of modification indices, and in each study, four direct effects from mediators to adolescent substance use were added (though not exactly the same ones in each study). The final models had reasonable fit. In Study 1 the model had chi square (98 *df*, $N = 601$) of 163.56, CFI = .97, and root mean square error of approximation (RMSEA) = .033. In Study 2 the model had chi-square (108 *df*, $N = 881$) of 206.56, CFI = .97, and RMSEA = .033. Results for the structural models are presented in Figure 1 with standardized coefficients. Correlations among the exogenous variables, included in the model but excluded from the figure for graphical simplicity, are in Table 3. Residual correlations among the mediator variables, also included in the model but excluded from the

Table 2
Prevalence Rates (%) for Substance Use Indices, for Two Studies

Scale point	Cigarette smoking NY	Cigarette smoking HI	Overall alcohol use NY	Overall alcohol use HI	Marijuana use NY	Marijuana use HI	Scale point	Heavy drinking NY	Heavy drinking HI
Never	93	84	53	55	97	89	Never	91	91
1–2 times	4	8	26	24	2	3	Once	5	5
3–5 times	1	5	10	11	<1	3	Twice	2	2
Few times a year	1	1	8	5	<1	1	≥Three	2	2
Few times a month	1	1	2	2	<1	1			
Few times a week	<1	<1	<1	2	<1	2			
Every day	<1	<1	<1	<1	<1	<1			

Note. NY = New York; HI = Hawaii. $N = 601$ for the New York sample, $N = 881$ for the Hawaii sample.

Table 3
Correlations of Variables With Descriptive Statistics, for Two Studies

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Range	M	SD	Skew
1. Good behav. sc	xx	.41	−.22	−.15	.41	−.20	.66	−.20	−.40	−.20	−.12	.24	−.23	−.25	18–90	59.7	11.9	−0.0
2. Good emot. sc	.52	xx	−.17	−.31	.32	−.22	.42	−.26	−.31	−.16	−.17	.15	−.22	−.23	13–65	41.9	10.1	−0.1
3. Poor behav. reg.	−.42	−.35	xx	.60	−.15	.43	−.27	.36	.19	.14	.20	.01	.28	.18	15–75	45.2	10.6	0.1
4. Poor emot. reg.	−.20	−.38	.68	xx	−.20	.41	−.27	.40	.23	.20	.24	−.10	.31	.25	14–70	32.2	10.5	0.6
5. Parental support	.48	.32	−.30	−.28	xx	−.42	.40	−.22	−.28	−.15	−.17	.14	−.19	−.21	11–55	38.9	10.2	−0.4
6. Parent conflict	−.28	−.26	.53	.51	−.50	xx	−.26	.37	.18	.10	.08	−.01	.19	.17	3–15	7.9	3.5	0.4
7. Academic comp.	.64	.45	−.41	−.31	.53	−.29	xx	−.23	−.36	−.17	−.18	.21	−.20	−.27	8–40	29.1	5.5	−0.4
8. Negative events	−.31	−.36	.47	.48	−.38	.44	−.36	xx	.21	.21	.29	−.07	.41	.33	0–18	4.9	3.1	0.6
9. Toler. deviance	−.36	−.27	.33	.24	−.39	.27	−.40	.26	xx	.27	.17	−.34	.26	.34	10–50	18.4	9.1	1.5
10. Sub. prototypes	−.17	−.15	.18	.21	−.19	.15	−.25	.22	.24	xx	.26	−.31	.41	.31	18–90	41.7	14.4	−0.0
11. Perc. consensus	−.26	−.23	.17	−.19	.28	.21	−.23	.30	.19	.27	xx	−.14	.46	.39	0–300	73.6	59.0	0.8
12. Cognitive risk	.19	.10	−.14	−.09	.17	−.06	.24	−.08	−.24	−.34	−.14	xx	−.19	−.25	8–40	32.9	6.2	−1.3
13. Friends sub. use	−.30	−.24	.33	.32	−.33	.27	−.34	.39	.31	.40	.44	−.20	xx	.59	0–12	4.1	4.6	0.7
14. Adolesc. sub. use	−.35	−.29	.40	.39	−.37	.31	−.45	.48	.38	.48	.34	−.30	.73	xx	0–22	1.6	2.9	3.0
Range	14–70	8–40	8–40	17–85	11–55	3–15	58–40	0–18	10–50	18–90	0–300	8–40	0–12	0–22				
M	48.8	26.3	60.9	40.5	38.1	7.6	30.4	4.4	19.5	39.4	38.4	32.5	1.8	1.2				
SD	9.4	7.2	16.5	12.8	8.7	3.5	5.8	3.1	9.8	15.0	48.1	5.7	3.2	2.5				
Skew	−0.4	−0.1	0.4	0.6	−0.8	0.5	−0.8	0.8	1.5	0.4	1.7	−1.7	1.9	3.3				

Note. Study 1 data below diagonal, Study 2 data above diagonal. Sc = self-control; reg. = regulation; behav. = behavioral, emot. = emotional.

figure, were generally low; in Study 1 the range was −.31 to .19 (mean $|r| = .10$) and in Study 2 the range was −.25 to .19 (mean $|r| = .10$). As noted in Figure 1, the exogenous variables accounted for reasonable amounts of variance in the mediators, more so for the behavioral/attitudinal constructs (22–25% for tolerance for deviance to 49–51% for academic competence) than for the social–cognitive constructs (6–9% for cognitive risk to 14–16% for perceived consensus). Prior variables in the model accounted for 36–38% of the variance in peer use. While the patterning of results was similar across studies, the model variables accounted for more of the variance in adolescent substance use in the New York sample (64%) than the Hawaii sample (42%).

The hypothesized results were replicated across studies. The four regulation variables each had unique effects to the predicted mediators, and the mediators had pathways to peer use (plus some direct effects to substance use). Emotional aspects of regulation had significant unique effects net of behavioral aspects, and this was true both for good self-control and poor regulation. As predicted, the constructs of good self-control and poor regulation tended to operate through different pathways. Good self-control primarily had paths to protective factors and, independently, poor regulation had paths to risk factors. Though there were some crossed effects (e.g., good self-control inversely related to tolerance for deviance), the results were mostly consistent with our formulation about different types of pathways for the two systems.

Specific results (all significant at $p < .05$ with robust standard errors) showed that good behavioral self-control had positive paths to academic competence and perceived risk, as well as inverse paths to tolerance for deviance and prototypes of users. Emotional self-control had two significant unique effects in each study, with a positive path to academic competence in Study 1, inverse paths to negative life events in both studies, and an inverse path to tolerance for deviance in Study 2. (Note that all these effects partialed the correlations of regulation measures with parenting and demographic variables.) The parental variables also had unique effects; in both studies, parental support was positively related to academic competence and inversely related to tolerance for deviance.

Measures for poor behavioral and emotional regulation each had replicated effects. In order of magnitude of coefficients, poor behavioral regulation had positive paths to negative life events and tolerance for deviance, and had a direct effect to affiliation with peer substance users. Poor emotional regulation independently had positive paths to negative life events and prototypes of users (both studies), plus a path to more negative life events (Study 1) and paths to more tolerance for deviance and perceived consensus (Study 2). An inverse path from poor emotional regulation to academic competence in Study 2 replicates an effect noted in Wills et al. (2006).[5] Conflict with parents had a path to negative life

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[5] Tests of the indirect effects in Mplus showed the total indirect effect for good behavioral self-control was significant in both studies, $t = 3.07$, $p < .01$ and $t = 4.25$, $p < .0001$, as was the total indirect effect for good emotional self-control, $t = 2.52$, $p < .01$ and $t = 3.28$, $p < .001$. The total indirect effect for poor behavioral regulation was significant in both studies, $ts = 3.58$, $p < .001$ and 4.14, $p < .0001$, as was the total indirect effect for poor emotional regulation, $ts = 3.47$, $p < .001$ and 4.96, $p < .0001$. There were no direct effects from any of the regulation constructs to adolescent substance use.
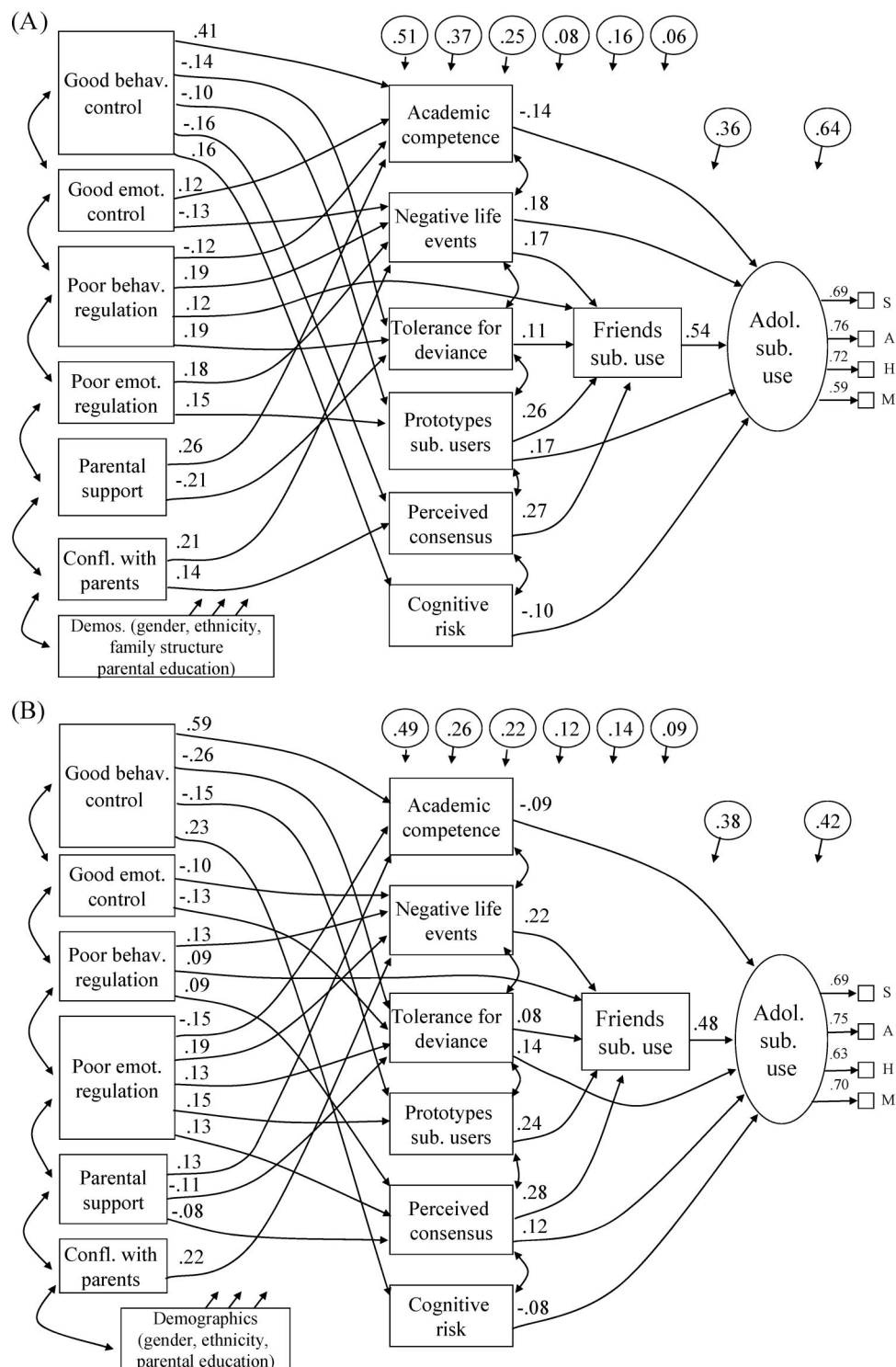
Figure 1. Structural models for relation of good self-control and poor-regulation measures to mediator and criterion variables. (A) Model for New York sample. (B) Model for Hawaii sample. Behav. = behavioral; emot. = emotional; confl. = conflict; sub. = substance; demos. = demographics. Values are standardized coefficients; all coefficients are significant at $p < .05$ with robust standard errors. Straight single-headed arrows represent path effects; curved double-headed arrows indicate covariances. For covariances of exogenous variables (included in the model but excluded from the figure for graphical simplicity), see Table 3; for residual correlations of endogenous variables, see text. Values at top of figure are squared multiple correlations, the variance accounted for in a given construct (to which the arrow points) by all variables to the left of it in the model.

events in both studies (independent of family structure) and had a path to more perceived consensus for substance use in Study 1.

The mediators had paths to peer substance use and/or direct effects to adolescent substance use (all significant at $p < .05$ with robust standard errors); these are unique relations because the effect for a given mediator is independent of its residual correlations with the others. Four variables (negative life events, tolerance for deviance, prototypes of users, and perceived consensus) had paths to more affiliation with peer substance users. Life events and prototypes also had direct effects to adolescent substance use in Study 1, and tolerance for deviance and perceived consensus had direct effects to adolescent substance use in Study 2. Academic competence and cognitive risk had inverse direct effects to adolescent substance use in both studies. Note that several of the direct effects were replicated. The direct effects also have theoretical significance because they indicate processes that affect risk for substance use through mechanisms other than social affiliations.

Discussion

In this research we outlined a theoretical approach to adolescent substance use and tested this model empirically in two populations that differed considerably in ethnicity and socioeconomic characteristics. The measures had good reliability in both samples. Results from structural modeling analyses were replicated across samples and supported the predictions, showing that constructs from the two regulation systems had independent effects and different types of relationships to substance use. These findings were obtained with control for parenting characteristics and demographic variables, and the replication across studies supports the robustness of this theoretical approach.

The essential proposition of this research is that two different systems operate to affect liability for early substance use and that they do so by affecting exposure to more proximal risk or protective factors. Results showed the two domains of regulation measures were statistically distinct and their effects were mediated through the hypothesized variables. Our prediction that the two systems would have different types of pathways to substance use, with good self-control primarily related to factors that require behavioral or cognitive effort, received some support. However there was not always a sharp distinction between pathways for the two systems, as measures for good self-control showed some inverse relations to risk factors. The differences found here in field studies with multiple-indicator measures are perhaps not as marked as might be found for single indices of impulse and reflection as found in controlled laboratory studies. However, we think that the present approach shows clearly that two different systems are operative and that each has a number of pathways to an important health behavior outcome. Explicating how regulation constructs affect a range of mediators and how these are related to adolescent substance use and problems are addressed in more detail in other places (e.g., Wills & Ainette, 2010; Wills, Pokhrel, Morehouse, & Fenster, 2011).

We found significant unique effects for emotional self-control and poor emotional regulation, results that statistically were not easy because of the substantial correlations of emotional measures with behavioral measures. The present results showed more effects for behavioral measures, but in each study, significant effects for emotional measures were also found. Although some theoretical

approaches have construed self-control largely in terms of behavioral inhibition or disinhibition, the present results suggest that in settings where interpersonal interactions involving emotion regulation (e.g., with peers or teachers) may be crucial for outcomes, it is useful to include attention to emotional regulation processes. The substantial correlation between behavioral and emotional control is consistent with suggestions that they have roots at earlier ages in common processes such as attentional focusing (Rothbart et al., 2000; Wills et al., 2006), and this question is itself a topic for further research.

Some aspects of the studies could be noted as limitations. Data were obtained from one source using a survey approach and it would be desirable to have measures obtained through other methods as well (e.g., laboratory tests). The data for poor regulation constructs were obtained through explicit (self-report) measures, but it has been suggested that measures developed to tap implicit processes are better able to tap less conscious aspects of functioning (e.g., the Implicit Attitude Test; Stacy & Wiers, 2010), and further research using implicit measurement approaches would also be useful. Finally, the structural modeling analyses were based on cross-sectional data. This is useful for theory generation because predictions can easily be disconfirmed and interpretations in terms of reverse causality (e.g., life events such as unemployment leading to drug use, or drinking leading to lower educational attainment) are less plausible at this age than they would be in adulthood. However, prospective research with dual-process measures would be desirable for addressing the hypotheses in a longitudinal context.

Implications for Health Behavior Research

The results extend the existing literature on self-regulation through demonstrating that good self-control and poor regulation are statistically distinct and show unique contributions to etiological variables for substance use (i.e., they are not opposite poles of one continuum). We showed that the regulation constructs were related in the predicted manner to both behavioral and cognitive variables and demonstrated that emotional and behavioral aspects of regulation each made unique contributions to the mediators. The results showed that the two dual-process domains have different types of relations to substance use, and findings from a New York sample were replicated in a sample of Asian Americans and Pacific Islanders, a population not typically studied in health psychology research.

These results could be useful for other areas of health behavior research where the two domains of regulation processes may be differentially related to outcomes, such as dietary intake (Riggs, Kobayakawa-Sakuma, & Pentz, 2007; Rothman, Sheeran, & Wood, 2009; Wills, Isasi, Mendoza, & Ainette, 2007) or physical activity (Fleig, Lippke, Pomp, & Schwarzer, 2011). Regulation concepts are also suitable for intervention studies because evidence shows that both cognitive and behavioral aspects of self-control can be modified (e.g., Diamond, Barnett, Thomas, & Munro, 2007; Finkel, DeWall, Slotter, Oaten, & Foshee, 2009; Oaten & Cheng, 2006). Interventions could aim not only to modify proximal factors for risk behavior (e.g., reactions to peer smoking) but also to target the processes that predispose some persons to be exposed to risk factors in the first place (e.g., planning used so as to be preferentially in social situations with nonsmokers). The

findings suggest an alternative approach to interventions, including training for enhancing good self-control but also implementing approaches aimed at reducing the level of poor regulation and/or minimizing its impact. Finally, we note that good self-control buffers the impact of several adverse influences, including negative life events and media smoking exposure (Wills, Ainette, Stoolmiller, Gibbons, & Shinar, 2008; Wills, Gibbons, et al., 2010). Health psychology interventions commonly rely on main effects, but moderation aspects may be particularly germane for situations where life stress or media-derived temptations can work to undermine the effect of an intervention (Masten & Powell, 2003; Wills & Bantum, in press).

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