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Influence of Conduct Problems and Depressive Symptomatology on Adolescent Substance Use: Developmentally Proximal Versus Distal Effects

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Abstract

The identification of developmentally specific windows at which key predictors of adolescent substance use are most influential is a crucial task for informing the design of appropriately targeted substance use prevention and intervention programs. The current study examined effects of conduct problems and depressive symptomatology on changes in alcohol, cigarette, and marijuana from 8th through 12th grade. We examined the effects of relatively developmentally distal versus proximal mental health problems on adolescent substance use and tested for gender differences. With a national, longitudinal sample from the Monitoring the Future study ($N = 3,014$), structural equation modeling was used to test the effects of 8th and 10th grade conduct problems and depressive symptomatology on subsequent changes in alcohol, cigarette, and marijuana use from 8th through 12th grade. Results indicated that relatively distal (8th grade) mental health problems were stronger predictors of increases in alcohol, cigarette, and marijuana use than were relatively more proximal (10th grade) mental health problems. 8th grade conduct problems had the strongest effects on alcohol and marijuana use, and 8th grade depressive symptomatology had the strongest effects on cigarette use. Few gender differences were observed. These results suggest that intervening in earlier appearing conduct problems and depressive symptomatology may lead to a reduction in adolescent substance use in 10th and 12th grades and beyond.

Keywords

Adolescence; conduct problems; depressive symptomatology; substance use; longitudinal

The costs, both human and economic, of substance use by young people are enormous. Underage alcohol use alone accounts for over 3,100 deaths, 2.4 million injuries and harmful events, and over \$61 billion in economic costs in the United States each year (Miller, Levy, Spicer, & Taylor, 2006). In order to inform appropriately targeted substance use prevention and intervention programs for adolescents, it is important to identify developmental periods at which known predictors of substance use are particularly influential.

The current study focuses on the effects of adolescent mental health problems, broadly considered, on subsequent substance use. Guided by a developmental psychopathology theoretical framework that gives attention to both developmentally distal and proximal

effects on later psychopathology and problem behaviors (Cicchetti & Rogosch, 2002; Schulenberg, Maslowsky, Patrick, & Martz, in press), we examine effects of relatively distal versus proximal conduct problems (CP) and depressive symptomatology (DS) on adolescent alcohol, cigarette, and marijuana use. CP and DS are the categories of mental health symptoms most strongly associated with substance use during adolescence (Armstrong & Costello, 2002; Kandel et al., 1997). The literature to date offers evidence for each of two competing hypotheses regarding potential developmental specificity of the effects of mental health symptoms on substance use: 1) relatively more distal mental health problems will be more associated with substance use, particularly to the extent that they represent early-emerging mental health problems, which tend to be more severe and associated with more developmental difficulties (e.g. Moffitt, 1993; Weissman et al., 1999), or 2) mental health problems occurring closer in time to substance use will have a stronger effect than those occurring more distally, because developmentally proximal predictors are often stronger than distal predictors (Martin & Martin, 2002; Schulenberg et al., in press). An empirical test pitting these two hypotheses against one another will help to clarify the extent to which the established contributions of mental health problems to substance use reflect effects of distal or proximal symptomatology, information that will be critical to the appropriate timing of substance use prevention programs targeting mental health problems.

Effects of Conduct Problems and Depressive Symptomatology on Substance Use

Among clinical samples, conduct disorder and depressive disorders are the mental health conditions most likely to be comorbid with adolescent substance abuse (Armstrong & Costello, 2002; Kandel et al., 1997). In community samples, the association of conduct problems (CP) such as rule breaking, aggressive, and delinquent behaviors, with substance use is clear. Numerous studies have documented the prospective effect of CP on increased alcohol, cigarette, and marijuana use among adolescents, with particularly strong evidence of connections of CP with alcohol and marijuana use (Dodge et al., 2009; King, Iacono, & McGue, 2004; Lansford et al., 2008; Maslowsky & Schulenberg, in press; Mason, Hitchings, & Spoth, 2008).

Depressive symptomatology (DS) refers to feelings of sadness, hopelessness, and loss of pleasure in normal activities. Their severity varies, though they need not reach the level of clinical significance in order to have a negative impact on daily function (Gotlib, Lewinsohn, & Seely, 1995). The link between DS and substance use in community samples is not as clear as that of CP with substance use. Some studies document a positive, prospective effect of DS on adolescent substance use (Clark, Ringwalt, & Shamblen, 2011; King et al., 2004; Repetto, Caldwell, & Zimmerman, 2005), some find no association (Mason et al., 2008; Dodge et al., 2009), and some have found a negative effect (Fite, Colder, & O'Connor, 2006; Maggs, Patrick, & Feinstein, 2008). The evidence regarding the prospective effects of DS on substance use can thus be described as inconsistent and in need of further investigation.

There are several potential explanations for the inconsistent evidence regarding effects of DS on substance use. The first is that DS may be part of a distinct, though relatively less common, internalizing pathway into substance use (Dierker, Vesel, Sledjeski, Costello, & Perrine, 2007; Hussong, Jones, Stein, Baucom, & Boeding, 2011). Though the majority of substance use problems in adolescence are preceded by CP and other externalizing symptoms, the dual pathways hypothesis posits that the internalizing pathway represents a second route into substance use (Dierker et al., 2007). This pathway is characterized by inhibited temperament that progresses into internalizing symptoms in childhood and adolescence. Internalizing symptoms are associated with using substances to cope with

psychological distress, a known risk factor for substance abuse (Hussong et al., 2011). Because it is relatively less common, not all studies detect the internalizing pathway. A second possibility is that the association with DS is substance-specific. Indeed, there is evidence that DS is particularly strongly related to cigarette use during adolescence (Dierker et al., 2007; Repetto et al., 2005).

Another important consideration is the directionality of the relation between mental health and substance use. The two likely have a reciprocal relation in later adolescence and early adulthood (Brook, Brook, Zhang, Cohen, & Whiteman, 2002; Needham, 2007). However, there is strong evidence that, in adolescence, mental health problems generally precede substance use (Birmaher et al., 1996; Kessler et al., 2005; Merikangas et al., 2010). Psychiatric epidemiology estimates and reviews of prospective longitudinal studies indicate that CP and DS emerge on average at least 3–4 years before substance use in adolescence (Birmaher, et al., 1996; Kessler et al., 2005). Therefore, in studies focusing on adolescence, it is appropriate to examine mental health problems as predictors of substance use.

Gender Differences in Conduct Problems, Depressive Symptomatology, and Substance Use

DS is more common among girls during adolescence, and CP are more common among boys (Hankin, Abramson, Moffitt, Silva, & McGee, 1998; Loeber & Keenan, 1994). The prevalence of substance use is generally higher among boys than girls during adolescence, though gender differences are relatively small in recent cohorts (Johnston, O'Malley, Bachman, & Schulenberg, 2013). Although some studies have found that DS is more strongly associated with substance use by girls and CP more strongly associated with substance use by boys (e.g. Latimer, Stone, Voight, Winters, & August, 2002), gender differences tend to be small. Boys and girls show more similarities than differences in the associations between early psychopathology and later substance use (Costello, Erkanli, Federman, & Angold, 1999). Nonetheless, gender differences in prevalence of DS and CP have led to a conventional wisdom that DS is more associated with girls' substance use and CP are more associated with boys' substance use.

Proximal versus Distal Predictors

Substance use has roots in both distal and proximal developmental processes (Dodge et al., 2009; Zucker, Donovan, Masten, Mattson, & Moss, 2008). Generally in developmental studies, proximal predictors tend to be stronger than distal ones, although the source of the associations between temporally proximal phenomena is not always clear. Such associations may reflect measurement covariance, which tends to be stronger among more proximal time points, or shared variance due to unmeasured factors common to more proximal time points. Given this tendency for proximal predictors to be stronger, identifying a risk factor that is a more powerful predictor of substance use when it occurs earlier, or more distally, may indicate developmental specificity of that predictor that can be leveraged in prevention programs.

In the current study, we performed three sets of analyses specifically designed to compare the effects of developmentally proximal versus distal mental health symptoms. We first examined the distal effect of 8th grade mental health problems on 12th grade substance use. Next, we tested for proximal effects of 8th grade mental health on 10th grade substance use and then of 10th grade mental health problems on 12th grade substance use.

Three specific hypotheses were tested. First, we expected that distal effects of mental health symptoms on substance use would be stronger than those of proximal mental health

symptoms. That is, we expected 8th grade mental health problems would have a stronger effect on 12th grade substance use than would 10th grade mental health problems. We expected that 8th grade mental health would also have strong effects on 10th grade substance use, with these effects reflective of the importance of 8th grade mental health rather than of proximity (which we expected to be ruled out by smaller effects of 10th grade mental health on 12th grade substance use). Second, we expected positive effects of CP and DS on alcohol, cigarette, and marijuana use. In keeping with evidence of potential substance-specificity of effects of mental health on substance use reviewed above, we expected that CP would relate more to alcohol and marijuana use and DS more to cigarette use. Third, we did not expect gender differences in the effects of mental health on substance use.

Method

Data and Sample

Data were from the Monitoring the Future (MTF) Study (Johnston et al., 2013). From 1991–1993, MTF selected a subsample of 8th grade students from their annual national cross-sectional surveys to follow longitudinally into young adulthood. In the current study, the first three time points of data, 8th, 10th, and 12th grades, were used. These data were collected from 1991–1997. Each year, approximately 2,000 students were chosen, for a total of 6,000 students surveyed every two years. Because one original purpose of the study was to examine effects of school dropout on prevalence estimates of substance use at 12th grade, 8th grade students at high risk for school dropout were oversampled in the original data collection. Dropout risk was computed via a composite of variables known to predict educational attainment: parent educational attainment, grade point average, truancy, grade retention, required attendance at summer school, and school suspensions or expulsions. This risk index was bracketed into four strata. Those in the two higher-risk strata were oversampled for follow-up, and those in the two lower-risk strata were undersampled. As discussed below, appropriate weights were used to account for these design effects in the analyses.

8th grade data were collected in school; follow-up data were collected through mail surveys. Students were randomly assigned at 8th grade to complete one of two questionnaire forms. Mental health items were administered on only one of the two forms, therefore, approximately one half of the students are included in this study ($N = 3,014$ at 8th grade). Additional information regarding study methods is available in Bachman et al. (2008).

Students were modal age 14 years at the 8th grade time point ($N = 3,014$). Follow-up data were available at 10th grade (modal age 16) for 2,421 (80.3%) of students and at 12th grade (modal age 18) for 2,003 (66.5%) of students. Sample demographic characteristics and descriptive statistics are reported in Table 1. Students lost to attrition were more likely to be male than female, had higher rates of substance use, depressive symptomatology, and conduct problems at the 8th grade time point. Data were weighted to adjust for differential probabilities of selection into the larger MTF sample from which the longitudinal sample were drawn, as well as for the different probabilities of selection into the longitudinal sample based on risk stratum (see Johnston et al., 2013, for additional information regarding MTF sampling procedures).

Measures

Conduct problems (CP) were measured via four items regarding rule-breaking and aggressive behavior on a scale of 1 = “Never” to 5 = “5 or more times”. Cronbach’s α ranged from .61–.70 at the three time points. Each item began with the stem, “In the past twelve months, how often have you...”. The four items were: “taken something not

belonging to you worth over \$50?”, “gone into some house or building when you weren’t supposed to be there?”, “damaged school property on purpose?”, and “hurt someone badly enough to need bandages or a doctor?”. These items have been used in previous Monitoring the Future studies (e.g. Maslowsky & Schulenberg, in press; Maslowsky, Schulenberg, O’Malley, & Kloska, in press; Schulenberg & Zarrett, 2006; Staff, Osgood, Schulenberg, Bachman, & Messersmith, 2010)

Depressive symptomatology (DS) was measured via four items assessing negative affect and hopelessness on a scale of 1 = “Disagree” to 5 = “Agree”, Cronbach’s α ranged from .72–.81 at each of the three time points. Participants were asked, “How much do you agree or disagree with each of the following statements?” The four items were: “Life often seems meaningless”, “The future often seems hopeless”, “It feels good to be alive”, and “I enjoy life as much as anyone”. The latter two items were reverse coded. The items are similar to those on the Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977) and have been used in previous studies (Merline, Jager, & Schulenberg, 2008; Schulenberg & Zarrett, 2006).

Alcohol use was measured via a single item, “On how many occasions have you drank alcohol, more than just a few sips, in the past 30 days?” on a scale of 1 = “Never” 2= “1–2”, 3 = “3–5”, 4 = “6–9”, 5 = “10–19”, 6 = “20–39”, 7 = “40 or more”. In supplemental analyses, binge drinking was included as an outcome. It was measured via the item “Think back over the last two weeks. How many times have you had 5 or more drinks in a row?” on a scale of 1 = “none” to 6 = “ten or more times”. MTF substance use items are well - validated (Johnston et al., 2013).

Cigarette use was measured via a single item, “How frequently have you smoked cigarettes during the past 30 days?” on a scale of 1 = “Not at all” 2 = “Less than 1 cigarette per day”, 3 = “1–5 cigarettes per day”, 4 = “½ pack per day”, 5 = “1 pack per day”, 6 = “1 ½ packs per day”, 7 = “2 packs or more per day”.

Marijuana use was measured via a single item asking on how many occasions the adolescent had used marijuana or hashish in the past 30 days, on the same scale as alcohol use.

Age was measured at the 8th grade time point, ranging from 11 to 18 years old.

Analytic Strategy

All analyses were performed using structural equation modeling implemented in Mplus version 6.1 (Muthén & Muthén, 1998–2010) using the robust maximum likelihood estimator (MLR) to account for nonnormal distributions of observed variables and full information maximum likelihood (FIML) to account for missing data. Auxiliary variables were included in conjunction with FIML to aid in accounting for missing data by improving the plausibility of FIML’s missing at random assumption (Collins, Schafer, & Kam, 2001). Among the available variables, those most related to missingness at 12th grade that were included as auxiliary variables were: initial risk stratification score (a composite of academic performance variables, described above) and initial levels of other substance use (substances that were not the dependent variable were included in each model, e.g. in models predicting alcohol use, initial levels of cigarette and marijuana use were included as auxiliary variables).

All analyses controlled for level of substance use at the first time point included in each model (either 8th or 10th grade). The outcome therefore represents net change in substance use from the first to second time point modeled in each analysis. Models also controlled for the effect of age at 8th grade on levels of CP, DS, and substance use at the first time point.

Although the modal age at 8th grade was 14 years, age ranged from 11–18. The prevalence of substance use, CP, and DS increases with age in adolescence (Cohen, Cohen, Kasen, & Velez, 1993; Johnston et al., 2013; Zoccolillo, 1992). Age was controlled to adjust for differential levels of mental health problems or substance use associated with a student's younger or older age relative to same-grade peers. In order to ensure that 10th grade mental health problems in the 10th→12th grade models did not simply reflect a continuation of 8th grade mental health problems, but rather represented later emerging symptoms, we controlled for the effects of 8th grade DS on 10th grade DS, of 8th grade CP on 10th grade CP, and of 8th grade DS and CP on 10th grade substance use.

CP, DS, and each of the substance use variables were represented as latent variables. CP and DS latent variables were created using four items each. Alcohol, marijuana, and cigarette use latent variables were created using the single item measure of use of each substance. Single item indicators were corrected for reliability by specifying 15% measurement error in each construct (Figure 1). The amount of measurement error to be specified in the substance use variables was determined using sensitivity analysis (Kline, 2004). Models were estimated specifying 10%, 15%, and 20% measurement error on each construct. 15% measurement error was selected for two reasons: 1) it led to the best rates of model convergence, and 2) it represents a conservative estimate of the amount of error in the measures and avoids false inflation of the estimated relations between the variables that can result from specifying too much measurement error.

Model Estimation

Alcohol, cigarette, and marijuana use were modeled separately as dependent variables. In each of the time period analyses (8→10, 8→12, 10→12), a single group model was estimated for the total sample and then multiple group models were estimated to test for moderation by gender. Multiple group models allow an empirical test of differences in parameters between two groups by comparing model fit when the parameters are forced to be equal to each other versus free to vary. Zero-order correlations of the study variables at each time point are reported in Table 2.

Measurement models were estimated first to ensure adequate fit. A separate measurement model was fit for each substance and each analysis (8th→10th, 8th→12th, 10th→12th, single and multiple group models). All latent variables were entered simultaneously in the measurement model and covaried with each other. In multiple group models, all factor loadings were constrained to be equal across groups. Factor variances were treated as a structural parameter and were therefore allowed to vary across group in the measurement model (Kline, 2004). All measurement models fit well (all CFI and TLI > .95, all RMSEA < .05).

Next, structural models were fit. In multiple group models, factor means were free to vary across groups by default. Equivalence of the remaining structural parameters (factor variances, regression coefficients, and correlations of residual variances) across groups was tested by comparing nested models with these parameters constrained to be equal versus free to vary across groups using the robust X^2 comparison (Satorra & Bentler, 2010). Table 3 summarizes latent variable means and variances as specified in the final estimated models.

Results

Results are summarized in Table 4. CP and DS were entered simultaneously in all models; all reported effects therefore represent the unique contributions of CP and DS to substance use. The first set of models tested the hypothesized distal effect of 8th grade mental health problems on changes in substance use from 8th to 12th grade. Higher levels of 8th grade CP

led to significant increases in alcohol and marijuana use ($B = .13, p < .05$, and $B = .26$, respectively, $p < .001$), but not cigarette use, from 8th to 12th grade. Higher levels of 8th grade DS predicted increases in cigarette use ($B = .09, p < .05$), but not in alcohol or marijuana use.

The second set of models tested the proximal effect of 8th grade mental health problems on changes in substance use from 8th to 10th grade. These models showed largely the same patterns as the 8th→12th grade models. Higher CP led to a significant increase in alcohol and marijuana use ($B = .16$ and $B = .23$, respectively, $ps < .001$), but not cigarette use, and higher DS led to a significant increase in cigarette use ($B = .11, p < .001$), but not alcohol or marijuana use.

The final set of models tested the proximal effect of 10th grade mental health problems on changes in substance use from 10th to 12th grade. As noted above, 8th grade levels were controlled in these analyses to ensure focus on 10th grade emergence of CP and DS. None of the significant effects found for 8th grade mental health problems were found here. In fact, only one effect was significant: higher levels of DS in 10th grade led to a significant increase in marijuana use from 10th–12th grade ($B = .10, p < .001$), which was not evident in the 8th grade predictor models. The total amounts of variance explained in the substance use outcomes were highest in these models, versus the models examining the effects of 8th grade mental health problems; however, this was due to the much stronger stability coefficients from 10th to 12th grade substance use than from 8th to 10th and 8th to 12th grade substance use. Thus, consistent with the first two hypotheses, relatively distal (8th grade) CP and DS were more predictive of 12th grade substance use than were relatively proximal (10th grade) CP and DS; and CP was more predictive of increases in alcohol and marijuana use and DS was more predictive of increases in cigarette use.

Gender Differences

Additional models tested for gender differences in the effects of mental health on subsequent substance use. Only two significant gender differences were detected. 8th grade CP led to increases in alcohol use from 8th to 12th grade among boys only, and higher levels of CP led to decreases in alcohol, cigarette, and marijuana use from 10th–12th grade among girls only. Potential explanations for the latter, unexpected result are discussed further below. Overall, these findings support the third hypothesis, that gender differences in coefficients would be minor.

Supplementary Analyses

In order to examine whether the observed pattern of results applied to indicators of more problematic substance use, we also examined the effects of 8th and 10th grade mental health problems on binge drinking. The results followed the same pattern as those presented for alcohol use during the past 30 days. Namely, 8th grade CP, but not DS, predicted increases in binge drinking from 8th–10th and 8th–12th grade. 10th grade CP and DS did not predict changes in binge drinking from 10th–12th grade. These results indicate that the relative importance of earlier emerging versus proximal mental health problems on adolescent substance use applies to more problematic measures of alcohol use in addition to measures of more normative use.

Additional supplementary analyses further examined the unexpected negative effect of 10th grade CP on 12th grade substance use among girls. In bivariate analyses, girls' 10th grade CP had a small, positive association with their 12th grade alcohol, cigarette, and marijuana use. When the analyses were rerun without controlling for 10th grade substance use, these small positive associations on 12th grade substance use remained. Thus, we suspect that the

unexpected negative effect of 10th grade CP on 12th grade substance use was a statistical artifact attributable to the strong positive association between CP and substance use in 10th grade as well as the high stability of substance use between 10th and 12th grade rather than due to a substantive suppression effect.

Discussion

The purpose of this study was to test whether the effects of mental health symptoms on adolescent alcohol, cigarette, and marijuana use are attributable to more developmentally proximal or distal mental health symptoms. We examined relatively proximal and distal effects of conduct problems and depressive symptomatology on alcohol, cigarette, and marijuana use from 8th through 12th grades in a national, longitudinal sample. As there is prior theoretical and empirical evidence to support both developmentally proximal and distal effects of mental health problems on substance use, we endeavored to empirically test whether relatively distal or proximal mental health problems are more reliably associated with later substance use.

Distal versus Proximal Mental Health Problems

The primary hypothesis, that 8th grade mental health problems would have a stronger and more consistent pattern of effects than 10th grade mental health problems on increases in substance use through 12th grade, was supported. 8th grade mental health symptoms showed clear effects on both 10th and 12th grade substance use. In general, higher levels of 8th grade CP led to greater increases in alcohol and marijuana use, and higher levels of 8th grade DS led to greater increases in cigarette smoking. Despite the fact that they were more temporally distant from 12th grade substance use, 8th grade mental health symptoms showed an overall stronger association with 12th grade substance use than did 10th grade mental health problems, which had few significant effects on 12th grade substance use. The two exceptions were a positive effect of 10th grade DS on 12th grade marijuana use for the total sample and a negative effect of 10th grade CP on alcohol, cigarette, and marijuana use for girls only. The weak pattern of prediction by 10th grade versus 8th grade mental health problems indicates that there may be unique predictive power of earlier mental health problems, an effect strong enough to supersede the effects of more proximal behavior.

That substance use has both developmentally distal and proximal predictors is to be expected based on developmental psychopathology theory, which recognizes joint contributions of distal and proximal influences. Empirical studies often favor proximal factors, perhaps because these data are easier to come by (e.g. Martin & Martin, 2002). However, consistent with an emphasis on powerful developmentally distal effects on later psychopathology and problem behaviors, developmental psychopathology underscores the necessity of locating risk factors within the appropriate developmental timeframe when they are more and less powerful (Cicchetti & Rogosch, 2002; Schulenberg et al., in press). As we show, through appropriately controlled comparisons, CP and DS that are manifest by 8th grade are more predictive of later substance use than are CP and DS that manifest later in adolescence. Through cascading effects, development psychopathology specifies how earlier difficulties can cumulate and contribute to later difficulties in other domains (Dodge et al., 2009). Identifying specific periods of heightened developmental risk contributes to better specification of the etiology of adolescent substance use, an important advantage of applying a developmental psychopathology perspective to etiology.

In addition to the relative strengths of the effects of 8th grade versus 10th grade mental health problems on substance use, it is also important to consider the absolute sizes of these effects. After controlling for the substantial stability of substance use by including either 8th or 10th grade substance use in the model, CP and DS accounted for 3–9% of the variance in change

in substance use over the two-to four -year period studied. Thus, mental health explained a modest amount of variance in increases in adolescent substance use. Such modestly-sized risk factors are typical when attempting to predict change over time in substance use. Especially during adolescence, when substance use is especially multiply determined, most effects are likely to be modest, and isolating significant risk factors for increased substance use provides valuable information for how to target early prevention and intervention.

Finally, another potential explanation of these findings, which unfortunately cannot be evaluated within the age-restricted boundaries of the current dataset, is that 8th grade mental health problems marked a longer term presence of these problems, in which case the 8th grade measurement is simply one point in a substantially longer and relatively stable behavioral pathway. This alternative possibility merits further exploration. A number of long-term prospective studies starting as early as the preschool years have found that early appearing externalizing, and to a lesser degree internalizing behaviors, predict substance abuse outcomes some 15 to 20 years later (e.g., Mayzer, Fitzgerald, & Zucker, 2009). Such distal effects of early onset CP and DS demonstrate the potency of symptoms that emerge early. The fact that 8th grade mental health problems were about equally powerful in predicting increases in both 10th grade and 12th grade substance use suggests that 8th grade (and likely earlier) is a key period for negative sequelae of mental health problems and thus perhaps a consequential intervention window. As we show, 10th grade mental health problems are hardly predictive at all of increases in 12th grade substance use, due in part to the relatively high stability of substance use from 10th to 12th grade, suggesting that 10th grade does not represent a consequential intervention window in general. Still, as we show, depressive symptomatology at 10th grade significantly predicts increases in marijuana use at 12th grade, suggesting importance nuances to our findings as well as to the relationship between depressive symptomatology and marijuana use.

Overall, the results indicate that early emerging mental health problems have a stronger influence on adolescent substance use than later emerging symptoms, even when the early emerging symptoms are relatively distal from the substance use outcome. This has important implications for both theory and practice. With regards to theory, models of the developmental sequence leading to substance use (e.g. Dodge et al., 2009, Zucker et al., 2008) and empirical studies based on these models should include early emerging mental health problems in the sequence. With regards to practice, these results indicate that limited prevention dollars may be better directed toward earlier occurring mental health problems to prevent later substance use.

Substance Specificity of Effects of Conduct Problems and Depressive Symptomatology

Our second hypothesis was that DS would have positive effects on later substance use. DS did indeed have positive effects, but they applied specifically to cigarette smoking. This result is consistent with several previous studies documenting a positive prospective relation between DS and cigarette use (Dierker et al., 2007; Repetto et al., 2005). The substance-specific association of DS with cigarette use may also help to explain why the literature shows mixed results on the effect of DS on substance use. Studies focusing on other substances or on index variables that combine multiple types of substance use may not detect the effect of DS, which appears to operate primarily on cigarette use.

The effects of CP were specific to alcohol and marijuana use; CP were not associated with changes in cigarette use. Previous studies have implicated CP in the development of problematic substance use, including heavy and chronic marijuana use (Brook, Zhang, & Brook, 2011) and alcohol use disorders (Lansford et al., 2008). Overall, the substance-specificity of the effects of CP and DS indicate that while early intervention in both CP and DS maybe a promising approach for preventing substance use, lower DS could be expected

to impact cigarette use while lower CP could be expected to manifest in lower marijuana and alcohol use.

Gender Differences in the Effects of Mental Health Problems on Substance Use

Our final hypothesis was that we would observe few gender differences in the effects of mental health problems on substance use, based on previous research that has found these relationships to be more similar than different in boys and girls (Costello et al., 1999; King et al., 2004). The few significant gender differences we did observe were quite small in magnitude. The only large differences were in the effects of 10th grade CP on changes in substance use from 10th–12th grade, which showed a negative association among girls and no association among boys. This unexpected finding was explained by supplementary analyses indicating that the negative association was induced by controlling for levels of substance use in 10th grade and the high stability of substance use from 10th to 12th grade. When 10th grade substance use was not controlled, the effect of CP on substance use was positive as expected in both boys and girls.

Overall, the gender difference results indicate that popular suppositions that DS is a stronger substance use risk factor for girls and CP for boys do not appear to be empirically grounded. These results add to the literature indicating that despite prevalence differences in mental health symptoms, with DS more prevalent in girls and CP more prevalent in boys, youth of either gender who manifest each set of symptoms should be considered equally at risk for increased substance use across adolescence (Armstrong & Costello, 2002).

Strengths and Limitations

This study has numerous strengths, including the national multi-cohort, multi-wave longitudinal sample of adolescents, which allowed us to identify the developmentally specific effect of relatively more distal mental health problems on later substance use. This effect is implied by psychiatric literature indicating that early emerging symptoms tend to be more severe and more predictive of later problems, but the contrast in predictive power has not previously been empirically evaluated. Second, the effects of mental health symptoms on three different, commonly used substances, alcohol, cigarettes, and marijuana, were examined. Previous studies have often examined the effects of CP and DS either on only one of these substances or on an index variable that combines them and obscures substance-specific effects of mental health problems. We tested for gender differences, in order to determine whether a commonly held perception that higher prevalence of DS among girls and of CP among boys would lead to stronger association those symptoms to substance use among members of the respective gender, an assertion that was not supported by the current results.

There were also several limitations. First, as is common in longitudinal studies, there was attrition, with 33.5% of the sample attriting by the 12th grade measurement point. However, this attrition was anticipated within the study design; those most likely to attrit were oversampled and were therefore still reasonably well represented at 12th grade (Bachman et al., 2008). We also took several steps in the analysis to minimize the impact of missing data on the results. We used full information maximum likelihood (FIML) to account for missing data, and we additionally included auxiliary variables related to attrition in all models to aid in meeting the missing at random assumption of FIML. Analyses were also run using just those cases with complete data at all three time points (not shown). Importantly, results did not change regardless of how we handled missing data, therefore minimizing the possibility that our results were driven or biased by study attrition. Second, the data were all self-reported, and some of the associations observed in this study may be attributable to the fact that all data are from one reporter, thus introducing unmeasured commonalities into the

results. Additional unmeasured factors (e.g. more similar school or peer environment, continuity of individual behaviors and attitudes) may have contributed to stronger associations between more proximal time points. However, the differential associations observed in 8th grade mental health predicting 12th grade substance use more strongly than 10th grade mental health do help to alleviate some of the concerns of single-reporter bias and of unmeasured variables driving effects. Another limitation was that the measures of the mental health symptoms were brief—four items each to measure CP and DS. Brief measurement is one of the tradeoffs made in survey research in order to obtain large national samples. Of note, however, is that these measures had moderate to good internal consistency, and they have been applied effectively in several previous studies (e.g., Pilgrim et al., 2006; Schulenberg & Zarrett, 2006). Of course, additional studies with more in-depth measurement of mental health symptoms would be important in replicating the current results. An additional limitation concerns the study's restricted age range, covering just the period from 8th to 12th grades. Although large scale, population representative longitudinal studies covering the entire age span between preschool and early adulthood are understandably rare, when new ones become available with a broad enough variable network, it will be essential to investigate whether the apparent early childhood-to-late adolescent linkages can be replicated, and also whether the “earlier is stronger” relationship will be upheld. There was also some variation in the initial age of participants at 8th grade; ages ranged from 11–18, with modal age 14. Age was controlled in statistical analyses to account for variation in developmental stage and also life experiences that may vary based on participants' age. Finally, the waves of data collection were spaced two years apart. Given the dynamic developmental processes occurring in adolescence, there is certainly more insight to be gained regarding proximal and distal effects of mental health problems on substance use in more frequent observations spaced more closely together. This represents an important extension on the current findings to be pursued in future studies.

Conclusions

Understanding true risk factors for substance use during adolescence -that is, characteristics that give us *advance* warning about likely substance use onset and escalation - requires longitudinal research that is developmentally informed. Such research allows the consideration of punctuated times when risk factors are especially powerful in predicting future course. Substance use etiology research has given little attention to such considerations. The current study demonstrates that developmentally distal mental health problems are relatively more predictive of increases in substance use through the end of high school than are developmentally proximal problems, an important insight that underscores the advances that can be made by infusing substance use etiology with developmental considerations.

Specifying developmental timing of the effects of early predictors of substance use is a key step in enabling development and implementation of successful interventions to prevent substance-use related harm to youth and to society. Delaying initiation of substance use is a demonstrated method of reducing problematic substance use in young adulthood (Kellam et al., 2008; Spoth, Trudeau, Gyll, Shin, & Redmond, 2009). The current results indicate that intervening in early CP and DS, despite their temporal distance from later substance use, could lead to a reduction in adolescent substance use in 10th and 12th grades, perhaps by delaying the onset of use by some youth. There is a significant developmental window between onset of mental health problems and substance use (Birmaher et al, 1996; Merikangas et al., 2010). Screening programs administered during this time to identify mental health problems among adolescents could help to break the link between mental health problems and substance use by directing at-risk youth to developmentally tuned intervention programming. National level programming is currently in the early stages of

articulating what those interventions should be (NIAAA, 2011). The present work suggests the importance of carrying out considerably more of this type of developmentally tuned activity.

Given the significant morbidity and mortality imparted by adolescent substance use and its developmental sequelae, an investment in delaying the onset of substance use in adolescence should be considered an investment in overall adolescent health. Mental health problems represent one of several domains of risk for substance use. This study has demonstrated that interventions that target adolescent mental health problems in order to delay or reduce substance use should focus on relatively early mental health problems, particularly those that have onset by 8th grade.

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Figure 1.

Analytic model of mental health problems predicting substance use in adolescence. CP = Conduct problems; DS = Depressive symptomatology. In 10th→12th grade models, in addition to the paths portrayed here, 10th grade CP controlled for 8th grade CP, 10th grade DS controlled for 8th grade DS, and 10th grade substance use controlled for 8th grade CP and DS.

Table 1

Sample Characteristics and Means and Standard Deviations of Analysis Variables- Grades 8, 10, 12

	8 th grade (N = 3,014)	10 th grade (N = 2,421)	12 th grade (N = 2,003)
Gender (%)			
Male	49.3	47.0	43.2
Female	50.7	53.0	56.8
Race (%)			
White	60.8	64.8	66.2
Black	14.0	12.5	11.5
Hispanic	10.8	8.6	8.3
Other	14.4	14.1	14.0
		M (SD)	
Conduct Problems	1.33 (0.62)	1.28 (0.56)	1.22 (0.49)
Depressive Symptoms	1.97 (0.95)	1.92 (0.90)	1.86 (0.90)
Alcohol Use	1.42 (0.91)	1.58 (1.04)	1.97 (1.38)
Cigarette Use	1.31 (0.84)	1.54 (1.16)	1.90 (1.46)
Marijuana Use	1.09 (0.51)	1.30 (1.01)	1.61 (1.52)

Table 2

Zero-Order Correlations of Study Variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Conduct problems-8th grade	–															
2. Conduct problems-10th grade	.34 ***	–														
3. Conduct problems-12th grade	.23 ***	.39 ***	–													
4. Depressive symptoms-8th grade	.20 ***	.11 ***	.04	–												
5. Depressive symptoms-10th grade	.10 ***	.21 ***	.12 ***	.37 ***	–											
6. Depressive symptoms-12th grade	.10	.16 ***	.17 ***	.27 ***	.51 ***	–										
7. Alcohol use-8th grade	.35 ***	.21 ***	.10 ***	.18 ***	.13 ***	.09 ***	–									
8. Alcohol use-10th grade	.23 ***	.32 ***	.14 ***	.11 ***	.20 ***	.15 ***	.33 ***	–								
9. Alcohol use-12th grade	.16 ***	.18 ***	.25 ***	.03	.09 ***	.08 ***	.22 ***	.43 ***	–							
10. Cigarette use-8th grade	.33 ***	.12 ***	.02	.22 ***	.15 ***	.11 ***	.47 ***	.24 ***	.13 ***	–						
11. Cigarette use-10th grade	.23 ***	.25 ***	.08 **	.21 ***	.21 ***	.16 ***	.32 ***	.45 ***	.20 ***	.50 ***	–					
12. Cigarette use-12th grade	.19 ***	.17 ***	.17 ***	.15 ***	.20 ***	.20 ***	.25 ***	.35 ***	.38 ***	.36 ***	.61 ***	–				
13. Marijuana use-8th grade	.25 ***	.13 ***	.04	.12 ***	.04	.06 *	.38 ***	.15 ***	.07 **	.37 ***	.22 ***	.13 ***	–			
14. Marijuana use-10th grade	.24 ***	.36 ***	.22 ***	.12 ***	.16 ***	.14 ***	.26 ***	.47 ***	.24 ***	.27 ***	.46 ***	.31 ***	.28 ***	–		
15. Marijuana use - 12th grade	.21 ***	.26 ***	.31 ***	.09 ***	.19 ***	.19 ***	.19 ***	.36 ***	.41 ***	.16 ***	.34 ***	.44 ***	.17 ***	.53 ***	–	
16. Age-8th grade	.10 ***	.04	.03	.09 ***	.08 ***	.06 *	.09 ***	.03	.06 ***	.14 ***	.09 **	.07 **	.08 ***	.07 **	.02	–

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

Table 3

Estimates and Equivalence of Latent Variable Means and Variances in Single and Multiple Group Structural Equation Models

Time Period	Substance	Model	Group	Conduct Problems (CP)			Depressive Symptoms (DS)			Substance Time 1		Substance Time 2	
				N	Mean	Variance	Mean	Variance		Mean	Variance	Mean	Variance
8th–12th grade	Alcohol	Full Sample		2,944	0.73	0.18	1.42	0.71		1.18	0.73	0.54	1.56
		Gender	Male	1,513	1.07	0.27 <i>a</i>	1.79	0.56 <i>a</i>		1.23	0.82 <i>a</i>	0.95	1.90 <i>a</i>
	Cigarettes		Female	1,379	0.91	0.08 <i>a</i>	1.89	0.85 <i>a</i>		1.16	0.56 <i>a</i>	0.62	1.10 <i>a</i>
		Full Sample		2,962	0.72	0.18	1.45	0.76		1.67	0.60	1.47	1.70
		Gender	Male	1,527	1.09	0.28 <i>a</i>	1.74	0.77		1.59	0.60	1.48	1.71
			Female	1,386	0.91	0.09 <i>a</i>	1.83	0.76		1.60	0.60	1.36	1.70
	Marijuana	Full Sample		2,965	0.67	0.18	1.44	0.70		0.59	0.23	0.87	1.81
		Gender	Male	1,527	1.09	0.28 <i>a</i>	1.74	0.77		1.59	0.60	1.48	1.71
			Female	1,386	0.91	0.09 <i>a</i>	1.83	0.76		1.60	0.60	1.36	1.70
		Full Sample		2,951	0.72	0.18	1.43	0.72		1.16	0.73	0.68	0.92
	Alcohol	Gender	Male	1,518	1.06	0.27 <i>a</i>	1.79	0.57 <i>a</i>		1.20	0.83 <i>a</i>	0.79	1.04 <i>a</i>
			Female	1,381	0.89	0.08 <i>a</i>	1.89	0.86 <i>a</i>		1.13	0.55 <i>a</i>	0.63	0.70 <i>a</i>
10th–12th grade	Cigarettes	Full Sample		2,968	0.72	0.18	1.46	0.72		1.68	0.60	1.57	1.13
		Gender	Male	1,528	1.06	0.24 <i>a</i>	1.76	0.57 <i>a</i>		1.63	0.60	1.57	1.24 <i>a</i>
			Female	1,388	0.89	0.09 <i>a</i>	1.86	0.90 <i>a</i>		1.63	0.60	1.56	1.03 <i>a</i>
		Full Sample		2,964	0.72	0.18	1.48	0.72		0.60	0.23	0.80	0.84
	Marijuana	Gender	Male	1,524	1.07	0.25 <i>a</i>	1.84	0.74		0.57	0.23	0.98	1.04 <i>a</i>
			Female	1,388	0.90	0.09 <i>a</i>	1.94	0.73		0.55	0.23	0.89	0.67 <i>a</i>
	Alcohol	Full Sample		2,828	0.23	0.08	0.93	0.82		0.65	0.86	0.44	1.48
		Gender	Male	1,438	0.12	0.08 <i>a</i>	0.93	0.73		0.62	1.05 <i>a</i>	0.47	1.83 <i>a</i>
			Female	1,339	0.02	0.03 <i>a</i>	1.03	0.85		0.45	0.69 <i>a</i>	0.16	1.14 <i>a</i>
		Full Sample		2,829	0.24	0.08	0.91	0.83		1.58	1.09	1.52	1.69
	Cigarettes	Gender	Male	1,439	0.11	0.03 <i>a</i>	2.49	0.93		1.51	1.09	1.69	1.51
			Female	1,339	0.00	0.04 <i>a</i>	2.57	0.82		1.70	1.49	1.55	1.60
	Marijuana	Full Sample		2,829	0.25	0.08	0.93	0.85		0.92	0.83	1.03	1.83

Time Period	Substance	Model	Group	N	Conduct Problems (CP)			Depressive Symptoms (DS)			Substance Time 1			Substance Time 2		
					Mean	Variance	Mean	Mean	Variance	Mean	Mean	Variance	Mean	Mean	Variance	Variance
	Gender		Male	1,154	0.00	0.11 ^a	0.68	0.76	0.61	1.03 ^a	0.68	2.47 ^a				
			Female	1,170	-0.13	0.04 ^a	0.77	0.87	0.51	0.65 ^a	0.34	1.29 ^a				

^a Estimates significantly different in males versus females, $p < .05$

Table 4

Results of Single and Multiple Group Structural Equation Models

Time period	Substance	Model	Group	N	Conduct Problems (CP)		Depressive Symptoms (DS)		Substance Time 1		R ²	CFI	TLI	RMSEA	X ²	DF
					B		B		B							
8th–12th	Alcohol	Full Sample		2,944	0.13 *		–0.05		0.21 ***		0.08	1.00	0.99	0.01	44.05	35
		Gender	Male	1,513	0.19 a**		–0.02		0.25 ***		0.13	0.98	0.98	0.02	132.57	85
			Female	1,379	–0.09 a		–0.03		0.27 ***		0.05					
	Cigarettes	Full Sample		2,965	0.03		0.09 *		0.43 ***		0.23	0.99	0.99	0.01	54.85	35
		Gender	Male	1,527	0.04		0.09 *		0.43 ***		0.23	0.98	0.97	0.02	158.91	89
			Female	1,386	0.02		0.09 *		0.43 ***		0.23					
	Marijuana	Full Sample		2,962	0.26 ***		0.03		0.13 *		0.12	1.00	1.00	0.00	34.33	35
		Gender	Male	1,522	0.25 ***		0.03		0.13 *		0.11	0.98	0.98	0.02	139.37	89
			Female	1,388	0.20 ***		0.04		0.18 *		0.11					
	Alcohol	Full Sample		2,944	0.16 ***		0.02		0.30 ***		0.17	1.00	1.00	0.01	42.03	35
		Gender	Male	1,518	0.16 **		0.01		0.34 ***		0.19	0.99	0.98	0.02	126.69	86
			Female	1,381	0.11 **		0.01		0.33 ***		0.17					
8th–10th	Cigarettes	Full Sample		2,968	0.01		0.11 ***		0.59 ***		0.40	0.99	0.99	0.02	59.85	35
		Gender	Male	1,528	0.01		0.10 **		0.57 ***		0.37	0.97	0.97	0.03	173.30	90
			Female	1,388	0.00		0.11 ***		0.63 ***		0.45					
	Marijuana	Full Sample		2,964	0.23 ***		0.06		0.28 ***		0.20	1.00	1.00	0.00	36.21	35
		Gender	Male	1,524	0.26 ***		0.04		0.26 ***		0.19	0.98	0.98	0.02	132.22	89
			Female	1,388	0.20 ***		0.05		0.32 ***		0.21					
	Alcohol	Full Sample		2,363	0.01		–0.02		0.54 ***		0.29	0.97	0.97	0.02	310.37	136
		Gender	Male	1,152	0.04 a		0.00		0.54 ***		0.31	0.96	0.95	0.02	549.92	300
			Female	1,170	–0.14 a*		0.01		0.55 ***		0.25					
	Cigarettes	Full Sample		2,365	–0.01		0.06		0.74 ***		0.56	0.97	0.96	0.02	335.06	136
		Gender	Male	1,154	0.06 a		0.06 *		0.70 ***		0.55	0.95	0.95	0.03	596.64	302
			Female													

Time period	Substance	Model	Group	N	Conduct Problems (CP)			Depressive Symptoms (DS)			Substance Time 1			R ²	CFI	TLI	RMSEA	X ²	DF
					B		B	B		B	B		B						
	Marijuana	Full Sample	Female	1,170	-0.15 ^{a**}		0.07 [*]	0.80 ^{***}		0.60									
				2,365	0.04		0.10 ^{***}	0.62 ^a		0.45									
			Male	1,154	0.11		0.09 ^{**}	0.61 ^{***}		0.48									
				1,170	-0.16 ^{***}		0.13 ^{**}	0.67 ^{***}		0.41									

*
 $p < .05$,

**

$p < .01$,

$p < .001$

^a Estimates significantly different in males versus females, $p < .05$

Note. All regression coefficients are standardized.