Adolescent Trajectories of Depressive Symptoms: Co-development of Behavioral and Academic

Problems

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Abbreviations. Center for Epidemiologic Studies-Depression (CES-D); Growth Mixture Modeling (GMM); New Approaches, New Solutions (NANS); Maximum Likelihood with Robust estimator (MLR).

ABSTRACT

Purpose. Increasing evidence suggests the existence of heterogeneity in the development of depressive symptoms during adolescence, but little remains known regarding the implications of this heterogeneity for the development of commonly co-occurring problems. In this study, we derived trajectories of depressive symptoms in adolescents and examined the co-development of multiple behavioral and academic problems in these trajectories. **Methods.** Participants were 6910 students from secondary schools primarily located in disadvantaged areas of Quebec (Canada) who were assessed annually from age 12 to 16. Trajectories were identified using growth mixture modeling. The course of behavioral (delinquency, substance use) and academic adjustment (school liking, academic achievement) in trajectories was examined by deriving latent growth curves for each covariate conditional on trajectory membership. **Results.** We identified five trajectories of *stable-low* (68.1%), *increasing* (12.1%), *decreasing* (8.7%), *transient* (8.7%), and *stable-high* (2.4%) depressive symptoms. Examination of conditional latent growth curves revealed that the course of behavioral and academic problems closely mirrored the course of depressive symptoms in each trajectory. **Conclusions.** This pattern of results suggests that the course of depressive symptoms and other adjustment problems over time is likely to reflect an important contribution of shared underlying developmental process(es). **Keywords.** Depression, developmental trajectories, adolescence, delinquency, substance use, academic adjustment.

IMPLICATIONS AND CONTRIBUTION

We find five trajectories of depressive symptoms in adolescents and demonstrate that the course of behavioral and academic problems mirrors the course of symptoms in each trajectory. Mirror co-development likely reflects shared underlying processes and supports the relevance of systematically considering co-occurring problems in clinical assessment and intervention development.

Depression is a highly prevalent and disabling condition, which increases during adolescence.[1,2] The risk factors which explain the global rise in depressive symptoms and the incidence of major depression during adolescence have been extensively documented.[3] However, recent evidence suggests that the course of depressive symptoms is not identical for all adolescents, but is characterized by considerable heterogeneity. This evidence comes from a growing number of studies which have identified distinct developmental trajectories in subgroups of adolescents.[4-16]

Despite disparities in samples and methods, several commonalities can be extracted from these studies. First, between three and six trajectories of depressive symptoms have been consistently documented. Second, a *stable-low* trajectory, comprising a majority of individuals who do not experience elevated symptoms during adolescence, was identified in virtually all investigations. Third, at least three other trajectories have been identified in a large proportion of studies: an *increasing* trajectory of adolescents who experience low symptoms in early adolescence that go up over time,[4,5,7-10,12,14,15] a *decreasing* trajectory of adolescents with elevated symptoms in early adolescence that go down over time,[7-10,12-15] and a *stable-high* trajectory of individuals with consistently elevated symptoms.[4,5,10,13-15]

Despite this mounting evidence of developmental heterogeneity in depression, the theoretical and practical implications of trajectories remain largely unclear. A research gap is the implication of diverse pathways for the development of other adjustment problems which commonly co-occur with depression. Adolescent depressive symptoms have consistently been associated with behavioral difficulties, such as delinquency and substance abuse,[17,18] as well as academic problems, such as lower academic achievement and performance and lower school liking, bonding or connectedness.[19,20] The co-occurrence of depressive symptoms with other

problems is particularly prevalent during adolescence and increases the risk of long-term psychosocial impairments.[21]

Several mechanisms may explain how depressive symptoms relate to co-occurring problems. First, depressive symptoms may influence behavioral and academic problems. For instance, depression has been agued to increase the risk of substance use via a self-medication mechanism[22] and to influence academic adjustment by disrupting cognitive functioning and learning processes.[23] Second, behavioral and academic problems may influence depressive symptoms. The Dual Failure model notably holds that conduct problems in childhood increase the risk of mood problems via a combination of academic and social failures.[24] Third, co-occurrence may be explained by shared processes (or risk factors). For instance, Problem Behavior Theory suggests that multiple problems tend to cluster in the form of a 'syndrome' that proximally results from an overall proneness to problem behavior.[25]

Although substantial research has focused on mechanisms of co-occurrence in adolescent depression (e.g.,[26]), few studies have examined how heterogeneity in the course of depressive symptoms relates to the development of other problems over time. Previous trajectory studies have either examined behavioral and academic problems as predictors or outcomes of trajectories[7,13,15,16] or derived joint trajectories of depressive symptoms with behavioral problems (e.g., [27,28]). These studies have produced mixed findings, except for the trajectory of *stable-low* depressive symptoms, which was consistently associated with lower behavioral and academic problems compared to other trajectories.

An alternative strategy to investigate the development of co-occurring problems in trajectories is to use conditional growth curves.[29] In this approach, growth curves are derived to model the course of co-occurring problems in each trajectory (one curve per problem per

trajectory). The method offers several advantages. Compared to the predictor/outcome approach, this strategy takes advantage of information collected over time, offers a dynamic view of co-occurrence, and provides a descriptive insight regarding mechanisms of co-occurrence by revealing whether changes in depressive symptoms precede, follow or move together with changes in other problems. Compared to the joint trajectory approach, this approach allows to derive trajectory-specific patterns of co-development and is better suited for the simultaneous examination of multiple behavioral and academic problems. Despite these advantages, we are aware of no investigation that has used this approach to examine the development of co-occurring problems in trajectories of depressive symptoms.

In this study, we identified developmental trajectories of depressive symptoms in a large prospective sample of students followed throughout secondary school (age 12 to 16). We used growth mixture modeling[30] to extract subgroups of participants characterized by different course of depressive symptoms during adolescence. Based on previous findings, we expected to identify four trajectory classes of *stable-low*, *increasing*, *decreasing*, and *stable-high* depressive symptoms. We then investigated the co-development of behavioral (delinquency, substance use) and academic adjustment (school liking, academic achievement) in trajectories using conditional growth curves. We expected to find consistently lower behavioral and academic problems in the trajectory of *stable-low* symptoms over time, but made no prediction regarding how other trajectories would relate to co-occurring problems given limited findings from previous studies.

METHODS

Participants

Participants from the two main cohorts of the New Approaches New Solutions (NANS) dropout prevention evaluation[31] were assessed annually from grade 7 to grade 11. NANS cohorts 1 (2002-2007) and 2 (2003-2008) were merged (n=10 683). Three quarters of participants attended a secondary school in a disadvantaged area of Quebec (Canada) and were exposed to NANS. These schools were selected using stratified random sampling to be representative of all schools in disadvantaged areas of Quebec in terms of geographical location, size, and language. The remainder of participants attended a comparison school in an area of average SES and were not exposed to NANS. Data were obtained each Spring via self-reported questionnaires administered in class by teachers supervised by trained experimenters. Seventy-seven percent (77%) of eligible participants provided free and informed consent to participate in the study. All procedures were approved by the Institutional Review Board of the University of Montreal.

For this study, we selected the participants who were aged 12 at entry in grade 7 (roughly 80% of each cohort). We excluded participants who were older, moved to a school outside of a NANS school during the study or did not respond on the depressive symptoms measure at age 12 (or responded inappropriately by reporting the highest value on all items, including reverse-coded items). Excluded participants were more likely to be males and had poorer adjustment on all study variables at age 12. The final sample included 6910 participants. Participants were mostly female (56%) and Quebec-born Caucasians (91%). Other participants were from a diversity of origins. Rates of available data for depressive symptoms were 100% at age 12, 74% at age 13, 41% at age 14, 41% at age 15, and 54% at age 16. Rates were similar for behavioral

and academic covariates. Lower rates of available data at ages 14 and 15 were due to a restricted data collection by design given a teacher union strike in wave 4 of NANS (age 14 for cohort 1, age 15 for cohort 2).

Measures

Depressive symptoms. Depressive symptoms were assessed using the Center for Epidemiologic Studies-Depression (CES-D) questionnaire.[32] The CES-D includes 20 items exploring how participants felt in the past week. The scale has been validated in French adolescents[33] and showed good to excellent internal consistency across time points (α=.87–.91).

Delinquency. Delinquency was assessed using a validated 16-item scale inquiring about involvement in various delinquent activities in the past 12 months.[34] Items such as "in the past 12 months, have you intentionally destroyed things which were not yours" were dichotomized (0=no; 1=yes) and summed up. Internal consistency was good to excellent at all time points (α=.87–.94).

Substance use. Substance use was measured using a 4-item scale,[34] probing the frequency of past-year alcohol and drug use. The scale included items such as "did you get intoxicated with beer, wine or hard liquor?" (0=never; 3=very often). Internal consistency was acceptable at all time points (α=.74–.77).

School liking. School liking was measured using a 4-item scale.[34] The scale included items such as "I like school" (1=not at all;7=absolutely). School liking is conceptually close to school bonding and connectedness[20] and has little or no overlap with measures of behavioral adjustment. Internal consistency of this scale was good at all time points (α=.86-.88).

Academic achievement. Academic achievement was measured using self-reported mean grades in Mathematics and Language arts. Participants reported their grades using the following item "To the best of your knowledge, what are your average grades in [mathematics or French] this year?" based on the 0-100% scale typically used in Quebec report cards. Internal consistency was acceptable at all time points (α=70–.72).

Statistical Analyses

All analyses were carried out using Mplus 6.21.[35] We derived trajectories of depressive symptoms using growth mixture modeling (GMM).[30] We defined time according to age and merged the two cohorts together. We estimated models with different numbers of trajectories (1 to 8) using the robust maximum likelihood estimator (MLR) to account for non-normality. In order to select the best model, we considered multiple criteria, including information criteria, likelithood ratio tests, and substantive interest. We tested various models in preliminary analyses, before focusing on solutions with four growth factors (intercept, linear growth, quadratic growth, cubic growth) and within-class variation allowed only around the intercept. We also tested separate trajectories by gender. We found similar solutions and thus took gender into account as a predictor of trajectories. All models were estimated with a large number of initial start values (5000, with 100 optimizations) to avoid selecting solutions at local maxima.

We examined the co-development of behavioral and academic problems in trajectories of depressive symptoms by deriving growth curves for each of the covariates conditional on trajectories using Mplus TRAINING option. Growth curves were defined by growth parameters (intercept, slope, quadratic and cubic trends). We tested whether trajectories differed in the course of co-occuring problems by comparing the fit of (a) models with the same course (identical growth parameters) for a covariate in two specific trajectories and (b) models with

different growth parameters in the same two trajectories. This test of nested models was repeated

for all pairwise comparisons between trajectories using the Mplus MODELTEST option.

Missing values on depressive symptoms and covariates over the follow-up period tended to be

higher in males and participants who had poorer emotional, behavioral, and academic adjustment

at age 12 (Appendix A). Missing data were handled in all models using full-information

maximum likelihood with the MLR estimator to preserve sample size and reduce potential

missingness bias.[36] We did not adjust for nesting in school because 26% of participants switched

from one NANS school to another during the study. Sensitivity analyses indicated that

adjustment for school clustering at age 12 (using the "type=complex" option) did not modify

results, except for likelihood ratio tests, which did not discriminate between trajectory solutions

(analyses available upon request).

RESULTS

Descriptive Statistics

Table 1 presents the means and standard deviations for depressive symptoms and behavioral and academic covariates from age 12 to 16. Depressive symptoms remained relatively stable throughout the secondary school period, with a slight decline at age 16. Delinquency also remained relatively stable. Substance use and academic adjustment respectively increased and declined from age 12 to 16.

Selection of Trajectory Model

Figure 1 compares the information criteria for different trajectory solutions. Fit was better (lower values) in models with a larger number of trajectories, but fit improvements became gradually smaller (especially beyond a 4-class model). Likelihood ratio tests (Table 2) suggested that there was little statistical advantage in fit beyond a 5-class model (except for the BLRT which failed to discriminate between solutions). Whereas qualitatively different trajectories emerged in models from 2 to 5 trajectories, additional trajectories in models with 6 classes appeared to represent quantitative variations around these trajectories. We thus selected the 5-class model, which was composed of five clearly-distinguished trajectories and included a small yet important trajectory of individuals with stable-high symptoms.

Description of Trajectory Model

Figure 2 presents the five trajectories of depressive symptoms. The trajectory labeled *stable-low* depressive symptoms included the majority of adolescents (68.1%) and was characterized by low scores on the CES-D (below 10) between ages 12 and 16. The trajectory labeled *increasing* depressive symptoms was the second largest class (12.1%) and was

characterized by moderate depressive symptoms at age 12, which steadily increased during secondary school to reach high levels by age 16. The trajectory labeled *decreasing* symptoms (8.7%) included participants who reported high symptoms at age 12, followed by a rapid and stable decline in symptoms. The trajectory labeled *transient* comprised a similar proportion of adolescents (8.7%) and was characterized by moderate symptoms at age 12, which increased to high levels at ages 13 and 14, before leveling down to moderate levels by ages 15 and 16. Finally, the trajectory labeled *stable-high* symptoms included a minority of adolescents (2.4%) who reported consistently elevated symptoms.

Gender as a Predictor of Trajectories

We examined whether gender predicted trajectory membership. Relative to the *stable-low* trajectory class, females emerged as significantly more likely than males to be found in the *stable-high* (odds ratio[OR]= 3.5, *p*<.001), *decreasing* (OR=2.6, *p*<.001), and *transient* (OR=1.9, *p*<.001) classes, but not the *increasing* class (OR=1.1, *p*>.05). Females were also more likely to be members of *stable-high* (OR=3.1, *p*<.001), *decreasing* (OR=2.3, *p*<.001), and *transient* (OR=1.7, *p*<.01) classes relative to the *increasing* class, as well as the *stable-high* (OR=1.8, *p*<.05) and *decreasing* (OR=1.4, *p*<. 05) classes relative to the *transient* class.

Course of Behavioral and Academic Problems Conditional on Trajectories of Depressive Symptoms

We next examined the co-development of behavioral and academic problems in trajectories by deriving conditional growth curves. Comparison of nested models (not shown) indicated that growth curves for all co-occurring problems were significantly different in the five trajectory classes. A remarkably similar pattern of results emerged for all covariates (Figure 3). The course of delinquency, substance use, school liking, and academic achievement tended to

closely follow the course of depressive symptoms in each trajectory. However, The precise course of covariates in trajectory classes varied in relation to the general course in the full sample for the same covariate. For instance, the course of substance use and academic achievement in all five trajectories were tilted counter-clockwise reflecting the general trend for these covariates to increase over time.

Visual inspection suggests specificities beyond this general pattern. The three non-stable trajectories (*decreasing, transient, increasing*) reached higher levels of behavioral than academic problems relative to the *stable-low* and *stable-high* trajectories. Trajectory peaks in the non-stable trajectories reached higher or equal levels of behavioral problems than the stable-high trajectory, which was not the case for trajectories of depressive symptoms (rank order differences). Co-development between depressive symptoms and academic covariates was more similar in the *sable high* and *stable-low* classes than the three non-stable trajectories. Finally, between-class variability in delinquency tended to increase over time, while between-class variability in achievement tended to decrease.

Ancillary Analyses

We conducted a more traditional test of behavioral and academic problems as predictors and outcomes of trajectories (Appendices B and C). These analyses indicated that behavioral and academic predictors primarily distinguished trajectories on the basis of concurrent depressive symptoms at age 12 and that behavioral and academic outcomes distinguished trajectories on the basis of concurrent depressive symptoms at age 16. These results are consistent with our main findings and suggest that these findings do not represent an artefact of our analytical approach.

DISCUSSION

We identified five trajectories of depressive symptoms in a large sample of secondary school students followed from age 12 to 16. Consistent with most previous studies, we replicated four trajectories of *stable-low*, *increasing*, *decreasing*, and *stable-high* symptoms. Interestingly, we also identified a *transient* (rise-and-decline) trajectory which is more idiosyncratic to this study. Also consistent with previous studies,[4,5,7,9,10] most participants with elevated depressive symptoms at a given age had non-stable, temporary elevated symptoms. However, participants in these trajectories (*increasing*, *decreasing*, *transient*) maintained higher symptoms than the *stable-low* trajectory at all time points, including outside trajectory peaks. Together, the *stable-high*, *increasing*, *decreasing*, and *transient trajectories* indicate that one adolescent out of three had symptoms that remained moderate and/or elevated across secondary school. This emphasizes the high prevalence and stability of adolescent depressive symptoms.[2,37] Although we found similar trajectories in males and females, females to be more likely to be members of trajectories of early and stable symptoms (*stable-high*, *decreasing*, *transient*). This may reflect a variety of factors, including earlier pubertal timing and greater reactivity to life stressors related to entry into secondary school in females compared to males.[38]

The main contribution of this study was to examine the co-development of behavioral and academic adjustment problems in trajectories of depressive symptoms using a conditional growth curve approach. This innovative approach allowed us to identify a clear and consistent pattern of co-development over time: the course of each behavioral and academic problem closely mirrored the development of depressive symptoms in each trajectory. This statement should however be qualified in two ways. First, the course of each covariate in trajectories varied as a function of the course of this covariate in the full sample. Second, peak level academic difficulties tended to

remain lower than peak level behavioral difficulties in the trajectories of temporary symptoms (*increasing*, *decreasing*, *transient*) relative to the two stable trajectories (*stable-high*, *stable-low*). This is likely to reflect lower general lability of academic adjustment compared to behavioral and emotional adjustment over the secondary school years.

Although previous studies reported a similar "wax and wane" pattern of conduct problems with other difficulties,[29,39] this generalized mirror pattern is a novel finding in adolescent depression research. At a descriptive level, the fact that depressive symptoms tended to co-develop together with, rather than to precede or follow behavioral and academic problems, is not suggestive of causal or consequence models. Our results are generally more consistent with a common process model, in which underlying developmental processes give rise to simultaneous trends in depressive symptoms and other problems over time. This model appears to provide a primary explanation for our results across covariates and trajectories, but does not preclude the existence of direct influences between depressive symptoms and other problems, which have been documented in our research and the larger literature.[26,40]

Several underlying processes may explain co-development over time. A first possibility is a time-varying individual vulnerability. A personality trait that is stable yet fluctuating over time such as neuroticism has been suggested to explain the co-occurrence of conduct problems and depressive symptoms.[39] A second possibility is time-varying environmental influences. Individuals in the *stable-high* trajectory may be exposed to chronic stress (e.g., family dysfunction, etc.), while individuals in *transient*, *increasing*, and *decreasing* trajectories may react to temporary negative life events (e.g., secondary school entry in the *decreasing* trajectory). A third possibility is a combination of individual and environmental influences. Problem Behavior Theory holds that individual and environmental risk factors contribute to a general

proneness to deviance, which leads to the clustering of emotional, academic, and behavioral difficulties.[25] In line with diathesis-stress models of depression,[41] individual and environmental factors are likely to interact in a complex fashion. Genetic, biological, or psychological vulnerability to depressive symptoms in some individuals may only be activated when these individuals are confronted with high stress. Adolescents in the *stable-high*, *transient*, *increasing*, and *decreasing* classes may all share a common vulnerability that gets "switched on" at a different timing and for a different duration by chronic stress (*stable-high*) or acute stress (*transient*, *increasing*, *decreasing*).

This study is not without limitations. First, all study variables were self-reported, including depressive symptoms. Shared method variance may have contributed to the identification of mirror patterns of co-development. Second, rates of missing data were high, though a good portion resulted from missingness by design given a teachers union strike in one year. Full information maximum likelihood should also have reduced attrition biases,[36] but no statistical solution is a panacea. Third, we could not perfectly adjust for nesting within school because several participants switched school during the study. Fourth, adolescents in the NANS sample attended schools primarily located in disadvantaged areas. It is unclear whether the trajectories and relations found here generalize to students who attend school in an advantaged area (e.g., private schools). The nature of the sample may have influenced the trajectory solution (e.g., identification of a unique *transient* trajectory) or patterns of co-development, since participants in high-risk samples may be more likely to develop multiple problem behaviors.

Future research is needed to determine the nature of the underlying developmental process(es) that give rise to the mirror co-development of depressive symptoms and associated behavioral and academic problems. Trajectory studies that examine multiple individual and

environmental time-varying influences such as pubertal timing, genetic vulnerability, personality factors, and stressful life events would be particularly informative and would allow undertaking formal tests of competing explanations. An intriguing question which could be addressed by these studies is whether there are distinct underlying developmental processes of co-development or a single underlying process shared by all trajectories.

In terms of clinical implications, our findings suggest that depressive symptoms co-develop together with behavioral and academic adjustment problems in a relatively systematic manner. This reinforces the notion that clinical assessment of adolescents with depressive symptoms should always consider potential co-occurring problems. Depression prevention and treatment approaches may benefit from a focus on multiple co-occurring problems rather than depression only and from devoting greater attention to non-specific risk factors which are known to exert an influence on multiple adjustment problems.[42]

REFERENCES

1.   Fergusson DM, Woodward LJ. Mental health, educational, and social role outcomes of adolescents with depression. Arch Gen Psychiatry 2002;59(3):225-231.

2.   Lewinsohn PM, Hops H, Roberts RE, et al. Adolescent psychopathology: I. Prevalence and incidence of depression and other DSM-III-R disorders in high school students. J Abnorm Psychol 1993;102(1):133-144.

3.   Thapar A, Collishaw S, Pine DS, Thapar AK. Depression in adolescence. Lancet 2012;379(9820):1056-1067.

4.   Brendgen M, Lamarche V, Wanner B, Vitaro F. Links between friendship relations and early adolescents' trajectories of depressed mood. Dev psychol 2010;46(2):491-501.

5.   Brendgen M, Wanner B, Morin AJ, Vitaro F. Relations with parents and with peers, temperament, and trajectories of depressed mood during early adolescence. J Abnorm Child Psychol 2005;33(5):579-594.

6.   Chaiton M, Contreras G, Brunet J, et al. Heterogeneity of Depressive Symptom Trajectories through Adolescence: Predicting Outcomes in Young Adulthood. J Can Acad Child Adolesc Psychiatry 2013;22(2):96-105.

7.   Costello DM, Swendsen J, Rose JS, Dierker LC. Risk and protective factors associated with trajectories of depressed mood from adolescence to early adulthood. J Consult Clin Psychol 2008;76(2):173-183.

8.   Dekker MC, Ferdinand RF, van Lang ND, et al. Developmental trajectories of depressive symptoms from early childhood to late adolescence: gender differences and adult outcome. J Child Psychol Psychiatry 2007;48(7):657-666.

9.   Duchesne S, Ratelle CF. Attachment security to mothers and fathers and the

developmental trajectories of depressive symptoms in adolescence: which parent for

which trajectory? J Youth Adolesc 2014;43(4):641-654.

10.   Fernandez Castelao C, Kroner-Herwig B. Different trajectories of depressive symptoms

in children and adolescents: predictors and differences in girls and boys. J Youth Adolesc

2013;42(8):1169-1182.

11.   Mazza JJ, Fleming CB, Abbott RD, et al. Identifying trajectories of adolescents'

depressive phenomena: an examination of early risk factors. J Youth Adolesc

2010;39(6):579-593.

12.   Mezulis A, Salk RH, Hyde JS, et al. Affective, biological, and cognitive predictors of

depressive symptom trajectories in adolescence. J Abnorm Child Psychol May

2014;42(4):539-550.

13.   Stoolmiller M, Kim HK, Capaldi DM. The course of depressive symptoms in men from

early adolescence to young adulthood: identifying latent trajectories and early predictors.

J Abnorm Psychol 2005;114(3):331-345.

14.   Wickrama KA, Wickrama T, Lott R. Heterogeneity in youth depressive symptom

trajectories: social stratification and implications for young adult physical health. J

Adolesc Health 2009;45(4):335-343.

15.   Wickrama T, Wickrama KA. Heterogeneity in adolescent depressive symptom

trajectories: implications for young adults' risky lifestyle. J Adolesc Health

2010;47(4):407-413.

16.   Yaroslavsky I, Pettit JW, Lewinsohn PM, et al. Heterogeneous trajectories of depressive

symptoms: Adolescent predictors and adult outcomes. J Affec Disord 2013;148(2-3):391-

9.

17.   Angold A, Costello EJ. Depressive comorbidity in children and adolescents: empirical,

theoretical, and methodological issues. Am J Psychiatry 1993;150(12):1779-1791.

18.   Armstrong TD, Costello EJ. Community studies on adolescent substance use, abuse, or

dependence and psychiatric comorbidity. J Consult Clin Psychol 2002;70(6):1224-1239.

19.   Jaycox LH, Stein BD, Paddock S, et al. Impact of teen depression on academic, social,

and physical functioning. Pediatr 2009;124(4):e596-605.

20.   Resnick MD, Bearman PS, Blum RW, et al. Protecting adolescents from harm. Findings

from the National Longitudinal Study on Adolescent Health. JAMA 1997;278(10):823-

832.

21.   Lewinsohn PM, Rohde P, Seeley JR. Adolescent psychopathology: III. The clinical

consequences of comorbidity. J Am Acad Child Adolesc Psychiatry 1995;34(4):510-519.

22.   Khantzian EJ. The self-medication hypothesis of addictive disorders: focus on heroin and

cocaine dependence. Am J Psychiatry 1985;142(11):1259-1264.

23.   Kovacs M, Goldston D. Cognitive and social cognitive development of depressed

children and adolescents. J Am Acad Child Adolesc Psychiatry 1991;30(3):388-392.

24.   Patterson GR, DeBaryshe BD, Ramsey E. A developmental perspective on antisocial

behavior. Am Psychol 1989;44(2):329-335.

25.   Jessor R, Jessor SL. Problem behavior and psychosocial development: A longitudinal

study of youth. New York: Academic Press, 1977.

26. Rohde P. Comorbidities with adolescent depression. In: Nolen-Hoeksema S, Hilt LM, eds. *Handbook of depression in adolescents*. New York: Taylor & Francis Group, 2009:139-178.

27. Diamantopoulou S, Verhulst FC, van der Ende J. Gender differences in the development and adult outcome of co-occurring depression and delinquency in adolescence. J Abnorm Psychol 2011;120(3):644-655.

28. Wiesner M, Kim HK. Co-occurring delinquency and depressive symptoms of adolescent boys and girls: a dual trajectory modeling approach. Dev Psychol 2006;42(6):1220-1235.

29. Barker ED, Oliver BR, Maughan B. Co-occurring problems of early onset persistent, childhood limited, and adolescent onset conduct problem youth. J Child Psychol Psychiatry 2010;51(11):1217-1226.

30. Muthen B, Shedden K. Finite mixture modeling with mixture outcomes using the EM algorithm. Biometrics 1999;55(2):463-469.

31. Janosz M, Bélanger J, Dagenais C, et al. Evaluation of the New Approaches, New Solutions intervention Strategy: Summary of the final report. Montréal Groupe de recherche sur les environnements scolaires, Université de Montréal, 2010.

32. Radloff LS. The CES-D Scale: a self-report depression scale for research in the general population. Appl Psychol Measur 1977;1(3):385-401.

33. Riddle AS, Blais MR, Hess U. A Multi-Group Investigation of the CES-D's Measurement Structure Across Adolescents, Young Adults and Middle-Aged Adults. Montreal, Canada: Centre interuniversitaire de recherche en analyse des organisations (CIRANO), 2002.

34. Le Blanc M, McDuff P, Fréchette, M. Manuel sur des mesures de l'adaptation sociale et personnelle pour les adolescents québécois. Montréal: Université de Montréal, Groupe de recherche sur l'inadaptation psychosociale chez l'enfant, 1996.

35. Muthén LK, Muthén BO. Mplus User's Guide. Sixth Edition. Los Angeles, CA: Muthén & Muthén, 2010.

36. Enders CK. Applied missing data analysis. New York, NY: Guilford Press, 2010.

37. Tram JM, Cole DA. A multimethod examination of the stability of depressive symptoms in childhood and adolescence. J Abnorm Psychol 2006;115(4):674-686.

38. Galambos NL, Berenbaum SA, McHale SM. Gender development in adolescence. In: Lerner RM, Steinberg L, eds. Handbook of adolescent psychology. Volume I: individual bases of adolescent development (Third edition). Hoboken, NJ: Wiley & Sons, 2009:305-357.

39. Lahey BB, Loeber R, Burke J, et al. Waxing and waning in concert: dynamic comorbidity of conduct disorder with other disruptive and emotional problems over 7 years among clinic-referred boys. J Abnorm Psychol 2002;111(4):556-567.

40. Brière FN, Fallu JS, Janosz M, Pagani LS. Prospective associations between meth/amphetamine (speed) and MDMA (ecstasy) use and depressive symptoms in secondary school students. J Epidemiol Community Health 2012;66(11):990-4.

41. Monroe SM, Simons AD. Diathesis-stress theories in the context of life stress research: implications for the depressive disorders. Psychol Bull 1991;110(3):406.

42. Gladstone TR, Beardslee WR, O'Connor EE. The prevention of adolescent depression. Psychiatr Clin North Am 2011;34(1):35-52.

FIGURE LEGENDS

Figure 1. Comparison of information criteria for models with 1 to 8 trajectories

Figure 2. Trajectories of depressive symptoms in NANS secondary school adolescents

Figure 3. Development of behavioral and academic problems conditional on trajectories of

depressive symptoms: (a) delinquency, (b) substance use, (c) school liking (reversed), (d)

academic achievement (reversed)

Table 1

Mean and Standard Deviations for Depressive Symptoms and Behavioral and Academic Covariates from age 12 to 16

	Mean (SD)				
	age 12	age 13	age 14	age 15	age 16
Depressive Symptoms	12.27 (10.15)	12.53 (10.38)	12.13 (9.90)	12.37 (9.97)	11.59 (10.18)
Delinquency	1.60 (2.70)	1.82 (3.06)	1.81 (3.32)	1.70 (3.09)	1.74 (3.23)
Substance Use	.19 (.43)	.34 (.54)	.49 (.60)	.58 (.61)	.65 (.64)
School Liking	4.18 (1.37)	4.01 (1.26)	3.99 (1.25)	3.97 (1.23)	4.03 (1.24)
Academic Achievement	76.79 (10.18)	76.40 (10.25)	75.28 (10.41)	73.08 (9.38)	72.48 (9.80)

Table 2.

Likelihood Ratio Tests Comparing Different Trajectory Solutions

	Likelihood Ratio Tests		
	VLMR	Adjusted LMR	BLRT
1 Class	-	-	-
2 Classes	1672.98 (5) ***	1635.97 (5) ***	1672.98 (5)***
3 Classes	1050.15 (5) ***	1026.92 (5) ***	1050.15 (5) ***
4 Classes	734.98 (5) ***	718.72 (5) ***	734.98 (5) ***
5 Classes	457.31 (5) ***	447.19 (5) ***	457.31 (5) ***
6 Classes	419.04 (5)	407.77 (5)	419.04 (5) ***
7 Classes	342.29 (5)	334.72 (5)	342.29 (5) ***
8 Classes	298.18 (5)	291.60 (5)	298.18 (5) ***

Note. Adjusted LMR = Lo-Mendell-Rubin adjusted likelihood ratio test; BLRT = Bootstrapped Likelihood Ratio Test.

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

F. Figure 1
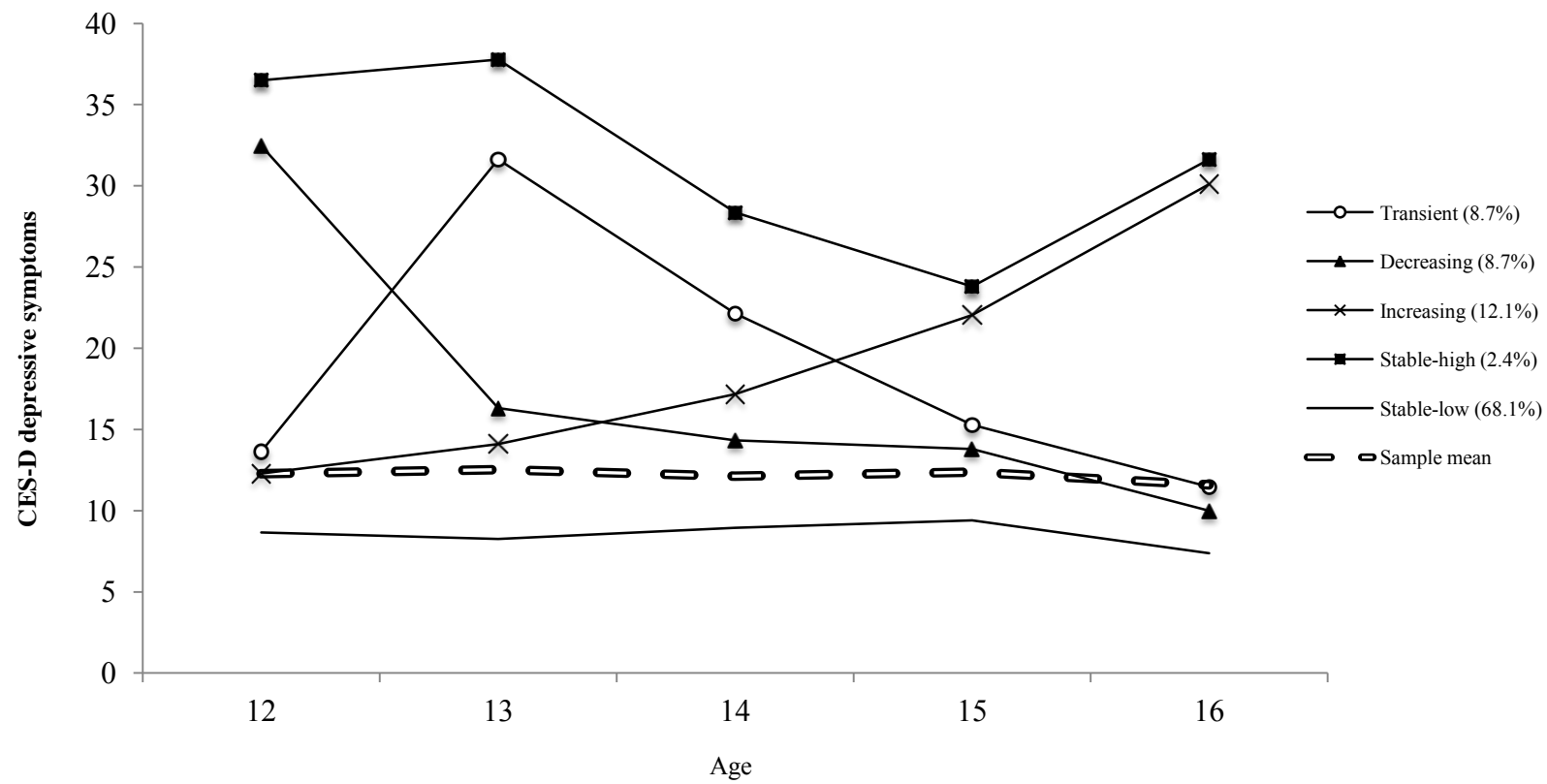
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Figure 1. Comparison of information criteria for models with 1 to 8 trajectories
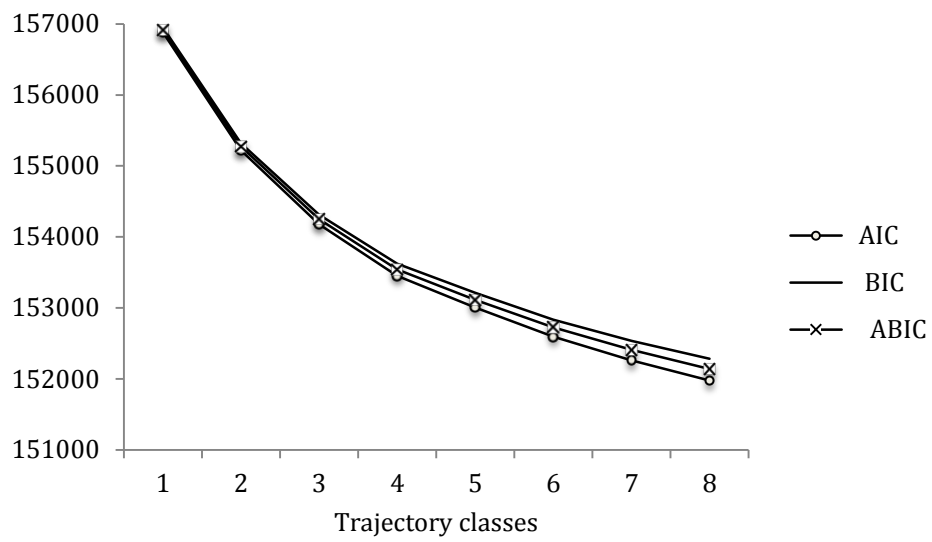
Note. AIC = Aikaike Information Criterion; BIC = Bayesian Information Criterion; ABIC = Sample-Size Adjusted Bayesian Information Criterion
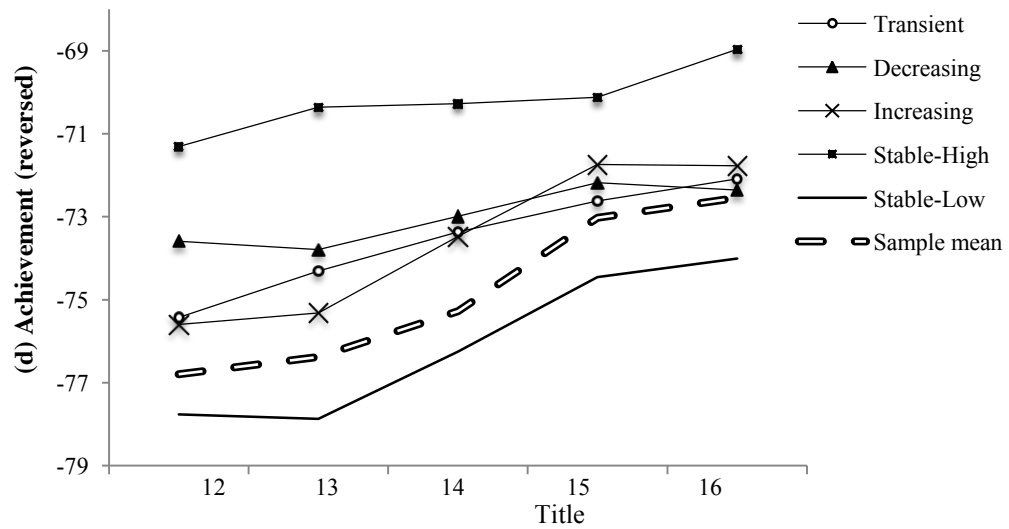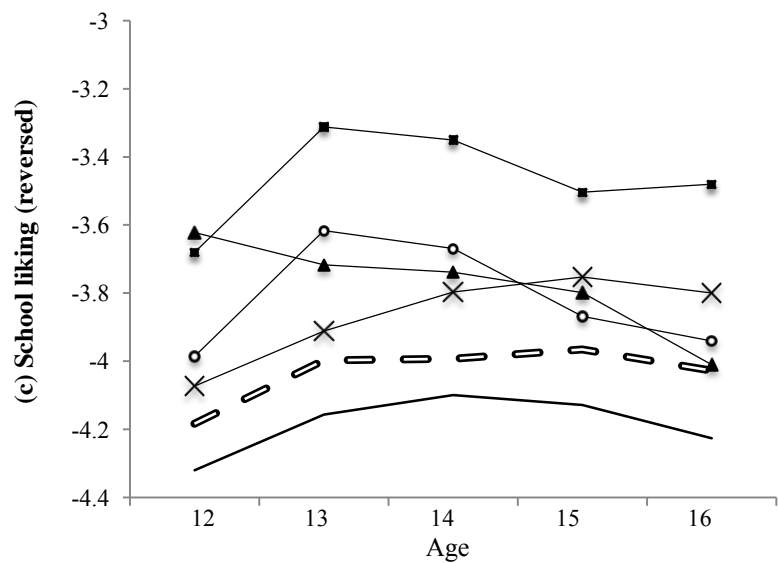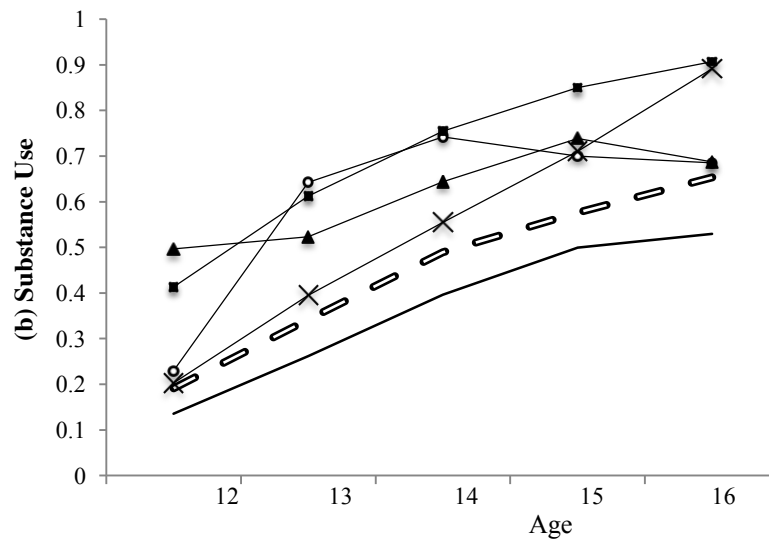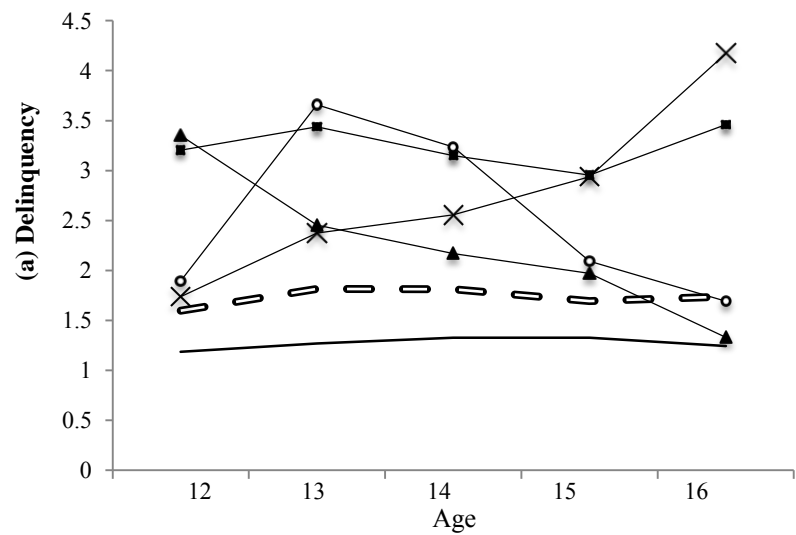
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Figure 2. Trajectories of depressive symptoms in NANS secondary school adolescents

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Figure 3. Development of behavioral and academic problems conditional on trajectories of depressive symptoms: (a) delinquency, (b) substance use, (c) school liking (reversed), (d) academic achievement (reversed)

(a) Delinquency

(b) Substance Use

(c) School liking (reversed)

(d) Achievement (reversed)

Legend:
- —○— Transient
- —▲— Decreasing
- —✕— Increasing
- —■— Stable-High
- ——— Stable-Low
- - - ◯ - - Sample mean

Appendix A.

Non parametric correlations between study variables at age 12 and number of missing values on depressive symptoms and covariates over the follow-up period (ages 13 to 16)

	Number of Missing Values at Follow-Up (ages 13 to 16; 0 to 4)				
	Depressive symptoms	Delinquency	Substance Use	Academic achievement	School liking
Predictors (age 12)					
Gender (1=male)	.14**	.15**	.13**	.12**	.12**
Depressive symptoms	.08**	.07**	.07**	.07**	.07**
Delinquency	.11**	.11**	.10**	.10**	.10**
Substance use	.09**	.10**	.09**	.09**	.09**
School liking	-.08**	-.08**	-.08**	-.07**	-.07**
Academic achievement	-.15**	-.15**	-.15**	-.14**	-.14**

** = p < .01

Appendix B

Associations between academic and behavioral predictors at age 12 and trajectory class membership

	Trajectory Class Membership, Odds Ratios [1]			
	Reference = Stable-low			
	Transient	Decreasing	Increasing	Stable-high
Behavioral predictors				
Delinquency (1 SD unit)	2.0 ***	2.8 ***	2.0 ***	2.5 ***
Substance use (1 SD unit)	1.6 ***	2.5 ***	1.6 ***	1.9 ***
Academic predictors				
School liking (1 SD unit)	0.8 ***	0.6 ***	0.7 **	0.8 **
Academic Achievement (1 SD unit)	0.7 ***	0.6 ***	0.7 ***	0.5 ***

[1] Odds ratios derived from multinomial regression using the Mplus R3STEP option

*** p < .001; ** p < .01; * p < .05

Appendix B (Continued)

Associations between academic and behavioral predictors at age 12 and trajectory class membership

| | Trajectory Class Membership, Odds Ratios | | | | | |
| | Reference = Increasing | | | Reference = Transient | | Reference = Decreasing |
	Transient	Decreasing	Stable high	Decreasing	Stable high	Stable high
Behavioral predictors						
Delinquency (1 SD unit)	1.0	1.4 ***	1.3 **	1.4 ***	1.3 **	0.9
Substance use (1 SD unit)	1.0	1.6 ***	1.2 *	1.6 ***	1.2	0.7 **
Academic predictors						
School liking (1 SD unit)	1.1	0.9	1.0	0.8 **	1.0	0.8 **
Academic achievement (1 SD unit)	1.1	0.9	0.7	0.9 *	0.7 ***	0.8 *

[1] Odds ratios derived from multinomial regression using the Mplus R3STEP option

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

Appendix C

Mean academic and behavioral outcomes at age 16 of trajectories of depressive symptoms

	Estimated mean [1]				
	Stable-low	Stable-high	Increasing	Decreasing	Transient
Behavioral outcomes					
Delinquency	1.0 [c]	3.0 [b]	4.1 [b]	1.1 [a,c]	1.4 [a]
Substance use	-0.04 [c]	0.3 [b]	0.4 [b]	0.1 [a]	0.1 [a]
Academic outcomes					
School liking	4.2 [c]	3.5 [a]	3.8 [a,b]	4.0 [b]	3.9 [b]
Academic achievement	74.1 [c]	69.0 [a]	71.8 [b]	72.3 [b]	72.1 [b]

[1] Estimated means and statistical tests are derived from equality tests of means across classes using posterior probability-based multiple imputations with the Mplus Auxiliary (e) option

Note. Groups with the same superscripts do not differ statistically.

Modified Table 2.

Fit and Likelihood Ratio Tests for Different Trajectory Solutions (taking nesting into account

with the Mplus "type = complex" option)

	Information Criteria			Likelihood Ratio Tests		
	BIC	ABIC	AIC	VLMR	Adjusted LMR	BLRT
1 Class	156948	156916	156880	-	-	-
2 Classes	155319	155272	155217	1672.99 (14) ***	1659.59 (14) ***	N/A
3 Classes	154313	154250	154177	1050.15 (9) ***	1037.12 (9) ***	N/A
4 Classes	153623	153543	153452	734.99 (11) ***	727.51 (11) ***	N/A
5 Classes	153210	153114	153004	457.32 (9) ***	451.64 (9) ***	N/A
6 Classes	152835	152723	152595	419.04 (10) ***	414.35 (10) ***	N/A
7 Classes	152537	152410	152263	342.29 (35) ***	341.20 (35) ***	N/A
8 Classes	152283	152140	151975	298.20 (14) ***	295.81 (14) ***	N/A

Note. BIC = Bayesian Information Criterion; ABIC = Sample size adjusted Baryesian Information Criterion; AIC = Aikaike Information Criterion; VLMR = Vuong-

Lo-Mendell-Rubin Likelihood ratio test; Adjusted LMR = Lo-Mendell-Rubin adjusted likelihood ratio test; BLRT = Bootstrapped Likelihood Ratio Test.

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

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Modified Figure 2. Trajectories of depressive symptoms in NANS secondary school adolescents (taking nesting into account)
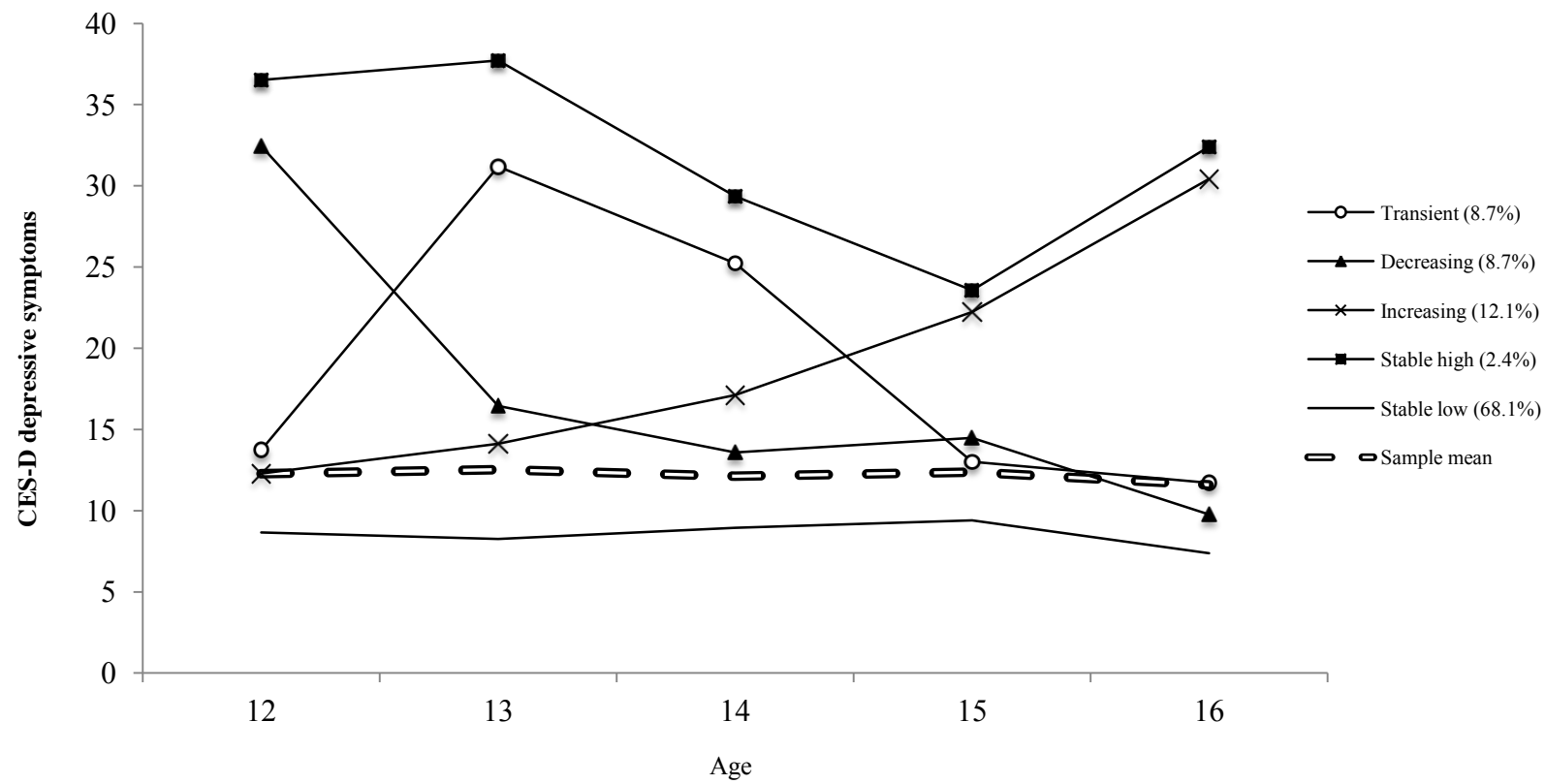
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Modified Figure 3. Development of behavioral and academic problems conditional on trajectories of depressive symptoms (taking nesting into account) : (a) delinquency, (b) substance use, (c) school liking (reversed), (d) academic achievement (reversed)

(a) Delinquency

(b) Substance Use

(c) School liking (reversed)

(d) Achievement (reversed)
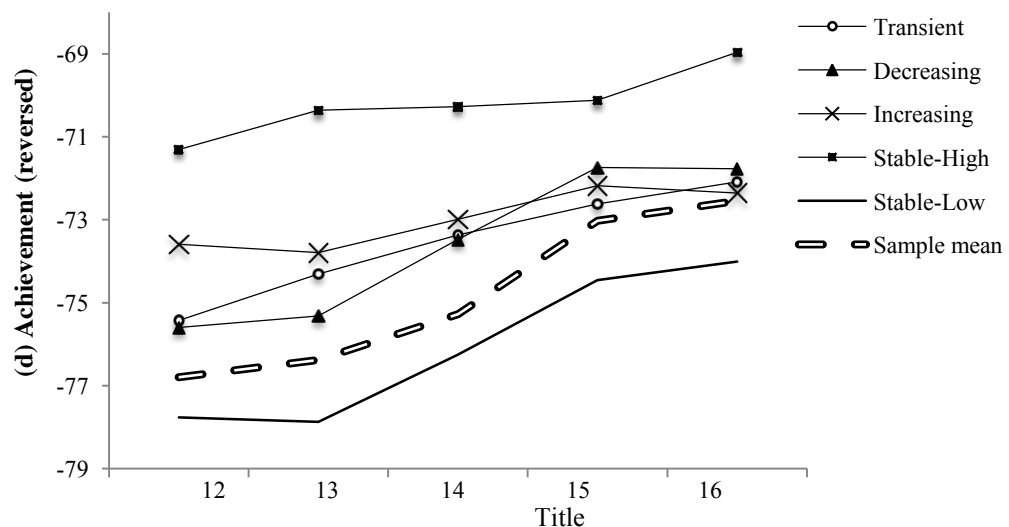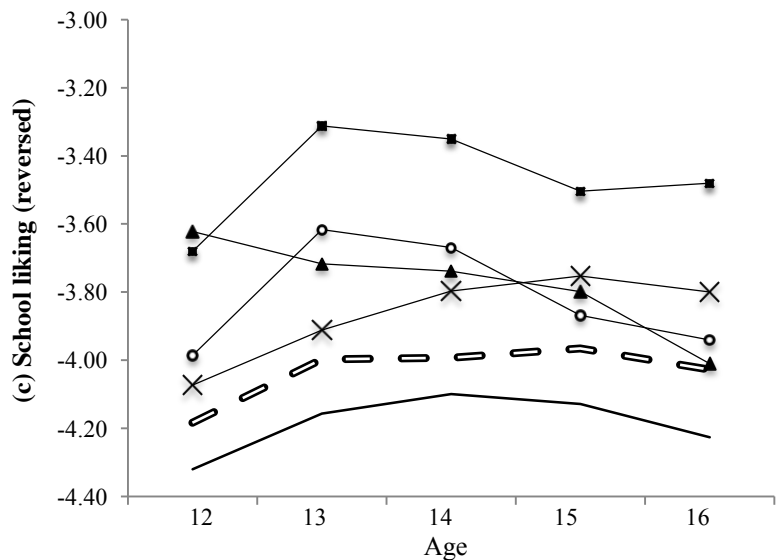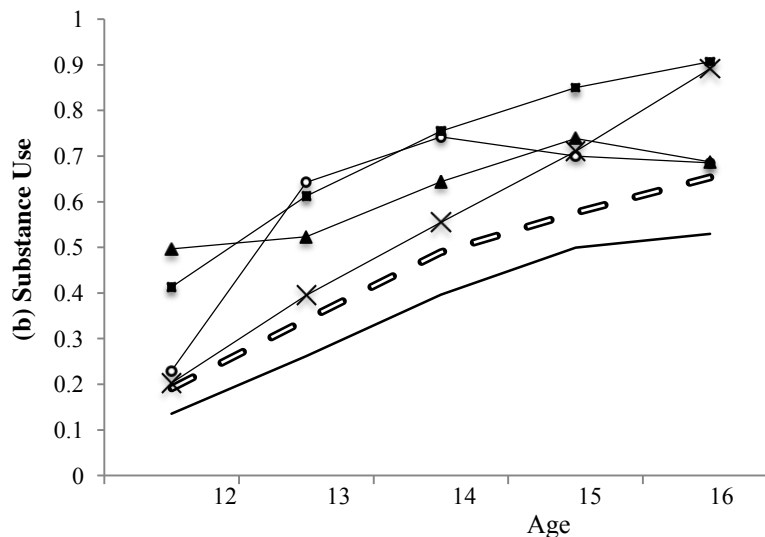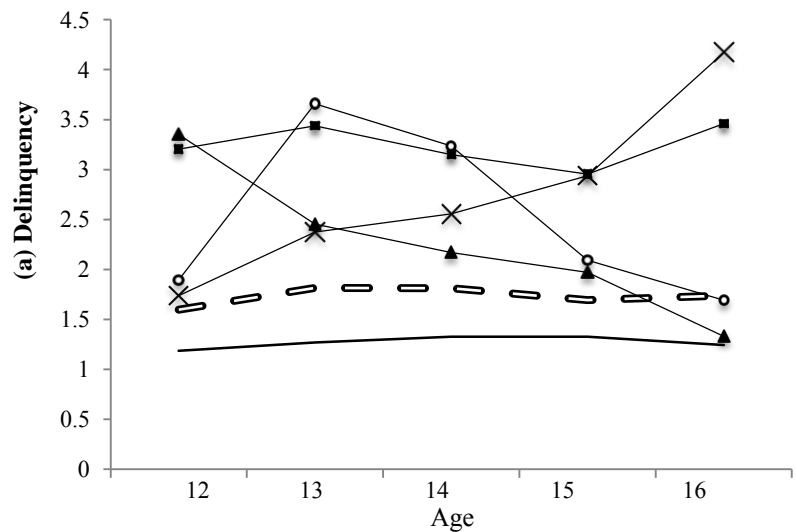
Transient
Decreasing
Increasing
Stable-High
Stable-Low
Sample mean

Highlights

- Evidence suggests multiple trajectories of depressive symptoms in adolescents

- Implications of these trajectories for commonly co-occurring problems are unclear

- We identified five trajectories in adolescents followed from age 12 to 16

- Behavioral and academic problems mirrored the course of symptoms in trajectories

- Co-occurring problems should always be considered in assessment and intervention