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Associations Between First Use of Substances and Change in Internalizing Symptoms Among Girls: Differences by Symptom Trajectory and Substance Use Type

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Abstract

This study examined how girls' initial use of alcohol, cigarettes, and marijuana related to changes in depressive, generalized anxiety, and social anxiety symptoms, and whether these changes varied based on which internalizing symptom trajectories the girls were on. Data came from the Pittsburgh Girls Study, a community-based study of girls assessed at ages 5-8 and followed for 6 years. Growth mixture modeling was used to identify trajectory groups. The results indicated that for girls on a "high depressive symptom" trajectory, initial use of marijuana was related to further increases in depressive symptoms. Initial uses of alcohol and cigarettes were associated with overall increases in depressive symptoms, and the initial use of cigarettes was associated with an overall increase in generalized anxiety symptoms. Initial use of all substances was related to change in social anxiety, but the direction of change varied by trajectory group and substance. Links between initial use and internalizing symptoms depended on the type of substance, type of internalizing symptom, and trajectory group.

Internalizing disorders (depression and anxiety) and substance use disorders (abuse and dependence) often co-occur within individuals (e.g., Grant et al., 2004; Swendsen et al., 1998; Swendsen & Merikangas, 2000). However, less is known about how substance use relates to internalizing symptoms and disorders, although there is some evidence that this is not a linear association (Rodgers et al., 2000). Even less is known about how the first use of substances relates to internalizing symptoms. The goal of this study was to examine links between the first use of alcohol, cigarettes, and marijuana and changes in symptoms of depression, generalized anxiety, and social anxiety among pre-adolescent and early-adolescent girls; an emphasis was placed on determining whether these associations differed for girls on different trajectories of internalizing symptoms.

The first use of substances may be thought of as a pivotal developmental event in the lives of young people. Although the initial use of a substance in and of itself is unlikely to directly cause or be caused by a single other factor—including internalizing symptoms—these initial use events are likely markers of changes in developmental processes, such as a shift in the relative importance of parents and peers in a girl's life. We can also consider changes in internalizing symptoms as developmental "events" or processes that are accompanied by a

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variety of contextual changes that may place a girl at risk for initial substance use. For example, a girl who experiences an increase in depressive symptoms might then see her grades drop and her apathy or hopelessness could cause further disengagement from school. This could lead to affiliation with delinquent peers and/or disengagement from parents, which would represent additional risk factors for substance use. This increase in depressive symptoms, then, would not *cause* the initial substance use per se; instead, it would be a marker for a change in process, which may be associated with exposure to contexts that lead to substance use. In addition, certain normative developmental processes may present exaggerated risk for substance use initiation among girls with significant internalizing symptoms. For example, the increasing importance of peer relationships during early adolescence may be associated with increased social anxiety due to concerns about fitting in; a particularly socially anxious girl may be more vulnerable to peer influences and use substances in order to fit in.

Theoretical Perspectives on Substance Use and Internalizing Symptoms

There are a number of theories that seek to explain links between internalizing symptoms and disorders and substance use, abuse, and dependence. For example, the self-medication model proposes that people use substances in an attempt to cope with negative affect (e.g., Khantzian, 1985). Tran and Smith (2008) proposed a model integrating genetics, neurobiology, cognitive factors, and social learning to explain the link between social phobia and alcohol use disorders specifically, and recent research has indicated that there might be a particularly strong association between social anxiety and substance dependence (Buckner et al., 2008). There may also be a common genetic diathesis for both internalizing disorders (perhaps particularly MDD) and substance use disorders (Nurnberger et al., 2002). In addition, there is a link between internalizing disorders and externalizing behavior (e.g., Marmorstein, 2007); people may use substances due to processes related to antisocial behavior, resulting in an apparent link between internalizing disorders and substance problems that is simply due to their joint co-occurrence with antisocial behavior (Pardini, White, & Stouthamer-Loeber, 2007). However, the connection between these perspectives and *initial* substance use—as opposed to regular/heavy use, abuse, and/or dependence—remains unclear. For example, it is also possible that the self-medication model may apply only later (after initial use) because people may need to experience for themselves the anxiolytic effects of alcohol before they self-medicate with it. Therefore, the direct application of these theories of heavy use and disorders to initial substance use specifically is somewhat premature.

Findings on First Substance Use and Internalizing Symptoms

We are aware of little research addressing possible links between depressive, generalized anxiety, and social anxiety symptoms and disorders and first use of substances. The available evidence seems to indicate that there may be differences by type of symptom, age of participant, and whether dimensional measures of symptoms or categorical measures of clinically-significant disorders are used. In one study, the number of depressive and generalized anxiety symptoms at baseline (ages 9, 11, and 13) was positively related to alcohol use initiation 3 years later (Kaplow, Curran, Angold, & Costello, 2001). In contrast, one study reported that major depression in pre-adolescence (age 11) did not relate to drinking by age 14 (McGue, Iacono, Legrand, Malone, & Elkins, 2001); perhaps more severe clinical levels of depression relate differently to substance use than dimensional measures of depressed mood. Among boys, both generalized and social anxiety predicted first use of alcohol and tobacco, while only generalized anxiety predicted first use of marijuana (Marmorstein, White, Loeber, & Stouthamer-Loeber, in press). Among 9^{th}- and 10^{th}-grade students, depressed mood was positively related to alcohol use initiation 2 years later (Brook, Whiteman, Gordon, Nomura, & Brook, 1986). Therefore, the bulk of the evidence from studies of pre-adolescents through early adolescents using dimensional measures of internalizing problems supports the notion that they increase risk for initial use of substances. However, high school seniors with high

levels of internalizing symptoms in the fall were less likely to begin using alcohol by the spring semester (Stice, Myers, & Brown, 1998); similarly, scores on a scale assessing depression, guilt, and obsessiveness did not predict the onset of marijuana use among pre-adolescent to early adult youth (Brook, Kessler, & Cohen, 1999). It seems possible that predictors of initial substance use in late adolescence and early adulthood differ from those in pre-adolescence through mid-adolescence.

Thus, it is not clear whether internalizing symptoms positively predict or protect against substance use initiation, however, the weight of the evidence seems to indicate that among younger people, higher scores on dimensional measures of internalizing symptoms are likely to positively predict increased risk for initial substance use. In addition, there may be differences in these links according to type of internalizing symptom. The present study attempts to resolve several of these discrepancies in the literature by incorporating several features: annual examination of a sample of girls over a period of 6 years, separate consideration of different types of internalizing symptoms and different types of substances, and consideration of the possibility that these links may vary across different trajectories of internalizing symptoms. This last point is particularly important, as these associations may differ for youth with high (clinical) levels of internalizing symptoms, compared to lower symptom levels (e.g., McGue et al., 2001 versus Kaplow et al., 2001).

Internalizing Symptom Trajectories

Few studies that we are aware of have identified trajectories of internalizing symptoms among pre-adolescents. Sterba, Prinstein, and Cox (2007) examined maternal reports of internalizing (depressive and anxiety) symptoms from ages 2 to 11 and found three trajectories for each gender: low stable, high stable, and decreasing/increasing. Brendgen, Wanner, Morin, and Vitaro (2005) examined trajectories of depressive symptoms from ages 11 to 14 and identified four groups: stable low, stable moderate, sharp increasing, and high increasing. Finally, Dekker and colleagues (2007) identified six trajectories of depressive symptoms for each gender from ages 4 to 18. For girls, they were: low decreasing, very low increasing, low stable, moderate stable, adolescent onset increasing high, and high increasing (though the last two trajectories were comprised of only 10 and 14 participants, respectively, out of a total of 1060 participants). These differences in trajectory models could be due to several factors. First, the types of symptoms examined varied (Sterba et al. grouped together all internalizing symptoms, while Brendgen et al. and Dekker et al. examined only depressive symptoms). Second, these studies differed in the age ranges that were examined. Third, the studies differed in the degree of group differentiation and the size of the groups. For example, in the Dekker et al. study, the three different “low” groups all had predicted levels of approximately one symptom or less but were nevertheless identified as distinct trajectory classes. This study addressed a gap in knowledge regarding different types of internalizing symptom trajectories by separately examining symptoms of three distinct types of disorders (as opposed to examining only depressive symptoms, or lumping all internalizing symptoms together; in particular, this represents the first attempt to describe trajectories of social and generalized anxiety symptoms that we are aware of) in girls from childhood through pre-adolescence (which avoided the increase in depressive symptoms that often has its onset in adolescence).

Current Study

The goal of the current study was to examine how pre- and early-adolescent girls' initial use of alcohol, cigarettes, and marijuana was correlated with increases or decreases in depressive, generalized anxiety, and social anxiety symptoms. We were particularly interested in how these associations might differ across individuals, based on which trajectory of internalizing symptoms they were on. Therefore, we used growth mixture modeling to define typical internalizing symptom trajectories and then examined whether the initial use of each substance

was associated with deflections from these typical trajectories for all girls, none of the girls, or only girls on certain trajectory(s).

We examined only girls for several reasons. There may be gender differences in the links between internalizing symptoms and substance use and related problems (Armstrong & Costello, 2002; Conner, Pinquart, & Gamble, 2009), and girls have higher rates of internalizing problems than boys (e.g., Costello, Mustillo, Erkanli, Keeler, & Angold, 2003). Therefore, combining males and females may mask important information about these associations.

We examined different types of internalizing symptoms separately because they may relate in different ways to substance use. These internalizing problems have been shown in factor-analytic studies to be separate constructs with unique patterns of comorbidity (Lahey et al., 2008), and different types of internalizing symptoms relate to substance use in different ways (Kaplow et al., 2001; Marmorstein et al., in press). In addition, these syndromes may relate to different reasons for substance use. For example, a depressed girl may use substances to decrease her negative affect, while a socially anxious girl may use a substance in an effort to fit in with others. Initial substance use may also have different consequences for different types of internalizing symptoms. For example, using alcohol at a party may result in decreased social anxiety, since the girl may feel she is fitting in with her alcohol-using peers. Trying marijuana, in contrast, may represent a separation from parents' and society's rules, which could be linked to delinquent behavior and declining grades, which could result in increased depression.

We focus on these three types of internalizing symptoms for several reasons. First, prior theory and research provided a basis on which to form hypotheses for these types of symptoms (compared with, for example, school phobia, for which we are aware of no prior research or theory relating it to substance use). Second, we had reliable and valid measures of these constructs from early childhood through early adolescence. Third, these internalizing symptoms frequently continue into adulthood (unlike, for example, separation anxiety), allowing a comparison of the results of this study with studies of later heavy substance use.

We expected that overall, initial substance use would be associated with an increase in internalizing symptoms; because we were examining “events” (substance use and symptoms) that occurred during the same year, this does not imply that either predicts the other but merely that they tend to occur around the same time. We expected these increases to be particularly apparent for girls who were on high or increasing symptom trajectories, because they had already shown a predisposition to experience internalizing symptoms. These effects were expected to be less strong for social anxiety, however, due to research indicating that social anxiety may not be related to substance use in the absence of disorder (Morris et al., 2005) and because using substances could increase feelings of fitting in with peers, which could decrease social anxiety.

Method

Participants

Participants were girls in the Pittsburgh Girls Study (PGS), a community-based study. Using an accelerated longitudinal design, four cohorts (initially assessed at ages 5, 6, 7, and 8) were recruited from all neighborhoods in the city of Pittsburgh. All of the households with girls in the appropriate age range in the 23 lowest-income neighborhoods were targeted, and 50% of qualifying girls in the other 66 neighborhoods were targeted. Out of these households, 3,118 potential participants were identified; after applying exclusion criteria (e.g., severe developmental disabilities) and being unable to locate some families, 85.3% of the families agreed to participate (n=2,451; 1,003 from the lowest-income neighborhoods, 1,448 from the other neighborhoods). After the initial assessment at age 5, 6, 7, or 8, girls were assessed

annually. In this study, we used the first six waves of data. Retention was high: the average retention rate was 94.5% over 6 years (ranging from 97.2% in Year 2 to 92.5% in Year 6). The sample sizes at each age were: age 5=588; age 6=1201; age 7=1782; age 8=2370; age 9=2325; age 10=2299; age 11=1737; age 12=1143; age 13=565. For additional information regarding the sample and overall study design, see Hipwell et al. (2002).

Fifty-two percent of the girls were African-American and 41% were Caucasian; most of the rest of the sample were of "mixed" or "other" ethnic/racial background. At the time of the first assessment, 17% of the parents had completed less than 12 years of formal education, and 34.6% of households were receiving public assistance.

This study was approved by the University of Pittsburgh IRB, and informed consent (from parents) and assent (from girls) was obtained as appropriate.

Measures

Depressive Symptoms—The number of depressive symptoms each girl experienced was assessed using the parent-report version of the Child Symptom Inventory (CSI-4; Gadow & Sprafkin, 1994). Parent reports were used because they were available across the entire age span (5-13). This questionnaire has 7 items that are scored 0 to 3 and 5 dichotomous items (scored .5 for no symptom and 2.5 for a symptom; Keenan et al., 2004). This checklist has been validated for children aged 5 to 13 (Grayson & Carlson, 1991). In this sample, the alpha reliability coefficient for the depressive symptoms scale averaged .70 across the six waves. A score of 8 on this measure corresponds to a T-score of 70, a recommended cutoff for high levels of depressive symptoms (Gadow & Sprafkin, 1997). Averaging across ages, 6.61% of the sample had mean depressive symptom scores of 8 or above.

Anxiety—Generalized and social anxiety were assessed using the parent-report version of the Screen for Child Anxiety and Related Emotional Disorders (SCARED; Birmaher et al., 1997); the 41-item version of this measure was used (Birmaher et al., 1999). Parent reports were used because they were available across the entire age span (5-13). Each of the items was rated on a 3-point scale ("not true or hardly ever true," "sometimes true," and "true or often true"). Two of the five subscales (Birmaher et al., 1997) were used in this study: the generalized anxiety scale, which had 9 items, and the social anxiety scale, which had 7 items (Birmaher et al., 1997). The reliability and validity of this measure and these subscales have been supported in other studies (Birmaher et al., 1997; Birmaher et al., 1999; Muris, Merckelbach, Ollendick, King, & Bogie, 2002; Muris, Merckelbach, van Brakel, & Mayer, 1999; Muris & Steerneman, 2001). In this sample, the alpha reliability coefficients averaged .83 for the generalized anxiety scale and .85 for the social anxiety scale. For generalized anxiety, the suggested clinical cutoff for this scale is 9 (Birmaher, Khetarpal, Cully, Brent, & McKenzie, 1995). Averaging across ages, 6.98% of the sample had mean generalized anxiety symptom scores of 9 or above. For social anxiety, the suggested clinical cutoff for this scale is 8 (Birmaher et al., 1995). Averaging across ages, 14.28% of the sample had mean social anxiety symptom scores of 8 or above.

Substance Use—First use of alcohol, tobacco, and marijuana were assessed using self and parent reports (Loeber et al., 1999) at each assessment (if either reported that the girl had used the substance, the girl was considered to have used that substance). Questions relating to alcohol use were asked separately for beer, wine, and hard liquor; these were combined into an "any alcohol" variable for the purposes of this study. Alcohol questions specified that use must have been without parental permission, though the quantity may have been as little as "a sip" (or "trying" beer, wine, or liquor). Questions about tobacco asked whether the girl had "tried" cigarettes, "smoked" a cigarette, or chewed tobacco, and questions about marijuana asked whether the girl had "tried" or "smoked" marijuana.

Statistical Analyses

Growth mixture modeling (SAS PROC TRAJ; Jones, Nagin, & Roeder, 2001; Nagin, 1999; Nagin & Tremblay, 2001) was used to define trajectory groups and examine predictors of deflections (increases or decreases in symptoms) off those trajectories. First, trajectories of internalizing symptoms (depressive, generalized anxiety, and social anxiety) were identified using data from all six waves of the study and combining the four cohorts. The trajectories ranged from ages 5 to 13 (the youngest cohort was first assessed at age 5 and at the sixth assessment the oldest cohort was 13). The natural log of the symptom counts was used to adjust for skew. For each type of internalizing symptom, we began with a 2-group model, then added trajectory groups one at a time until the best-fitting number of trajectories was determined. In considering which model fit best, we followed procedures outlined in Nagin (2005). Specifically, we examined fit statistics (primarily the Bayesian Information Criterion [BIC], while also looking at Akaike's Information Criterion [AIC]), considered the size of the trajectory groups (we eliminated models with trajectory groups comprised of less than 5% of the sample; although power calculations for these types of models is not straightforward, the power to detect effects decreases with decreasing trajectory group sizes, particularly for low-frequency events like trying marijuana, so we used this 5% cutoff in order to avoid failing to detect clear group differences; Nagin, 2005), examined the average posterior probabilities (PP) of assignment to the most likely class (all were well above the .7 minimum threshold suggested by Nagin, 2005), and inspected how well the trajectories were distinguished from each other. In these initial analyses, we included linear, quadratic, and cubic slope terms in the models in order to allow each trajectory group substantial freedom to change over time. Once the best-fitting number of trajectories was determined, we examined the significance of each slope term and pared down the slope terms, using BIC scores as a guide, until the best-fitting model was obtained (Nagin, 2005). (BIC and AIC scores for each model tested are available from the first author upon request.) We also compared parent-reported global assessment of functioning (GAF) scores (averaged across the 6 waves of data collection) across trajectory groups to provide a further measure of group differentiation.

Once the overall trajectories of each type of internalizing symptom were defined, we added initial use of each substance (alcohol, cigarettes, and marijuana, considered separately) as a predictor to each model. Specifically, we first conducted an omnibus test of whether the effects of this predictor on the trajectory groups differed. The omnibus tests of trajectory group differences yielded information about whether the initial use of a certain substance was associated with significantly different changes in internalizing symptoms for girls in different trajectory groups. When the effect on trajectory groups differed significantly, individual parameter estimates (and their associated significance levels) provided specific information about how the initial use of each substance related to changes in internalizing symptoms for girls in each trajectory group.

Proc Traj uses maximum likelihood estimation to deal with missing data in forming the trajectories; therefore, all participants who contributed at least one data point (i.e., the entire sample) were used in forming the trajectories. All participants also contributed information regarding their first use of each substance; if a girl had missing data for substance use at a particular age, her data was not included in the analysis that assessed whether first use of a substance was associated with change in the internalizing symptom at that age. Proc Traj assumes that within-group variability is zero. There are both advantages and disadvantages of using an analytic approach that makes this assumption. For example, models that allow variation around a group mean often yield a well-fitting model with fewer groups. However, allowing variation around a group mean also introduces uncertainty into the meaning of a "group" (for example, a participant could be assigned to one group, but follow a trajectory that in some way is closer to that of another group). Thus, within-group heterogeneity introduces

additional uncertainty into the models and the meaning of estimates of the effects of covariates. For these reasons, we have elected to utilize an approach that does not allow for within-group variation. For further discussion of the pros and cons of this approach, see Nagin (2005).

These analyses allowed us to determine: (1) whether there were differing associations between the first use of a substance and changes in internalizing symptoms among members of different trajectory groups; and (2) the direction and significance of increases and decreases from each trajectory group that were associated with the first use of a particular substance. These deflections represented changes in internalizing symptoms that were associated with using a substance for the first time during that same year (i.e., the increase or decrease in the internalizing symptom may have occurred either before, after, or at the same time as the initial use, as long as they occurred in the same year-long period).

The main focus of this study was on potential trajectory group differences. However, in cases where trajectory group differences were non-significant, we examined whether the associations between first use of a substance and change in the internalizing symptom were significantly greater than zero for all trajectory groups. We did this to avoid failing to detect clear patterns in associations between first use and changes in internalizing symptoms that affected all participants similarly (for example, when the first use of a substance was associated with an increase in symptoms among members of all trajectory groups). This analysis yielded information about whether using the substance for the first time was associated with a deflection from the overall pattern of symptom change for all girls.

Finally, we conducted supplemental analyses to examine whether household poverty (i.e., received public assistance at any point during the study period vs. did not receive public assistance) and/or racial/ethnic background (coded as African-American, Caucasian, or other) affected these results. Specifically, we repeated all primary analyses adjusting for both of these variables simultaneously. The results were nearly identical to those reported below. The only difference was that there was a positive overall effect of initial alcohol use on generalized anxiety (that did not differ by trajectory group [χ^2=12.70, *df*=5, p<.05]; in addition, the effect of initial cigarette use on social anxiety could not be analyzed in these supplemental analyses [standard errors could not be calculated due to small cell sizes for particular combinations of these variables]). Because of this lack of differences, we chose to present the simpler models without poverty and ethnicity.

Results

Descriptive Analyses

By the 6th wave (ages 10-13), 28% (688) of participants had used alcohol, 12% (282) had used tobacco, and 4% (96) had used marijuana. In the oldest cohort, by age 13, 40% of participants had used alcohol, 18% had used cigarettes, and 7% had used marijuana, which is fairly consistent with the 2008 Monitoring the Future (MTF) data, which indicate that among 8th-graders (approximately age 13-14), 39% had used alcohol, 21% had used tobacco, and 15% had used marijuana (Johnston, O'Malley, Bachman, & Schulenberg, 2009). The slightly lower rates of marijuana use in our study compared to the MTF data may be attributable to the higher proportion of African-American girls in our sample compared the MTF sample because, generally, African-American adolescents are less likely to use substances than whites (Wallace, Bachman, O'Malley, Schulenberg, Cooper, & Johnston, 2003). Among those who had used alcohol, 83% used it first (prior to any use of cigarettes and/or marijuana). Among those who had used cigarettes, 53% used them first (prior to any use of alcohol and/or marijuana). Among those who had used marijuana, 17% used it first (prior to using alcohol and/or cigarettes).

Overall raw mean scores, across all ages, for the internalizing scales were as follows: depressive symptoms=4.37 (SD=2.11, median=3.83, range=2-16); generalized anxiety symptoms=4.34 (SD=2.75, median=4.00, range=0-15); social anxiety symptoms=4.97 (SD=2.73, median=5.00, range=0-13.83).

All three types of internalizing symptoms were significantly (p<.001) associated with each other. Averaging across ages, cross-sectional correlations were: depressive symptoms-generalized anxiety r=.40, depressive symptoms-social anxiety r=.22, generalized anxiety-social anxiety r=.39.

Overview of Trajectory Results

Parameter estimates and standard errors, as well as their associated significance levels (representing the effects of initial use of substances on individual trajectories of internalizing symptoms), are presented in Table 1. Trajectory groups for each type of internalizing symptom are presented in Figure 1. When results indicated that initial use of a substance was associated with a deflection (increase or decrease) from a trajectory, these effects are illustrated in Figures 2 and 3. Figures 2 and 3 plot prototypical trajectories for a hypothetical girl who is a member of the trajectory group in question who first tried the substance at age 11 (along with a plot of the overall trajectory for comparison purposes). A single age (age 11) was chosen simply to illustrate these effects in a concrete way; similar plots could have been made for a girl who tried substances at any of the ages included in this study. These represent model-predicted values, and of course there is actual variation in the levels of internalizing symptoms even among girls who are in the same trajectory group who first used a substance at the same age. As illustrated by the figures, these model-predicted deflections from the typical trajectories are characterized by deflections from the trajectory at the age at which substance use occurs, followed by a resumption of the general trajectory trend at the new level.

Depressive Symptoms

Depressive symptom trajectories are presented in Figure 1a. A 4-trajectory model fit best: a “stable low” trajectory (49.6%; PP=.91), a “stable high” trajectory (9.4%; PP=.86), an “increasing symptom” trajectory (24.6%; PP=.78), and a “decreasing symptom” trajectory (16.4%; PP=.77). Entropy for this model was .75 (entropy values range from 0 to 1; values closer to 1 indicate greater precision in classification). The “stable high” group had symptom levels of approximately 9.5, which is above the clinical cutoff score of 8 (Gadow & Sprafkin, 1997).

Average GAF scores differed across trajectory groups (F=232.58, p<.0001). Post-hoc Sheffé tests indicated that all trajectory groups differed from all other trajectory groups on this measure. Mean GAFs for each group were: stable low=86.19 (SD=6.05); decreasing=81.76 (SD=7.35); increasing=80.31 (SD=7.84); stable high=74.20 (SD=9.55).

Parameter estimates representing the effects of initial use of substances on individual trajectories of depressive symptoms are presented in Table 1. When the first use of alcohol and cigarettes were examined, there were no significant differences among trajectory groups (χ^2=3.34, df=3, p>.05 for alcohol; χ^2=4.74, df=3, p>.05 for cigarettes), indicating that the first use of these substances was associated with similar changes (or lack thereof) on girls in all four trajectory groups. Because there were no significant differences in effects across groups, we tested whether the associations between first use of alcohol and cigarettes were significantly different from zero for girls in all trajectory groups. In both cases, they were (alcohol: χ^2==26.44, df=4, p<.0001; cigarettes: χ^2==24.48, df=4, p<.0001), indicating that the initial use of alcohol and cigarettes was associated with an increase in depressive symptoms, but this did not differ by trajectory group membership.

When the first use of marijuana was examined, there were significant differences across trajectory groups (χ^2=9.02, *df*=3, *p*<.05), indicating that the first use of marijuana was associated with different changes in depressive symptoms across trajectory groups. Inspection of the parameter estimates indicated that the initial use of marijuana was associated with a specific increase in depressive symptoms among girls who already were experiencing high levels of depressive symptoms. Figure 2 depicts the model-predicted levels of depressive symptoms in a hypothetical girl in the "stable high" trajectory group who first used marijuana at age 11. The model-predicted deflection represents approximately a 1.4 symptom increase among girls in this group who try marijuana, which amounts to two-thirds of a standard deviation based on the sample average of depressive symptoms (SD=2.11).

Generalized Anxiety

Generalized anxiety trajectories are presented in Figure 1b. A 5-trajectory model fit best, with a "stable low" trajectory (7.4%; PP=.86), a "moderate" trajectory (39.0%; PP=.83), a "stable high" trajectory (31.1%; PP=.88), a "low increasing symptom" trajectory (16.1%; PP=.83), and a "moderate decreasing symptom" trajectory (6.3%; PP=.80). The "stable high" trajectory had scores around 7.5. Entropy for this model was .77.

Average GAF scores differed across trajectory groups (F=49.54, *p*<.0001). Post-hoc Sheffé tests indicated that the stable high trajectory group differed from all other trajectory groups on this measure; in addition, the stable low group differed from the moderate group and the moderate group differed from the low increasing symptom group (*p*<.05). Mean GAFs for each group were: stable low=87.0 (SD=6.99); moderate=83.35 (SD=7.30); stable high=79.95 (SD=8.69); low increasing symptom=85.21 (SD=7.41); moderate decreasing symptoms=85.19 (SD=6.72).

Parameter estimates representing the effects of initial use of substances on individual trajectories of generalized anxiety symptoms are presented in Table 1. When the first use of alcohol, cigarettes, and marijuana was examined, there were no significant differences among trajectory groups for alcohol (χ^2=2.53, *df*=4, *p*>.05), cigarettes (χ^2=5.03, *df*=4, *p*>.05), or marijuana (χ^2=1.62, *df*=4, *p*>.05), indicating that the first use of these substances was associated with similar effects for girls in all five trajectories.

Due to this lack of trajectory differences, we tested whether the associations between first use of each substance and generalized anxiety were significantly different from zero for girls in all trajectory groups. The effects were not significantly different from zero for alcohol (χ^2=5.64, *df*=5, *p*>.05) or marijuana (χ^2=1.81, *df*=5, *p*>.05), indicating that there was no association between initial use of alcohol or marijuana and generalized anxiety. Results for cigarettes, however, were significant (χ^2=17.29, *df*=5, *p*<.01), indicating that across trajectory groups, initial use of cigarettes was associated with a significant increase in generalized anxiety symptoms.

Social Anxiety

Social anxiety trajectories are presented in Figure 1c. A 5-trajectory model fit best, with a "stable moderate" trajectory (19.8%; APP=.82), a "stable high" trajectory (57.7%; APP=.94), an "increasing symptom" trajectory (7.0%; APP=.86), a "moderate decreasing symptom" trajectory (7.2%; APP=.87), and a "high decreasing symptom" trajectory (8.4%; APP=.84). Entropy for this model was .84. The "stable high" trajectory had scores around 7.4, just under the recommended cutoff of 8 for a clinical diagnosis (Birmaher et al., 1995).

Average GAF scores differed across trajectory groups (F=7.81, *p*<.0001). Post-hoc Sheffé tests indicated that the moderate decreasing symptom trajectory group differed from all other

trajectory groups except the high decreasing symptom group on this measure ($p<.05$). Mean GAFs for each group were: stable moderate=83.27 (SD=7.99); stable high=82.45 (SD=7.94); increasing symptom=82.20 (SD=9.02); moderate decreasing symptom=85.88 (SD=7.27); high decreasing symptom=84.01 (SD=8.10).

Parameter estimates representing the effects of initial use of substances on individual trajectories of social anxiety symptoms are presented in Table 1. When the first use of alcohol was examined, there were significant differences across trajectory groups ($\chi^2=15.10$, $df=4$, $p<.01$), and inspection of the parameter estimates indicated that that the first use of alcohol was associated with an increase in social anxiety among girls who were experiencing increasing levels of social anxiety, but a decrease in social anxiety among girls who were already experiencing decreasing levels of social anxiety. This effect is illustrated in Figure 3a, which depicts the model-predicted levels of social anxiety symptoms in two hypothetical girls who each used alcohol at age 11 (one of whom is a member of the "increasing symptom" trajectory group, and the other of whom is a member of the "high decreasing symptom" trajectory group). The model-predicted deflections represent approximately a 1.3 symptom increase among girls in the "increasing symptom" group who try alcohol, and approximately a 1.2 symptom decrease among girls in the "high decreasing symptom" group who try alcohol. These deflections represent slightly less than one-half of a standard deviation, based on the sample average of social anxiety symptoms (SD=2.73).

When the first use of cigarettes was examined, there were significant differences across trajectory groups ($\chi^2=26.62$, $df=4$, $p<.001$), and inspection of the parameter estimates indicated that the first use of cigarettes was associated with an increase in social anxiety among girls who were experiencing decreases in their social anxiety, but a decrease in social anxiety among girls who were experiencing increasing levels of social anxiety. This effect is illustrated in Figure 3b, which depicts the model-predicted levels of social anxiety symptoms in two hypothetical girls who each used cigarettes at age 11 (one of whom is a member of the "increasing symptom" trajectory group, and the other of whom is a member of the "high decreasing symptom" trajectory group). The model-predicted deflections represent approximately a 1.6 symptom increase among girls in the "high decreasing symptom" group who try cigarettes, and approximately a 1.3 symptom decrease among girls in the "increasing symptom" group who try cigarettes. These deflections represent somewhat more and slightly less than one-half of a standard deviation, respectively, based on the sample average of social anxiety symptoms (SD=2.73).

When the impact of first use of marijuana was examined, there were significant differences across trajectory groups ($\chi^2=9.54$, $df=4$, $p<.05$), and inspection of the parameter estimates indicated that the first use of marijuana was associated with a relative decrease in social anxiety among girls who were experiencing increasing levels of social anxiety. This effect is illustrated in Figure 3c, which depicts the model-predicted levels of social anxiety symptoms in a hypothetical girl in the "increasing symptom" trajectory group who first used marijuana at age 11. The model-predicted deflection represents approximately a 1.8 symptom decrease among girls in this group who try marijuana. This deflection represents two-thirds of a standard deviation, based on the sample average of social anxiety symptoms (SD=2.73).

Discussion

The results of this study indicate that the effects of the first use of substances depended on the type of substance, the type of internalizing symptoms, and the internalizing symptom trajectory that the girl was on. Trajectory group differences were found such that: (1) initial use of marijuana was related to increases in depressive symptoms among girls experiencing high levels of depressive symptoms; (2) initial use of alcohol was related to increases in social

anxiety among girls experiencing increasing levels of social anxiety, but decreasing levels of social anxiety among girls experiencing decreasing levels of social anxiety; (3) initial use of cigarettes was related to increases in social anxiety among girls experiencing decreasing social anxiety, but decreases in social anxiety among girls experiencing increasing levels of social anxiety; and (4) initial use of marijuana was related to decreases in social anxiety among girls experiencing increasing levels of social anxiety. In addition, the initial use of alcohol or cigarettes was associated with increases in depressive symptoms for girls overall, and the initial use of cigarettes was associated with increases in generalized anxiety symptoms overall.

As mentioned in the Introduction, it is unlikely that the initial use of a substance directly *caused* changes in internalizing symptoms. Although regular heavy use might result in physiologic changes that could affect symptoms, initial use is unlikely to cause such changes (and the number of regular users in this young sample was too low to examine heavy use). Similarly, it is unlikely that a change in an internalizing symptom was a direct, unique *cause* of a girl using a substance for the first time. Instead, it is likely that these changes—initial substance use and changes in internalizing symptoms—represent transition points in development and are markers for broader changes that are occurring in a variety of contexts (e.g., family, peer, school) in a girl's life. The results of this study highlight that these initial use events may have different contexts, causes, or implications for girls who are on different trajectories of internalizing symptoms; conversely, increases or decreases in internalizing symptoms may have different meanings for girls who are on different trajectories, which may relate to their risk for substance use. Future research will be needed to clarify the mechanisms behind these associations.

The finding that initial use of marijuana was particularly associated with increased depressive symptoms among girls who already had stable high levels of depressive symptoms is consistent with literature linking regular marijuana use to depression (see review by Degenhardt, Hall, & Lynskey, 2003). Specifically, after reviewing the literature on marijuana and depression, Degenhardt and colleagues concluded that heavy marijuana use may increase depression in some people (Degenhardt et al., 2003). Although the present study focused on initial use (not heavy use) and could not tease apart the direction of effect, our findings suggest that those who already have high levels of depressive symptoms may be most vulnerable. Alternatively, those who already have high levels of depressive symptoms may be the most likely to try marijuana, which may further increase their vulnerability to depressive symptoms.

The results regarding the associations between initial substance use and social anxiety are particularly intriguing but difficult to interpret. For example, among girls who have low levels of social anxiety in early childhood and who increase in social anxiety through pre-adolescence (7%), first use of cigarettes or marijuana was related to *decreased* social anxiety, whereas initial use of alcohol was associated with *increased* social anxiety. In contrast, among girls who are quite socially anxious in early childhood but whose social anxiety is decreasing over the course of childhood and pre-adolescence, the first use of cigarettes is related to *increased* social anxiety and the first use of alcohol is related to *decreased* social anxiety. Given the complexity of these results, more research on contextual factors (e.g., the temporal ordering of the initiation of alcohol, cigarettes, and marijuana; substance use expectancies; reasons for substance use) is needed. For example, social anxiety may have different meanings for children with friends and those without friends. Incorporating measures of peer substance use would seem especially important in understanding the complex associations; perhaps the use patterns of youth with high levels of social anxiety tend to mimic those of their friends more than among other youth.

It should be noted that 58% of this sample was categorized in the “stable high” group of social anxiety. Although our measure of anxiety is widely-used and well-validated (Birmaher et al., 1997; Birmaher et al., 1999; Muris et al., 2000; Muris et al., 2002; Muris et al., 1999; Muris

& Steerneman, 2001), it is often used as a screen and may be less useful in making discriminations at higher levels of severity. However, it should be noted that this "stable high" group had near-clinical average levels of social anxiety (their average levels were approximately 7.4, with 8 as the suggested cutoff for clinical levels, though these cutoffs are for boys and girls combined; Birmaher et al., 1995)—even though over half of the sample fell into this group. Another factor that should be considered is the fact that we used parental reports of anxiety symptoms, which may be limited, for example, in capturing the cognitive aspects of a girl's anxiety. Studies using different measures of social anxiety, preferably completed by different informants, would be particularly useful in examining whether these results are replicable.

In addition to these trajectory group differences, several findings pointed to similar links between the first use of substances and internalizing symptoms across all trajectory groups. Specifically, the initial uses of alcohol and cigarettes were associated with overall increases in depressive symptoms, and the initial use of cigarettes was associated with an overall increase in generalized anxiety symptoms. This indicates that some internalizing symptom-initial substance use associations are relatively consistent across all trajectory groups—that is, these links are not always dependent on prior levels or trajectories of internalizing symptoms.

Another contribution of this study was our identification of trajectories of depressive, generalized anxiety, and social anxiety symptoms among girls. The patterns of our trajectories were similar to those reported by Brendgen et al. (2005), though they found a "moderate stable" group whereas our analogous group decreased in depressive symptoms; this may be because of the shorter (and somewhat different) ages examined in their study (ages 11-14). We found fewer groups than Dekker et al. (2007), who identified six; this could be because they examined ages 4 to 18 and therefore groups were differentiated by how their depressive symptoms evolved during adolescence. In addition, they had three different "low" groups (low decreasing, very low increasing, and low stable), all of which had predicted levels of approximately 1 symptom or less and were, therefore, only somewhat differentiated from each other.

In a previous study (Marmorstein et al., in press), we examined associations between generalized and social anxiety and risk for first use of substances among boys. Those results indicated that higher levels of both types of anxiety were associated with increased risk for initial use of alcohol, cigarettes, and marijuana during the subsequent year; in addition, generalized anxiety predicted increased risk for initial use of marijuana. Therefore, in both studies, increased social anxiety was sometimes associated with increased risk for first use of substances. However, only an overall link between generalized anxiety and initial use of cigarettes was found for girls in the present study, while links for alcohol and marijuana were also found for boys in the previous study. This could be due to several factors. Associations between generalized anxiety and initial substance use may truly differ for boys and girls. Alternatively, methodological differences between the two studies may account for these disparate findings. For example, boys in the previous study were followed from ages 6 to 18, while the oldest girls in this study were only 13. Initial substance use in adolescence may differ in its meaning and correlates from initial substance use at earlier ages. Further research directly comparing boys and girls would be useful.

This study had several limitations. Because the oldest girls in the sample were 13, we were necessarily examining only early-onset use; these results may not apply to girls with later substance use onsets. We were unable to tease apart the temporal direction of effect. This sample included only girls; we do not know whether these results would generalize to boys. We were not able to examine potential ethnic or racial differences in the number or slopes of trajectory groups (due to sample size limitations). The use of different substances was interrelated, but we lacked the statistical power to examine the possibility that girls who tried,

for example, cigarettes only were different from girls who tried both cigarettes and alcohol. We had a relatively low rate of marijuana use in this sample (4%). The entropy scores for our models were lower than would be ideal; however, our BIC-based model selection approach has been supported by other work (e.g., Nagin, 2005). There are limitations to this analytic approach; for example, the within-class variability is assumed to be zero, when this might not be the case (this assumption, however, simplifies both the computations used to estimate the model and the interpretation of group differences). In addition, null results can be due to poor class differentiation; although our groups appear to be relatively well-validated (based on PPs and group differences in GAF scores), there is no clear way to rule-out this possibility. Finally, we consider first use events and changes in internalizing symptoms to be markers of developmental processes that are likely surrounded by a variety of other changes in individuals, their families, their peers, and the broader contexts in which they live. We cannot specify the mechanisms through which these associations between first use events and changes in internalizing symptoms occurred.

There are also several caveats that should be noted. We examined initial substance use events, not regular use or infrequent, experimental use. It is likely that the amounts ingested during this initial use episode varied across participants, and that their use patterns following this initial use episode were quite variable as well. In addition, it should be emphasized that the "effects" reported in this study are statistical associations of the independent variable with the dependent variable; they do not indicate the temporal ordering of the effect in the real world (the dependent variable may have preceded the independent variable) or demonstrate causality. Similarly, the clinical significance of these effects is not known. As noted above, the average effects ranged from approximately one-half to two-thirds of a standard deviation, which could be large enough to affect the life of an individual girl, but do not represent a change from minimal symptoms to a full disorder. These relatively small effects are consistent with our conceptualization of these first use events as markers of developmental transitions (and not as, for example, traumatic events, which would likely have stronger effects on internalizing symptoms).

Implications for Research, Policy, and Practice

Despite this study's limitations, the results have implications for prevention, treatment, and future research. Girls with high levels of depressive symptoms who try or start using marijuana should be considered at high risk for exacerbations in depressive symptoms. In addition, young girls who try or start using alcohol or cigarettes should be considered at risk for increased depressive symptoms, and young girls who try or start using cigarettes should also be considered at risk for increased generalized anxiety symptoms. In addition, substance (and perhaps particularly marijuana) use prevention programs should target young girls who are highly depressed. The associations between social anxiety and initial substance use are particularly complex. Although it is premature to suggest clinical implications of our findings, clinicians should be cautious not to assume that socially anxious girls are at higher risk for substance use (a common assumption due to the self-medication hypothesis) than less socially anxious girls. Researchers should, whenever possible, consider the possibility that different substances and different types of internalizing symptoms may be associated in distinct ways. Links between social anxiety and substance use appear to be particularly complex and therefore in need of research attention. Finally, future research should explore potential mediators and moderators (e.g., peer substance use, substance-related expectancies) of these associations.

Acknowledgments

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Figure 1a.

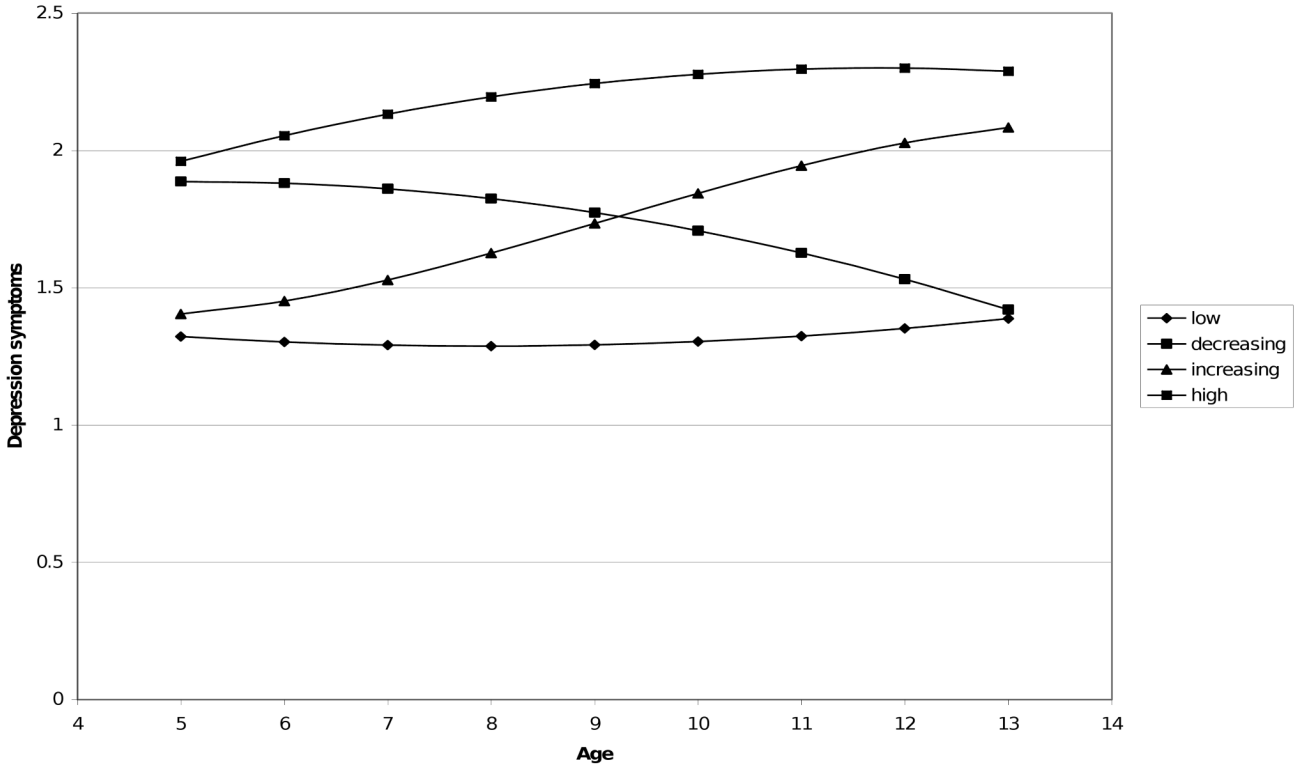
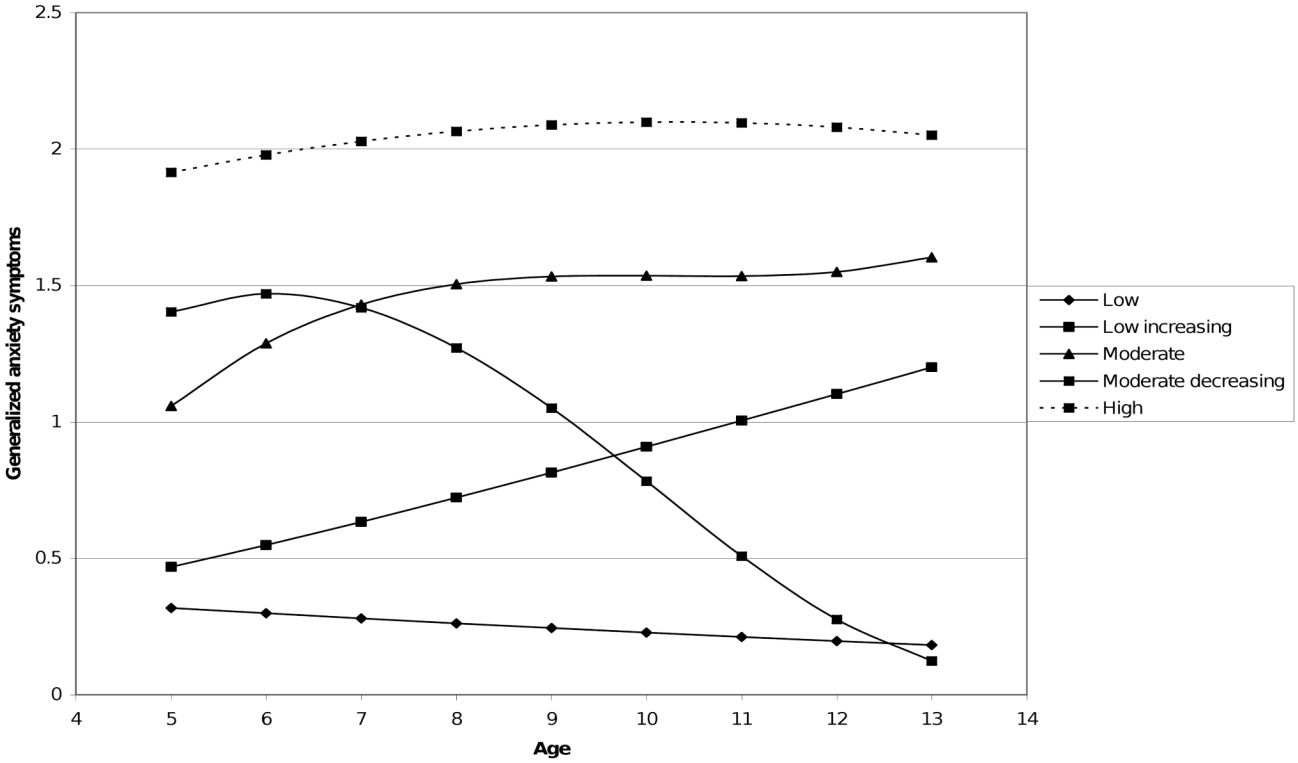


Figure 1b.



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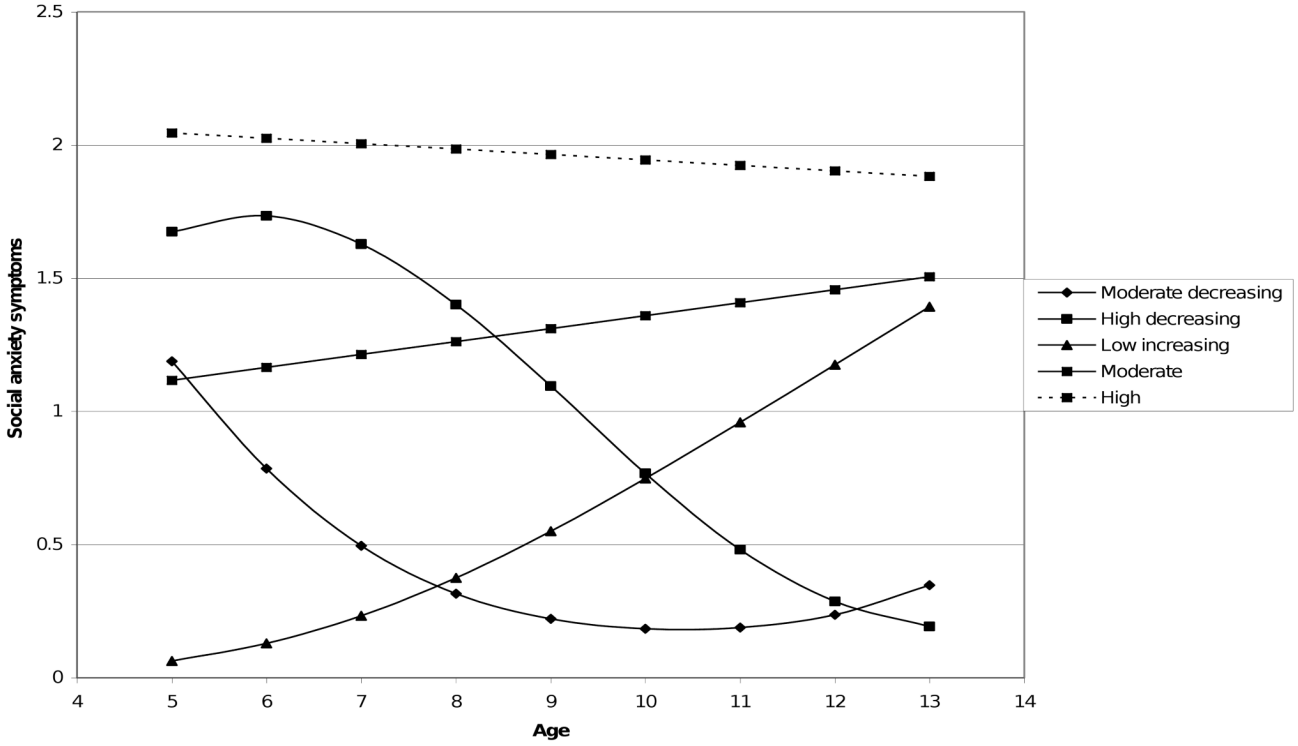


Figure 1.

Figure 1a. Trajectories of depressive symptoms (values presented are the log of the number of symptoms).

Figure 1b. Trajectories of generalized anxiety (values presented are the log of the number of symptoms).

Figure 1c. Trajectories of social anxiety (values presented are the log of the number of symptoms).

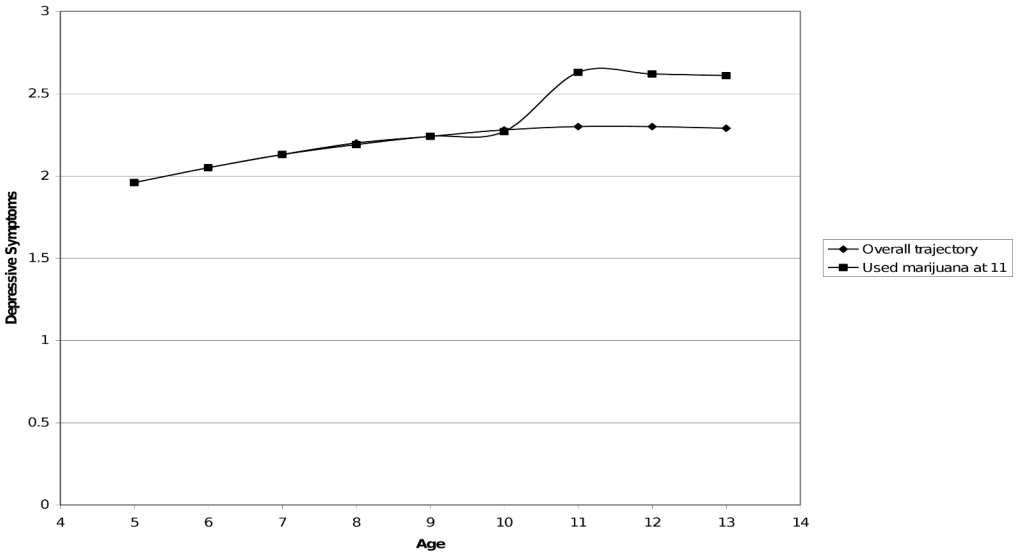
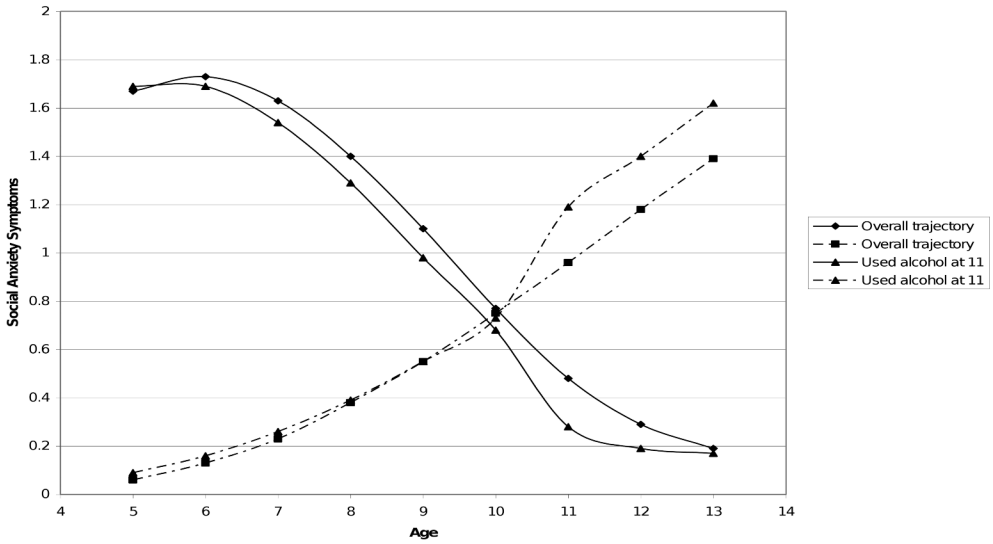


Figure 2.
Prototypical plot of the model-predicted levels of depressive symptoms for a hypothetical girl in the "stable high" trajectory group who used marijuana for the first time at age 11 (along with the overall model-predicted trajectory for comparison; values presented are the log of the number of symptoms).

Figure 3a.



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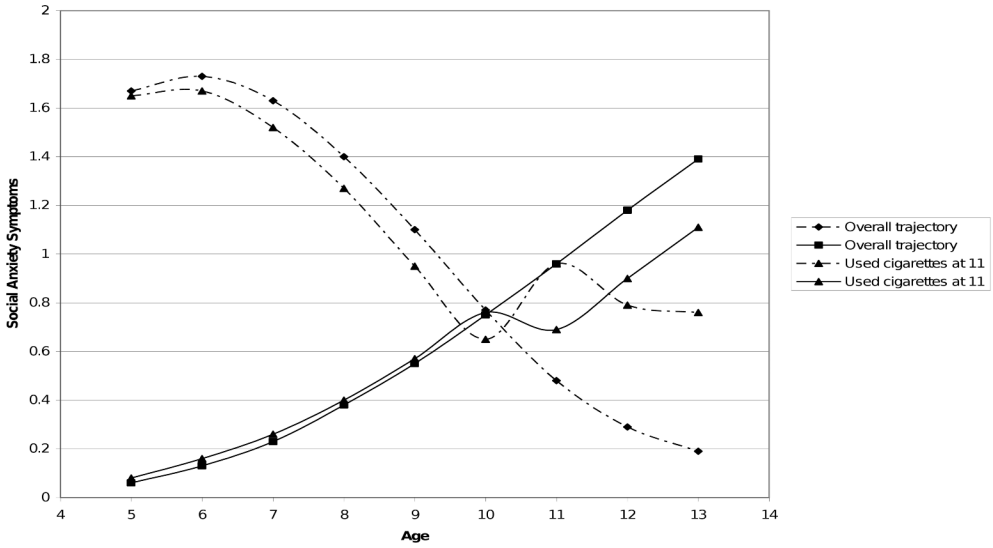

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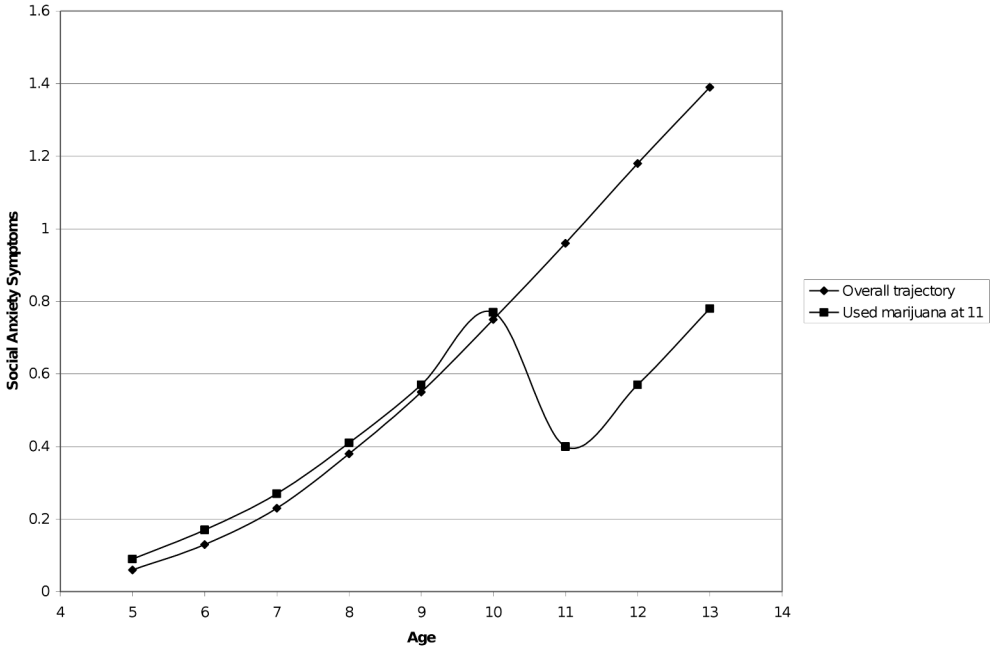

Figure 3.

Figure 3a. Prototypical plots of the model-predicted levels of social anxiety for hypothetical girls in the “increasing” and “high decreasing” trajectory groups who used alcohol for the first time at age 11 (along with the overall model-predicted trajectories for comparison; values presented are the log of the number of symptoms).

Figure 3b. Prototypical plots of the model-predicted levels of social anxiety for hypothetical girls in the “increasing” and “high decreasing” trajectory groups who used cigarettes for the first time at age 11 (along with the overall model-predicted trajectories for comparison; values presented are the log of the number of symptoms).

Figure 3c. Prototypical plot of the model-predicted levels of social anxiety for a hypothetical girl in the “increasing” trajectory group who used marijuana for the first time at age 11 (along with the overall model-predicted trajectory for comparison; values presented are the log of the number of symptoms).

Table 1

Parameter Estimates (Standard Errors) Representing the Effects of Initial Use of Alcohol, Cigarettes, and Marijuana on Depressive, Generalized Anxiety, and Social Anxiety Symptom Trajectories

	Depressive Symptoms[a]				Generalized Anxiety Symptoms[b]					Social Anxiety Symptoms[c]				
	Traj 1	**Traj 2**	**Traj 3**	**Traj 4**	**Traj 1**	**Traj 2**	**Traj 3**	**Traj 4**	**Traj 5**	**Traj 1**	**Traj 2**	**Traj 3**	**Traj 4**	**Traj 5**
Alcohol	.047*	.088§	.076*	.136**	.034	.132§	.027	.202	.017	.226	-.232*	.275**	-.054	-.042
	(.024)	(.051)	(.035)	(.044)	(.158)	(.076)	(.042)	(.235)	(.041)	(.154)	(.118)	(.108)	(.063)	(.031)
Cigarettes	.067§	.148§	.067	.205***	.405**	.135	.163**	-.024	.073	--[d]	.615***	-.297*	-.003	-.013
	(.041)	(.079)	(.047)	(.057)	(.159)	(.109)	(.065)	(.192)	(.062)		(.133)	(.130)	(.112)	(.048)
Marijuana	.047	-.151	.044	.340***	-.298	.417	-.043	.109	-.007	.867§	.378	-.663*	-.051	-.132
	(.142)	(.138)	(.176)	(.113)	(.309)	(.808)	(.311)	(.127)	(.127)	(.524)	(.262)	(.327)	(.189)	(.101)

§ $p \leq .10$

* $p \leq .05$

** $p \leq .01$

*** $p \leq .001$

traj=trajectory group; positive parameter estimates indicate that the initial use is associated with a symptom increase, while negative parameter estimates indicate that the initial use is associated with a symptom decrease.

[a] traj1=stable low; traj2=decreasing; traj3increasing; traj4=stable high

[b] traj1=stable low; traj2=low increasing; traj3=moderate; traj4=high decreasing; traj5=stable high

[c] traj1=moderate decreasing; traj2=high decreasing; traj3increasing; traj4=stable moderate; traj5=stable high

[d] Too little variability to calculate parameter estimate