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Potential Causal Relationship Between Depressive Symptoms and Academic Achievement in the Hawaiian High Schools Health Survey Using Contemporary Longitudinal Latent Variable Change Models

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Abstract

There is a relatively consistent negative relationship between adolescent depressive symptoms and educational achievement (e.g., grade-point average [GPA]). However, we are less certain of the causal direction for this association due to the lack of longitudinal data with both indicators measured across at least two time periods, and due to the lack of application of more sophisticated contemporary statistical techniques. We present multivariate results from a large longitudinal cohort-sequential study of high school students (N = 7,317) with measures of self-reported depressive symptoms and self-reported GPAs across multiple time points (following McArdle, 2009; McArdle et al., 2001) using an ethnically diverse sample from Hawai'i. Contemporary statistical techniques included: bivariate dynamic structural equation modeling (DSEM); multi-group gender-and-ethnic DSEMs; ordinal scale measurement of key outcomes; and imputation for incomplete longitudinal data. The findings suggest that depressive symptoms affect subsequent academic achievement, and not the other way around, especially for Native Hawaiians as compared to non-Hawaiian females. We further discuss the scientific, applied, and methodological-statistical implications of the results, including the need for further theorizing and research on mediating variables. We also discuss the need for increased prevention, early intervention, screening, identification, and treatment of depressive symptoms and disorders. Finally, we argue for utilization of more contemporary methodological-statistical techniques, especially when violating parametric-test assumptions.

Keywords

Adolescents; depressive symptoms; academic achievement; longitudinal dynamic analysis; Native Hawaiian

Introduction

Many of the most important studies in developmental psychology deal with the relationships among some form of psychopathology connected with real-life outcomes (Eccles, 2007; Robbins & Rutter, 1990; Roeser & Eccles, 1998). The present study addresses the central question, "Do depressive symptoms cause lower academic achievement (i.e., grade-point average [GPA]), or does lower academic achievement cause depressive symptoms?" Although theories and some empirical findings exist regarding this area of study, the question has been largely unanswered. This is a critical question to address given the increased morbidity (e.g., comorbidity) and mortality (e.g., suicidality) in adolescents due to depressive symptoms, depressive disorder, and underachievement (e.g., Abela & Hankin, 2008; Allen & Astuto, 2009; Birmaher et al., 1996; Essau, 2009; Kovacs & Goldston, 1991; Mandel, 1997; Rudolph, 2009). In addition, child and adolescent depression and academic failure are associated with adult recurrence of depression, difficulties in psychosocial functioning, and other comorbidities (Group for the Advancement of Psychiatry, 1999).

We also ask whether this causal relationship differs as a function of basic and important demographic variables, especially regarding ethnicity. This question is of equal importance given that ethnic minorities more than European-American youth tend to have higher levels of depressive symptoms (e.g., Allen & Astuto, 2009; Rudolph, 2009).

Further, given that it would be unethical to deliberately manipulate depressive symptoms and academic achievement and observe their effects, we utilize contemporary longitudinal dynamic models (e.g., Ferrer & McArdle, 2010; Flaherty, 2008; McArdle, 2009) for demographic contrasts (e.g., ethnicity), incomplete data, and commonly skewed distributions. These types of "dynamic" models take into account changes across time in the key outcome variables in question.

Causal Relationship Between Depressive Symptoms and Grade-Point Average

Theories, models, and mechanisms of adolescent depressive symptoms and depression fall into the following categories: genetic, biological, developmental, cognitive, interpersonal-peer/ romantic relationships, interpersonal-family relationships, and contextual (e.g., stressful life events) (Abela & Hankin, 2008; Rudolph, 2009). Although inferences can be made from these approaches, none explicitly state the temporal and causal link between depressive symptoms and GPA. However, there are generally three parsimonious scenarios:

1. ***Depressive symptoms (D) cause lower GPAs (D → GPA), with the possibility of a mediating third variable (D → V3 → GPA).*** Depressive symptoms can include biological-physical changes (e.g., insomnia or hypersomnia) as well as emotional variations (e.g., loss of interest or pleasure, fatigue or loss of energy, feelings of worthlessness or guilt, suicidality) (American Psychiatric Association, 2000). These changes could directly and adversely impact positive academic achievement (e.g., GPA; Juvonen, Nishina, & Graham, 2000; Kovacs & Goldston, 1991; Lehtinen, Raikkonen, Heinonen, Raitakari, & Keltikangas-Jarvinen, 2006; Weinberg & Rehmet, 1983), including in combination with other personality variables (e.g., self-criticism for boys; see Shahar et al., 2006). Accompanying attributes of depressive symptoms, such as prolonged concentration difficulty, psychomotor deficits, cognitive perceptions of pessimism, and negative self-evaluations, could also cause poor achievement (Kovacs & Goldston, 1991). Mediating third variables could include increases in substance use (Diego, Field, & Sanders, 2003; Field et al., 2001) and a decline in homework quality and productivity (Field et al., 2001). These conceptualizations are consistent with developmental psychopathological, cognitive, cognitive-behavioral, and psycho-

social (interpersonal) theories of adolescent depressive symptoms and depression (e.g., Abela & Hankin, 2008; Birmaher et al., 1996; Lewinsohn et al., 1994; Reynolds & Johnson, 1994; Rudolph, 2009).

2. ***Lower GPAs cause depressive symptoms (GPA → D), with the possibility of a mediating third variable (GPA → V3 → D).*** Poor academic performance and failure could cause depressive symptoms (e.g., for students with learning disabilities; see Weinberg & Rehmet, 1983), especially for youth who place personal significance to their GPAs and may be dissatisfied with poor GPAs (Lehtinen et al., 2006; particularly for females; see Pelkonen, Marttunen, & Aro, 2003). Repeated academic failure could cause negative emotions (including self-dissatisfaction; see Pelkonen et al., 2003) and cognitive attributions that could lead to depressive symptoms, especially when occurring in social-cultural environments that may value high achievement (e.g., collectivist cultures that value high achievement, including Chinese culture; see Chen et al., 1995) or infer stigma (e.g., students in learning-disability placements; see Dalley, Bolocofsky, Alcorn, & Baker, 1992). For example, Chen et al. (1995) found empirical evidence consistent with lower GPA causing depressive symptoms, but perhaps mediated by maternal rejection and conflicting parental relationships. These investigators also theorized that shame and guilt may play mediating roles.

3. ***Third variable (V3) causes both depressive symptoms and lower GPAs (V3 → D & GPA).*** Although this is a possible theoretical mechanism, the literature has not considered this to any appreciable degree, other than possible broad macro-level variables, including demographic influences (e.g., low socio-economic status). However, more proximal third variables may include chronic influences (e.g., substance abuse) or acute or crisis events (e.g., life-threatening trauma).

These distinct mechanisms, do not, of course, preclude a less parsimonious scenario where two or all three are actually occurring (Chen et al., 1995). In the case of negative circumstances, this could relatively quickly lead to a downward-spiral series of events resulting in severe depressive symptoms and very low GPA (Juvonen et al., 2000). For example, a youth may experience depressive symptoms, which causes a decrease in the student's GPA, which in turn, may further extend the duration and severity of the depressive symptoms, and so on.

Determining which of the above mechanisms is occurring either solely or in combination is critical. Previous research has demonstrated the relationship between the broader constructs of affect and academic achievement (Roeser & Eccles, 1998; Roeser, Eccles, & Sameroff, 1998), including with minority populations (e.g., cross-cultural samples, e.g., Rubie, Townsend, & Moore, 2004; students with learning disabilities, e.g., Yasutake & Bryan, 1995). On a scientific level, by specifically examining depressive symptoms and achievement, the results will advance our science in this general area of the nature of the relationship between adolescent affect and achievement (e.g., GPA; see for review, Birmaher et al., 1996; Kovacs & Goldston, 1991). For example, if depressive symptoms cause lower GPAs, then theoretical formulations will need to incorporate this finding (e.g., hypothesizing mediating variables).

On an applied level, knowing which mechanism or mechanisms are at work and more common will direct practitioners to develop and implement different types of preventive interventions and treatments. For example, if depressive symptoms cause lower GPAs, then a more multidisciplinary approach will be needed (e.g., educators, mental health providers; Shahar et al., 2006). Focus must be made on screening for, identifying, and treating youth with depressive symptoms and depressive disorders. Taking on an even more preventive

stance, antecedent, including environmental causes, of depressive symptoms should also be addressed (e.g., child abuse & neglect, Harkness & Lumley, 2008; peer harassment & self-blaming, Juvonen et al., 2000).

However, if poor GPAs cause depressive symptoms, predicting and preventing decreases in GPA should be the foci because these efforts will lead to less depressive symptoms (e.g., Pelkonen et al., 2003). The preventive interventions would likely be educational in nature.

Finally, if a third variable causes both depressive symptoms and lower GPA, then the preventive intervention will depend on the nature of the third variable. For example, the preventive intervention may involve the youth himself or herself (e.g., being taught adaptive coping skills), as well as those around him or her (e.g., family members, peers, teachers, school counselors) (e.g., parent training, school-based intervention to improve sense of school belongingness). However, regardless of the nature of the third variable causing both depressive symptoms and lower GPA, remediation of poor academic performance and treatment of depressive symptoms remain relevant.

Empirical Findings Regarding Depressive Symptoms and Grade-Point Average

Despite the enormous amount of research that has been conducted on educational achievement, only a small proportion of this research body has investigated the association between academic achievement in the form of academic achievements in school and individual psychological adjustment, such as depressive symptoms (Shahar et al., 2006). Table 1 provides an overview of previously published research, and indicates that this research has generally found significant but small, negative associations between indicators of academic achievement, such as high school GPA and depressive symptoms. The pattern that emerged indicated that when the GPA range was not restricted and/or the depressive symptom measure was not combined with non-depressive constructs including anxiety, the correlation between GPA and depressive symptoms ranged from −.16 to −.36 (see Table 1), with only a few exceptions ($r = -.05$, Johnson, McGue, & Iacono, 2006; $r = -.09$ at Time 1, Roeser & Eccles, 1998; $r = .05$, Bos, Sandfort, De Bruyn, & Hakvoort, 2008).

The negative relationship between GPA and depressive symptoms was further confirmed by other studies. For example, Field et al. (2001) found high school seniors with high levels of depressive symptoms (Center for Epidemiologic Studies—Depression Scale) had lower GPAs as compared with students with lower levels of depressive symptoms. Juvonen et al. (2000), utilizing structural equation modeling (SEM) and a middle school sample, found evidence for perceived peer harassment leading to psychological distress (i.e., depressive symptoms as measured by the Children's Depression Inventory, self-worth), which in turn lead to poor school adjustment (i.e., actual GPA, number of classroom hours missed during semester of data collection). Although this study was not longitudinal in nature, the findings were consistent with a model in which depressive symptoms predicted lower GPAs.

To determine the causal relationship between GPA (school achievement) and depressive symptoms (psychological adjustment), longitudinal studies are needed (see Avenevoli, Knight, Kessler, & Merikangas, 2008; Duncan, 1975; Flaherty, 2008; McArdle, 2009). One study involving a younger age group from the Republic of China found that academic difficulties in learning the Chinese language ($r = -.30$) and mathematics ($r = -.23$) at age 8 predicted higher levels of depressive symptoms at age 10 (Chen et al., 1995). Pelkonen et al. (2003) found that dissatisfaction with self-reported school marks predicted self-reported depressive symptoms 6 years later for a Finnish urban-community cohort of children from mid-adolescence (age 16) to young adulthood (age 22), with the effect more pronounced for females. Lehtinen et al. (2006) assessed parents of Finnish students when the students were 9, 12, and 15 years of age, and then assessed the students when they were 21–36 years of

age. Although the researchers found an overall negative association between GPA and later depressive symptoms, with 12- and 15-year old girls' lower GPA predicting depressive symptoms 12 and 17 years later, the investigators concluded that there was no consistent relationship across age and gender. In another longitudinal study, Shahar et al. (2006) found a correlation of −.22 between 1993–1994 GPA (0 = F to 12 = A+) and 1995 depressive symptoms (Beck Depression Inventory) for a multi-ethnic, middle school sample. Finally, in a longitudinal study using cluster analysis (Repetto, Caldwell, & Zimmerman, 2004), African American adolescents who had consistently high levels of depressive symptoms (Brief Symptom Inventory) across two time periods had lower GPAs than those who had consistently low levels of depressive symptoms across the two time periods.

Although there have been studies that examined the longitudinal *changes* in adolescent depressive symptoms (e.g., Van Den Eijnden, Meerkerk, Vermulst, Spikerman, & Engels, 2008; Wiesner & Kim, 2006) and adolescent academic achievement as indicated by GPA (e.g., Gutman, Sameroff, & Cole, 2003), only two studies could be identified that included both GPA and depressive symptoms in a longitudinal design that involved examining trajectories. Repetto and colleagues (2004) surveyed African American high school students from the 9th grade with GPAs of 3.0 or lower, at-risk for high school dropout, and not diagnosed with emotional impairment or developmental disability. Depressive symptoms (six items from the Brief Symptom Inventory) and GPA (8th to 10th grades) were utilized; however, the analyses did not include incomplete data. The students were clustered in four groups based on their depressive symptoms: (1) consistently high; (2) consistently low; (3) decreasing; and (4) increasing. Using multivariate analysis of variance (MANOVA), students who were consistently high in depressive symptoms were more likely to be female, have anxiety and stress, and have lower self-esteem and GPA. Johnson and colleagues (2006) examined academic achievement trajectories in adolescences in the Minnesota Twin Family Study. Although data on a composite measure of "grades" were collected across multiple years, the depressive symptom indicator was collected only in Year 1 and was not significantly associated with the measure of academic achievement.

When examining depressive symptoms and GPA, it is also important to consider the effects of demographic variables, such as ethnicity. The negative relationship found between GPA and Center for Epidemiological Studies-Depression (CESD) scores is particularly salient for children and adolescents of ethnic minority ancestry (Hishinuma et al., 2006; Hishinuma, Foster et al., 2001). Given the general finding of lower educational achievement being associated with poorer psychological adjustment (e.g., Hishinuma, Foster et al., 2001), and given the differential academic achievement among racial and ethnic groups (e.g., African Americans with lower high school GPAs than European Americans, Anderman, 2002; European Americans with lower high school GPAs than Asian-Pacific Islanders, Anderman, 2002), this area of study is critical in better understanding the well-being of ethnic minorities. As described earlier, Chen et al. (1995) proposed that collectivist cultures that place high value on academic achievement may provide the social environment and mediating variables that result in lower GPAs causing increased levels of depressive symptoms.

In summary, previous studies have laid a solid foundation on the association between depressive symptoms and GPA, and have begun to address the causal direction of the relationship. However, the empirical evidence does not clearly support one causal mechanism over another, let alone determine whether there are differential effects based on demographic variables, such as ethnicity. In addition, methodological and statistical issues (e.g., using more contemporary statistical techniques, taking into account the measurement scale of key outcomes, addressing incomplete data) have hindered making more conclusive statements regarding causality.

Hawaiian High Schools Health Survey (HHSHS) Study

The Hawaiian High Schools Health Survey (HHSHS) Study presents a unique opportunity to study the relationship between affect and academic achievement, and more specifically, between depressive symptoms and GPA. The HHSHS was conducted by the National Center on Indigenous Hawaiian Behavioral Health (NCIHBH; formally the Native Hawaiian Mental Health Research Development Program [NHMHRDP]). Of the approximately 1.2 million people residing in Hawai‘i, 19.8% are of Native Hawaiian ancestry when considering all full- and part-Native Hawaiians (typically referred to as being “Native Hawaiian” or “Hawaiian”) (U.S. Census, 2000).

The background to the NCIHBH and HHSHS involves the significantly adverse health impact that Native Hawaiians—the indigenous people of the Hawaiian islands—have experienced due to Western contact (e.g., Blaisdell, 1993). For example, of the major ethnic groups in Hawai‘i, Native Hawaiians have the shortest life-expectancy (Park, Braun, Horiuchi, Tottori, & Onaka, 2009). Results from a variety of sources indicate that Native Hawaiians are also more “at risk” for psychological difficulties than residents of Hawai‘i of other ethnic backgrounds (e.g., Andrade et al., 2006; Danko et al., 1988; Marsella, Oliveira, Plummer, & Crabbe, 1995; Werner & Smith, 1992; Yuen, Nahulu, Hishinuma, & Miyamoto, 2000). One of the aims of the HHSHS study was to assess the adjustment of a large community-based sample of adolescents of Native Hawaiian ancestry, as well as a comparison sample of adolescents from other ancestral groups (e.g., Asian American, other Pacific Islander, European American).

The HHSHS consists of a battery of self-reported measures that assess demographic, academic, cultural, and psycho-social adjustment variables. Included in this battery are a variety of well-known psychometric instruments, including one that measures depressive symptoms (i.e., CESD; see Radloff, 1977; Zimmerman & Coryell, 1994) and another that measures self-reported GPA. The CESD has particular scientific and clinical importance in its prediction of Diagnostic Interview Schedule for Children (DISC) major depressive disorder for this sample (Prescott et al., 1998). The HHSHS was administered from the 1991–1992 to 1995–1996 school years for Grades 9–12 with up to five participating schools on three Hawaiian islands. Therefore, this study includes a large sample ($N = 7,317$) of longitudinal data on both depressive symptoms and self-reported GPA across multiple years and grade levels for the critical adolescent period of high school (primarily 14–18 year olds).

Using the HHSHS, the NCIHBH conducted preliminary analyses involving depressive symptoms and self-reported GPA. A statistically significant and negative relationship of −.18 ($p < .05$; Hishinuma et al., 2006; Hishinuma, Foster et al., 2001) was obtained. This negative association remained significant even when controlling for other demographic variables (i.e., ethnicity, gender, grade level, main wage earners’ educational attainment, main wage earners’ employment status) and academic measures (i.e., actual cumulative GPA, absolute difference between self-reported GPA and cumulative GPA).

In addition, Native Hawaiian adolescents tend to have lower levels of Western achievement (e.g., GPA) than non-Hawaiians in Hawai‘i (e.g., Hishinuma, Johnson et al., 2001), and correspondingly higher levels of depressive symptoms (e.g., McArdle, Johnson et al., 2001). However, Native Hawaiian youth also have higher levels of protective factors, including family support (Goebert et al., 2000), which may “buffer” between academic achievement and depressive symptoms (Chen et al., 1995). Further, for the HHSHS sample, females have higher levels of depressive symptoms than males (McArdle, Johnson et al., 2001), consistent with the literature (Rudolph, 2009).

Methodological and Statistical Issues

Despite the progress made thus far, more definitive conclusions regarding the causal relationship between depressive symptoms and GPA could not be made because of the methodological procedures and designs and statistical techniques of previous research. Past studies either did not include longitudinal data of both depressive symptoms and GPA across at least two time periods (resulting in incomplete cross-lag models) and/or lacked analyses using more contemporary SEM growth and trajectory modeling (e.g., Hong, Veach, & Lawrenz, 2005; Johnson et al., 2006; Juvonen et al., 2000; Lehtinen et al., 2006; Repetto et al., 2004; Shahar et al., 2006).

Overall, the sample sizes of previous investigations were relatively small, which not only decreased the statistical power (thus perhaps increasing Type II errors), but also consequently limited the use of complex SEMs (Juvonen et al., 2000).

Prior studies did not substantially address incomplete ("missing") data (e.g., Repetto et al., 2004)—in some cases due to the limitations of the statistical software program being utilized (e.g., EQS Version 5.7 for SEM; Juvonen et al., 2000).

Aside from Juvonen et al. (2000), who addressed the non-normal distribution of key outcome variables by using the maximum likelihood "robust" method, past research did not more substantively address the assumptions of parametric tests by examining the measurement scale of the key variables as part of the data analysis plan, even though it is known that scaling of measurements is critical to understanding lead-lag relationships.

Further, not all previous research examined the effects of important demographic variables, such as ethnicity, despite the potential for differential results based on these types of variables (e.g., Rudolph, 2009). Aside from Chen et al.'s (1995) study, previous investigations (e.g., Anderman, 2002) did not include a large proportion of under-researched Asian American and Pacific Islander adolescents, let alone disaggregate this population despite the documented heterogeneity of these different ancestries. This minority population is proportionately one of the fastest growing in the U.S. (e.g., Barringer, Gardner, & Levin, 1993; Day, 2010). Further, these types of minority-based research are increasingly important given that in 2008 nearly half (47%) of U.S. children younger than five years of age were minorities (U.S. Census, 2009), and that by 2042 the U.S. will no longer have a majority race (Frey, 2008).

Purposes

The purposes of the present study are two-fold: (1) to determine more conclusively whether depressive symptoms cause lower GPA, or vice versa, taking advantage of the HHSHS's methodology (e.g., longitudinal data) and using contemporary statistical techniques; and (2) to ascertain whether the causal relationship between depressive symptoms and GPA differs as a function of the important demographic variable of ethnicity (i.e., Native Hawaiian vs. non-Hawaiian).

Method

Participants

Participants were adolescents from the NCIHBH HHSHS Study who were part of a five-year longitudinal cohort study ($N = 7,317$) in Hawai'i (see Andrade et al., 1994, 2006). The 7,317 adolescents (N) completed a total of 12,284 surveys. Table 2 presents the sample size by school year, high school, and grade level for five years of data collection. These data

reflect a large sample of high school students in Hawai‘i, with over-sampling of Native Hawaiian youths.

We classified all students into one of four broad groups. Native Hawaiian versus non-Hawaiian ancestry was based on questions about the parents' ethnic background. Students whose parents had any Native Hawaiian ancestry were classified as "Hawaiians" and all others were classified as "non-Native Hawaiians." This type of classification is used in Hawai‘i given that the majority of Native Hawaiians are of mixed ancestry. A second grouping was based on the students' self-reported sex (as male or female). These two groupings led to four student group combinations: (1) Native Hawaiian Males (n = 1,456), (2) Non-Native Hawaiian Males (n = 881), (3) Native Hawaiian Females (n = 1,733), and (4) Non-Native Hawaiian Females (n = 973).

Procedures

Parents and students were given written notification of the nature and purpose of the research study prior to administration. Parents who did not wish their child to participate in the study returned a postcard. Students whose parents did not decline participation were presented with a formal assent on the day of the administration. Students who provided their assent were administered the survey in their homerooms by their teachers. This type of "passive consent" was approved at the time that the study was implemented (i.e., initiated in 1992). The majority of the surveys were completed by the students within 30–45 minutes. Based on the existing enrollments, approximately 60% of the students were surveyed. Separate analyses indicated that a higher proportion of males were not surveyed. In addition, those who were not surveyed had more absences, suspensions, and conduct infractions, and had lower actual GPAs (Andrade et al., 2006). All procedures were approved by the Institutional Review Board (Committee of Human Studies) of the University of Hawai‘i at Mānoa.

Measures

Self-Reported Grade-Point Average (GPA). This variable was operationally defined by a single survey question, "On the average, what were your grades on your last report card?" with 10 response choices offered. We reconstructed this GPA variable using numerical values (in parentheses): A (4.0), A− (3.7), B+ (3.3), B (3.0), B− (2.7), C+ (2.3), C (2.0), C− (1.7), "D or less" (1.0), or "Don't know" (converted to a missing score). This measurement of academic achievement demonstrated high concurrent validity with actual cumulative GPA in a sub-study of the same persons in one school year (r = .76; Hishinuma, Johnson et al., 2001) and construct validity with adjustment indicators (e.g., Carlton et al., 2006; Hishinuma, Foster et al., 2001; arrests/serious trouble with the law, Hishinuma et al., 2005; substance use, Hishinuma et al., 2006; Makini et al., 2001). It should be noted that for the present analysis, we did not use the actual GPA because this measure was available for only one school year of data collection, whereas the self-reported GPA was available for all five years of data collection.

Self-Reported Depression. In one section of the survey, all students were asked to rate their depressive symptoms using the well-known *Center for Epidemiological Studies-Depression* (CESD) inventory (see Radloff, 1977, 1991; Zimmerman & Coryell, 1994). In the standard scoring system, the 20 CESD items are scored on a 0-to-3 scale and these scores are summed over the 20 items to form a CESD total score ranging from 0 to 60 (see Santor & Coyne, 1997).

A practical scoring system for the CESD was created and used in our earlier work (in McArdle et al., 2001), and we expand upon this process here. The typical CESD item

responses are based on "the number of days per week," with four response categories: (1) "Rarely or none of the time (0–1 day)," (2) "Some or a little of the time (1–2 days)," (3) "A moderate amount of the time (3–4 days)," and (4) "Most or all of the time (5–7 days)." As an alternative to the 0–3 scale, it is also possible to simply alter the scale points to more directly reflect the average number of days per week for each symptom (therefore, 1 = 0.5 days; 2 = 1.5 days; 3 = 2.5 days; and 4 = 6 days).

The unidimensionality of the CESD items has been questioned in prior research (Allen & Astuto, 2009; Beals, Manson, Keane, & Dick, 1991; Dick, Beals, Keane, & Manson, 1994; Radloff, 1977, 1991). In our own work on this topic (McArdle et al., 2001; Prescott et al., 1998), we found that two or more common factors were needed to account for all interrelationships among the CESD items. In these analyses, the first common factor in the three-factor solution was indicated by the most items (13) and these items reflected the basic construct of depression. The other two factors were "Happy" (Radloff, 1991; or "Negative Affect" when reverse scored; see Prescott et al., 1998) and "Interpersonal" (Prescott et al., 1998; Radloff, 1991). In order to utilize a more homogeneous measure of depressive symptoms, we used the 13-item subscale as an indicator of the basic construct of depression, rather than either of the other two subscales alone or in combination. Therefore, we considered only these 13 items here (i.e., Items 1, 2, 3, 5, 6, 9, 10, 11, 13, 14, 17, 18, & 20). To simplify the overall scaling, but retain the individual differences across time in these scores, we first (1) altered all items to be in the metric of days per week, then (2) averaged over the responses to the unidimensional items (13 out of 20), and finally (3) rounded the resulting averages into six reasonably sized categories of days per week (i.e., weekly [WCESD]; average days per week = 0–1, 1–2, 2–3, 3–4, 4–5, and 5–7). Incomplete data were not placed in any specific category. The first category (0–1 days) included over 64% of the responses, while the last category (5–7 days) included less than 0.5% of responses within any year. Although the skew seemed rather severe, it was likely a reflection of the construct of depressive symptoms (i.e., most youth do not have many depressive symptoms in a given week).

Data Analyses

The HHSHS's large sample size and multiple repeated measures of both constructs through adolescents provided the opportunity to apply sophisticated statistical techniques. Contemporary longitudinal dynamic structural equation models (DSEMs; Ferrer & McArdle, 2010; McArdle, 2009; McArdle & Nesselroade, 2003; Singer & Willett, 2003) were used to analyze the bivariate relationship between depressive symptoms and self-reported GPAs. These models are practically useful because they encompass the popular latent growth models and autoregressive time series models. Examination of the "coupling" effects allowed for causal inferences to be made between Variable 1 in Time 1 leading to Time-1-to-Time-2 changes in Variable 2, as well as Variable 2 in Time 1 leading to Time-1-to-Time-2 changes in Variable 1.

Group differences based on the four gender-ethnicity group combinations were compared in order to determine the accuracy, size, and direction of the dynamic relationships for each group. Two types of group comparisons were conducted: (1) four separate-group analyses corresponding to the four different gender-ethnicity groups; and (2) simultaneous multiple-group analysis. By including ethnicity (i.e., Native Hawaiian vs. Non-Hawaiian), we addressed cross-cultural issues regarding the potential causal relationship between depressive symptoms and GPA. Finally, we examined whether the findings varied dependent upon the grade level intervals.

It is typical in past research to omit data from participants who do not have complete data. To decrease the bias introduced when only complete data are utilized, we included all

longitudinal and cross-sectional data, including incomplete data. These procedures provided the best estimate of the parameters of change *as if everyone had continued to participate* (Diggle, Liang, & Zeger, 1994; Little, 1995; McArdle & Anderson, 1990; McArdle & Bell, 2000; McArdle & Hamagami, 1991; McArdle, Prescott, Hamagami, & Horn, 1998). Contemporary techniques of imputation of incomplete data were applied (maximum likelihood estimates, missing at random [MLE-MAR]; Little & Rubin, 1987; McArdle & Hamagami, 1992). The previous HHSHS analyses described the use of a multiple imputation procedure for handling incomplete data (McArdle et al, 2001). This approach is reasonable for data missing within or over time, and it can be used when the incompleteness is due to attrition and other factors and the lack of data are considered *missing at random* (MAR; after Little & Rubin, 1987). In the case of the present study, the large *majority* of the missing data was due not to systematic biases of concern (e.g., attrition), but instead, due to our sampling strategy with the goal of over-sampling Native Hawaiians and obtaining data from Grades 9–12 for certain cohorts (see Table 2).[1] In computational terms, the available information for any participant on any data point (i.e., any variable at any occasion) is used to build up *maximum likelihood estimates* (MLEs) that optimize the model parameters with respect to any available data.

We addressed violations of parametric-test assumptions (i.e., skewed distribution of interval scales) by treating the key outcomes as ordinal in measurement scale (Muthén & Muthén, 2006; Hamagami, 1998), the latter providing a stronger pattern of influence resulting in greater confidence in the findings.[2]

Detailed explanation and results of these analyses were beyond the more clinical and applied scope of the present article, but can be found in McArdle, Hamagami, Hishinuma, and Chang (2011).

[1]The HHSHS data used here are based on a complex sampling strategy highlighted in Table 2. This survey was conducted for the first three years of the study (1991–1992 to 1993–1994 school years) and for all high school grade levels (9^{th}–12^{th}). During Year 1 (1991–1992), the decision was made to also survey in Year 2 (1992–1993) students from two other high schools (High Schools 4–5) that would allow for more meaningful comparisons with a large non-Hawaiian adolescent cohort group. As with High Schools 1–3, students from High Schools 4–5 were surveyed for all high school grade levels (9^{th}–12^{th}) in Years 2–3 (1992–1993 & 1993–1994). In order to obtain complete longitudinal data across all four grade levels for the 9^{th} graders who were surveyed in Year 1 (1991–1992) for High Schools 1–3, and for the 9^{th} graders who were surveyed in Year 2 (1992–1993) for High Schools 4–5, the decision was made to: (a) in Year 4 (1994–1995) survey the 12^{th} graders from High Schools 1–3, and (b) in Year 4 (1994–1995), survey 11^{th} and 12^{th} graders from High Schools 4–5, and in Year 5 (1995–96) survey 12^{th} graders from High Schools 4–5. Among students who were in the 9^{th} grade, 3,644 (50.3%) never had an opportunity to take the survey, 2,938 (40.6%) took the survey, and 660 (9.1%) had the opportunity to take the survey, but did not for whatever reason (e.g., parent declined, student declined, student moved to another school). Seventy-five participants were not included in the previous count due to anomalies such as repeating a grade level. For the 10^{th} grade: 3,286 (45.4%) never had the opportunity to take the survey, 2,707 (37.4%) took the survey, 1,249 (17.3%) had the opportunity to take the survey, but did not for whatever reason; for the 11^{th} grade: 2,685 (37.1%), 2,984 (41.2%), 1,573 (21.7%), respectively; and for 12^{th} grade: 1,822 (25.2%), 3,498 (48.3%), 1,922 (26.5%) respectively.

[2]To carry out calculations for the ordinal approach, we rely on the approach created by Muthén for LISCOMP software (see Muthén & Satorra, 1995). In this approach, the first step is to use MLE-MAR to estimate the empirical distance between each entry of a categorical variable. Since we have 9 possible ratings of GPA at each occasion, we can estimate 8 thresholds describing the difference between these categories. Since we have only 6 possible categories of WCESD, we estimate 5 thresholds to describe the difference among these categories. In the second step, we assume the underlying latent variables are normally distributed (with mean 0 and variance 1) and we estimate the correlations among latent variables using polychoric procedures. Finally, in a third step, a consistent estimator of the asymptotic covariance matrix of the latent correlations is based on a *Weighted Least Squares Mean* (WLSM) *Adjusted* estimator. Additional model assumptions based on the structure of the thresholds (i.e., invariant over time) or the model correlations (following a latent curve hypothesis) are added and the comparative goodness of fit is obtained. We contend that this ordinal approach is more appropriate and accurate in addressing skewed distributions than the traditional transformational approach because the latter does not take into account the exact unequal distances between measurement values.

Results

Longitudinal Bivariate Dynamic Latent Change Models

Figure 1 presents the longitudinal bivariate dynamic latent change model being tested. Conceptually, a bivariate dynamic model can be used to relate the latent scores from one variable to another over time. More formally, we first assume we have observed both sets of scores $Y[t]$ and $X[t]$ measured over a defined interval of time (Δt), but we assume the latent variables are defined over an equal interval of time ($\Delta t = 1$). The g_1 and h_1 are the latent slope scores, which are constant over time, and the changes are based on additive parameters (α_y and α_x), self-feedback parameters (β_y and β_x), and *coupling* parameters (γ_{yx} and γ_{xy}). The coupling parameter (γ_{yx}) represents the time-dependent effect of latent $x[t]$ on $\Delta y[t]$, and the other coupling parameter (γ_{xy}) represents the time-dependent effect of latent $y[t]$ on $\Delta x[t]$. These latent change score models allow a family of fairly complex nonlinear trajectory equations (e.g., non-homogeneous equations).

Table 3 presents the results of the SEM parameter estimates for the dynamic system where GPA and WCESD are allowed to impact the trajectory of each other over Grades 9th to 12th based on the full bivariate dynamic path diagram of Figure 1. This use of a latent variable measurement model for GPA and WCESD requires some kinds of identification constraints and we employ $\mu_0 = 0$ and $\sigma_0^2 = 1$, for both variables. When the dynamic model is estimated for these ordinal latent variables, the impact of GPA on the changes in WCESD is clearly negligible ($\gamma = -0.07$, $t < |-1|$); however, the impact of WCESD on changes in GPA is statistically significant and large ($\gamma = -2.17$, $t > |-2.5|$). The fits listed show models where: (a) overall model fits the data well ($\chi^2 = 83$ on $df = 50$, $\varepsilon = .009$), (b) GPA → WCESD coupling set to zero fits just as well ($\chi^2 = 82$ on $df = 51$, $\varepsilon = .009$), (c) WCESD → GPA coupling set to zero does not fit as well ($\chi^2 = 113$ on $df = 51$, $\varepsilon = .013$), and (d) both couplings set to zero does not fit either ($\chi^2 = 111$ on $df = 52$, $\varepsilon = .013$). In addition, a model where we assume no cross-lagged impacts at all (i.e., a "parallel process" model) leads to a substantial loss of fit ($\chi^2 = 191$, on $df = 54$, $\varepsilon = .019$) and a model assuming no slopes at all (i.e., a standard cross-lagged regression) is even worse ($\chi^2 = 1{,}172$ on $df = 59$, $\varepsilon = .060$). Therefore, there seems to be directional dynamic influences operating—the direction of impacts accumulated over all grade levels suggests that WCESD → GPA and not the other way around.

Gender-Ethnicity Group Differences in Bivariate Dynamic Latent Change Models

Table 4 presents the results based on the four gender-ethnicity group combinations: Male Native Hawaiians, Male Non-Hawaiians, Female Native Hawaiians, and Female Non-Hawaiians. In essence, we ask, "Do the dynamics operate the same way in each sub-group?" One practical way to examine this form of invariance is to split up the data into different groups, allow the dynamics to differ, and see whether these relaxed assumptions improve the model fit substantially (for details, see McArdle, 2009; McArdle & Hamagami, 1996),

For all four groups, the status of WCESD dictates how both WCESD and GPA change. WCESD alone seems to decline itself, while GPA is negatively influenced by the status of depressive symptoms. The significant negative coupling of WCESD on change scores of GPA intimates that a change in GPA is solely based on the previous state of WCESD. The higher the depressive state at the current state, the larger the decrease in GPA.

Using a simultaneous multiple-group approach, we started with the separate models of Table 4 and added invariance constraints on dynamical parameters to the four-group model with Non-Hawaiian as a reference group. By evaluating a fit difference between the constrained model versus the invariance model*, relatively speaking*, we found gender-ethnicity group differences—that is, dynamic processes of change in GPA and that in depressive symptoms

were not the same across four groups. For the Native Hawaiian males, Native Hawaiian females, and Non-Hawaiian males, depressive symptoms appeared to cause a negative impact on GPA, with the possibility that for Non-Hawaiian males, higher GPA may also lead to a decline in depressive symptoms. For Non-Hawaiian females, both coupling parameters were statistically non-significant, indicating that a negative coupling effect of depressive symptoms on change in GPA was not strong. Some differences in parameter estimates were expected between separate group modeling and simultaneous multiple-group modeling because in multiple-group modeling, we need to impose equality constraints on threshold parameters for both CES-D and GPA repeated measures that allows us to compare targeted dynamical parameters across groups, whereas equality constraints on these threshold parameters are not imposed for four separate models.

Different Grade-Level Intervals

Finally, to double check our within-time equality constraints (on βs and γs), we examined the equality of dynamic constraints over time. In the previous models listed above, we required the same dynamic result to appear over every time interval from 9^{th} to 10^{th}, 10^{th} to 11^{th}, and 11^{th} to 12^{th}. In these final analyses, we relaxed these dynamic assumptions, examined the groups as a whole, and within each separate sub-group, and we basically found no evidence for differential dynamics over grade level or time.

Discussion

The main substantive question posed in this study was, “Do depressive symptoms cause lower GPAs or do lower GPAs cause depressive symptoms?” The collective results suggested that depressive symptoms cause lower GPAs, and not the other way around. In addition, this finding was found for each of the four gender-ethnicity groups (i.e., Native Hawaiian males, non-Hawaiians males, Native Hawaiian females, and non-Hawaiian females), with relatively stronger effects for all but the Non-Hawaiian female group. Further, the findings were consistent across different grade-level intervals (i.e., 9^{th} to 10^{th}, 10^{th} to 11^{th}, & 11^{th} to 12^{th}).

Although answering the question of causation would have been more parsimoniously addressed through a randomized experimental-control design (as in McArdle & Prindle, 2008), ethical considerations preclude such a research endeavor here. To our knowledge, this is the first study of its kind that included: (a) the application of advanced contemporary statistical techniques (i.e., longitudinal linear dynamic change models, treatment of key outcomes as ordinal, imputation of incomplete data); (b) a cohort sequential data set that included measures of both depressive symptoms and GPA across multiple years to allow for complete cross-lag modeling; (c) a large sample size that provided ample statistical power to allow for multi-group SEMs; and (d) a determination of whether the findings were applicable across different genderethnic group combinations and different grade-level intervals, including utilizing an under-researched ethnic group of Native Hawaiian and non-Hawaiian adolescents residing in Hawai‘i’s diverse Asian American and Pacific Islander culture.

Implications

The results of the present study indicate that depressive symptoms precede changes in GPA, and thus serve as a potential cause of GPA, but not vice versa. This advances our science of theories of adolescent depressive symptoms and depression by explicating an often under-developed theory of the link between depressive symptoms and academic achievement. Although cognitive, cognitive-behavioral, interpersonal, psycho-social, and contextual theories (e.g., Rudolph, 2009) are able to explain the causal depressive symptom-GPA

relationship by hypothesizing a direct relationship (i.e., D → GPA) and/or a mediated third-variable mechanism (i.e., D → V3 → GPA), caution is noted given that such hypotheses are largely done on an *ad hoc* basis (i.e., explaining the phenomenon after the fact). Therefore, it is important to both theorize potential mediators and test them systematically using contemporary methodological-statistical techniques. Based on previous research, such mediators could include concentration difficulty (Kovacs & Goldston, 1991), homework decline (Field et al., 2001), self-criticism (especially for boys, Shahar et al., 2006), and substance use (Diego et al., 2003; Field et al., 2001). Extrapolating from broader theories of adolescent depressive symptoms and depression, other potential mediators could include: helplessness or hopelessness, negative belief systems, maladaptive information processing, poor coping skills, social skills deficits, negative interpersonal interactions, and stress generation (for reviews, see Abela & Hankin, 2008; Birmaher et al., 1996; Lewinsohn et al., 1994; Reynolds & Johnson, 1994; Rudolph, 2009).

On an applied level, given that depressive symptoms are the antecedent conditions for lower GPA, preventing depressive symptoms is paramount because this will have the potential to not only decrease the human toll due to depressive symptoms and perhaps major depressive disorder, but will also have the potential to decrease the risk of subsequent lower GPAs. Unfortunately, the majority of the scientific literature focuses on the epidemiology, identification, and treatment of depressive symptoms and disorders rather than on primary prevention and early intervention per se (e.g., McWhinnie, Abela, Hilmy, & Ferrer, 2008; Shochet & Hoge, 2009; Spence, 2008, 2009). Additional challenges include developing and implementing universal prevention programs that are not only effective, but also sustainable (Shochet & Hoge, 2009; Spence, 2009). However, research specific to depressive symptoms has identified precursors to depressive symptoms (e.g., child abuse & neglect, Harkness & Lumley, 2008; peer harassment & self-blaming, Juvonen et al., 2000) that could serve as starting points to prevent depressive symptoms from occurring in the first place. In addition, more recently, the field has been studying adolescent depression prevention programs and their effectiveness with promising results (e.g., Gillham, Brunwasser, & Freres, 2008; McWhinnie et al., 2008; Shochet & Hoge, 2009; Spence, 2008)

Emphasis must also be made on screening, identification, and treatment of depressive symptoms and disorders, not only to ameliorate the ill-effects of depressive symptoms, but to also potentially prevent lower GPAs. Given the biological and psycho-social nature of such assessments and interventions, a more multidisciplinary approach will be needed (e.g., educators, mental health providers; Shahar et al., 2006). This will be challenging because parents and teachers tend to have an easier time identifying externalizing symptoms and disorders (e.g., conduct disorder) than internalizing symptoms and disorders (e.g., depression, anxiety) (Jensen, Traylor, Xenakis, & Harris, 1988). Accurate screening and identification of depressive symptoms and disorders, and effective treatment should then lead to preventive interventions that minimize decreases in GPA performance.

At the very least, decreases in GPA, especially dramatic ones, should be potential markers to educators, school counselors, and parents that youth experiencing such GPA declines may already be experiencing affective difficulties, including depressive symptoms and disorders.

The present study was one of the few that examined depressive symptoms and longitudinal data on minorities (Allen & Astuto, 2009). The results from the present study indicated that for both the Native Hawaiian male and female groups, the negative impact of depression on GPA was stronger as compared to the non-Hawaiian female group. One plausible reason for this finding may be that while Native Hawaiian youths tend to have more protective factors, such as family support, as compared to non-Hawaiians (e.g., Goebert et al., 2000), perhaps Native Hawaiian youths with higher levels of depressive symptoms have not only decreased

protective and resiliency factors, but also increased risk factors, beyond that of non-Hawaiians. Regardless, this finding suggests that prevention interventions, screening and identification, and treatment of depressive symptoms are particularly important for Native Hawaiian youth. Additionally, culturally sensitive and culturally responsive efforts may be needed to increase access, utilization, and compliance to effective interventions. Such efforts will not only decrease the human toll caused by depressive symptoms on Native Hawaiian adolescents, but also have the potential to prevent future decreases in academic achievement. In addition to further research on Native Hawaiian youth, investigations are needed on other ethnic groups to determine whether similar findings occur, especially for non-Asian American/Pacific Islander youth.

Together, the approaches of prevention and intervention will decrease the morbidity and mortality associated with both depressive symptoms and poor academic performance at a critical point in adolescents' lives. Such efforts may make the difference between a youth having positive attributions, high academic achievement, and a healthy mental health pathway, versus another adolescent having perpetually negative attributions, poor educational performance (e.g., dropping out of high school), and a distinctly unhealthy mental health future (e.g., stress, comorbidity, suicidality).

From a methodological-statistical perspective, the present study applied rigorous contemporary methods and procedures with the goal of ascertaining the most accurate estimated results and subsequent conclusions. This study highlighted the importance of the collection of and availability to large databases with key outcomes measured across multiple time periods contrasted by demographic variables. Future research must take advantage of longitudinal designs in investigating the developmental aspects of depressive symptoms (e.g., Abela & Hankins, 2008) and achievement. In addition, the methodological-statistical procedures utilized in the present investigation may serve as a prototype for similar research endeavors that involve "real-life" design and data collection issues (e.g., non-randomized methods, incomplete data, skewed distributions), including with other commonly used instruments (e.g., Beck Depression Inventory-II, Beck, Steer, & Brown, 1996; State-Trait Anxiety Inventory, Spielberger, 1983).

Limitations

As indicated in the Procedures section, we know that the participation rate was lower for males and for those who had greater levels of at-risk behaviors (i.e., absences, truancies, suspensions, conduct infractions, lower GPA). Unfortunately, we do not know the participation rate broken down for the four gender-ethnicity group combinations. Although the overall participation rate of 60% was relatively high (Esbensen, Miller, Taylor, He, & Freng, 1999), especially for a minority adolescent population, the potential effects of this type of sample bias should be considered when interpreting the findings and implications.

There were no other measured variables defined in this analytic system, although surely there are other sources to the changes in both GPA and CESD (Hishinuma, Foster et al., 2001). For example, it is likely that other sources of individual differences (e.g., social support; Goebert et al., 2000) are responsible for additional influences. However, many potentially important constructs were not measured the same way across the five waves of data collection. Unfortunately, one of these constructs was Hawaiian cultural identification (Hishinuma et al., 2000), which was measured differently across the five school years. Future research should incorporate these types of variables into the model (Allen & Astuto, 2009) to determine their impact upon the depressive symptom-GPA causal link. Finally, the group-difference models attempted to account for only observed group differences in gender and ethnicity, and it is likely that latent sub-groups or classes of similar groups of adolescents were involved (see Flahrety, 2008; McArdle & Prindle, 2008; Van Horn, et al.,

2009). It is possible for example, to isolate groups of adolescents for whom GPA → ΔDepressive symptoms. This might be particularly the case for students and families for whom education is a prominent issue (e.g., students with learning disabilities; Weinberg & Rehmet, 1983) and for whom personal significance is placed on their GPA and may be dissatisfied with poor academic performance (Lehtinen et al., 2006; Pelkonen, Marttunen, & Aro, 2003). For all of these reasons, the substantive results presented may not replicate in further analyses of specific sub-groups.

The present study utilized CESD Factor 1 (negative affect), consisting of 13 negatively worded items (e.g., “I felt depressed”). Further research is needed on other concepts of depressive symptoms, major depressive disorder, and dysthymia, including CESD Factor 2 (positive affect; e.g., “I was happy”) and Factor 3 (interpersonal; “I felt that people dislike me”). Different results and conclusions may result, including when examining gender and ethnicity, given that females and males may differ in attributes associated major depressive disorder (e.g., Bennett, Ambrosini, Kudes, Metz, & Rabinovich, 2005).

There are limitations of the modeling approach used here. Some of these are based on the current analyses and some based on the available data. The statistical model used is fairly flexible, but it still presumes invariance at several levels largely because parameter identification becomes much more difficult when more complexity is added. The results presented here did not fully evaluate the assumptions of an invariant over-grade measurement model, and these assumptions are worth examining in more detail. In addition, for example, in all the DSEMs fitted here, we assumed a dynamic process that takes the same amount of time no matter what pair of grade levels we were considering. We recognize that it is possible that more changes occur between some grade levels (i.e., Grades 9 & 10) than between others (i.e., Grades 10 & 11), or that the changes between longer times are not a simple accumulation (i.e., Grades 9 to 11 is a function of the other times).

The data we used were somewhat limited as well. For example, the assumption of invariance over different patterns of incomplete data is likely to be incorrect to some degree and we know that specific forms of self-selection effects can lead to parameter bias (see McArdle & Hamagami, 1992). However, as stated prior, the majority of the missing data were not due to biases of theoretical concern, but due to the sampling strategy (i.e., over-sampling of Native Hawaiian adolescents, assuring certain cohorts will have data for all four grade levels).

Conclusion

The present study found evidence for depressive symptoms preceding and causing subsequent decreases in high school academic achievement in the form of GPA, with this phenomenon being more pronounced for Native Hawaiian adolescents as compared to non-Hawaiian female youth. For ethical reasons, a randomized experimental-control design could not be used; instead, contemporary methodological-statistical procedures were used, including applying longitudinal dynamic change modeling, using all data including incomplete data, and treating key outcomes accurately based on an ordinal scale. The major implications of the results indicate that further theorizing and research are needed on mediating variables, and the potential importance of increased effort in prevention, early intervention, screening, identification, and treatment of depressive symptoms and disorders to decrease the morbidity and mortality of both depressive symptoms and lower academic achievement in the form of GPA. Particular focus should be made on supporting Native Hawaiian youth in light of the stronger adverse effects of depressive symptoms on GPA. This effort should include culturally appropriate interventions.

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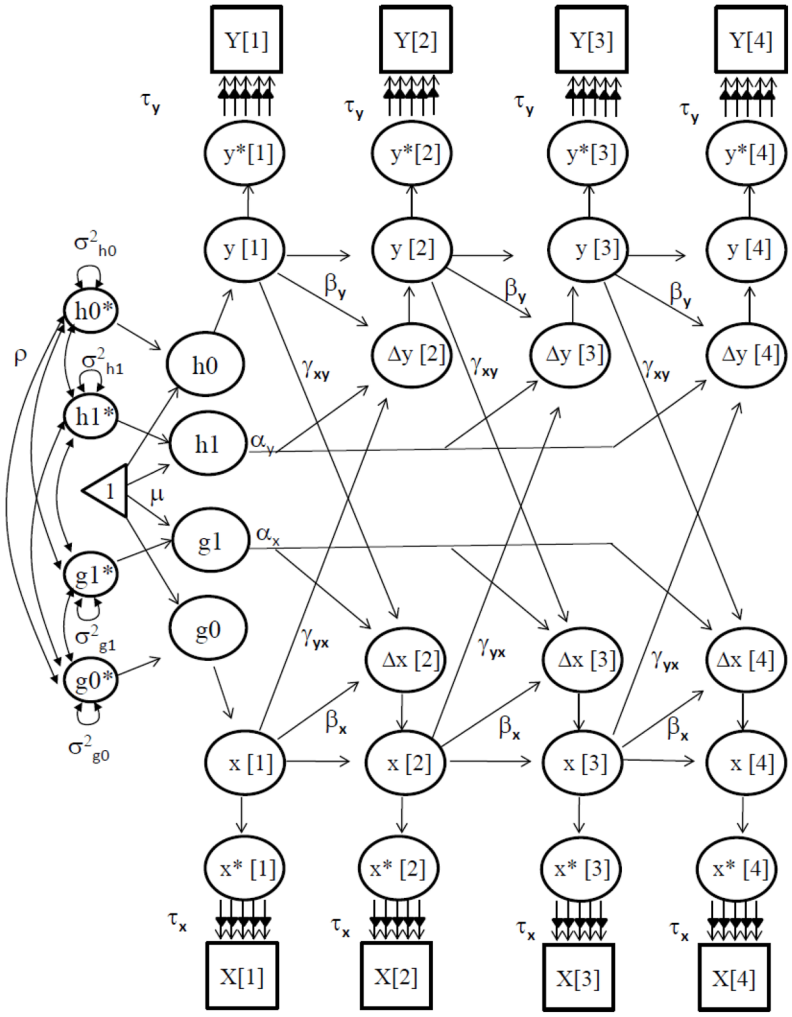

Figure 1.

A bivariate dual change score model for categorical response variables over grade-level in two measured variables (*Y* and *X*). Notes: α_y and α_x represent constant change related to the slope factors y_s and x_s; β_y and β_x represent proportional change in *Y* and *X*; cross-trait coupling is indicated by γ_{yx} and γ_{xy}. g_1 and h_1 are the latent slope scores that are constant over time, and the changes are based on additive parameters (α_y and α_x), self-feedback parameters (β_y and β_x), and *coupling* parameters (γ_{yx} and γ_{xy}). Δx and Δy indicate latent change scores of *X* and *Y*, respectively. τ_x and τ_y indicate the thresholds for *X* and *Y*, respectively. Error variance (ψ^2) is assumed to be constant at each grade level within each factor. The model includes estimates for intercepts (y_0 and x_0), mean intercepts (μ_{y0} and μ_{x0}), and mean slopes (μ_{y1} and μ_{x1}). Other parameters are used to generate the decomposition of the correlation between the intercept and slope for *X* and *Y*. * indicates latent response strength that is estimated based on ordinal response variables.

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Table 1

Brief Summary of Published Literature on Academic Achievement and Depressive Symptoms

Study	*r*	*p*	Academic Achievement Measure	Depressive Symptom Measure	Sample	Notes
Bos, Sandfort, De Bruyn, & Hakvoort (2008)	.05	Non-significant	GPA (in Dutch, English, biology, & math)	General Health Questionnaire (14 items)	*N* = 866 (479 boys, 387 girls), mean of 13.6 years old, 77.6% Dutch	
Zimmerman, Caldwell, & Bernat (2002)	−.03	Non-significant	Actual GPA	Brief Symptom Index	*N* = 591, 9th graders, African Americans	Selection of participant GPAs of 3.00 or less in 8th grade
Johnson, McGue, & Iacono, 2006	−.05	Non-significant	GPA (composed of multiple indicators of grade)	Diagnostic Interview for Children and Adolescence (DICA)	*N* = 824 (443 pairs of girls, 381 pairs of boys), Caucasians	
Hong, Veach, & Lawrenz (2005)	−.09 (boys) −.10 (girls)	< .05	Self-reported GPA (what grades are mostly like)	Hopkins Symptom Checklist-25 (short version)	*N* = 1,672, Taiwanese, 10th & 11th graders, 2001–2002	Depression was combined with anxiety, translated into Chinese
Zimmerman, Caldwell, & Bernat (2002)	−.10	< .05	Self-reported GPA	Brief Symptom Index	*N* = 591, 9th graders, African Americans	Participants restricted GPAs of 3.00 or less in 8th grade
Anderman (2002)	−.16	< .01	A=1, B=2, C=3, D or lower = 4; reverse scored	9-item scale	*N* = 20,745, multi-ethnic	From the National Longitudinal Study of Adolescent Health
Roeser & Eccles (1998)	−.09 (Time 1) −.27 (Time 2)	< .01 < .01	A=5, B=4, C=3, D=2, Failing=1 (in core subjects)	Symptom Checklist-90-R (SCL-90-R) (at Time 1) Children's Depression Inventory (CDI) (at Time 2)	*N* = 1,046, 7th & 8th graders, African Americans and Euro-Americans	From the MacArthur Network on Successful Adolescent Development in High Risk Settings
Hishinuma, Foster et al. (2006)	−.18	< .05	Self-reported GPA	Center for Epidemiological Studies-Depression (CES-D) Inventory	*N* = 1,250, 9th–12th graders, Asian Americans, Pacific Islanders	From the National Center on Indigenous Hawaiian Behavioral Health (NCIHBH)
Shahar, Henrich, Winokur, Blatt, Kuperminc, & Leadbeater (2006)	−.27	< .01	Actual GPA (0 = F, 12 = A+)	Beck Depression Inventory (BDI)	*N* = 499, middle school, multi-ethnic, 1995–1996	
Chen, Rubin, & Li (1995)	−.29 −31	< .001 < .001	Chinese language achievement Mathematics	Children's Depression Inventory	*N = 210*	

Study	*r*	*p*	Academic Achievement Measure	Depressive Symptom Measure	Sample	Notes
Gilman & Anderman (2006)	−.35	< .01	Self-reported GPA (mean across years)	Depression from Behavioral Assessment System for Children-2nd ed. (BASC-2)	*N* = 654, 9th graders, spring 2005, primarily Caucasian	
Juvonen, Nishina, & Graham (2000)	−.36	< .001	Actual GPA (spring report card)	Children's Depression Inventory (CDI)	*N* = 243, middle school students, multi-ethnic	

Note:

GPA = grade-point average.

The results from four studies are not reported above because the studies did not provide the correlation between depressive symptoms and GPA. Lehtinen, Raikkonen, Heinonen, Raitakari, & Keltikangas-Jarvinen (2006) reported *t/F* values separate for boys versus girls. Field, Diego, and Sanders (2001), Pelkonen, Marttunen, and Aro (2003), and Repetto, Caldwell, and Zimmerman (2004) contrasted different types of depressed groups on measures similar to GPA.

Table 2

Summary of Available Data in the Hawaiian High Schools Health Survey (HHSHS), Waves by School Year, High School, and Grade Level (N = 7,317; D=12,284 Surveys Completed)

		School Year					
		1	2	3	4	5	
High School	Grade Level	1991–92	1992–93	1993–94	1994–95	1995–96	Total
1	9th	103	70	100			273
	10th	88	82	76			246
	11th	75	70	84			229
	12th	75	47	66	71		259
	Incomplete *	0	0	1			1
2	9th	119	110	118			347
	10th	94	69	100			263
	11th	85	56	79			220
	12th	71	37	54	23		185
	Incomplete *	0	0	3			3
3	9th	354	364	290			1,008
	10th	315	335	326			976
	11th	293	319	297			909
	12th	318	304	298	296		1,216
	Incomplete *	0	2	3	1		6
4	9th		417	385			802
	10th		388	371			759
	11th		329	312	327		968
	12th		229	275	294	310	1,108
	Incomplete *		1	4	4		9
5	9th		265	288			553
	10th		243	244			487
	11th		251	220	221		692

		School Year					
		1	2	3	4	5	
High School	Grade Level	1991–92	1992–93	1993–94	1994–95	1995–96	Total
	12th		172	185	194	205	756
	Incomplete*		4	3	2		9
Total		1,990	4,164	4,182	1,433	515	12,284

*Students who did not provide their grade level within the survey.

Table 3

Dynamic Structural Equation Model (SEM) Results from a Bivariate Dual Change Score Model for Ordinal Scalings of Grade-Point Averages (GPAs) and Weekly Center for Epidemiologic Studies-Depression (WCESD) Scale, including Alternative Misfits

	Ordinal Scaling	
Parameters	**GPA**	**WCESD**
Fixed Effects		
Mean intercept, μ_0	=0 (=0)	=0 (=0)
Mean slope, μ_1	0.026 (1.00)	−0.052 (−2.34)
Constant change, α	=1	=1
Proportional change, β	−0.109 (0.27)	−0.010 (−0.02)
Coupling, γ GPA → WCESD	−0.074 (−0.37)	
Coupling, γ WCESD → GPA	−2.170 (−2.57)	
Scaling coefficients, T	−1.8, −1.4, −0.7, −0.3, 0.01, 0.6, 1.1, 1.7	0.5, 1.4, 2.0, 2.7, 3.6
Random Effects		
Intercept variance, σ_0^2	=1 (=0)	=1 (=0)
Slope variance, σ_1^2	4.58 (1.3)	0.01 (0.71)
Cova. Slope & Level, σ_{01}	−0.45 (−1.5)	−0.03 (−0.07)
Unique variance, ψ^2	0.43 (14.7)	0.81 (13.1)
Goodness-of-Fit		
“Dual Coupling” Misfit	82.6/50/0.009	
“No GPA→ WCESD”	82.0/51/0.009	
“No WCESD→ GPA”	113./51/0.013	
“No Couplings” Misfit	111./52/0.013	
“No Cross-Lags” Misfit	191./54/0.019	
“No Slopes” Misfit	1172./59/0.060	

Notes: “Dual” model sample size is N = 7,258 with 130 patterns of incomplete data; Ordinal ω4= .725, Not all model parameters are listed here.

Table 4

Full Information Maximum Likelihood Estimate-Missing at Random (MLE-MAR) Estimates of Dynamical Parameters (and t-values) Based on Four Separate Bivariate Latent Change Score Models with a Fixed Ordinal Measurement Model (Threshold Parameters based on Table 3)

	(a) Male Hawaiian (*n* = 2,531)	(b) Male Non-Hawaiian (*n* = 1,192)	(c) Female Hawaiian (*n* = 2,286)	(d) Female Non-Hawaiian (*n* = 1,184)
μ_{WCESD}	−.16 (−2.37)	−.10 (−1.20)	−.09 (−3.32)	−.11 (−1.07)
μ_{GPA}	.04 (1.50)	.08 (1.91)	−.02 (−0.40)	.002 (0.04)
β_{WCESD}	−.98 (−11.1)	−1.02 (−9.61)	−.86 (−3.79)	−.65 (−3.78)
β_{GPA}	.42 (1.09)	.26 (0.73)	−.07 (−0.18)	.25 (0.67)
$\gamma_{GPA \rightarrow WCESD}$	−.45 (−1.76)	−.22 (−0.77)	−.34 (−0.69)	.15 (0.33)
$\gamma_{WCESD \rightarrow GPA}$	−.72 (−2.72)	−.92 (−6.22)	−.99 (−7.24)	−.65 (−2.78)
χ^2	81	74	42	63
df	52	51[a]	52	50[b]
ε_a	.015	.014	.000	.015

Notes:

[a] indicates that there is no response in one category in WCESD, thus one less *df.*

[b] indicates that there is no response in the last category in WCESD in Grades 9 and 10, with the highest threshold parameter rendered un-estimable.

Variances of all slope components are fixed at 1.0 for simplicity.

ε_a = Root Mean Square Error of Approximation.