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Mechanisms of Influence on Youth Substance Use for a Social-Emotional and Character Development Program: A Theory-Based Approach

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Exploring Mechanisms of Influence on Youth Substance Use for a Social-Emotional and Character Development Program: A Theory-Guided Approach

Abstract

Background: To best address the multifaceted etiology of adolescent substance use, program development and evaluation should be theory-guided. We aimed to address this need using data from a longitudinal, randomized control trial of a social-emotional character development program guided by the Theory of Triadic Influence (TTI).

Method: Study data come from the Chicago matched-pairs cluster-randomized control trial of Positive Action (PA). A diverse, dynamic cohort of approximately 1,200 students from 14 low-performing schools were followed from grade 3 to grade 8. In addition to testing the overall effect of PA on different forms of substance use at study endpoint, analyses evaluated whether effects on each outcome were mediated by longitudinal change across all study time points for measures of constructs that map onto each of the three major streams of influence in the TTI: one intrapersonal (i.e., self-control), one interpersonal (i.e., deviant peer affiliation), and one environmental (i.e., school attachment).

Results: Students in PA schools reported fewer experiences with drinking, getting drunk, and overall substance use. When considering each potential mediator individually, results were consistent with changes in both self-control and deviant peer affiliation serving as mechanisms for PA’s effects on all forms of substance use. In models examining the potential mediators simultaneously, significant indirect effects of PA on substance use via changes in self-control remained evident.
Discussion: Findings are consistent with theory and past research suggesting the influence of self-control and peer group affiliation on the substance use behaviors of youth. Implications and future research directions are discussed.

Trial Registration: This trial is registered at ClinicalTrials.gov NCT01025674.

Keywords: Theory of triadic influence; substance use; social emotional and character development programs
Exploring Mechanisms of Influence on Youth Substance Use for a Social-Emotional and Character Development Program: A Theory-Guided Approach

Early initiation of substance use is a prevalent high-risk health behavior among adolescents. According to the Youth Risk Behavior Survey, 18.1% of surveyed ninth grade students reported ever trying a cigarette, 19% reported having had at least one drink of alcohol in the previous 30 days, and 24.3% reported using marijuana at least once in their lifetime (CDC, 2019). The prevalence of early substance use initiation among youth is problematic given its association with multiple adverse outcomes (e.g., school dropout, Fernandez-Suarez, 2016, and Valkov, 2018; negative mental health outcomes Poudel & Gautum, 2017; future substance use, Van Ryzin & Dishion, 2014; high-risk sexual activity, Stueve & O’Donnell, 2005; and violence, Lim et al., 2015). In addition, given its ability to exacerbate health inequities through its disproportionate impact on low-income communities (Voisin & Kim, 2018), the need exists to better understand factors that influence substance use initiation and maintenance. According to health behavior theories such as the Theory of Triadic Influence (TTI; Flay et al., 2009), behaviors such as substance use are understood to be multi-etiological in nature. Moreover, a combination of factors unique to the individual (i.e., intrapersonal stream of influence), factors reflective of one’s social context (i.e., interpersonal stream of influence), and factors within the broader environment (sociocultural environmental stream of influence) simultaneously influence health behavior decision making (Flay et al., 2009). As such, understanding and addressing the multifaceted etiology of adolescent substance use warrants incorporating intrapersonal, interpersonal, and environmental influences.

Within the TTI’s Intrapersonal stream of influence, self-control is a factor that merits further examination for its relationship with adolescent substance use. Self-control is defined as
the set of skills, capacities, and behaviors that individuals need to function in a self-regulation feedback loop (Gillebaart, 2018). Self-regulation includes the ability to formulate goals and desired end-results, as well as everything individuals do to direct their behavior towards their desired end-results (Gillebaart, 2018). Associations have been found between levels of self-control and adolescent engagement in substance use. In one study where 6th grade students were assessed annually until 9th grade, self-control had significant associations with both initial use and growth in substance use over time (Wills & Stoolmiller, 2002). A follow-up study also demonstrated that self-control is able to serve as a protective buffer against substance use, even when youth experience adverse events (Wills et al., 2008). In a related study that included middle- and high-school students, youth substance use was associated with both behavioral self-control and emotional self-control (Wills et al., 2006). A cohort study including over 21,000 participants also found that greater levels of self-control in childhood was associated with a decreased likelihood of smoking in adulthood (Daly et al., 2016). Thus, interventions aiming to address adolescent substance use should aim to enhance youths’ self-control.

The behaviors of peers, which are categorized within the TTI’s Interpersonal stream of influence, can also influence early initiation of substance use among youth. Specifically, deviant peer affiliation, which measures the degree to which students associate with peers who engage in high-risk behaviors, has been shown to have an association with adolescent substance use. For example, one study including youth in grades 6-8 found marijuana use among friends was predictive of individual marijuana use (Kobus et al., 2010). Another study including a low-income, ethnically diverse sample of fifth graders, peer substance use predicted alcohol, tobacco, and marijuana use not only in adolescence, but also during adulthood (Jones et al., 2019). Similarly, analyses of data from the Seattle Social Development Project have shown that deviant
peer affiliation is associated with adolescent smoking and alcohol use (Cambron et al., 2018). A longitudinal study of New Zealand youth from age 14 to age 21 found alcohol, nicotine and cannabis abuse, and dependence to be associated with deviant peer affiliation (Fergusson et al., 2002). In a separate study including youth ages 12-18, dyadic analyses showed the similarity in substance use behaviors between best friends, and the influencing role of more popular friends on less popular friends (de Water et al., 2016). These studies illustrate how interpersonal influences can impact youths’ substance use initiation. Thus, interventions aiming to address adolescent substance use should also aim to minimize deviant peer affiliation.

The third stream of the TTI represents factors in the broader environment that can ultimately influence attitudes towards a behavior. Within the adolescent population, one important environment that influences attitudes towards substance use is that of the school. The related concepts of school connectedness and attachment reflect feelings of belonging and pride in one’s school (Chapman et al., 2013); prior research has shown that, in general, students are less likely to engage in risky behaviors, including substance use, when they feel more school attachment or connectedness (Chapman et al., 2013). For example, one study that analyzed data from the National Longitudinal Study on Adolescent Health found that greater levels of school connectedness were associated inversely with prevalence of cigarette smoking (Dornbush et al., 2001). In a longitudinal study that surveyed students in grade 8, grade 10, and again after one year of post-secondary school, low levels of school connectedness in grade 8 were associated with subsequent alcohol, marijuana, and tobacco use (Bond et al., 2007). Another study that analyzed longitudinal data from the COMPASS study found that increases in school connectedness across time were associated with less frequent binge drinking, and marijuana and tobacco use (Weatherson et al., 2018). An additional longitudinal study that included over 2,000
middle-school children found that the prevention of substance use initiation was associated with a positive school climate (Daily et al., 2020). Thus, interventions aiming to address adolescent substance use should aim to enhance school attachment.

Given the aforementioned literature, it is not surprising that existing programs have aimed to address substance use by addressing self-control, deviant peer affiliation, and/or school attachment. For example, adolescents who participated in the afterschool Positive Youth Development Collaborative (PYDC) received an 18-lesson curriculum designed to promote decision-making skills and resist peer pressure, which are related to self-control and peer affiliation, respectively. A study of PYDC discovered that participants in the treatment group had a significant reduction in past-30-day use of alcohol, marijuana, and other drugs (Tebes et al., 2007). The Iowa Strengthening Families Program is another multifaceted program that also addressed, amongst other things, prosocial behaviors and peer resistance skills (Spoth et al., 2019). Findings from a randomized controlled trial of the program revealed that positive youth relationships in middle school were associated with students’ past year substance use, and use of marijuana in high school was associated with past year substance use and decreased positive relationship affect (Spoth et al., 2019). In the Healthy School Ethos (HSE) intervention, the school environment is addressed not via a curriculum, but instead via an action-team used to promote social support, school engagement, and teacher- and peer-relationships. A pilot study of the HSE intervention in London found relationships between student participation and reduced substance use (Bonell et al., 2010). School-based social-emotional and character development programs (SECD) aim to address factors within all three streams of influence described in the TTI. For example, the Positive Action program’s impact on a composite measure of adolescent substance use was found to be mediated by improvements in a latent measure of character that
included self-control (Lewis et al., 2012). However, the influence of the mediational pathways was not tested for self-control specifically, nor was it tested for each form of substance use. Thus, further research is needed to understand whether multiple mediators influence the intervention-to-substance use prevention pathway for each form of substance use individually and simultaneously.

In light of the aforementioned research and existing gaps, the goal of the present study was to test one longitudinal, multiple-mediator, model examining adolescent substance use overall, and by each form of substance use. Understanding whether one mediator is most influential (e.g., self-control, peer affiliation, or school attachment) may help resource-limited settings identify priority areas for programs they plan to implement. If, instead, as theory would suggest, each pathway is significant, strategies to overcome barriers to implementation fidelity can be prioritized during program planning. We used data from a school-based program that was implemented among youth in low-income Chicago public schools. The curriculum of the program, Positive Action (PA), aligns with the three streams of influence in the TTI. Specifically, by fostering (among other things) self-control (Intrapersonal), peer affiliation (Interpersonal), and school attachment (Environmental), the PA program posits that it simultaneously promotes positive behaviors while preventing negative behaviors (Flay & Allred, 2010). Our research hypotheses were: 1. Students in schools that receive PA will engage in less substance use (overall, and by substance) at study end point in grade 8 in comparison to students in schools that served as controls; 2. When examining mediational pathways for the constructs corresponding to the three streams of influence in the TTI separately, the estimated indirect effects of PA on each form of substance use via change over time in the TTI construct will be significant; and 3. When examining mediational pathways corresponding to the three streams of
influence simultaneously (i.e., multiple mediator model), estimated indirect effects of \( PA \) on substance use via change over time in each construct will be significant.

**Materials and Methods**

**Intervention**

Positive Action [\( PA \)], a comprehensive and universal program with curricula delivered by the classroom teacher, consists of age-appropriate, interactive lessons per grade. The six units of program curriculum align with the TTI’s three streams of influence. That is, within the curriculum, self-control, deviant peer affiliation, and school attachment (amongst other constructs) are directly and indirectly targeted. Units 1 through 3 address self-discovery. Unit 2 also addresses school safety, and Unit 4 addresses positive social skills and social interactions; thus, these units should lead to decreased affiliations with deviant peers. Units 5 and 6 are designed to help students identify social and emotional strengths. As such, these units should improve self-control by explaining what it is and how it is performed. The School Climate Development Curriculum is designed to promote a positive learning environment throughout the school (e.g., classroom, playground, etc.). Therefore, the curriculum should lead to improvements in school attachment.

**Design and sample**

Data for this study come from the longitudinal, Chicago randomized control trial of \( PA \). Fourteen diverse, low-performing, schools located in areas of high poverty were matched into 7 pairs, and schools within each pair were randomized to the treatment (receipt of \( PA \)) or control (business-as-usual) condition. Details about the inclusion criteria for eligible Chicago Public Schools, as well as the matching process, are published elsewhere (Lewis et al., 2017). Treatment and control schools did not differ on any matching variables at baseline or at several
points throughout the study (Lewis et al., 2017). The sample included approximately 1,200 students; the dynamic cohort was followed starting in grade 3 (year 2004) to grade 8 (year 2010). The place-focused intent-to-treat design allows for this kind of mobility as late entrants to the trial are included in the study (Vuchinich et al., 2012). Demographic makeup of the students was 53% female, 48% African American, 27% Latinx/a/o, 7% White and 12% other (e.g., Asian, and Native American, and “Other”). The population in this study was highly mobile, evidenced by the 3.1 average number of waves per student. Approximately 58% of the Wave 1 sample size was present at Wave 8.

**Data Collection Procedures**

Study participation required parental consent throughout the duration of the study. Data were collected from students via questionnaires that were administered during class time by research staff. During early waves (1-5), research staff read the survey instructions and items aloud to students. All procedures were approved by the Institutional Review Boards of the institutions involved.

**Measures**

The primary independent variable for this study was condition status (PA or control). The outcome of interest was substance use at wave 8; the variable was analyzed as a composite, as well as by specific item (e.g., alcohol use, tobacco use, marijuana use). The three mediators were available across all eight waves of data collection. The Intrapersonal variable was self-control; the Interpersonal variable was deviant peer affiliation; and the Environmental variable was school attachment. All the measures are student self-report.

**Substance Use Behaviors**
Substance use behaviors were assessed using five items adapted from the Risk Behavior Survey (Centers for Disease Control and Prevention, 2004). These questions were not asked of students until Wave 5 (Grade 5) given their sensitive nature. Students were asked to indicate if they had ever 1) smoked a cigarette (or used some other form of tobacco), 2) used alcohol (beer, wine, or liquor), 3) gotten drunk on alcohol, 4) used marijuana, and 5) used any more serious drug. Responses to these items were 1= no; 2= yes, once; 3= yes, 2 to 5 times; and 4= yes, more than 5 times. A composite (mean) substance use score was created as an average of all five questions. We analyzed this composite as well as the individual items. Alphas for the composite score ranged from .71 to .79.

**Mediators**

*Self-control* was assessed using four items from the Social-Emotional and Character Development Scale (SECDS; Ji, DuBois, & Flay, 2013). Items were “I wait my turn in line patiently,” “I keep my temper when I have an argument with other kids,” “I follow the rules even when nobody is watching,” and “I ignore other children when they tease me or call me a bad name.” Responses to these items were on a 4-point scale that allowed students to indicate how often they performed each behavior (1= none of the time; 2= some of the time; 3= most of the time; and 4= all of the time). A scale was created at each wave by taking the mean of all the items. Alphas ranged from .64 to .82 across the eight waves.

*Deviant peer affiliation* was assessed using four items adapted from the Conventional Friends scale (Elliott et al., 1996). Students were asked to respond to the prompt “How many of your friends do these things?” with a 4-point scale (1= none; 2= some; 3= most; and 4= all). Items were “Bully other kids,” “Get into fights at school,” “Do bad things,” and “Make fun of
other kids.” A scale was created at each wave by taking the mean of all the items. Alphas ranged from .81 to .87 across the eight waves.

*School attachment* was assessed using four items. These items were adapted from the People in My Life Scale (Cook, Greenberg, & Kusche, 1995), and measures of relationships to school and teachers (Goodenow, 1993; Murray & Greenberg, 2001). Students were asked if they agree with a series of statements on a 4-point scale (1 = NO!, 2 = no, 3 = yes, 4 = YES!). Statements were “I feel like I belong to this school,” “I care about my school,” “I wish I were in a different school,” and “I’m proud I go to this school.” A scale was created at each wave by taking the mean of all the items. Alphas ranged from .75 to .89.

**Analysis**

Analyses were run in Mplus v8.5. For all three hypotheses, missing data were handled using full information maximum likelihood (FIML). We first tested the overall effects of condition on each substance use outcome in separate models (i.e., what is traditionally referred to as the ‘c’ path in mediation testing). These analyses tested our first hypothesis that substance use would be lower at study end point for students in PA schools relative to those in control schools. We used two-tailed *p* values of .05 to assess significance.

We then estimated mediational models to test our second and third hypotheses. For hypothesis 2, we estimated single mediator models. These models tested each mediator (i.e., change over time in self-control, deviant peer affiliation, or school attachment) individually without other mediators in the same model. Mediators were modeled using all eight waves of data. Time was measured as years since beginning of program implementation to more accurately reflect the data collection times versus treating each time point as equally spaced, which was a total of 5.58 years by the end of grade 8. Five models were run for each mediator,
one per outcome (i.e., cigarettes, drinking, getting drunk, marijuana, and the substance use composite; given the very low frequency of “other drug” use, we did not conduct separate analyses for this outcome but did include it in the substance use composite), for a total of 15 models. Analyses tested for mediation of program effects by using a structural equation model (SEM) approach. This involved testing a model that broke down effects on outcomes into direct effects of PA on the outcomes and indirect effects via the program’s effects on growth/change over time (i.e., slope) of the mediators (Mackinnon, 2008). Temporally adjacent waves of the mediators were correlated (e.g., Wave 1 with Wave 2, Wave 2 with Wave 3) as health behavior theories such as the TTI (Flay et al., 2009) posit trial behavior influences future behavior. Model fit indices also supported these correlations. Mediator variables were centered to aid in interpretation of the results. Distributions of outcome variables were non-normal so we used bootstrap estimation with 1,000 random re-samples (Efron & Tibshirani, 1993). Bias-corrected bootstrapped 95% confidence intervals were used to test for indirect effects. This method has been found to provide greater power and more accurate Type I error rates than the product and other resampling methods for testing indirect effects, which appear to be more susceptible to bias stemming from skewness and non-normality in the distributions of indirect effects (MacKinnon et al., 2004). For all models, when testing the mediator to outcome path, the outcome was modeled onto the slope of the mediator. These models are shown in Figure 1; in these models, the ‘a’ path is represented by the condition to slope of the mediator, the ‘b’ path is represented by the slope of the mediator to the outcome, and the ‘c’ path is represented by the condition to outcome path with the mediator included in the model. Additionally, given the low intra-class correlations (as defined by Singer & Willet, 2003) between schools for each form of substance
use at wave 8 (ICC range of 0.02 for cigarettes to 0.07 for drinking), the skewed distribution of each outcome, and the small number of clusters, we did not estimate multi-level models.

Finally, to test hypothesis 3, a multiple (i.e., 3) mediator model was run for each outcome, for a total of 5 multiple mediator models. In addition to the model specifications listed above, we added several correlations that aligned with the interrelationships across streams of influence posited by the TTI (Flay et al., 2009). We correlated error terms of mediator variables within each waves (e.g., self-control at Wave 1 with deviant peer affiliations at Wave 1 and school attachment at Wave 1). We also modelled the intercorrelations among the intercept and slope growth parameters of the mediators (i.e., all 3 intercepts with one another and all 3 slopes with each other). These models are shown in Figure 2.

**Results**

Substance use was reported by adolescents in both control and PA schools. Approximately 17% of students in control schools had tried cigarettes once, 7% had tried 2 to 5 times, and 5% had tried more than once; the corresponding percentages for students in PA schools were approximately 7%, 7%, and 6%, respectively. With respect to drinking, approximately 22% of students in control schools had tried drinking once, 15% had tried 2 to 5 times, and 10% had tried more than 5 times. The corresponding percentages for getting drunk among control students was approximately 11%, 7%, and 5%, respectively. For PA students, approximately 22% reported drinking once, 13% reported 2 to 5 occasions, and 5% reported more than 5 occasions; the corresponding percentages for getting drunk reported by PA students was approximately 9%, 6%, and 3%, respectively. Marijuana use was reported to have occurred once by approximately 6% of students in control schools, 8% reported use 2 to 5 times, and 5% reported use more than 5 times; for students in PA schools, these percentages were
approximately 5%, 6% and 5%, respectively. The use of other drugs was only reported by 3% of students in control schools and approximately 4% by students in PA schools.

**Hypothesis 1**: Students in schools that receive PA will engage in less substance use (overall, and by substance) at study end point in grade 8 in comparison to students in schools that served as controls

In testing the effect of condition on the outcome ("c" path), results showed that students in PA schools reported fewer instances of drinking ($\beta$ [standardized path coefficient] = -.20, $p<.001$), getting drunk ($\beta = -.14, p<.01$), and overall substance use ($\beta = -.14, p<.05$). Therefore, our first hypothesis was partially supported. Results are in Table 1.

**Hypothesis 2**: When examining mediational pathways for the constructs corresponding to the three streams of influence in the TTI separately, the estimated indirect effects of PA on each form of substance use via change over time in the TTI construct will be significant.

Results for the single mediator models are shown in Table 2. In these models, condition effects on the slope of the mediators ("a" path) were significant for self-control and deviant peer affiliation such that students in PA schools had more relative improvement over time in self-control ($\beta$s for the five models ranging from .30 to .32, $ps<.01$) and greater relative decline in deviant peer affiliation ($\beta$s for the five models ranging from -.18 to -.19, $ps<.01$). The corresponding "a" path for school attachment was marginally significant for each model except marijuana ($\beta$ and $p$ for the four models excluding marijuana: $\beta =0.16, p=.08$). Paths from the slope of the mediators to the grade 8 substance use outcomes ("b" path) were significant for self-control and deviant peer affiliations for all outcomes. As expected, greater improvements in self-control were associated with lower levels of alcohol, cigarette and marijuana use, and overall substance use. For example, higher self-control was associated with less cigarette use at Grade 8.
(β= -0.37, p<.01). Also as expected, relatively greater increases in deviant peer affiliation were associated with greater levels of alcohol, cigarette and marijuana use, and overall substance use (e.g., for drinking, β =0.35, p<.001). Greater improvements in school attachment did not exhibit associations with any of the substance use outcomes (βs ranging from -.09 to -.22, ps > .10).

Using the bias-corrected 95% bootstrap confidence intervals to examine hypothesis 2, we found significant indirect effects for all outcomes with self-control: cigarettes (β =-.11, CI= -.35, -.04), drinking (β = -.10, CI= -.29, -.04), getting drunk (β =-.14, CI= -.34, -.04), marijuana (β = -.14, CI= -.43, -.06), and the substance use composite (β = -.15, CI= -.42, -.06). For deviant peers, we found a significant indirect effect for the same outcomes: cigarettes (β = -.05, CI= -.11, -.01), drinking (β= -.07, CI= -.15, -.02), getting drunk (β= -.07, CI= -.15, -.02), marijuana (β= -.09, CI= -.21, -.03), and the substance use composite (β= -.08, CI= -.18, -.03). For school attachment, we did not find significant indirect effects for any outcome. These findings provide partial support for our hypothesis.

**Hypothesis 3**: When examining mediational pathways corresponding to the three streams of influence simultaneously (i.e., multiple mediator model), estimated indirect effects of PA on substance use via change over time in each construct will be significant.

In the multiple mediator model testing hypothesis #3, using the bias-corrected 95% bootstrap confidence intervals, we found significant indirect effects through self-control for the same five outcomes as the single mediator models: cigarettes (β =-.14, CI= -.58, -.04), drinking (β = -.13, CI= -.47, -.03), getting drunk (β =-.14, CI= -.60, -.04), marijuana (β = -.15, CI= -.57, -.05), and the substance use composite (β = -.17, CI= -.56, -.06). We did not find a significant indirect effect on any outcome through deviant peer affiliation or school attachment. These models provide partial support for our hypothesis. Results are presented in Table 3.
Discussion

Our first hypothesis was guided by the Theory of Triadic Influence, as the theory posits that programs that address the more underlying causes of behavior should be more successful in influencing behavior change. As previous research had shown that the PA program reduces substance use overall (Lewis et al., 2012), we sought to examine the differential impact on varying types of substance use. We found that the program had its greatest impact on alcohol-related behaviors. Given that alcohol is the most prevalent form of substance use by the time adolescents reach grade 12 (Johnson et al., 2014), the impact on the alcohol use behaviors among grade 8 students in our study is noteworthy, particularly given that students in the study were in environments that increased their risk for adverse mental, emotional and behavioral health outcomes (Yoshikawa, Aber & Beardslee, 2012).

We found the program under examination had a significant impact on self-control (Intrapersonal stream of influence) and deviant peer affiliation (Interpersonal stream of influence), and a favorable though not statistically significant impact on school attachment (Environmental stream of influence). Irrespective of program receipt, relative improvements in all three constructs were significantly or marginally associated with decreased alcohol use, and self-control and deviant peer affiliation were associated with additional forms of reduced substance use at grade 8. These results align with both past research suggesting the importance of these constructs in explaining adolescent substance use (e.g., Chapman, 2013; Kobus et al., 2010; Petraitis & Flay, 1997; Wills et al., 2008), as well as tenants of ecological theory that suggest focusing on more ultimate causes of behavior can influence substance use (e.g. Glanz et al., 2008).
Our mediation analyses were also guided by ecological theory, as we incorporated all three streams of influence from the TTI in the analyses. Results are consistent with the protective effects of self-control and peer affiliation established in prior research. In the single mediator and multiple mediator models, self-control emerged as a buffer against substance use. This finding is understandable, given that past research has consistently found associations between self-control and the substance use behaviors of adolescents (e.g., Daly et al., 2006; Wills & Stoolmiller, 2006; Wills et al., 2008). Additionally, the PA curriculum’s emphasis on emotion self-control and behavior self-control help to explain its greater development among students who received the intervention. Moreover, that substance use behaviors are innately individual-level behaviors may help explain the importance of a mediator that falls within the intrapersonal stream.

Nonetheless, substance use behaviors, particularly among adolescents, can also be seen as social behaviors, occurring among friends. Thus, it is not surprising that the single mediator models also highlighted the importance of deviant peer affiliation. These results are as expected, given theory and past research has shown the strong influence of peer behavior on adolescent substance use (e.g., Hussong, 2002). That deviant peer affiliation did not retain its significant in the multiple mediator model was unexpected. In these models, the ‘a’ paths retained the significance observed in the single mediator models, but the ‘b’ paths did not. Although multicollinearity is a possible explanation, post-hoc analyses did not reveal particularly high correlations between the slopes of self-control and deviant peers (results not shown). Thus, this is an area for future examination.

The limited influence of school attachment was surprising in view of prior research (e.g., Slater & Henry, 2007) implicating it as a protective factor for adolescent substance use. Upon reviewing the PA curriculum, it is possible that the school climate development curriculum,
which is separate from the core six-unit curriculum, was not subject to the same level of implementation and oversight. A further consideration is that some research supports the potential for contextual effects of school attachment whereby the average level of attachment among students in the school can influence risk for substance use, independent of the student’s own level of attachment (Slater & Henry, 2007). Thus, future implementation efforts should seek to better engage this curriculum component and research should explore the potential for mediational processes at multiple levels of analysis.

This study is the first, to our knowledge, to test a theory-guided, three-mediator longitudinal model to understand the mechanisms by which a program had its impact on adolescent substance use. Our hypotheses related to the multiple mediator model were only partially supported. In aiming to understand our findings, it is notable that we did not test the whole TTI, only paths from ultimate underlying causes to the outcome. The TTI does posit distal and proximal factors that influence intentions and behavior (Flay et al., 2009). Thus, it is possible that limiting our analyses to three ultimate underlying causes led to the findings we observed. As such, future research should consider including pathways from ultimate to distal to proximal across all three streams of influence (e.g., deviant peer affiliation (ultimate) to peer behavior (distal) to social normative beliefs (proximal) to adolescent substance use.

Our results should be viewed within the context of strengths and limitations. Strengths include the longitudinal nature, whereby we were able to follow a dynamic cohort of students across six years in time. In addition, we were able to successfully implement the study in a setting with participants that could most benefit from such an intervention, demonstrating feasibility for those seeking replication. Moreover, our analytic approach incorporated the ecological theory guiding program development. Nonetheless, our study is not without
limitations. All the measures of interest were based on student self-report. As such, future research should aim for data triangulation via supplemental reports from teachers, parents, and peers. Moreover, although our mediators were measured across eight points in time, our substance use outcomes were limited to measurement at one point in time (i.e., grade 8). Moreover, the substance use outcomes did not account for forms of substance use that we know are currently pressing public health concerns (e.g., e-cigarette use and prescription drug misuse). Additionally, given the number of mediators and outcomes we were interested in examining, we estimated multiple models; such multiple testing could lead to a Type I error. Lastly, although the setting in which our study took place was a strength, it is arguably also a limitation given that findings may not be generalizable. As such, replication across settings is essential.

To summarize, we observed that a theory-guided, school-based program that was not a traditional substance use prevention program, had an impact primarily on adolescent alcohol use. It is possible the program achieved its impact by focusing on more ultimate causes of behavior, particularly self-control and peer affiliation. Implications for schools aiming to implement such a program in resource-limited settings should include engaging those who deliver the curriculum (e.g., classroom instructors) to pay particular attention to lessons that address self-control and peer affiliation. With respect to future research, as this study followed students into grade 8, and these students are now young adults, a long-term follow-up study that examines the substance use (and related) trajectories would be particularly insightful.
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Figure 1

Single Mediator Models.

Note: Bolded solid lines are the mediational model pathways of interest. This figure does not include the observed variables of the mediator (all 8 waves of each scale used); adjacent waves of these observed variables were correlated (e.g., Wave 1 with Wave 2, Wave 2 with Wave 3, etc.).
Figure 2

Multiple Mediator Model.

Note: Bolded solid paths are the mediational model pathways of interest. This figure does not include the observed variables of the mediator (all 8 waves of each scale used); adjacent waves of these observed variables were correlated (e.g., Wave 1 with Wave 2, Wave 2 with Wave 3, etc.).
Table 1

Effects of Condition on Each Outcome at Grade 8 (‘c’ pathway)

<table>
<thead>
<tr>
<th>Outcome</th>
<th>N</th>
<th>Condition→Outcome (β)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cigarettes</td>
<td>330</td>
<td>-.04, p=.47</td>
</tr>
<tr>
<td>Drinking</td>
<td>332</td>
<td>-.20, p&lt;.001</td>
</tr>
<tr>
<td>Getting Drunk</td>
<td>333</td>
<td>-.14, p&lt;.01</td>
</tr>
<tr>
<td>Marijuana</td>
<td>332</td>
<td>-.09, p=.120</td>
</tr>
<tr>
<td>Substance Use Composite</td>
<td>333</td>
<td>-.14, p&lt;.05</td>
</tr>
</tbody>
</table>

Note: Models are just identified and therefore model fit is not presented.

Note: The Substance Use Composite included student responses to items assessing experiences with cigarettes, drinking, getting drunk, marijuana, and “other” drugs.

Note: β = standardized beta.
Table 2

Results of Single Mediator Models

<table>
<thead>
<tr>
<th>Outcome</th>
<th>N</th>
<th>Chi-Square (DF)</th>
<th>RMSEA</th>
<th>CFI</th>
<th>AIC</th>
<th>Condition ➔ Mediator (β Slope)</th>
<th>Mediator ➔ Outcome (β)</th>
<th>Condition ➔ Outcome (β direct)</th>
<th>Condition ➔ Outcome [β indirect] (CI+)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Self-Control</strong></td>
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<tr>
<td>Cigarettes</td>
<td>1116</td>
<td>71.55(36)</td>
<td>.03</td>
<td>.95</td>
<td>7890.82</td>
<td>-.31, p&lt;.01</td>
<td>-.37, p&lt;.01</td>
<td>.05, p=.61</td>
<td>-11 (-.35, -.04)</td>
</tr>
<tr>
<td>Drinking</td>
<td>1116</td>
<td>72.54(36)</td>
<td>.03</td>
<td>.95</td>
<td>7995.66</td>
<td>.30, p&lt;.01</td>
<td>-.35, p&lt;.01</td>
<td>-.12, p=.13</td>
<td>-10 (-.29, -.04)</td>
</tr>
<tr>
<td>Getting Drunk</td>
<td>1116</td>
<td>74.22(36)</td>
<td>.03</td>
<td>.95</td>
<td>7862.78</td>
<td>.31, p&lt;.01</td>
<td>-.37, p&lt;.01</td>
<td>-.05, p=.55</td>
<td>-14 (-.34, -.04)</td>
</tr>
<tr>
<td>Marijuana</td>
<td>1116</td>
<td>69.94(36)</td>
<td>.03</td>
<td>.95</td>
<td>7861.30</td>
<td>.32, p&lt;.01</td>
<td>-.43, p&lt;.01</td>
<td>.02, p=.88</td>
<td>-14 (-.43, -.06)</td>
</tr>
<tr>
<td>Substance Use Composite</td>
<td>1116</td>
<td>74.27(36)</td>
<td>.03</td>
<td>.95</td>
<td>7629.10</td>
<td>.32, p&lt;.01</td>
<td>-.47, p&lt;.01</td>
<td>-.03, p=.80</td>
<td>-15 (-.42, -.06)</td>
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<tr>
<td><strong>Deviant Peer Affiliation</strong></td>
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</tr>
<tr>
<td>Cigarettes</td>
<td>1110</td>
<td>44.16(36)</td>
<td>.01</td>
<td>.99</td>
<td>8906.76</td>
<td>-.18, p&lt;.01</td>
<td>.25, p&lt;.05</td>
<td>-.03, p=.59</td>
<td>-.05 (-.11, -.01)</td>
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<tr>
<td>Drinking</td>
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<td>43.51(36)</td>
<td>.01</td>
<td>.99</td>
<td>9009.69</td>
<td>-.18, p&lt;.01</td>
<td>.35, p&lt;.001</td>
<td>-.16, p&lt;.01</td>
<td>-.07 (-.15, -.02)</td>
</tr>
<tr>
<td>Getting Drunk</td>
<td>1110</td>
<td>46.72(36)</td>
<td>.02</td>
<td>.99</td>
<td>8877.28</td>
<td>-.19, p&lt;.01</td>
<td>.35, p&lt;.01</td>
<td>-.11, p&lt;.05</td>
<td>-.07 (-.15, -.02)</td>
</tr>
<tr>
<td>Marijuana</td>
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<td>49.12(36)</td>
<td>.02</td>
<td>.98</td>
<td>8876.48</td>
<td>-.19, p&lt;.01</td>
<td>.46, p&lt;.001</td>
<td>-.05, p=.43</td>
<td>-.09 (-.21, -.03)</td>
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<tr>
<td>Substance Use Composite</td>
<td>1110</td>
<td>44.28(36)</td>
<td>.01</td>
<td>.99</td>
<td>8654.03</td>
<td>-.19, p&lt;.01</td>
<td>.44, p&lt;.001</td>
<td>-.11, p=.06</td>
<td>-.08 (-.18, -.03)</td>
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<tr>
<td>School Attachment</td>
<td>1115</td>
<td>107.12(36)</td>
<td>.04</td>
<td>.91</td>
<td>8547.66</td>
<td>.16, p=.08</td>
<td>-.09, p=.57</td>
<td>-.05, p=.43</td>
<td>-.01 (-.10, .02)</td>
</tr>
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</tr>
<tr>
<td>Cigarettes</td>
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<td>.04</td>
<td>.91</td>
<td>8658.07</td>
<td>.16, p=.08</td>
<td>-.22, p=.11</td>
<td>-.11, p=.08</td>
<td>-.04 (-.19, .00)</td>
</tr>
<tr>
<td>Drinking</td>
<td>1115</td>
<td>110.82(36)</td>
<td>.04</td>
<td>.91</td>
<td>8529.28</td>
<td>.16, p=.08</td>
<td>-.09, p=.49</td>
<td>-.14, p=.01</td>
<td>-.02 (-.12, .02)</td>
</tr>
<tr>
<td>Getting Drunk</td>
<td>1115</td>
<td>118.75(36)</td>
<td>.05</td>
<td>.90</td>
<td>8524.65</td>
<td>.16, p=.75</td>
<td>-.10, p=.53</td>
<td>-.10, p=.13</td>
<td>-.02 (-.10, .03)</td>
</tr>
<tr>
<td>Marijuana</td>
<td>1115</td>
<td>116.26(36)</td>
<td>.05</td>
<td>.90</td>
<td>8304.33</td>
<td>.17, p=.08</td>
<td>-.17, p=.23</td>
<td>-.14, p=.05</td>
<td>-.03 (-.14, .01)</td>
</tr>
</tbody>
</table>

+ Note: CI = Confidence Interval. These are bias-corrected 95% confidence intervals for the bootstrapped indirect effect estimates.

Note: $\beta$ = standardized beta.

Note: The Substance Use Composite included student responses to items assessing experiences with cigarettes, drinking, getting drunk, marijuana, and “other” drugs.
Table 3
Results of multiple mediator models

<table>
<thead>
<tr>
<th>Outcome</th>
<th>N</th>
<th>Chi-Square (DF)</th>
<th>RMSEA</th>
<th>CFI</th>
<th>AIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cigarettes</td>
<td>1118</td>
<td>457.54(270)</td>
<td>.03</td>
<td>.94</td>
<td>22996.13</td>
</tr>
<tr>
<td>Drinking</td>
<td>1118</td>
<td>459.92(270)</td>
<td>.03</td>
<td>.94</td>
<td>23100.19</td>
</tr>
<tr>
<td>Getting Drunk</td>
<td>1118</td>
<td>461.85(270)</td>
<td>.03</td>
<td>.94</td>
<td>22968.89</td>
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<tr>
<td>Marijuana</td>
<td>1118</td>
<td>459.55(270)</td>
<td>.03</td>
<td>.94</td>
<td>22948.61</td>
</tr>
<tr>
<td>Substance Use Composite</td>
<td>1118</td>
<td>460.70(270)</td>
<td>.03</td>
<td>.94</td>
<td>22725.51</td>
</tr>
</tbody>
</table>

Outcome Condition→Self-Control Slope (β) Condition→Deviant Peer Affiliation Slope (β) Condition→School Attachment Slope→Outcome (β) Deviant Peer Affiliation Slope→Outcome (β) Attachment Slope→Outcome (β) Condition→Outcome [β indirect via Self-control] (CI)+ Condition→Outcome [β indirect via Deviant Peer Affiliation] (CI)+ Condition→Outcome [β indirect via School Attachment] (CI)+

Cigarettes .33, p<.01 -.18, p<.01 .17, p<.05 -.44, p=.09 -.08, p=.77 -.04, p=.84 .06, p=.59 -.14 (-.58, -.04) .02 (-.05, .17) -.01 (-.08, .07)
Drinking .32, p<.01 -.18, p<.01 .17, p<.05 -.40, p=.08 -.01, p=.98 -.14, p=.36 -.07, p=.47 -.13 (-.47, -.03) .00 (-.08, .11) -.02 (-.11, .02)
Getting Drunk .33, p<.01 -.18, p<.01 .17, p<.05 -.43, p=.10 .01, p=.98 -.02, p=.93 -.03, p=.77 -.14 (-.60, -.04) .00 (-.07, .14) -.00 (-.07, .05)
Marijuana .33, p<.01 -.19, p<.01 .17, p=.06 -.46, p=.06 -.00, p=1.00 -.05, p=.79 .03, p=.81 -.15 (-.57, -.05) .00 (-.11, .11) -.01 (-.08, .06)
Substance Use Composite .33, p<.01 -.18, p<.01 .17, p=.05 -.53, p<.05 -.04, p=.89 -.08, p=.61 .00, p=.97 -.17 (-.57, -.06) .01 (-.06, .15) -.01 (-.08, .05)

Note: CI=Confidence Interval. These are bias-corrected 95% confidence intervals for the bootstrapped indirect effect estimates.
Note: β = standardized beta.