LONGITUDINAL ANALYSIS OF ADOLESCENT DEPRESSION:
APPLICATION OF LATENT GROWTH CURVE MODELS

by

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ABSTRACT

In order to assess changes in level of depression from middle-adolescence to young adulthood, the present study applied latent growth curve modeling (LGCM) analysis to Center for Epidemiologic Studies Depression (CES-D) scale responses from the National Longitudinal Study of Adolescent Health (Add Health). Sex, standardized age, and ethnicity were used as model predictors of initial level and rate of change of depressive symptoms. Item Response Theory (IRT) analyses conducted on each wave of Add Health CES-D responses validated scale reliability. LGCM results show that while females have a higher initial mean depression level, this difference lessens over time. African-American, Asian-American and Hispanic adolescents have higher initial depression levels than other ethnicities and maintain this disparity over time. All adolescents show a trend towards lower depression level over time, from adolescence to young adulthood.

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CHAPTER 1: INTRODUCTION

As currently diagnosed, clinical depression is a mental disorder that is characterized as a collection of affective and physiological symptoms of heightened severity and increased frequency, including “depressed mood, loss of interest, appetite or weight change, hyper- or insomnia, psychomotor agitation or retardation, fatigue, feelings of worthlessness or guilt, diminished ability to think or concentrate or indecisiveness, and suicidal ideation or thoughts of death” (Lux & Kendler, 2010). Depression has been officially considered by mental health professionals as a distinct clinical malady in the general population for several decades and human phenomenon for centuries (Davison, 2006). Though the treatment of melancholia dates back to the time of Hippocrates, modern, clinical recognition of depression as a mental illness was included in the first Diagnostic and Statistical Manual (Grob, 1991), where it still resides in the most recent incarnation, or DSM-V (Frances, 2010; Wong & Licinio, 2001). Recent epidemiologic estimates of depression in the general population cite 18.1% of adults (over the last 12 months) in the United States as being clinically depressed (Kessler, 2005). However, special population groups such as children and adolescents have been generally excluded from consideration in symptomology and measurement in favor of more specific psychological issues, such as Whitaker’s (1982) study of adolescent anorexia, Golub and Harrington’s (1981) study of gender-specific biological correlates, and Miller, Chiles, and Barnes’ (1982) study of suicidal ideation and delinquency.

Adolescent Depression

Growing concern for childhood and adolescent populations regarding the symptomology and diagnosis of depression resulted in re-examination of depression criteria and measurement in youth. Estimates of major depressive disorder (MDD) among adolescents have varied depending on cut-off criteria. Lewinsohn, Petit, Joiner, and Seeley (2003) reported 19% lifetime prevalence, with adolescent females almost twice as likely to report depression as males. Additionally, different adolescent ethnic populations have reported differing levels of depression prevalence (Roberts, Roberts, & Chen, 1997).

More recently, several general models have been surmised to encompass the causes, risks, and outcomes of major adolescent depression. These models include Compas and Grant's (1993) hierarchical-sequential-model of depressive symptoms, Brodbeck, Abbott, Goodyer, and Croudace's (2011) general-distress factor model, Brage and Meredith's (1994) exogenous-endogenous causal model, Hyde, Mezulis, and Abramson's (2008) ABC (affective, biological, cognitive) integrated model, and Clark and Watson's (1991) tripartite model of disorder in adolescent and child psychiatric inpatients**.**

Additionally, concerns over inter-relationships of risk-factors, general factors, and co-morbid dysfunction involved in adolescent depression have driven research towards understanding the interaction of these factors of depression. Diego, Field, and Sanders (2003) and Hawkins, Catalano, and Miller (1992) related drug-abuse to adolescent depression. Burk et al. (2011) found alcohol use and Escobedo, Reddy, and Giovino (1998) found cigarette smoking to be linked depression during adolescence. Depression has also been shown to have differential effects on adolescents of different ethnic backgrounds (Van Voorhees, Paunesku, Fogel, & Bell, 2009). Family contexts also play a pivotal role in adolescent depression, as Aseltine (1996) found adolescents who experience parental divorce are more likely to report depression. Adolescents who experience familial poverty also show greater propensity towards a depressive state (Sagrestano, Paikoff, Holmbeck, & Fendrich, 2003). Furthermore, depression has a strong association with other disorders, particularly those involving anxiety, as respectively reported by Feldman (1993), Gorman (1996), and Angold, Costello, and Erkanli (1999). Thus, construct discriminant validity has repeatedly been re-assessed in both diagnosis (Steer, Clark, Kumar, & Beck, 2008) and factor structure of measurement (Edman et al., 1999; Edwards, Cheavens, Heiy, & Cukrowicz, 2010; Weckowicz, Muir, & Cropley, 1967). Consequently, attention has also been turned towards differences in diagnosis and measurement given differences between adolescent depression and adult depression, with issues such as differences in interpretation of measurement items (Berndt, Schwartz, & Kaiser, 1983) and scale sensitivity in non-adult populations (Shean & Baldwin, 2008).

Lastly, longitudinal research has attempted to define adolescent depression trajectories regarding important factors and subsequent adult outcomes, including the longitudinal effects of adolescent depression and personality continuities (Caspi, 2000), general continuities of adolescent mood disorders into adulthood (Fichter, Kohlboeck, Quadflieg, Wyschkon, & Esser, 2009), ecological factors of longitudinal differences in depression (Gutman & Sameroff, 2004), adolescent depression and later adult alcoholism (Huurre et al., 2010), and the continuation of childhood and adult depression into adulthood (Reinherz, Paradis, Giaconia, Stashwick, & Fitzmaurice, 2003; Stoolmiller, Kim, & Capaldi, 2005). Additionally, modern statistical modeling techniques such as structural equation modeling (SEM) and modern measurement analysis of latent traits such as item response theory (IRT) are making substantiation and interpretation of complex latent trait models possible (Byrne, 2009; Edelen & Reeve, 2007). Particularly, longitudinal structural equation modeling, known as latent curve modeling, facilitates modeling of complex phenomena where change over time is important to understand (Byrne & Crombie, 2003).

Models for Adolescent Depression

Several prominent models of adolescent depression have been formulated, including Compas, Ey and Grant's (1993) hierarchical-sequential-model of depressive symptoms, Brodbeck, Abbott, Goodyer, and Croudace's (2011) general-distress factor model, Brage and Meredith's (1994) exogenous-endogenous causal model, Hyde, Mezulis, and Abramson's (2008) ABC (affective, biological, cognitive) integrated model, and Clark and Watson's (1991) tripartite model of disorder in adolescent and child psychiatric inpatients. The hierarchical-sequential model attempts to explain adolescent depression as a structural relay of three conceptual orientations (Compas et al., 1993). See Figure B1 for model illustration. Compas, Ey and Grant's model progresses from depressed mood to depressive syndrome (or collection of symptoms), with adolescent depression culminating in depressive disorder (or altering of normal function). Factors that affect depression are conceptualized as mediating phenomena among these three strata (Compas et al.). These factors are described as biological processes, stress processes, and coping processes, respectively describing the physiological characteristics of the adolescent, as well as the environmental factors, and cognitive characteristics (Compas et al.).

Another model, the general-distress factor model, is an attempt to create a combination of specific factors (first order factors: mood and social-cognitive symptoms of depression, worrying symptoms, and somatic and information-processing symptoms) that explicate the most variance in a second-order factor: a composite of anxiety and depression (Brodbeck et al., 2011). See Figure B2 for model illustration. Rather than try to parse acute psychological distress into compartments of depression and anxiety, this model asserts that disentangling commonly co-morbid constructs weakens the validity of both constructs, and thus must be considered as a single factor (Brodbeck et al.). However, this model is based on exploratory factor analysis and would be strengthened by a confirmatory follow-up analysis (Brodbeck et al.). Another attempt to explain adolescent depression, the exogenous-endogenous causal model of adolescent depression posits that exogenous variables such as family strengths, parent-adolescent communication, and endogenous variables such self-esteem, loneliness, age, and gender interact to determine depression in adolescents (Brage & Meredith, 1994). See Figure B3 for model illustration. Unfortunately, the causal relationship can only be tentatively interpreted, as this was a cross-sectional study (Brage & Meredith).

The ABC model (affective, biological, cognitive) of adolescent depression focuses on the differences between gender in early adolescence regarding emotional reactivity, genetic vulnerability, pubertal hormones, pubertal timing and development, cognitive style, objectified body consciousness, and rumination (Hyde et al., 2008). See Figure B4 for model illustration. These factors are aspects contributing to vulnerability to depression, which is triggered by negative experiences during adolescence (Hyde et al.). Both the appeal and the limitation of this model is that it only attempts to explain the differences between sexes in ages around the beginning of puberty and middle adolescence (Hyde et al.). A popular, modern adolescent depression model, the tripartite model of adolescent depression is similar to the general-distress model in that it jointly considers depression and anxiety, but differs in that it considers different contributing factors (Clark, Steer, & Beck, 1994; Clark & Watson, 1991; Joiner, Catanzaro, & Laurent, 1996). Essentially, severe adolescent affective distress is characterized as a three factor model (Negative Affectivity, Positive Affectivity, and Physiological Arousal), with depression (lack of positive affect, or anhedonia) and anxiety (physiological arousal) as separate constructs, and with negative affect (or general distress) representing aspects of both factors (Clark et al.; Clark & Watson; Joiner et al.). Given its elegance, the model has been tested for fit successfully several times in several populations, showing promising explanatory power over many reiterations, regardless of applications to differing gender (De Bolle, Decuyper, De Clercq, & De Fruyt, 2010) or ethnicity (Lambert, McCreary, Joiner, Schmidt, & Ialongo, 2004), childhood and adolescent cohorts (Jacques & Mash, 2004; Ollendick, Seligman, Goza, Byrd, & Singh, 2003; Turner & Barrett, 2003) or elderly cohorts (Teachman, Siedlecki, & Magee, 2007), or even the primarily anxiety-disordered (Joiner et al., 1999). Therefore, this model should be useful in further adolescent depression research.

Factors of Adolescent Depression

Risk factors and correlates of adolescent depression have been examined extensively, with common factors established among both the general adolescent population and among adolescent sub-populations. External predictors of depression are parental divorce (Aseltine, 1996), poor parental relationships (Field, Miguel, & Sanders, 2001; Sagrestano et al., 2003), low community social organization/support (Latkin & Curry, 2003), high stress (Daley, Hammen, & Rao, 2000), presence and degree of substance-abuse (C. B. Fleming, Mason, Mazza, Abbott, & Catalano, 2008; Hawkins et al., 1992). Internal predictors of adolescent depression include gender (Li, DiGiuseppe, & Froh, 2006), ethnicity via specific vulnerabilities (Van Voorhees et al., 2009), low self-esteem (Fleming & Offord, 1990; Hops, Lewisohn, & Roberts, 1990), propensity to internalize behavior problems (Lewinsohn et al., 1994), cognitive distortions or polarizing (Haley, Fine, Marriage, Moretti, & Freeman, 1985), social withdrawal (Lewinsohn et al., 2003), external locus of control (Lefkowitz & Tesiny, 1985), ruminative coping (Li et al.; Muris, Roelofs, Meesters, & Boomsma, 2004), high levels of anxiety (Gorman, 1996), and avoidant problem solving (Van Voorhees et al., 2009). It is important to note that different subpopulations have different degrees of vulnerability to depression given these predictors (Li et al.; Roberts et al., 1997; Sagrestano et al.; Van Voorhees et al., 2009; Wichstrøm, 1999).

Depression has also been mentioned as a risk factor for concurrent problem behavior and psychological disorders during adolescence, such as anorexia and bulimia (Whitaker, 1982), illicit drug use (Diego et al., 2003; Hawkins et al., 1992), increased alcohol use (Diego et al.), cigarette smoking (Diego et al.; Escobedo et al., 1998), aggression (Loeber & Hay, 1997), suicide (Miller et al., 1982), and obesity (Franko, Striegel-Moore, Thompson, Schreiber, & Daniels, 2005). Perhaps of even greater importance are the long-term ramifications of adolescent depression, which has been linked to adult maladies, including depression (Romens, Abramson, & Alloy, 2009), alcoholism (Huurre et al., 2010), and other substance-abuse (Huurre et al.; Romens et al.;

Windle & Wiesner, 2004). Interestingly enough, those diagnosed with depression in early adolescence tend to maintain this condition into adulthood, particularly with females (Daley, Hammen, Davila, & Burge, 1998; Daley et al., 2000; Franko et al., 2005), and this trajectory is not exclusive to research conducted in the United States (Fichter et al., 2009). Adolescent and adult depression can be predicted by childhood factors, as well (Reinherz, Giaconia, Hauf, Wasserman, & Silverman, 1999).

Though adolescent depression has exhibited various levels of comorbidity with other psychological, psychosocial, and physiological disorders, its most common counterpart is anxiety (Ollendick et al., 2003). As worry and rumination are common aspects of depression and have logical ties to anxiety as a construct, eliminating the contribution of anxiety to psychological distress is practically flawed (Feldman, 1993; Petersen et al., 1993). Several attempts to factor analyze symptomologies and accompanying measures reporting the presence of these symptoms in both clinical and general populations have resulted in one second order factor, but at least two, and usually three or four factors when physiological aspects are included (Brooks & Kutcher, 2001). These factors are generally described as depressive symptomology, anxiety symptomology, and somatic (information-processing) issues, as in the tripartite model (Brodbeck et al., 2011). However, some studies suggest that adolescent depression is represented by a model categorizing affective, cognitive, and biological/physiological facets as second order factors (Conley & Rudolph, 2009; Hyde et al., 2008). Further research is necessary to determine the distinction and overlap of these concepts.

Measurement of Adolescent Depression

Measurement of adolescent depression has generally maintained a higher order factor as the functional presence/diagnosis of depression disorder, while utilizing three to four second order factors. Two self-report scales common in adolescent depression measurement are adult-derived scales: the Beck Depression Inventory (BDI) and the Center for Epidemiological Studies – Depression scale (CES-D) (Brooks & Kutcher, 2001; Doerfler, Felner, Rowlison, Raley, & Evans, 1988; Wilcox, Field, Prodromidis, & Scafidi, 1998). The BDI measures the sub-factors of depressive mood frequency and severity, emotionality and worry, and somatic disturbance, while the CES-D measures depressed and positive affect, decreased somatic activity, and interpersonal activity (Radloff, 1977; Weckowicz et al., 1967). Additionally, a shortened version of the CES-D based on IRT analysis was able to significantly decrease items necessary to measure the higher order factor, essentially making the test a single factor scale (Cole, Rabin, Smith, & Kaufman, 2004; Santor & Coyne, 1997). However, the one-factor solution was not recommended unless the test was shortened to five items, as multiple factors were exhibited otherwise (Edwards et al., 2010). Other studies have shown effective utilization of a 10-item CES-D, with a one factor interpretation being appropriate (Cole et al., 2004; Irwin M, 1999; O'Connor, Whitlock, Gaynes, & Beil, 2009). Additionally, factor structures may not be invariant across populations, as was shown in a recent meta-analysis of the test of the CES-D four-factor model across ethnicity groups (Kim, DeCoster, Huang, & Chiriboga, 2011). This is also consistent with research questioning the generalizability of the CES-D after IRT differential item functioning analyses, and factor structure invariance analyses revealed differing response patterns between

Caucasians and African-Americans (Cole, Kawachi, Maller, & Berkman, 2000; Yang & Jones, 2007) or American Indians (Manson, Ackerson, Dick, Baron, & Fleming, 1990), and when multiple groups are simultaneously compared (Perreira, Deeb-Sossa, Kathleen Mullan, & Bollen, 2005; Russell, Crockett, Shen, & Lee, 2008). However, other research has shown mixed results regarding differing cultures and response patterns regarding the CES-D four factor model, so interpretation of ethnic difference in measured depressive symptoms and frequency should be judiciously cautious (Chau-Kiu & Bagley, 1998; Cheng, Yen, Ko, & Yen, 2012; Crockett, Randall, Shen, Russell, & Driscoll, 2005; Edman et al.; Kazarian & Taher, 2010). Furthermore, the ability to detect differences in depression level must be considered. The BDI has shown to be better for use in clinical populations, while the CES-D has been a better discerner of depression level differences in the general population (Baldwin & Shean, 2006; Santor, Zuroff, Ramsay, Cervantes, & Palacios, 1995).

Statistical Analysis

Longitudinal analysis of responses acquired from these measures has varied in application of statistical methods. A review of literature shows that longitudinal research in adolescent depression has largely consisted of repeated measures AN(C)OVA (Reinherz et al., 2003), univariate and multivariate logistic regression (Caspi, 2000; Huurre et al., 2010; Sagrestano et al., 2003), and specialized chi-square tests for dichotomous variables (Reinherz et al., 2003). However, latent growth curve modeling (LGCM) was conducted in three adolescent depression risk-factor studies, while a hybrid of structural equation modeling (SEM) and regression analysis (akin to LCGM) was used to reveal emergent differences in depression regarding gender socialization (Fleming et al., 2008; Ge, Lorenz, Conger, Elder, & Simons, 1994; Overbeek, Vollebergh, Meeus, Engels, & Luijpers, 2001; Wichstrøm, 1999).

Latent Growth Curve Analysis

Latent growth curve modeling or latent curve modeling is a combination of principles of SEM and multiple regression analysis. Structural equation modeling is a generalization of factor analysis, in which factors are allowed unidirectional contributions to other factors, rather than only covariance between factors. In latent growth modeling, however, establishing an initial value (intercept) and rate of change (slope) over time are of primary interest. As such, the basic within-subject repeated measures model of an observed variable 'x' across time can be described as,

$$\boldsymbol{x} = \boldsymbol{\Lambda\xi} + \boldsymbol{\delta}, \tag{1}$$

where $\boldsymbol{x}$ is a vector of values of x across time points, $\boldsymbol{\Lambda}$ is a matrix of loadings that represent the latent structure and number of measurements of $\boldsymbol{x}$, ξ (decomposed as $\boldsymbol{[\alpha\ \beta]'}$) is the matrix containing intercept ($\boldsymbol{\alpha}$ or the initial value of x for the individual) and slope ($\boldsymbol{\beta}$ or individual rate of change of x), and $\boldsymbol{\delta}$ represents random residual or error in the model (Byrne & Crombie, 2003; Hancock & Choi, 2006). Because the within-subjects latent growth curve model only determines presence of change, the covariance matrix is utilized (Byrne & Crombie).

However, because comparison of group differences in $\boldsymbol{x}$ (and not simply covariance of factor describing $\boldsymbol{x}$) requires computation of sample means, between-subjects LGCM requires the use of both covariance and latent means matrices to compute both change and mean differences between individuals in change (Byrne & Crombie, 2003). Therefore, the residuals of the $\boldsymbol{\xi}$ from the within-subjects model become the variance of between-subjects slope and intercepts, which are then to be tested to determine differences (variance) among individuals (Byrne & Crombie). The ξ is further decomposed into,

$$\boldsymbol{\xi} = [\boldsymbol{\alpha}\ \boldsymbol{\beta}]' = [\boldsymbol{T}][\,\overline{\boldsymbol{\alpha}}\ \overline{\boldsymbol{\beta}}\,]' + [\boldsymbol{D}_{\boldsymbol{\alpha}}\ \boldsymbol{D}_{\boldsymbol{\beta}}]', \tag{2}$$

where the $\boldsymbol{T}$ matrix represents a transformative constant required to delineate individual differences in intercept and slope ($\boldsymbol{D}_{\alpha}$ and $\boldsymbol{D}_{\beta}$) within the model. Using this second LGCM model, groups can be defined by other categorical factors (ethnicity, parental-divorce, etc.) to test changes in mean (intercept) and changes in trajectories (slope) of latent trait over time (Byrne & Crombie). Therefore, to further demonstrate the utility of latent growth curve as a powerful tool for understanding relationships among longitudinal data, the aforementioned two step process will be utilized to determine if adolescent depression remains constant over time for individuals and if differences in mean depression and trajectories of depression can be attributed to factors commonly cited in the literature.

Item Response Theory (IRT). SEM requires measures with high reliability to effectively model and test factor structure-fit and invariance among groups. Additionally, items must provide enough information to facilitate the many parameter estimates involved in latent curve analysis. These considerations entail the necessity to evaluate the psychometric properties of items contributing to construct factors. Therefore, an IRT analysis of scale items information should be attempted to make reliability and validity of scale items evident before attempting LGCM analysis. Lastly, both IRT and LGCM analysis require large samples due to the number of degrees of freedom eliminated in estimating numerous item and model parameters. A large sample should also be a concern to ensure statistical power and model stability when performing these analyses. With these considerations, it is determined that an appropriately large and well-conducted study archival database containing a well-represented general adolescent population should be obtained. Additionally, repeated measurements of facets of adolescent life, including risk-factors and correlates of depression, along with repeated administration of a general adolescent depression scale (CES-D) is recommended to effectively evaluate any longitudinal model of adolescent depression factors.

Purpose of the Study

The purpose of the current project is to test a latent growth curve model for adolescent depression and related factors, while assessing the validity and reliability of the CES-D as applied to adolescents. These purposes are complimentary, as strengthening the case for utilization of the CES-D as a latent measurement of depression is necessary to propose its use in a complex, longitudinal model, such as latent growth curve models. By having the backbone of a good instrument, validated via a large, well-conducted sample, valid trajectories of adolescent depression and its correlates can be established. Adolescent depression research may then be furthered in a model-driven fashion, reducing the diffuse nature of research in this field. As model-based theories are the aim of behavioral research, this study hopes to contribute to more parsimoniously understanding factors regarding changes in adolescent depression.

CHAPTER TWO: METHOD

Participants

The National Longitudinal Study of Adolescent Health (Add Health) is an ongoing nationally representative, cluster-sampled longitudinal study conducted by the federal government in conjunction with researchers at the University of North Carolina system of colleges (Harris, 2009). The primary purpose is to provide a wealth of data to researchers to examine factors of adolescence and adolescent health (Harris). Many measures were conducted in both self-report and interview format, at both schools and homes during the initial waves of the study (I and II), when adolescent respondents were in high school (Harris). Later data collection (waves III and IV) was accomplished by maintaining contact information with respondents into adulthood (Harris). As such, this study is a powerful tool for researchers seeking to examine trajectories of adolescent factors into adulthood and better understand how adolescence relates to adult psychological and physical factors. The Add Health study (public-use data) is the source of data for the current study. This public-use dataset is a randomly sampled subset of the full restricted-use data, with all sensitive information removed, available through the Add Health website ("Add Health: About Public-Use Data," 2013).

From the Add Health study (public-use), 6503 participants were initially sampled (Wave 1) from US high schools. However, many of these cases were for specific reasons (genetic sampling, in particular) outside of representing a national sample of adolescent youth (Chantala, 2010). Therefore, as per Add Health documentation, 3,844 participants from the public-use dataset will be retained as the total sample for this study (Chantala).

Because of the use of cluster sampling (level 1 with regions, and level 2 with schools), as well as over-sampling of specific subpopulations, sampling cluster and weight variables were provided and used to normalize the sample as representative of the national population of adolescent youth, as well as account for participant attrition (Chantala). Therefore, some descriptive statistics presented are sample-weight adjusted and these weighted values were used in all analysis (unless specified). The mean of age of participants was 15.6 years (*SD* = 1.6) for wave 1, 16.5 years (*SD* = 1.6) for wave 2, and 21.9 years (*SD* = 1.6) for wave 3 (see Table A2 for raw age descriptive statistics). Ethnic distribution of this sub-sample was 62.7% Caucasian, 21.1% African-American, 1.1% American Indian, 3.2% Asian-American, 10.9% Hispanic, and 0.9% Other (see Table A1).

Materials

Interview and self-report data collected through the Add Health initiative were compiled and received in Stata-ready format for statistical analysis. These data include items concerning interested factors, ranging from general demographics, to school attitudes and behaviors, sexual and drug use behaviors, home-life and neighborhood information, as well as a 19-item iteration (Waves I and II) and 9-item iteration (Wave III) of the CES-D as a measure of depressive symptoms and frequency. These interviews and measurement administrations were conducted at high schools selected through cluster sampling on the behalf of federal and state governments and the University of North Carolina system (Harris). The CES-D scale was included as a part of the Add Health initiative for all waves of data collection. Though test-retest reliability with adolescent subjects has been suspect for the CES-D (r = .60), internal consistency estimates (α = .87 to .89) have been much more acceptable (Garrison, Addy, & Jackson, 1991; Roberts, Andrews, Lewinsohn, & Hops, 1990). Research regarding psychometric properties is lacking compared to other similar scales. Convergent validity analysis of the CES-D was shown to be mildly correlated with other youth self-report scales, such as the Child Depression Inventory with a correlation of r = .58 (Doerfler et al., 1988). Overall, the CES-D should be interpreted with some degree of caution in terms of change scores, while Brooks and Kutcher's (2001) recent review of adolescent depression scales cites that the CES-D may be a measure of "general emotional turmoil rather than depression" due to test-retest issues. Some examples of items from the CES-D include determining degree of agreement (over the past week) with the following statements: "You felt everything you did was an effort," "You were bothered by things that usually don't bother you," "You felt depressed," and reversed scores items such as "You felt that you were just as good as other people," "You were happy," and "You felt hopeful about the future" (Radloff, 1977). Valid response categories for all items were "never or rarely," "sometimes," "a lot of the time," and "most of the time or all of the time."

Procedure

Due to necessity of equivalent measures at each time point for LGCM analysis, 9-item iterations of wave I and II CES-D were constructed using corresponding items retained in wave III. Items retained their original numbering regardless of scale presented, for ease in comparison. Preliminary analyses were conducted to determine properties of interested variables from the Add Health dataset, including missing item analyses and tests of skewedness and kurtosis, as well as basic descriptive statistics. Multiple imputation was performed on missing CES-D responses using ordinal logistic regression (*mi impute ologit*) in Stata. Sex, age, ethnicity, and other CES-D item responses were used as predictors in order to prepare data for LGCM and IRT analysis, which require complete data. After this data clean-up, the IRT analysis (using Samejima's Graded Response Model – GRM, with Expected A Priori estimation - EAP) of item parameter estimates of the truncated CES-D scale (and comparison to 18-item iterations) was conducted with the sample-weighted, multiply-imputed data to determine scale characteristics in this sample. IRT analysis was conducted using Mplus Version 7 software. Additionally, Mplus software was used to model latent trait change (LGCM) among adolescents over time. As mentioned, the sample includes over-sampling of specific adolescent sub-populations and therefore dataset-included sample weights were applied for latent growth curve modeling. Sample weights included were overall longitudinal subject weights (GSWGT3), accounting for over-sampling of sub-populations and attrition, and school cluster sample weights (Cluster2), accounting for the lack of measurement independence among those in same school (Chantala). Factors affecting adolescent depression -- specifically ethnicity, age, and gender -- were used as model predictors after initial unconditional latent growth model parameter estimation. Age was transformed into standardized scores (z-scores), in order to aid in interpretation of the effect of age relative to peers. Variables utilized from the Add Health data for all analyses are included in Appendix C.

CHAPTER THREE: RESULTS

CES-D Scale Analysis

The 9-item CES-D scales used in waves 1 (W1) and 2 (W2) of the Add Health survey fared moderately compared to the 18-item iterations, in both classical test statistics and item response theory parameter estimates. Cronbach's alpha calculations (using multiply-imputed data [non-weighted data, due to software limitations]) revealed that mean internal consistencies for the 9-item iterations were less than the 18-item (W1: α = .786 versus α = .857; W2: α = .805 versus α = .868; W3: α = .805). See Tables A6, A7, and A8 for all item and test statistics. Test information functions (TIF) and conditional standard errors of measurement (CSEM) for the CES-D scale at each wave and iteration also reflected a relative loss of reliability and information with halving of items used (see Table A7 and A8). Wave 1 IRT test information estimates show that, while the 18-item scale gleans more information about the latent trait, it is not proportionally greater than its shorter iteration (W1 9-item scale: info = 6.82 at max θ = 0.48, *CSEM* = 0.38; W1 18-item scale: info = 9.56 at max θ = 0.62, *CSEM* = 0.32). Likewise is true in comparing the second wave longer and shorter iterations (W2 9-item scale: info = 8.17 at max θ = 0.40, *CSEM* = .35; W2 18-item scale: info = 11.00 at max θ = 0.52, *CSEM* = 0.30). Interestingly, the third wave scale, in which there is no longer iteration, was revealed to have the greatest reliability and provided the most information at a higher latent trait level than the two prior waves' 9-item scales (W3 9-item scale: info = 9.75 at max θ = 0.65, *CSEM* = 0.32). This suggests that the CES-D scale may be better at conveying information about level of depression when measuring post-adolescent individuals. However, examination of TIF plots (Table A9) reveals that most of the increased information offered by the wave 3 CES-D iteration is between thetas 0 and 1, indicating no improvement in measuring high levels of depression. Additionally, although the shortened CES-D scales (W1 and W2) are economical in terms of information per item, TIF plots show that the 18-item scales provide almost as much information at 3 standards deviations above the mean depression level as the 9-item scales provide at 2 standard deviations above. Clearly, diagnostic power for adolescents with markedly higher depression level is lost by truncation.

Items 3, 6, and 18 provided the best contributions to scale effectiveness, with respective item-total correlations (non-weighted) at wave 1 of .676, .752, and .687, at wave 2 of .733, .768, and .724, and at wave 3 of .714, .769, and .729, and respective maximum theta information estimates at wave 1 of 1.60 (at $\theta = 0.81$), 2.30 (at $\theta = 0.42$), 1.29 (at $\theta = 0.17$), at wave 2 of 1.92 (at $\theta = 0.70$), 2.72 (at $\theta = 0.38$), 1.84 (at $\theta = 0.13$), and at wave 3 of 1.72 (at $\theta = 0.86$), 4.41 (at $\theta = 0.67$), 1.93 (at $\theta = 0.25$). The effectiveness of the items at providing information about level of depression may be attributed to the fact that they exhibited higher discrimination than other items ranging from $\alpha = 1.36$ to $\alpha = 2.53$ across waves, while all other items ranged from $\alpha = 0.42$ to $\alpha = 0.91$ across waves. Items 4 and 7 seemed to be particularly problematic in regards to 9-item scale effectiveness, with poor item-total correlations [non-weighted] (W1: Item 4: $r = .542$, Item 7: $r = .542$; W2: Item 4: $r = .531$, Item 7: $r = 574$; W3: Item 4: $r = .554$, Item 7: $r = .531$) and the worst maximum theta information estimates relative to other items (W1: Item 4: 0.15 (at $\theta = 0.40$), Item 7: 0.26 (at $\theta = 0.02$); W2: Item 4: 0.15 (at $\theta = 0.45$), Item 7: 0.33 (at $\theta = -0.07$); W3: Item 4: 0.22 (at $\theta = 0.94$), Item 7: 0.20 (at $\theta = 0.31$)). As with the best items, these poor items featured exceptional discrimination parameters estimates, ranging from $\alpha = 0.42$ to $\alpha = 0.67$. This was markedly lower than any other CES-D items, and indicates a lack of ability among these two items to discern differences between latent levels of depression.

Item polytomous category threshold (difficulty) estimations varied among items, with most category 1 to 2 (lowest to second lowest) responses above zero, indicating that most items were effective above the mean trait level (see Tables A7 and A8) This is unsurprising, given that the population distribution should be that most are not depressed or exhibit very few depressive symptoms. Items 3, 6, and 18 had respective lowest category response thresholds above the mean trait level (zero) and markedly smaller gaps between all other category thresholds than the poorest items (items 4 and 7). In contrast, items 4 and 7 (with one exception in wave 3) had respective lowest category thresholds estimated below the mean trait level and markedly larger gaps between other thresholds than all other items. Given that the CES-D scale response totals were positively skewed (see Tables A3 and A4), with moderate leptokurtosis, it is unsurprising that the best items would distinguish between those at the mean score or above, while providing limited information for those below mean depression.

Raw CES-D scale scores ranged from 0 to 25 at wave 1, from 0 to 27 at wave 2, and from 0 to 25 at wave 3. Raw sample means from each wave varied, with wave 2 ($\bar{x}$ = 5.65, *SD* = 4.26) slightly higher than wave 1 ($\bar{x}$ = 5.61, *SD* = 4.17), but wave 3 ($\bar{x}$ = 4.52, *SD* = 4.06) was somewhat lower. See Table A3 and A4 for CES-D descriptive statistics. This was also reflected in sample-weighted means, with mean scores rising from wave 1 ($\bar{x}$ = 5.53 *SE* = 0.10) to wave 2 ($\bar{x}$ = 5.60, *SE* = 0.10), but falling in wave 3 ($\bar{x}$ = 4.52, *SE* = 0.09). See Table A5 for multiple-imputed, sample-weighted CES-D descriptive statistics.

At a glance, females tended to score higher than males at each wave, while Caucasians tended to score lower than non-Caucasians. However, as the primary interest of this study is trend analysis, significance testing of means comparisons was not conducted. A cursory glance at CES-D scale total distributions at each wave revealed marked positive skewedness and leptokurtosis (see Tables A3 and A4). Normally, a transformation would be warranted for further analysis. However, for the purpose of retaining score interpretation and expectancy of the population exhibiting this sort of score distribution, no transformation was performed. Another issue of concern is that variances of CES-D scores vary by ethnicity over time (see Tables A3 and A4). Therefore, heterogeneity of error variances may be an issue. Fortunately, both data non-normality and group heteroscedasticity can be addressed in the following latent growth curve modeling, via MLR (Maximum Likelihood Robust) estimation. This technique uses sandwich estimation procedure and variance-covariance matrix adjustment to estimate robust standard errors and model parameters in light of heteroscedasticity and data non-normality (Kauermann & Carroll, 2001; White, 1980).

Latent Growth Curve Analysis

A latent growth curve model was used to assess the effect of age (as z-score), sex, and ethnicity to level of depression and change in level of depression over time. Because all three waves of CES-D scale responses featured moderate positive skewing and leptokurtosis, the response data are considered non-normal. However, MLR estimation, which is robust to violation of data normality, was used in lieu of transformation of response data because interpretation of model results would be difficult to meaningfully convey. MLR estimation produces robust chi-square model fit statistics that require use of scaling in order to compare fit between models. However, Mplus does not provide MLR estimation scaling coefficients for multiply imputed data. Computing each multiply imputed model and calculating a mean chi-square and mean scaling coefficient was considered, yet no literature or Mplus documentation could provide justification for this approach. Therefore, direct significance tests of model fit between nested or null models and alternative models is tacitly infeasible. Only relative model statistics, such as Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Akaike's Information Criterion (AIC), Bayesian Information Criterion (BIC) and Root Mean Square of Error of Approximation (RMSEA) can be compared, which have no method of testing significant differences in statistic value. To address this, a secondary analysis for each phase of the LGCM analysis was conducted using each of the imputed datasets, separately, in an attempt to strengthen a case that the alternative model fit can be compared to the nested or null model. It is assumed that if, separately, all multiple-imputed datasets show the statistical significance (with Bonferroni adjustment) in differences in model fit in the corresponding phase of analysis, then the model fit differences can be assumed significant for those respective multiply imputed models.

Assumption Tests

Prior to interpretation of model estimations, three assumptions required of structural equation modeling (and thus LGCM) need to be assessed: linearity, homoscedasticity, and independence of measurement. As mentioned, multiple imputation precludes use of chi-square difference tests when using the MLR estimator necessary for non-normal data. Therefore, just as in determining significant model fit in the main LGCM analysis, significance testing of assumptions will be endeavored by estimating chi-square model fit statistics for each imputed dataset, individually. With this formality aside, testing these three assumptions is easy in the scope of LGCM as they can be specified as model parameters (Byrne & Crombie, 2003). Inclusion of a quadratic latent factor in addition to a linear (slope) factor can be used to test if quadratic model fit is better than linear model fit. Unfortunately, in the current analysis only three time points are included and thus a quadratic LGC model cannot be estimated due to lack of necessary degrees of freedom for model identification. Therefore, there is a (un-testable) possibility that the data may be better modeled as non-linear despite these analyses. Homoscedasticity is easily tested by specifying that respective error variance in each wave of CES-D data be estimated freely versus confined to the same value estimation. If the free estimation model fits significantly better than the restricted error variance parameterization model, then it is inappropriate to assume that the CES-D response data is homoscedastic across time points. In the case of the present analysis, the model allowing for free estimation of error variances is a significantly better model fit than the nested, even in the lowest $\Delta\chi^2$ imputation ($\Delta\chi^2(2) = 8.94$). Fortunately, MLR estimation allowed by Mplus software provides adjustments (Huber-White –variance covariance matrix adjustment) to estimates and robust standard errors in light of heteroscedasticity and non-normality (White, 1980). Lastly, independence of error variances can be tested by specifying covariance parameters between all three CES-D wave error variances. If a model with error covariances specification fits better than the model without, measurement error independence is an issue. Unfortunately, the lack of degrees of freedom to compare model fit is again an issue in the present analysis. Therefore, the tenability of this assumption is not testable. This is a major issue as the assumption is a particular concern for measures conducted in longitudinal studies. However, the amount of time between measures, at almost one year between wave 1 and 2 and over five years between waves 2 and 3, should, in theory, attenuate error covariance enough to marginalize carryover effects. Therefore, this assumption will be treated as tenable, but should be done so with caution regarding results interpretation.

The Unconditional Model

The first model estimated was the unconditional model to test if change in CES-D score does occur from adolescence into young adulthood. See Tables A10 and A11 for model fit statistics and model parameter estimates. The unconditional model fit the data well with both comparative fit index (CFI) and Tucker-Lewis index (TLI) fit statistics greater than the standard for good fit .95 (.991 and .973) and a root-mean-square error of approximation (RMSEA) below the standard of good fit .05 (.048). The model intercept estimation, or mean initial CES-D score was 5.616 ($SE = .095$, $p < .001$), while the model slope estimation, or mean change per time unit (year) was -0.168 ($SE = .015$, $p < .001$). These parameters indicate that level of depression, on average, declines over time into young adulthood. The following equation describes the model estimated:

$$\textbf{[CES-D Score]} = \textbf{5.616} - \textbf{.168(time-in-years)} + \textbf{[residual model error]} \qquad \textbf{(3)}$$

The variance of mean intercept parameter was 10.388 ($SE = .478$, $p < .001$), indicating that standard deviation among adolescents from the initial CES-D score was 3.22 and that model improvement could be accomplished with effective predictors. The variance of the mean slope parameter was 0.207 ($SE = .063$, $p = .001$), indicating that the standard deviation among adolescents from the mean change per year was 0.455, also indicating predictors could help model efficacy. Both these variances are indicative of substantial variation among individual starting values and trajectories of level of depression. The covariance estimation between intercept and slope was significant, at -0.668 (*SE* = .074, $p < .001$), standardized to a correlation of $r = -.455$ (*SE* = .060, $p < .001$), suggesting that adolescents with higher initial level of depression tended to have greater negative change of level of depression as time passed into young adulthood. In other words, the higher the depression level, the greater the decline of depression level over time which suggests a degree of convergence of level of depression over time. Because of the aforementioned issues involving tests of model fit significance with MLR estimation and multiple imputation, secondary analyses involving each of the five imputed datasets were attempted with the same specification to strengthen the case that the unconditional model was a good fit for the data. None of the imputed models fit indicated poor fit, with the imputed data for the worst model fit significantly better than the null model ($\chi^2(1) = 9.578$, $p < .001$). The mean chi-square for the multiple-imputation model was $\chi^2(1) = 9.896$.

The Sex-as-Predictor Model

The second model tested included sex as a predictor of both intercept and slope of level of depression within the context of a LGCM. See Tables A10 and A11 for model fit and parameter estimates. This iteration slightly improved model fit versus the unconditional model, with CFI and TLI fit statistics (.991 and .973) and RMSEA fit statistics improving from .048 to .039. Relative fit statistics Akaike information criterion (AIC) and Bayesian information criterion (BIC) reflected this, with model AIC value lowering to 63113.016 from 63267.791 and model BIC value 63175.559 from 63317.825. The sex-as-predictor model intercept estimation, or mean initial CES-D score was 4.887

(*SE* = .103, $p < .001$), while the model slope estimation, or mean change per time unit (year) was -0.132 (*SE* = .02, $p < .001$). These differences from the unconditional model are accounted for by the use of sex as a predictor, in that the coding of the sex variable (1 = female versus 0 = male) essentially transforms the unconditional intercept and slope into the male intercept and slope in this model. Thus the sex-effect estimated parameter is a modifier that accounts for female status and modifies the intercept and slope means to reflect the mean of female adolescents. As such, the mean female intercept of 1.475 (*SE* = .129, $p < .001$) and slope of -.073 (*SE* = .03, $p = .015$) suggest that female adolescents having a higher mean level of depression than males at study onset, yet decline at a greater rate. The following equation illustrates the described model:

$$\textbf{[CES-D Score]} = \textbf{4.887} + \textbf{1.475(female)} - \textbf{.132(time-in-years)} - \textbf{.073(time*female)} + \textbf{[residual model error]} \qquad \textbf{(4)}$$

Taken in whole, this indicates that male and female adolescents show marked differences in mid-adolescent level of depression, yet tend to converge in mean depression level as adulthood approaches. However, evaluation of model predictor effectiveness is possible by comparing residual model error between unconditional and predictive models. This predictive model has a mean intercept variance parameter estimation of 9.819 (*SE* = .472, $p < .001$), compared to an unconditional model intercept variance of 10.388. This indicates that 5.4% more of intercept variance (individual difference) was accounted for by the inclusion of sex as a predictor in the model. The same evaluation of model improvement can be attempted looking at slope parameter variance differences between the models. The variance of the mean slope parameter was 0.158 (*SE* = .018, $p < .001$) versus .207 in the unconditional model, which suggests a

5.8% decrease in slope variance compared to the unconditional model. Therefore, sex does account for some variation among adolescents in both level of depression in mid-adolescence and rate of change in level of depression from mid-adolescence to young adulthood (ages 21to 22). Additionally, the covariance estimation between intercept and slope was again significant, at -0.633 (*SE* = .075, $p < .001$), standardized to a correlation of $r = -0.457$ (*SE* = .062, $p < .001$), indicating that the inverse relationship of slope and intercept remained prevalent even with sex accounted for. Secondary analysis of the individual imputed datasets reflected the aforementioned analysis in that none of the imputed models fit indicated poor fit, with the imputed data for the worst model fit significantly better than the null model ($\chi^2(2) = 13.500$, $p = .0012$). The mean chi-square for the multiple-imputation model was $\chi^2(2) = 13.898$.

The Age-as-Predictor Model

The third model tested included age (transformed into z-score, and hence referred to as z_age) as a model predictor to determine the extent that difference in age at time of CES-D assessment influenced responses. See Tables A10 and A11 for model fit and parameter estimates. As with the sex-as-predictor model, this model slightly improved model fit versus the unconditional model, with CFI and TLI fit statistics (.992 and .976) and RMSEA fit statistics improving from .048 to .038. Relative fit statistics AIC and BIC echoed these results with model AIC value lowering to 63188.442 from 63267.791 and model BIC value 63250.985 from 63317.825. The z_age-as-predictor model intercept estimation was 5.637 (*SE* = .086, $p < .001$), while the model slope estimation, or mean change per time unit (year) was -0.171 (*SE* = .020, $p < .001$). Notice that these parameters are very similar to the unconditional model estimates, suggesting that including z_age as a predictor does not have as large an effect as including sex in the model. This is reflected in the parameter estimates for the effect of z_age. The mean z_age intercept effect of .513 (*SE* = .072, $p < .001$) and slope of -.083 (*SE* = .013, $p < .001$), while both significant, are less impactful considering the standard deviation for age is 1.56. However, it does suggest that older adolescents had a somewhat higher mean level of depression at study onset, but converged towards younger peers as time progressed. The following equation illustrates the estimated model:

$$\textbf{[CES-D Score]} = \textbf{5.637} + \textbf{.513(z\_age)} - \textbf{.171(time-in-years)} - \textbf{.073(time*z\_age)} + \textbf{[residual model error]} \quad \textbf{(5)}$$

The effect of standardized age at study onset is also assessed by comparing residual predictive model error to unconditional model error. The current model has a mean intercept variance parameter estimation of 10.139 (*SE* = .472, $p < .001$), compared to an unconditional model intercept variance of 10.388. Only 2.3% more of intercept variance was accounted for by the inclusion of z_age as a predictor in the model. The variance of the mean slope parameter was 0.201 (*SE* = .063, $p < .001$) versus .207 in the unconditional model, which suggests a 2.9% decrease in slope variance compared to the unconditional model. Therefore, standardized age does account for some variation in slope and intercept, though more so for slope. Additionally, the covariance estimation between intercept and slope was again significant, at -0.628 (*SE* = .073, $p < .001$), standardized to a correlation of $r = -0.440$ (*SE* = .059, $p < .001$), indicating that the inverse relationship of slope and intercept remained prevalent with standardized age included as a predictor. Secondary analysis of the individual imputed datasets reflected the multiple-imputed analysis in that none of the imputed models fit indicated poor fit.

The imputed data with the worst model fit significantly better than the null model ($\chi^2(2)$ = 12.856, p = .0016). The mean chi-square for the multiple-imputation model was $\chi^2(2)$ = 12.972.

The Ethnicity-as-Predictor Model

The fourth model evaluated included ethnicity as a model predictor to determine the extent that ethnicity influenced mean level of depression and rate of change of level of depression from middle adolescence into adulthood. See Tables A12 and A13 for model fit and parameter estimates. Unlike the prior predictor models, this model revealed mixed results for model fit. CFI and TLI fit statistics (.987 and .962) were slight degradations versus the unconditional model. However, RMSEA fit statistics improved from .048 to .028, indicating a marked improvement. Relative fit statistics AIC and BIC reflected the RMSEA results with model AIC value lowering to 63183.076 from 63267.791 and model BIC value 63295.653 from 63317.825. With ethnicity as a predictor, the model intercept estimation was 5.231 (*SE* = .097, $p < .001$) and the model slope estimation was -0.152 (*SE* = .018, $p < .001$). Ethnicity parameter estimations were a reflection of the handling of ethnicity as binary indicators. Because each ethnicity was mutually exclusive, one ethnicity needed to be base contrast (i.e., not an explicit predictor) in order to have the model successfully estimated. Caucasian ethnicity was chosen due to the large proportion of the sample and group sample means that suggested Caucasians had markedly lower mean CES-D scores than peers of other ethnicities. Therefore, the model must be interpreted differently. The base mean and intercept of this model represent Caucasian parameters and all predictive parameter estimations reflect the difference of mean and intercept from the Caucasian model means. African-American adolescents were estimated to have a mean intercept parameter of 1.314 (*SE* = .216, $p <$ .001), while Asian-American and Hispanic adolescents had respective estimates of 1.431 (*SE* = .486, p = .003) and 1.203 (*SE* = .274, $p <$ .001). Neither American Indian adolescents nor those indicating Other ethnicity had mean model intercept estimates significantly different from zero (see Table A12 for all parameter estimates). None of the ethnicity slope parameter estimates were significantly different from zero. This suggests that differences in mean level of depression existed at the onset of the study between Caucasians and African-American, Asian-American, and Hispanic adolescents, and that these differences were maintained into young adulthood. The following equation illustrates the described model:

[CES-D Score] = 5.231 + .1.314(African-Am.) + 1.431(Asian-Am.)

+ 1.203(Hispanic) – .152(time-in-years) (6)

+ [residual model error]

A comparison of residual variances between the unconditional model and ethnicity-as-predictor model reveal a slight increase in model effectiveness. The current model has a mean intercept variance parameter estimation of 10.029 (*SE* = .473, $p <$ .001), while the unconditional model intercept variance is 10.388. This represents 3.5% more intercept variance was accounted for by the inclusion of ethnicity as a predictor in the model. The variance of the mean slope parameter was 0.198 (*SE* = .063, $p <$ .001) versus .207 in the unconditional model, which interestingly suggests a 4.3% decrease in slope variance compared to the unconditional model. Despite the fact that none of the ethnicity predictor slope parameters were significant, this model decreased error variance in slope parameterization to an even greater degree than for intercept parameterization.

This reflects that, without accounting for intercept differences influenced by ethnicity, estimating change in level of depression is confounded by depression level at onset. The covariance estimation between intercept and slope in the current model was significant at -0.646 (*SE* = .073, $p < .001$). This represents correlation of $r = -0.459$ (*SE* = .060, $p < .001$), indicating that the inverse relationship of slope and intercept is maintained despite inclusion of ethnicity as a predictor. Secondary analysis of the individual imputed datasets reflected the multiple-imputed analysis in that none of the imputed models fit indicated poor fit. The imputed data with the worst model fit was significantly better than the null model ($\chi^2(6) = 22.737$, $p = .0009$) and the mean chi-square for the multiple-imputation model was $\chi^2(6) = 23.669$.

The Final Model: Age, Sex, and Ethnicity as Predictors

The final model assessed included standardized age, sex, and ethnicity as model predictors to determine the combined extent that these predictors influenced mean level of depression and rate of change of level of depression from middle adolescence into adulthood. See Tables A12 and A13 for model fit and parameter estimates. Although mean CFI and TLI fit statistics (.987 and .961) were slightly less than all other models tested, mean model RMSEA fit index (.027) was the best of all models. Additionally, relative fit statistics AIC and BIC were lower than all other models, at 62938.465 and 63076.059, respectively. The final model intercept estimate was 4.513 (*SE* = .094, $p < .001$), while the model slope estimate was -0.118 (*SE* = .022, $p < .001$). Because of the aforementioned handling of sex and ethnicity, the base group mean intercept and mean slope from which all predictor parameter estimates are contrasted is Caucasian male adolescents. As such, the mean female intercept of 1.525 (*SE* = .13, $p < .001$) and slope of -.083 (*SE* = .013, $p < .001$) suggest that, after controlling for age and ethnicity, female adolescents persist in having a higher mean initial level of depression and more precipitous slope than males. The mean standardized age intercept effect, after controlling for sex and ethnicity, is .52 (*SE* = .066, $p < .001$), with slope of -.08 (*SE* = .03, $p = .003$). Final model ethnicity parameter estimates remained similar to the prior predictor model, even after controlling for standardized age and sex. African-American adolescents were estimated to have a mean intercept parameter of 1.214 (*SE* = .204, $p < .001$), while Asian-American and Hispanic adolescents had respective estimates of 1.444 (*SE* = .464, $p = .002$) and 1.21 (*SE* = .262, $p < .001$). As with the prior ethnicity predictor model, American Indian and Other ethnicity adolescent intercept estimates were not significantly different from zero, nor were any ethnicity predictor slope estimates (see Table A12 for non-significant parameter estimates). The following equation illustrates the described model:

$$\begin{aligned}\textbf{[CES-D Score]} = {} & \textbf{4.513 + 1.525(female) + .52(z\_age)} \\ & \textbf{+ 1.214(African-Am.) + 1.444(Asian-Am.)} \\ & \textbf{+ 1.21(Hispanic) – .118(time-in-years)} \\ & \textbf{– .083(time*female) – .08(time*z\_age)} \\ & \textbf{+ [residual model error]}\end{aligned} \tag{7}$$

A comparison of residual variances between unconditional model and final model reveal an increase in model effectiveness. This model has a mean intercept variance parameter estimation of 9.199 (*SE* = .457, $p < .001$), while the unconditional model intercept variance is 10.388. This represents that 11.4% of the unconditional model's intercept variance was accounted for by the inclusion of all predictors in the final model.

The variance of the mean slope parameter was 0.179 (*SE* = .063, p = .005) versus .207 in the unconditional model, which implies a 13.5% decrease in slope variance relative to the unconditional model. These finding suggests that, though there is still a substantial variation in level of adolescent depression means and rate of change, the sex, age, and ethnicity have substantial predictive power in reducing individual variation around model intercept and slope. Female adolescents exhibit higher levels of depression in middle adolescence, in general, though the difference between the sexes reduces over time, into young adulthood (21-22 years of age). African-American, Asian-American, and Hispanic adolescents also exhibit higher levels of depression in middle-adolescence than other ethnicity peers, yet, in general, this difference does not attenuate over time as with a comparison of gender. Also of interest is that the sum of the intercept variance reduction percentages and sum of slope variance percentage reductions, respectively, are just slightly less than respective final model variance reductions in these estimates (11.4% versus 11.2%; 13.5% versus 13%). This suggests that there is synergy among the predictors in terms of explaining differences in mean and rate of change of level of depression, and that excluding any of these factors ignores the interplay these factors have in influencing adolescent depression level. Lastly, older adolescents surveyed at the onset on study reported somewhat higher mean levels of depression, but time seems to ameliorate this difference after adolescence.

The same is true for the overall trajectory of depression. The final model covariance estimation between intercept and slope in the current model was significant at -0.570 (*SE* = .075, p < .001), which represents a mean correlation of r = -0.445 (*SE* = .065, p < .001). This relationship illustrates that those adolescents that tended to have higher mean level of depression tended to regress towards the overall mean over time. Finally, to strengthen the tenability of the final model, the secondary analysis revealed the imputed data with the worst model fit was significantly better than the null model ($\chi^2(8) = 28.433$, $p = .0004$). The mean chi-square for the multiple-imputation model was $\chi^2(8) = 29.641$ ($SD = .715$).

CHAPTER FOUR: DISCUSSION

Discussion

In general, depression in adolescents declines as adulthood approaches, regardless of sex or ethnicity, with a regression towards the mean depression level in young adulthood. Females show markedly higher levels of depression relative to male peers, yet this differential slightly lessens in the early twenties. This reflects past findings of differences in adolescent depression level, where sex differences were notably different as early as 13 years of age (Hankin et al., 1998; Nolen-Hoeksema & Girgus, 1994) and persist in adulthood (Nolen-Hoeksema, 1987). Allgood-Merten, Lewinsohn, and Hops (1990) suggest that divergent coping mechanisms (ruminative versus problem-oriented) developed during adolescence may account for these differences. The multi-faceted interaction of coping style and common environmental factors (employment and interpersonal) has also shown explanatory power in all stages of an adult depression lifespan longitudinal study (Leach, Christensen, Mackinnon, Windsor, & Butterworth, 2008).

Despite a general trend towards less variation in level of depression post-adolescence, Asian-American, African-American, and Hispanic individuals maintain a higher reported severity and frequency of depressive symptoms. After this analysis was conducted and prepared, it was discovered that a similar analysis was conducted by Brown, Meadows, and Elder (2007) using the Add Health restricted (private-use) dataset, looking at ethnicity and social support factors regarding change in depression over adolescence. Their findings are echoed in this study, though the use of sex and ethnicities as model groups, rather than predictors, prevents direct comparison of model parameter estimates. Additionally, unlike the present study, the prior study justified using an item somewhat dissimilar (see notes in Appendix D) to a corresponding CES-D item (creating a 10-item shortened scale) and did not include American Indian as an ethnicity. Nonetheless, both the aforementioned study and the present study support past results indicative of prevailing differences in adolescent depression (Roberts et al., 1997; Van Voorhees et al., 2009) and adult depression (Walsemann, Gee, & Geronimus, 2009) between Caucasians and non-Caucasians.

However, according to this analysis approximately 88% of variance of mean level and 86% of variance in rate of change in level of depression in adolescents is unaccounted for after controlling for sex and ethnicity. Many other important factors already noted, including substance abuse, home life and parental situation, neighborhood situation, and peer association, could play important roles in determining presence and severity of depressive symptoms. These factors may also influence whether an adolescent effectively copes and recovers from depressive symptoms over time. Indeed, the Brown et al. (2007) study included several social support indicators in their longitudinal analysis, yet results were decidedly mixed, indicating the complexity of the issue. Many important potential developmental occurrences manifest between middle-adolescence and young adulthood, including the development of a stable identity, as well as momentum towards personal and professional goals still relatively distant from 15 and 16 year old individuals. It may be that, while these developmental processes occur for all healthy adolescents, certain disadvantages linger that perpetuate a differential in mental health. Ultimately, life, particularly in adolescence, is a process of constant and complex development in which no cross-section of occurrences can provide adequate context for studying a psyche always, by necessity, in flux. It is hoped that this study will, along many other longitudinal approaches to studying depression, contribute to further understanding of how poor mental health manifests in individuals over time.

Limitations

Though LGCM and its application to the wealth of data in the Add Health survey yielded interesting results, there were several caveats that must be noted. The primary concern was the necessity to shorten the CES-D instrument in order to have comparable scale scores at each time-point. This not only hurt the reliability of the scale at each wave, but also precluded the ability to test the interplay of sub-factors attributed to general depressiveness as stipulated in the tripartite model. Additionally, the inability to test the linearity and independence of measurement errors in the LGCM was unfortunate. A cursory glance at CES-D mean scores indicates that the second wave mean scores were higher than the first wave. Not being able to incorporate a quadratic factor into the LGCM could easily be assumed to hurt model fit and artificially force the trend line away from a more appropriate trajectory. While little correlation between measurement errors could easily be assumed for the second and third wave, the temporal proximity of the first and second wave make the assumption of lack measurement error correlation tenuous. Another limitation of this analysis was the inconsistency of time-point differences among participants. Although interview time differences between waves were generally close to the mean used to create static time-points for model estimation, there was variation that hurt the ability to produce valid model parameter estimates. Lastly, the necessity of special model estimation procedures (because of data non-normality and heteroscedasticity) combined with the lack of parsimony in comparing model fit statistics, created a barrier between the analysis and the reader that makes consuming this study's results more difficult.

Suggestions for Future Research

Several aspects of this study could be improved and expanded upon in subsequent analysis of Add Health data. Future LGCM analysis should consider using variable time parameters for each wave and participant, if necessary model degrees of freedom permit, as respective time-points at each wave varied among participants. Other important factors noted in the literature as influential to depression (or having logical potential for influence) are included in all waves of public-use Add Health data, including substance abuse, coping strategies, parental support, education data, sexual activity, SES, neighborhood status, physical health data, violence exposure, work experiences, pregnancy, religiosity, and number and types of relationships. These factors may serve to better explain variance (beyond sex and ethnicity) among mean initial level CES-D score and change over time. Outcomes in adulthood can also be analyzed via LGC models as sequelae of change models, where static outcomes can be predicted via growth (Duncan, Duncan, & Strycker, 2006, pp. 56-61). Structural paths from the slope and intercept factors to a categorical outcome are estimated in the sequelae model, indicating the influence of both initial level and trajectory on later outcome. Featuring these factors and their covariance with depression over time in a LGC sequelae-of-change model may be powerful, given appropriate predictors and well-operationalized potential outcomes, such as obesity, alcoholism, major depressive disorder, employment status, homelessness, or incarceration.

Additionally, a fourth wave of data has since been released for public-use that includes the shortened CES-D measure that would allow for better trajectory estimation and establish a solid link between depression in adolescence and factors that enable poor mental health to transcend different stages in life ("Add Health: About Public-Use Data,"). As lifespan depression studies have suggested a U-shaped trajectory regarding adult depression, perhaps the inclusion of a fourth time-point well into adulthood would create a better lifespan longitudinal model of depression (Mirowsky & Ross, 1992). This also stretches the data timeline from approximately seven years to 13 years, presumably providing a more stable projection of depression from adolescence to adulthood. Lastly, the inclusion of another time-point would overcome the inability to test linearity and measurement independence assumptions important to proper LGCM analysis. As past research has indicated a curvilinear trajectory in adult depressive symptom severity and frequency, a linear growth model may not be an appropriate representation when expanding the context outside of middle-adolescence and young adulthood. Establishing a common pattern of depressive symptomology among various stages of life has important implications for both diagnosis and treatment. Many of the factors that delineate the good and poor mental health may be better expressed as time-varying environmental and internal differences (and their interactions) rather than cross-sectional differences.

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APPENDICES

APPENDIX A

TABLES

Table A1

Sample Descriptive Statistics

Sex	All Ethnicities	Caucasian	African-American	American Indian	Asian	Hispanic	Other
Male	1,768	1,119	351	18	61	202	17
Female	2,076	1,293	459	25	62	218	19
Total	3,844	2,412	810	43	123	420	36
Male	46.0%	29.1%	9.1%	0.5%	1.6%	5.3%	0.4%
Female	54.0%	33.6%	11.9%	0.7%	1.6%	5.7%	0.5%
Total	100.0%	62.7%	21.1%	1.1%	3.2%	10.9%	0.9%

Table A2

Sample Descriptive Statistics: Age at Each Wave

Time point	Sex	Stat.	Cauc-asian	Afr.-Am.	Am. Ind.	Asian-Am.	Hispanic	Other	Total
Wave 1	M	$\bar{x}$	15.7	15.7	15.7	15.2	15.8	15.6	15.7
		SD	1.6	1.7	1.8	1.5	1.7	1.5	1.6
	F	$\bar{x}$	15.4	15.5	15.5	15.9	15.6	15.6	15.5
		SD	1.6	1.6	1.4	1.6	1.5	1.7	1.6
	Total	$\bar{x}$	15.5	15.6	15.6	15.6	15.7	15.6	15.6
		SD	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Wave 2	M	$\bar{x}$	16.6	16.6	16.7	16.1	16.7	16.5	16.6
		SD	1.6	1.7	1.8	1.5	1.7	1.5	1.6
	F	$\bar{x}$	16.3	16.4	16.4	16.8	16.4	16.5	16.4
		SD	1.6	1.6	1.4	1.6	1.5	1.7	1.6
	Total	$\bar{x}$	16.4	16.5	16.5	16.5	16.6	16.5	16.5
		SD	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Wave3	M	$\bar{x}$	22.1	22.1	22.1	21.6	22.2	22.0	22.1
		SD	1.6	1.7	1.9	1.5	1.7	1.7	1.6
	F	$\bar{x}$	21.7	21.9	21.9	22.2	21.9	21.9	21.8
		SD	1.6	1.6	1.5	1.6	1.5	1.7	1.6
	Total	$\bar{x}$	21.9	22.0	22.0	21.9	22.1	21.9	21.9
		SD	1.6	1.6	1.6	1.6	1.6	1.7	1.6

Table A3

Descriptive Statistics for CES-D Scale – Non-Imputed/Non-Sample-Weighted

Ethnicity	Sex	Wave 1 (1995)				Wave 2 (1996)			
		x̄	*sd*	*Skew*	*Kurt*	x̄	*sd*	*Skew*	*Kurt*
Caucasian	M	4.61	3.64	1.26	5.20	4.41	3.55	1.47	6.71
	F	5.79	4.28	0.97	3.82	5.96	4.47	1.03	3.89
	Total	5.24	4.04	1.12	4.37	5.24	4.14	1.24	4.85
African-American	M	5.48	3.87	1.01	4.47	5.26	3.64	0.97	4.22
	F	6.76	4.81	0.87	3.59	6.52	4.57	0.85	3.63
	Total	6.20	4.47	0.98	4.04	5.97	4.24	0.96	4.03
American Indian	M	7.06	4.39	0.17	2.26	6.72	4.35	0.70	2.20
	F	6.64	3.89	0.61	3.19	7.08	5.29	0.62	2.71
	Total	6.81	4.06	0.41	2.70	6.93	4.87	0.67	2.71
Asian	M	5.33	3.27	0.41	2.37	5.49	3.31	0.69	3.06
	F	8.00	4.52	0.75	3.22	8.31	5.18	0.41	2.36
	Total	6.68	4.15	0.85	3.73	6.91	4.56	0.78	3.09
Hispanic	M	5.04	3.46	0.80	3.74	5.67	3.77	0.92	4.00
	F	7.21	4.49	0.73	3.64	7.67	4.88	0.70	3.13
	Total	6.17	4.17	0.88	4.00	6.71	4.49	0.88	3.65
Other	M	5.24	3.27	0.29	2.29	5.88	4.01	0.63	2.76
	F	5.79	3.78	1.17	4.03	7.89	5.04	0.11	2.08
	Total	5.53	3.51	0.88	3.71	6.94	4.63	0.40	2.31
All Ethnicities	M	4.88	3.68	1.11	4.70	4.80	3.63	1.23	5.40
	F	6.23	4.46	0.92	3.73	6.37	4.62	0.92	3.58
	Total	5.61	4.17	1.04	4.20	5.65	4.26	1.10	4.30

Table A4

Descriptive Statistics for CES-D Scale – Non-Imputed/Non-Sample-Weighted

Ethnicity	Sex	Wave 3 (2001-02)			
		$\bar{x}$	*sd*	*Skew*	*Kurt*
Caucasian	M	3.70	3.29	1.32	5.35
	F	4.72	4.34	1.43	5.27
	Total	4.25	3.92	1.50	5.86
African-American	M	4.49	4.01	1.26	4.54
	F	5.13	4.35	1.21	4.23
	Total	4.86	4.22	1.24	4.39
American Indian	M	4.56	3.73	0.49	2.24
	F	5.72	3.95	0.61	2.65
	Total	5.23	3.86	0.58	2.60
Asian	M	4.68	3.45	1.04	4.95
	F	5.98	4.77	1.12	4.16
	Total	5.34	4.21	1.24	4.98
Hispanic	M	4.56	4.04	1.61	6.37
	F	5.71	4.65	0.91	3.21
	Total	5.15	4.40	1.21	4.30
Other	M	4.00	3.04	0.25	2.28
	F	5.16	3.88	0.44	2.57
	Total	4.61	3.51	0.49	2.79
All Ethnicities	M	4.00	3.56	1.38	5.55
	F	4.97	4.39	1.29	4.66
	Total	4.52	4.06	1.38	5.20

Table A5

Multiple-Imputed, Sample-Weighted CES-D Scale Descriptive Statistics

Ethnicity		Wave 1 (1995)			Wave 2 (1996)			Wave 3 (2001-02)		
		M	F	Total	M	F	Total	M	F	Total
Caucasian	$\bar{x}$	4.52	5.85	5.18	4.42	5.94	5.17	3.67	4.85	4.26
	SE	0.12	0.16	0.11	0.13	0.13	0.10	0.12	0.15	0.10
African-American	$\bar{x}$	5.90	7.15	6.53	5.78	6.96	6.38	4.94	5.42	5.18
	SE	0.27	0.31	0.23	0.27	0.28	0.21	0.34	0.30	0.25
American Indian	$\bar{x}$	5.61	6.18	6.45	5.03	7.44	6.16	5.97	5.85	5.91
	SE	1.17	0.92	0.54	1.25	1.26	0.93	1.69	0.83	1.04
Asian-American	$\bar{x}$	5.37	7.65	5.87	5.48	8.24	6.79	4.45	6.13	5.24
	SE	0.63	0.71	0.83	0.40	0.75	0.45	0.53	0.53	0.40
Hispanic	$\bar{x}$	5.20	7.09	6.11	5.87	7.67	6.74	4.82	5.40	5.10
	SE	0.27	0.36	0.27	0.29	0.42	0.28	0.27	0.41	0.23
Other	$\bar{x}$	5.39	4.71	5.06	5.80	7.62	6.69	3.63	4.17	3.89
	SE	0.83	0.75	0.55	0.96	1.31	0.82	1.01	0.73	0.64
All Ethnicities	$\bar{x}$	4.84	6.23	5.53	4.84	6.38	5.60	4.04	5.04	4.53
	SE	0.11	0.14	0.10	0.11	0.12	0.10	0.12	0.13	0.09

Table A6

CES-D Item and Scale Statistics

Time Point	CES-D Item	MI/Weighted Frequency Response by Category				MI/Non-Weighted Item/Scale Statistics	
		1	2	3	4	Mean Item-Total r	Mean Cronbach's α w/o
Wave 1	1	62.8%	30.6%	5.4%	1.3%	0.601	0.765
	3	74.0%	19.1%	5.1%	1.8%	0.676	0.754
	4	36.2%	32.1%	21.1%	10.6%	0.542	0.794
	5	40.9%	42.6%	12.6%	3.9%	0.594	0.770
	6	63.8%	27.7%	6.0%	2.5%	0.752	0.740
	7	43.5%	45.0%	9.2%	2.4%	0.542	0.776
	16	48.8%	32.3%	14.8%	4.1%	0.601	0.771
	18	55.0%	38.6%	4.5%	1.9%	0.687	0.752
	19	65.5%	28.6%	4.3%	1.6%	0.565	0.770
	9-item Scale	$\bar{x}$: 5.53		*SE*: 0.10		-	0.786
	18-item Scale	$\bar{x}$: 10.49		*SE*: 0.18		-	0.857
Wave 2	1	57.7%	34.2%	6.1%	2.0%	0.633	0.783
	3	72.0%	20.2%	6.0%	1.9%	0.733	0.768
	4	37.0%	34.2%	18.2%	10.6%	0.531	0.816
	5	39.1%	44.4%	12.9%	3.6%	0.580	0.794
	6	63.4%	28.1%	5.8%	2.8%	0.768	0.762
	7	41.9%	45.5%	10.4%	2.1%	0.574	0.792
	16	47.5%	34.0%	15.0%	3.6%	0.624	0.788
	18	54.2%	39.3%	4.6%	1.9%	0.724	0.770
	19	68.3%	27.8%	2.8%	1.1%	0.545	0.793
	9-item Scale	$\bar{x}$: 5.60		*SE*: 0.10		-	0.805
	18-item Scale	$\bar{x}$: 10.55		*SE*: 0.18		-	0.868
Wave 3	1	56.2%	35.4%	6.6%	1.8%	0.632	0.785
	3	75.7%	18.2%	4.3%	1.8%	0.714	0.772
	4	57.9%	22.9%	13.4%	5.8%	0.554	0.810
	5	50.3%	39.0%	7.7%	3.0%	0.604	0.790
	6	73.9%	19.9%	4.3%	2.0%	0.769	0.764
	7	48.5%	41.4%	7.8%	2.3%	0.531	0.801
	16	57.1%	26.7%	14.0%	2.1%	0.668	0.781
	18	58.1%	35.0%	5.2%	1.7%	0.729	0.769
	19	78.1%	18.2%	2.5%	1.2%	0.496	0.799
	9-item Scale	$\bar{x}$: 4.53		*SE*: 0.09		-	0.805

Table A7

CES-D IRT Item and Scale Statistics

Time Point	CES-D Item	IRT Category Response Thresholds: 1 to 2 β	1 to 2 *SE*	2 to 3 β	2 to 3 *SE*	3 to 4 β	3 to 4 *SE*	Item Discrim ination	Max θ	Info at Max θ
Wave 1	1	.49	.04	2.35	.07	3.69	.12	.86	.61	.55
	3	.77	.04	1.81	.07	2.63	.10	1.49	.81	1.60
	4	-.89	.07	1.21	.08	3.30	.11	.42	.40	.15
	5	-.39	.05	1.68	.06	3.18	.10	.71	.01	.38
	6	.39	.03	1.59	.07	2.31	.10	1.83	.42	2.30
	7	-.34	.05	2.37	.07	4.20	.14	.58	.02	.26
	16	-.06	.05	1.70	.08	3.56	.13	.60	.49	.29
	18	.15	.03	1.94	.07	2.71	.11	1.36	.17	1.29
	19	.65	.05	2.70	.08	3.86	.12	.74	.81	.41
	9-item Scale	Max θ: 0.48			Max θ Info: 6.82			*CSEM*: 0.38		
	18-item Scale	Max θ: 0.62			Max θ Info: 9.56			*CSEM*: 0.32		
Wave 2	1	.28	.04	2.12	.07	3.23	.11	.91	.41	.60
	3	.66	.04	1.69	.07	2.55	.13	1.65	.70	1.92
	4	-.83	.07	1.45	.08	3.32	.12	.42	.45	.15
	5	-.47	.04	1.64	.06	3.19	.10	.73	-.09	.40
	6	.36	.04	1.54	.08	2.22	.11	2.00	.38	2.72
	7	-.38	.05	2.05	.07	3.91	.12	.67	-.07	.33
	16	-.12	.05	1.61	.07	3.41	.12	.68	.37	.36
	18	.11	.03	1.82	.07	2.55	.10	1.64	.13	1.84
	19	.77	.04	3.03	.09	4.14	.16	.75	.87	.42
	9-item Scale	Max θ: 0.40			Max θ Info: 8.17			*CSEM*: 0.35		
	18-item Scale	Max θ: 0.52			Max θ Info: 11.00			*CSEM*: 0.30		

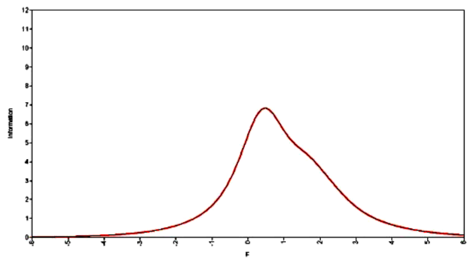
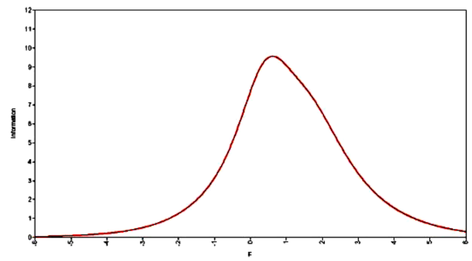
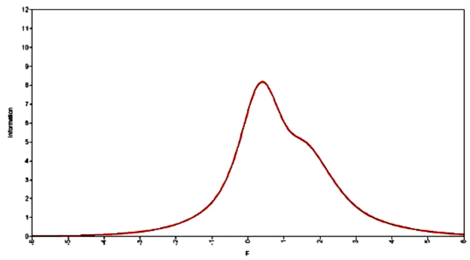
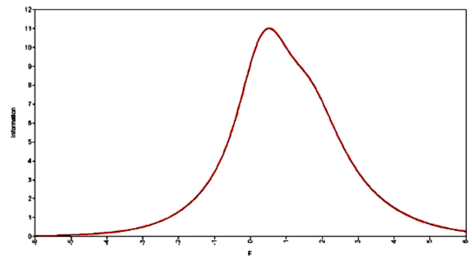
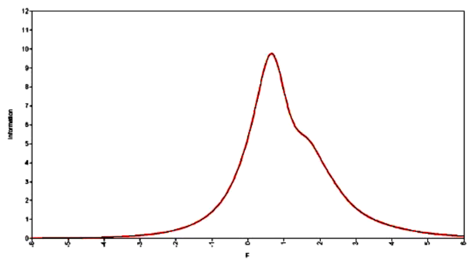
Table A8

CES-D IRT Item and Scale Statistics

Time Point	CES-D Item	IRT Category Response Thresholds 1 to 2		2 to 3		3 to 4		Item Discrimination	Max θ	Info at Max θ
		β	*SE*	β	*SE*	β	*SE*			
Wave 3	1	.22	.04	2.06	.06	3.29	.09	.92	.35	.62
	3	.82	.05	1.89	.09	2.62	.12	1.55	.86	1.72
	4	.42	.06	1.89	.10	3.57	.14	.52	.94	.22
	5	.00	.04	2.06	.06	3.27	.10	.77	.23	.43
	6	.67	.05	1.68	.10	2.33	.14	2.53	.67	4.41
	7	-.10	.06	2.81	.09	4.71	.16	.51	.31	.20
	16	.26	.04	1.53	.06	3.33	.13	.85	.55	.57
	18	.23	.03	1.76	.06	2.61	.10	1.67	.25	1.93
	19	1.34	.05	3.29	.11	4.36	.16	.69	1.47	.36
	9-item Scale	Max θ: 0.65			Max θ Info: 9.75			*CSEM*: 0.32		

Table A9

Test Information Function Graphs – CES-D 9-item and 18-item scales

Wave	CES-D 9-Item Scale TIF	CES-D 18-item Scale TIF
1		
2		
3		N/A

Note: X-axis is latent trait spectrum from -6 to 6. Y-axis is test information from 0 to 12.

Table A10

Model Parameter Estimates

Parameter Estimates	Parameter	Unconditional Model		Sex as Predictor Model		Age as Predictor Model	
		$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*
Means	Intercept	5.616***	.095	4.887***	.103	5.637***	.086
	Slope	-.168***	.015	-.132***	.02	-.171***	.013
Covariance	Intercept - Slope	-.668***	.074	-.633***	.075	-.628***	.073
Predictors (Intercept)	Sex (F)	-	-	1.475***	.129	-	-
	z-Age (W1)	-	-	-	-	.513***	.072
	Afr. Amer.	-	-	-	-	-	-
	Am. Ind.	-	-	-	-	-	-
	Asian	-	-	-	-	-	-
	Hispanic	-	-	-	-	-	-
	Other	-	-	-	-	-	-
Predictors (Slope)	Sex (F)	-	-	-.073*	.03	-	-
	z-Age (W1)	-	-	-	-	-.083***	.013
	Afr. Amer.	-	-	-	-	-	-
	Am. Ind.	-	-	-	-	-	-
	Asian	-	-	-	-	-	-
	Hispanic	-	-	-	-	-	-
	Other	-	-	-	-	-	-
Residual Variances	Intercept	10.388***	.478	9.819***	.472	10.139***	.472
	Slope	.207**	.063	.195**	.062	.201**	.063
	CES-D W1	6.569***	.441	6.659***	.447	6.515***	.443
	CES-D W2	8.585***	.536	8.511***	.533	8.624***	.535
	CES-D W3	6.245**	2.272	6.61**	2.25	6.24**	2.274

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

Table A11

Model Fit Statistics

Fit Index	Unconditional Model		Sex as Predictor Model		Age as Predictor Model	
	$\bar{x}$	*SD*	$\bar{x}$	*SD*	$\bar{x}$	*SD*
χ^2 Test of Model Fit	9.896	0.192	13.898	0.236	12.972	0.512
df	1	-	2	-	2	-
CFI	0.991	0	0.991	0	0.992	0
TLI	0.973	0	0.973	0.001	0.976	0
RMSEA	0.048	0.001	0.039	0	0.038	0
AIC	63267.79	13.56	63113.02	14.084	63188.44	13.025
BIC	63317.83	13.56	63175.56	14.084	63250.99	13.025
SRMR	0.013	0	0.011	0	0.012	0

Table A12

Model Parameter Estimates

Parameter Estimates	Parameter	Ethnicity as Predictor Model		Final Model	
		$\bar{x}$	*SE*	$\bar{x}$	*SE*
Means	Intercept	5.231***	0.097	4.513***	0.094
	Slope (linear)	-0.152***	0.018	-0.118***	0.022
Covariance	Intercept - Slope	-0.646***	0.076	-0.570***	0.075
Predictors (Intercept)	Sex (Female)	-	-	1.525***	0.130
	z-Age (at W1)	-	-	0.52***	0.066
	African American	1.314***	0.216	1.214***	0.204
	American Indian	0.761	0.879	0.792	0.825
	Asian	1.431**	0.486	1.444**	0.464
	Hispanic	1.203***	0.274	1.210***	0.262
	Other	0.582	0.501	0.557	0.569
Predictors (Slope)	Sex (Female)	-	-	-0.083***	0.013
	z-Age (at W1)	-	-	-0.080**	0.030
	African American	-0.062	0.042	-0.047	0.037
	American Indian	0.143	0.257	0.142	0.251
	Asian	-0.066	0.069	-0.064	0.067
	Hispanic	-0.050	0.040	-0.048	0.039
	Other	-0.131	0.112	-0.124	0.122
Residual Variances	Intercept	10.029***	0.473	9.199***	0.457
	Slope (linear)	0.198**	0.063	0.179**	0.063
	CES-D W1	6.643***	0.441	6.686***	0.449
	CES-D W2	8.524***	0.538	8.484***	0.534
	CES-D W3	6.519**	2.275	6.915**	2.259

$^*p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table A13

Model Fit Statistics

Fit Index	Ethnicity as Predictor Model		Final Model	
	$\bar{x}$	*SD*	$\bar{x}$	*SD*
χ^2 Test of Model Fit	23.669	0.554	29.641	0.715
df	6	-	8	-
CFI	0.987	0	0.987	0
TLI	0.962	0.001	0.961	0.001
RMSEA	0.028	0	0.027	0
AIC	63183.08	12.881	62938.47	12.799
BIC	63295.65	12.881	63076.06	12.799
SRMR	0.009	0	0.008	0

APPENDIX B

FIGURES

Figure B1

*Hierarchical-*sequential *Model of Depressive Symptoms*

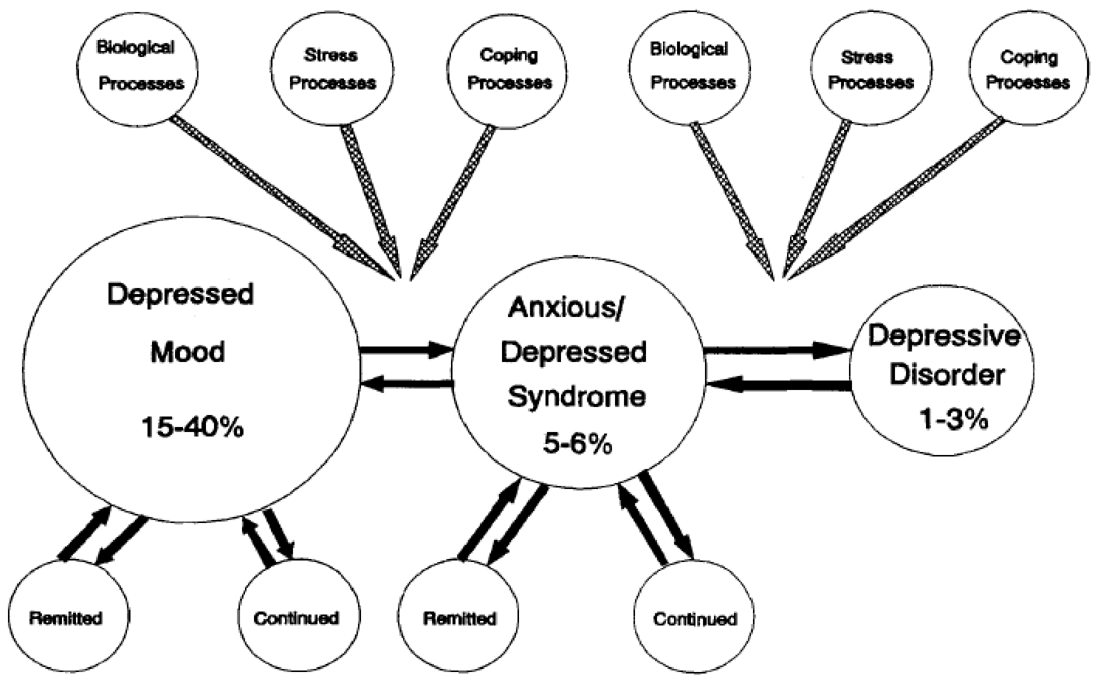


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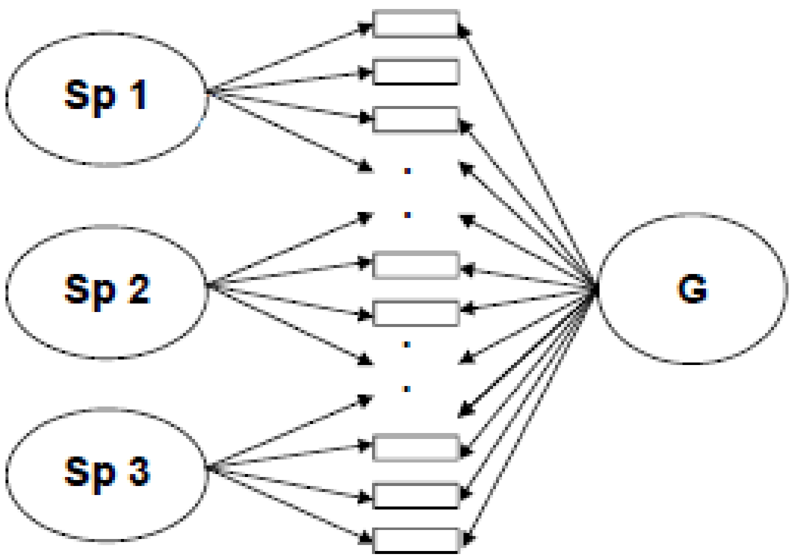
Figure B2

General-Distress Factor Model



G: General Distress. Sp1: Hopelessness-suicidality. Sp2: Restlessness-fatigue. Sp3: Generalized worrying.

Reprinted from "General and specific components of depression and anxiety in an adolescent population," by Brodbeck, J., Abbott, R. A., Goodyer, I. M., & Croudace, T. J., 2011, *BMC Psychiatry*, *11*(1), p. 191. Copyright 2011 by BioMed Central. Reprinted in accordance with BioMed Central Open Access Charter (See Appendix F, Figure F1).

Figure B3

Exogenous-Endogenous Causal Model

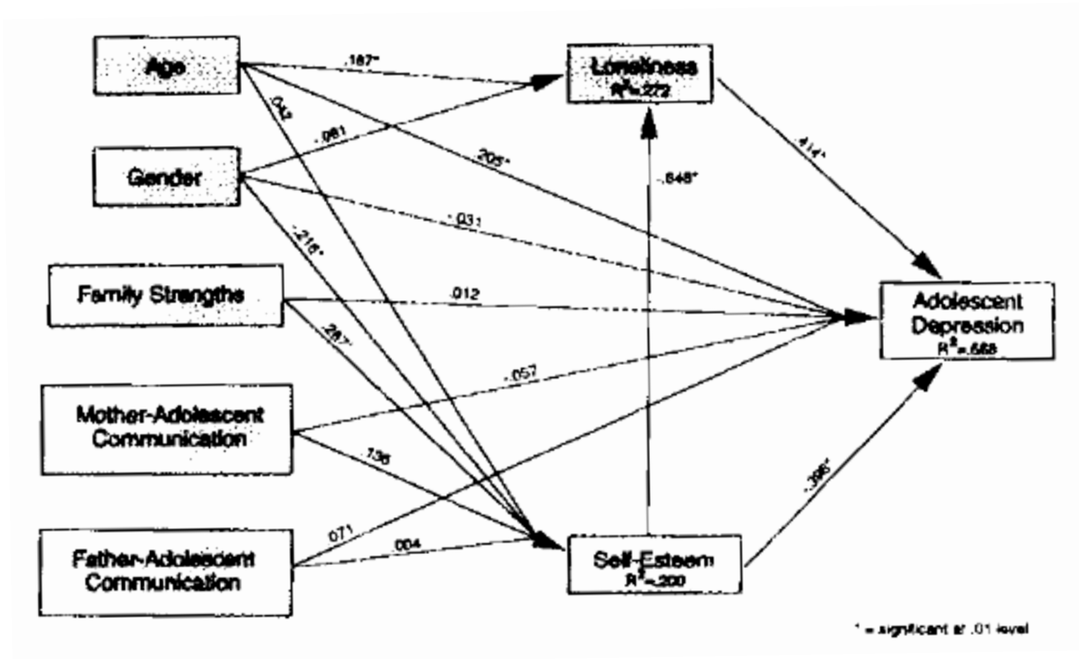


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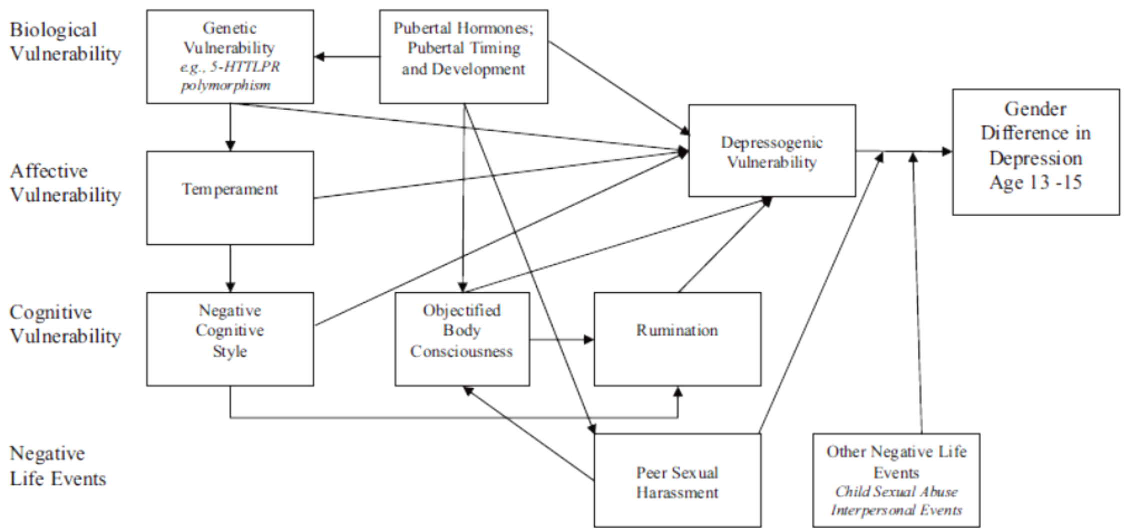
Figure B4

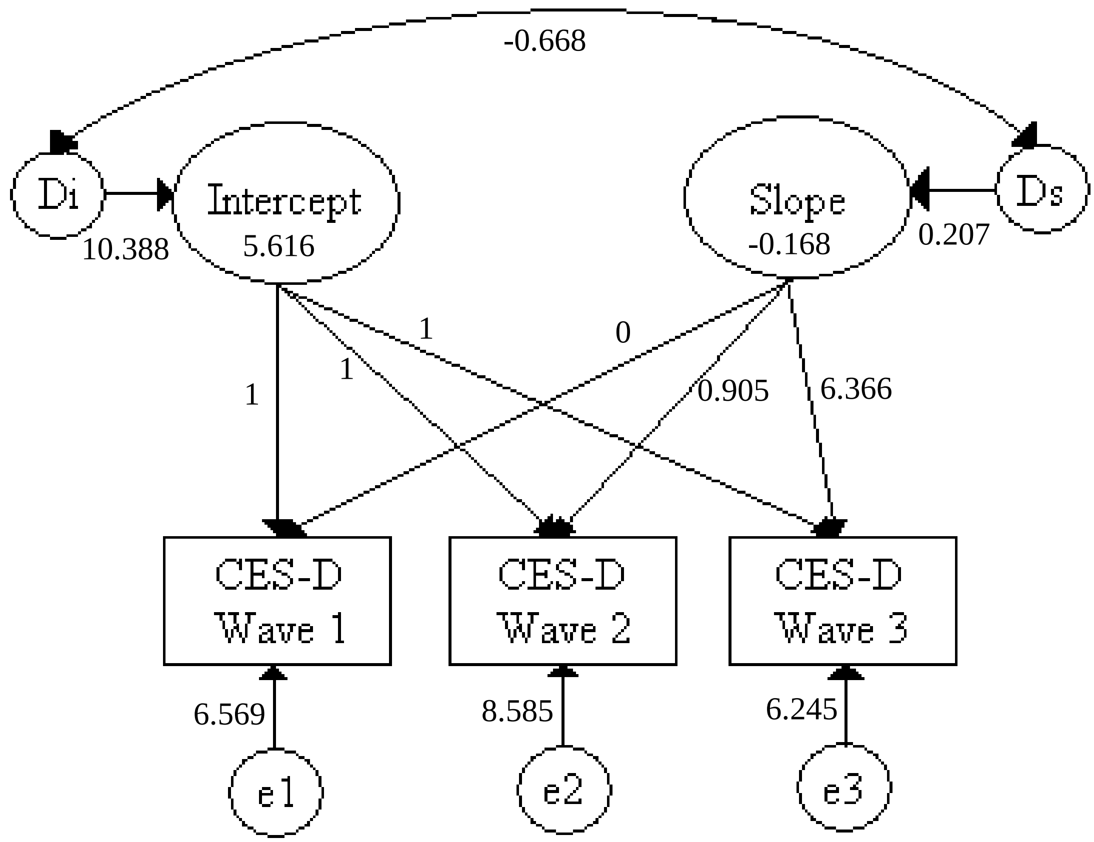
ABC (Affective, Biological, Cognitive) Integrated Model



Reprinted from "The ABCs of depression: Integrating affective, biological, and cognitive models to explain the emergence of the gender difference in depression," by Hyde, J. S., Mezulis, A. H., & Abramson, L. Y., 2008, *The Psychological Review, 115*(2), p. 292. Copyright 2008 by the American Psychological Association. Reprinted in accordance with APA fair use.

Figure B5

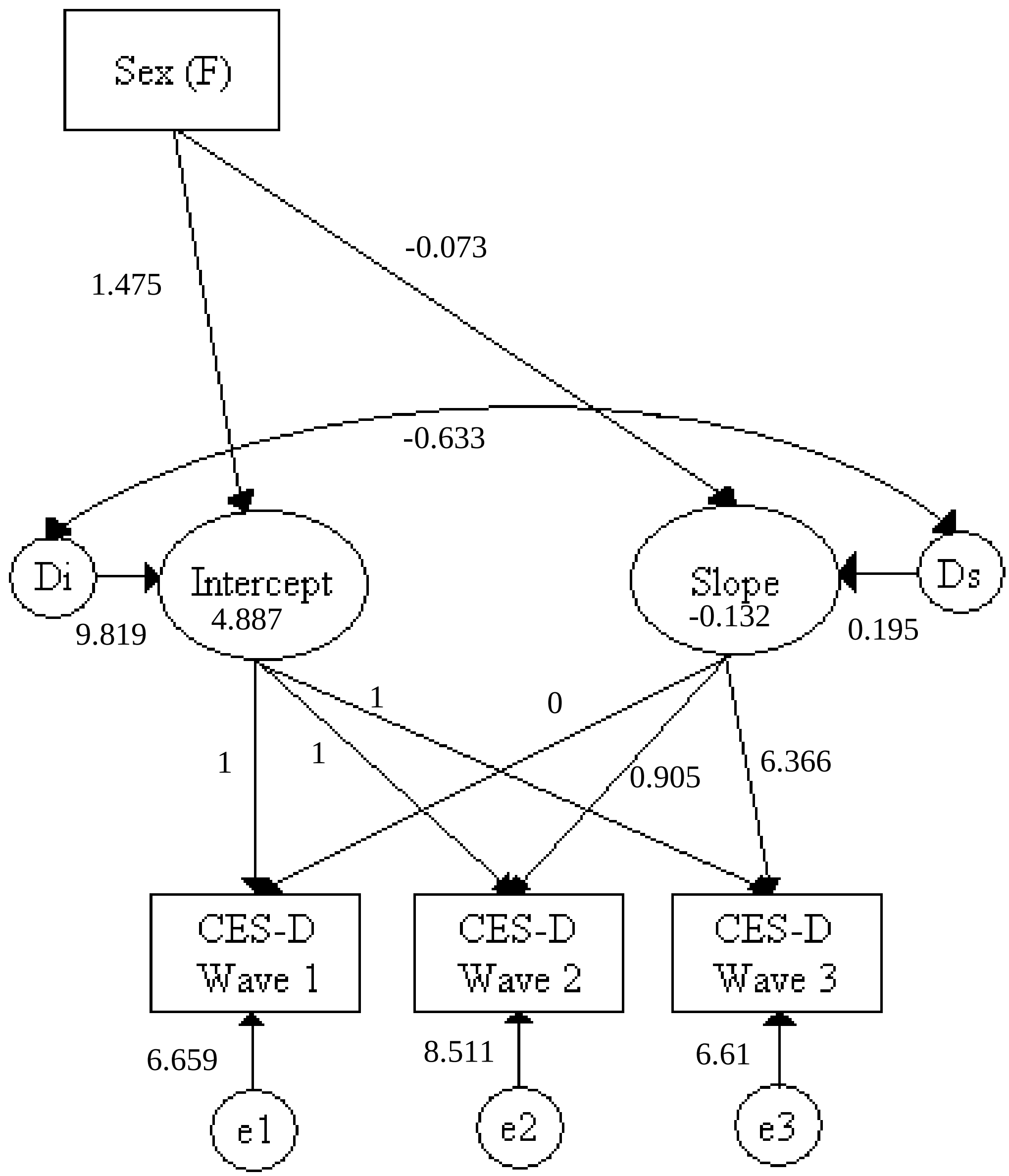
Unconditional Latent Growth Curve Model



Note: Unstandardized Parameter Estimates

Figure B6

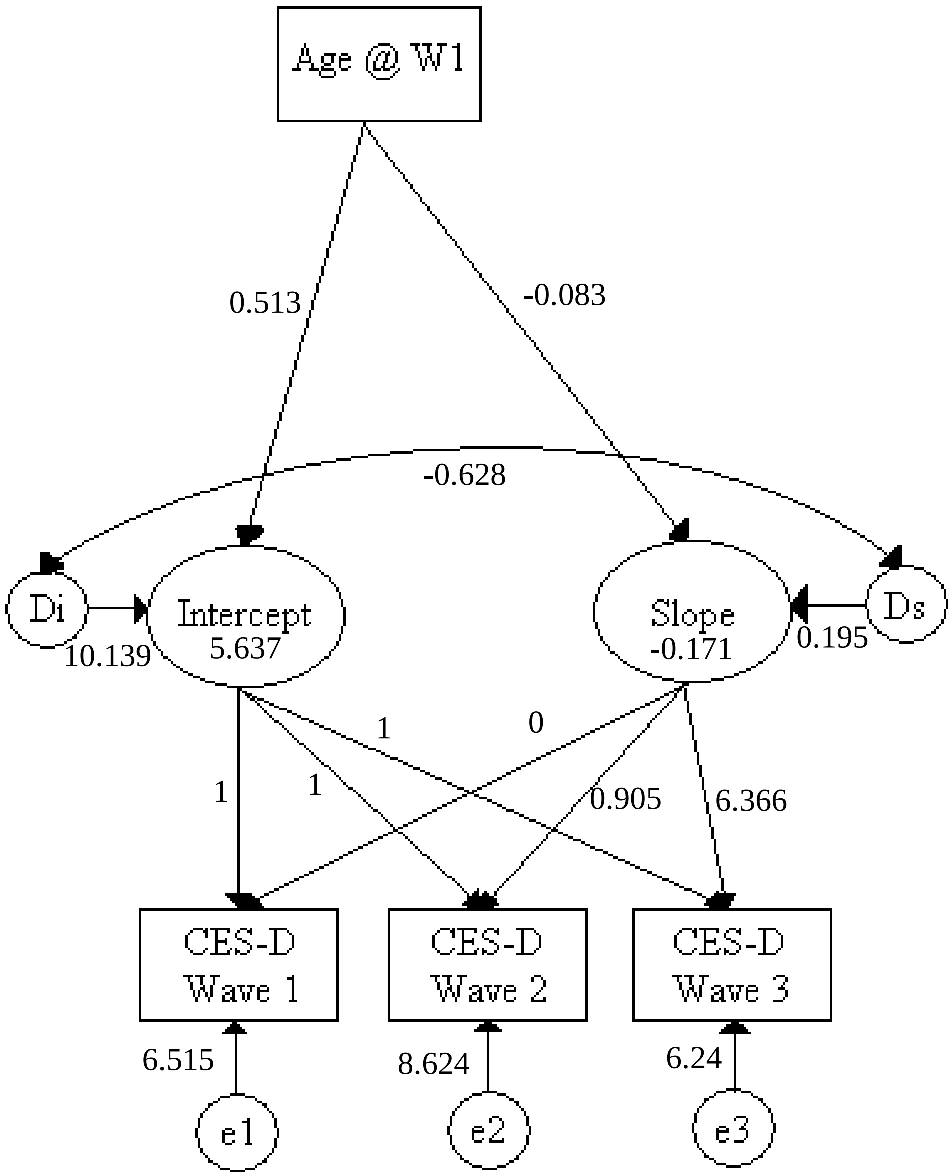
LGCM: Se*x-as-Predictor*



Note: Unstandardized Parameter Estimates

Figure B7

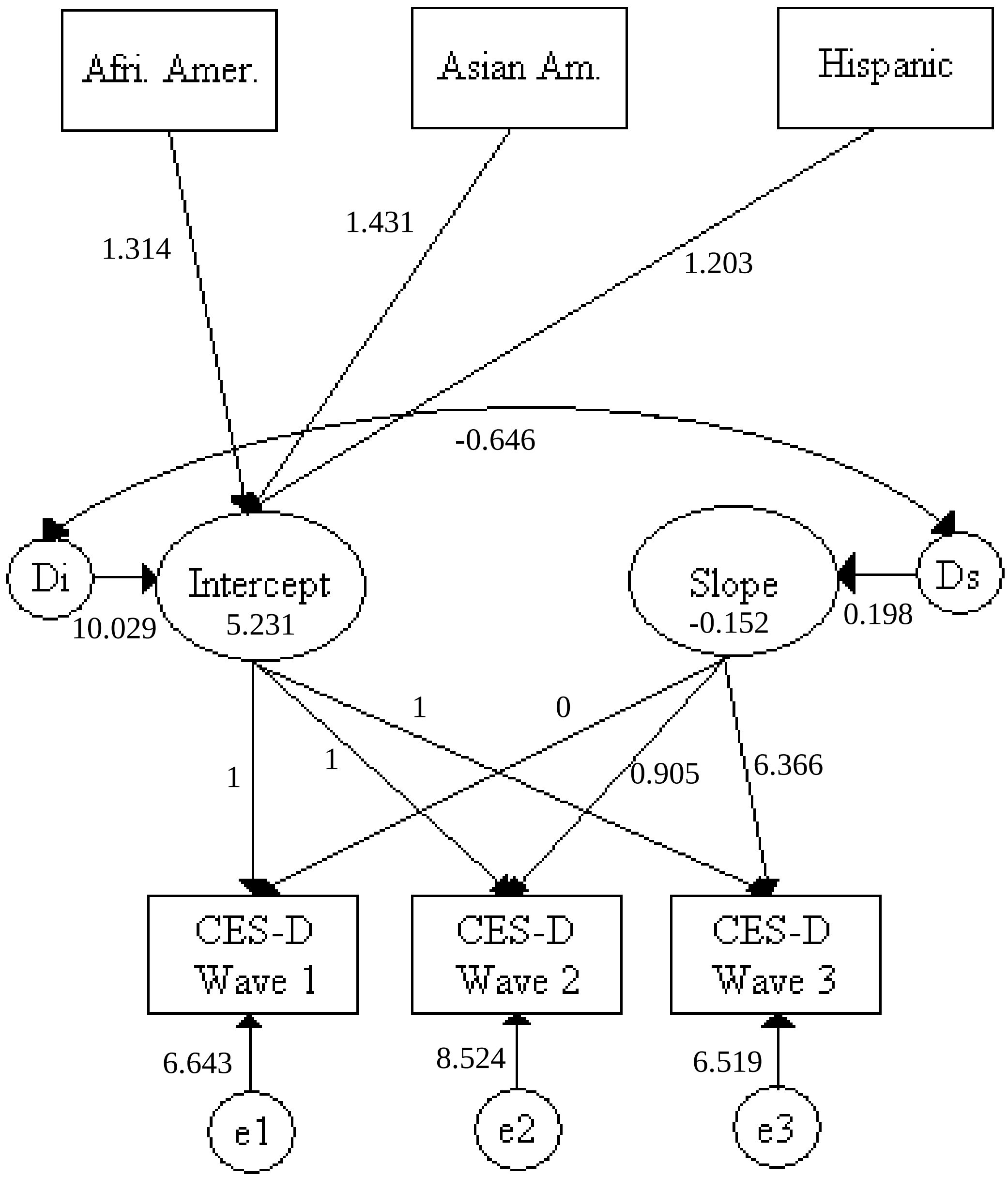
LGCM: Age-as-Predictor



Note: Unstandardized Parameter Estimates

Figure B8

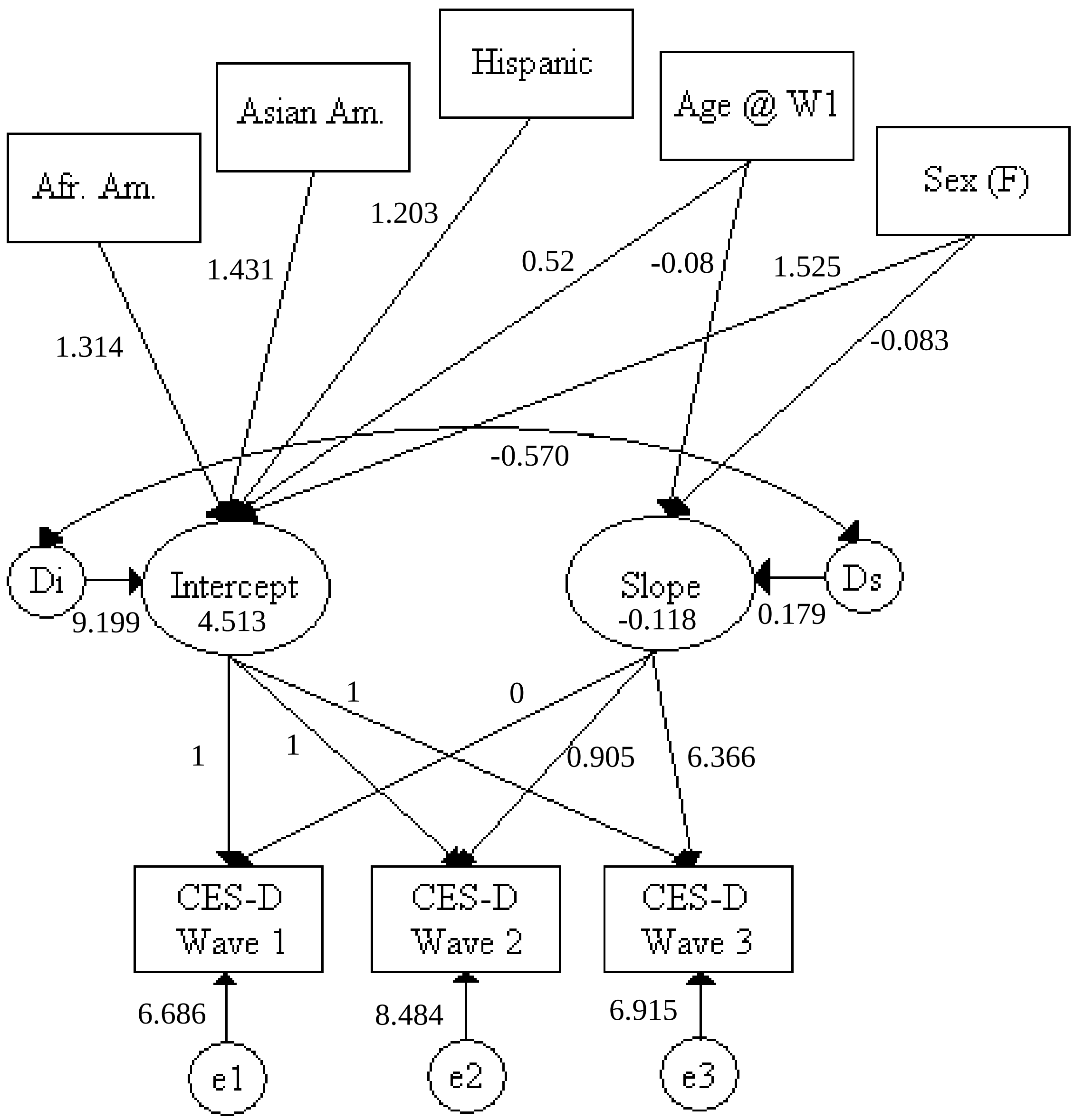
LGCM: Ethnicity-as-Predictor



Note: Unstandardized Parameter Estimates

Figure B9

LGCM: Final Model



Note: Unstandardized Parameter Estimates

APPENDIX C

LIST OF VARIABLES

Table C1

Variable List 1 of 4

Variable Name	Description	Recode	Calculat -ed	Recode Name
AID	Record ID Number	N	N	-
IMONTH	Wave 1 Interview Month	N	N	-
IYEAR	Wave 1 Interview Year	N	N	-
BIO_SEX	Wave 1 Sex	N	N	-
H1GI1M	Wave 1 Birth Month	N	N	-
H1GI1Y	Wave 1 Birth Year	N	N	-
H1GI4	Wave 1 Hispanic Origin Item	N	N	-
H1GI8	Wave 1Single Category Race Item	N	N	-
H1GI9	Wave 1 Interviewer Race Observation	N	N	-
H1FS1	Wave 1 Feeling Scale (CES-D) Item 1	Y	N	w1q1
H1FS2	Wave 1 Feeling Scale (CES-D) Item 2	Y	N	w1q2
H1FS3	Wave 1 Feeling Scale (CES-D) Item 3	Y	N	w1q3
H1FS4	Wave 1 Feeling Scale (CES-D) Item 4	Y	Y	w1q4R
H1FS5	Wave 1 Feeling Scale (CES-D) Item 5	Y	N	w1q5
H1FS6	Wave 1 Feeling Scale (CES-D) Item 6	Y	N	w1q6
H1FS7	Wave 1 Feeling Scale (CES-D) Item 7	Y	N	w1q7
H1FS8	Wave 1 Feeling Scale (CES-D) Item 8	Y	Y	w1q8R
H1FS9	Wave 1 Feeling Scale (CES-D) Item 9	Y	N	w1q9
H1FS10	Wave 1 Feeling Scale (CES-D) Item 10	Y	N	w1q10
H1FS11	Wave 1 Feeling Scale (CES-D) Item 11	Y	Y	w1q12R
H1FS12	Wave 1 Feeling Scale (CES-D) Item 12	Y	N	w1q13
H1FS13	Wave 1 Feeling Scale (CES-D) Item 13	Y	N	w1q14
H1FS14	Wave 1 Feeling Scale (CES-D) Item 14	Y	N	w1q15
H1FS15	Wave 1 Feeling Scale (CES-D) Item 15	Y	Y	w1q16R
H1FS16	Wave 1 Feeling Scale (CES-D) Item 16	Y	N	w1q18
H1FS17	Wave 1 Feeling Scale (CES-D) Item 17	Y	N	w1q19
H1FS18	Wave 1 Feeling Scale (CES-D) Item 18	Y	N	w1q20

Table C2

Variable List 2 of 4

Variable Name	Description	Recode	Calculat-ed	Recode Name
IMONTH2	Wave 2 Interview Month	N	N	-
IYEAR2	Wave 2 Interview Year	N	N	-
H2GI1M	Wave 2 Birth Month	N	N	-
H2GI1Y	Wave 2 Birth Year	N	N	-
H2FS1	Wave 2 Feeling Scale (CES-D) Item 1	Y	N	w2q1
H2FS2	Wave 2 Feeling Scale (CES-D) Item 2	Y	N	w2q2
H2FS3	Wave 2 Feeling Scale (CES-D) Item 3	Y	N	w2q3
H2FS4	Wave 2 Feeling Scale (CES-D) Item 4	Y	Y	w2q4R
H2FS5	Wave 2 Feeling Scale (CES-D) Item 5	Y	N	w2q5
H2FS6	Wave 2 Feeling Scale (CES-D) Item 6	Y	N	w2q6
H2FS7	Wave 2 Feeling Scale (CES-D) Item 7	Y	N	w2q7
H2FS8	Wave 2 Feeling Scale (CES-D) Item 8	Y	Y	w2q8R
H2FS9	Wave 2 Feeling Scale (CES-D) Item 9	Y	N	w2q9
H2FS10	Wave 2 Feeling Scale (CES-D) Item 10	Y	N	w2q10
H2FS11	Wave 2 Feeling Scale (CES-D) Item 11	Y	Y	w2q12R
H2FS12	Wave 2 Feeling Scale (CES-D) Item 12	Y	N	w2q13
H2FS13	Wave 2 Feeling Scale (CES-D) Item 13	Y	N	w2q14
H2FS14	Wave 2 Feeling Scale (CES-D) Item 14	Y	N	w2q15
H2FS15	Wave 2 Feeling Scale (CES-D) Item 15	Y	Y	w2q16R
H2FS16	Wave 2 Feeling Scale (CES-D) Item 16	Y	N	w2q18
H2FS17	Wave 2 Feeling Scale (CES-D) Item 17	Y	N	w2q19
H2FS18	Wave 2 Feeling Scale (CES-D) Item 18	Y	N	w2q20

Table C3

Variable List 3 of 4

Variable Name	Description	Recode	Calcula-ted	Recode Name
CLUSTER2	Wave 3 Sample Cluster Indicator	N	N	-
GSWGT3	Wave 3 Grand Sample Weight for Longitudinal Research	N	N	-
IMONTH3	Wave 3 Interview Month	N	N	-
IYEAR3	Wave 3 Interview Year	N	N	-
H3OD1M	Wave 3 Birth Month	N	N	-
H3OD1Y	Wave 3 Birth Year	N	N	-
H3SP5	Wave 3 Feeling Scale (CES-D) Item 1	Y	N	w3q1
H3SP6	Wave 3 Feeling Scale (CES-D) Item 2	Y	N	w3q3
H3SP7	Wave 3 Feeling Scale (CES-D) Item 3	Y	Y	w3q4R
H3SP8	Wave 3 Feeling Scale (CES-D) Item 4	Y	N	w3q5
H3SP9	Wave 3 Feeling Scale (CES-D) Item 5	Y	N	w3q6
H3SP10	Wave 3 Feeling Scale (CES-D) Item 6	Y	N	w3q7
H3SP11	Wave 3 Feeling Scale (CES-D) Item 7	Y	Y	w3q16R
H3SP12	Wave 3 Feeling Scale (CES-D) Item 8	Y	N	w3q18
H3SP13	Wave 3 Feeling Scale (CES-D) Item 9	Y	N	w3q19

Table C4

Variable List 4 of 4

Variable Name	Description	Recode	Calculat-ed	Recode Name
birthdat	Birthday as Integer	N	Y	-
w1date	Wave 1 Interview Month/Year as Integer	N	Y	-
w1age	Wave 1 Age as Integer	N	Y	-
w2date	Wave 2 Interview Month/Year as Integer	N	Y	-
w2age	Wave 2 Age as Integer	N	Y	-
w3date	Wave 3 Interview Month/Year as Integer	N	Y	-
w3age	Wave 3 Age as Integer	N	Y	-
race	Single Category Race	N	Y	-
sex	Participant Sex	N	Y	-
zage	Standardized Wave 1 Age	N	Y	-
ethcauc	Binary Caucasian Ethnicity Indicator	N	Y	-
ethafam	Binary African-American Ethnicity Indicator	N	Y	-
ethamin	Binary American Indian Ethnicity Indicator	N	Y	-
ethasia	Binary Asian-American Ethnicity Indicator	N	Y	-
ethhisp	Binary Hispanic Ethnicity Indicator	N	Y	-
ethothr	Binary Other Ethnicity Indicator	N	Y	-
w1qtot9	Wave 1 9-item CES-D Total	N	Y	-
w2qtot9	Wave 2 9-item CES-D Total	N	Y	-
w3qtot9	Wave 3 9-item CES-D Total	N	Y	-
w1qtot18	Wave 1 18-item CES-D Total	N	Y	-
w2qtot18	Wave 2 19-item CES-D Total	N	Y	-

APPENDIX D

CES-D QUESTIONNAIRE (RADLOFF, 1977)

Item	Item Wording	W1	W2	W3
1**	You were bothered by things that usually don't bother me.	*	*	*
2	You didn't feel like eating; your appetite was poor.	*	*	
3**	You felt that you could not shake off the blues even with help from your family and friends.	*	*	*
4**	You felt that you were just as good as other people. †	*	*	*
5**	You had trouble keeping your mind on what you were doing.	*	*	*
6**	You felt depressed.	*	*	*
7**	You felt that you were too tired to do things.	*	*	*
8	You felt hopeful about the future. †	*	*	
9	You thought your life had been a failure.	*	*	
10	You felt fearful.	*	*	
11	You sleep was restless. ***			
12	You were happy. †	*	*	
13	You talked less than usual.	*	*	
14	You felt lonely.	*	*	
15	People were unfriendly to you.	*	*	
16**	You enjoyed life. †	*	*	*
17	You had crying spells. ***			
18**	You felt sad.	*	*	*
19**	You felt that people disliked you.	*	*	*
20	It was hard to get started doing things.	*	*	

*** included in LGCM analysis. † reverse scored. *** Not comparable to original CES-D*

Note: Item Preface: "How often was each of the following things true during the past week?" Response set included: 0-never or rarely, 1-sometimes, 2-a lot of the time, 3-most of the time or all of the time, 6-refused, 8-don't know, 9-not applicable. Item 11 was not a CES-D item and item 17 used a non CES-D response criterion (month timeframe versus week timeframe).

Adapted from "The CES-D Scale:A Self-Report Depression Scale for Research in the General Population," by L. Radloff, 1977, *Applied Psychological Measurement, 1*(3), p. 387. Copyright 1977 by SAGE Publications. Adapted with permission (see Appendix F, Figure F3).

APPENDIX E

IRB APPROVAL LETTER

MIDDLE TENNESSEE STATE UNIVERSITY

March 20, 2013

John Short, Dr. Jwa Kim
Department of Psychology
jrs5j@mtmail.mtsu.edu, Jwa.Kim@mtsu.edu

Protocol Title: "Underlying Structure of Adolescent Depression: Application of Latent Growth Curve Model"

Protocol Number: 13-278

Dear Investigator(s),

The exemption is pursuant to 45 CFR 46.101(b) (4). This is because the research being conducted involves the use and collection of existing data that is de-identified.

You will need to submit an end-of-project report to the Compliance Office upon completion of your research. Complete research means that you have finished collecting data and you are ready to submit your thesis and/or publish your findings. Should you not finish your research within the three (3) year period, you must submit a Progress Report and request a continuation prior to the expiration date. Please allow time for review and requested revisions. Your study expires on March 20, 2016.

Any change to the protocol must be submitted to the IRB before implementing this change. According to MTSU Policy, a researcher is defined as anyone who works with data or has contact with participants. Anyone meeting this definition needs to be listed on the protocol and needs to provide a certificate of training to the Office of Compliance. **If you add researchers to an approved project, please forward an updated list of researchers and their certificates of training to the Office of Compliance before they begin to work on the project.** Once your research is completed, please send us a copy of the final report questionnaire to the Office of Compliance. This form can be located at www.mtsu.edu/irb on the forms page.

Also, all research materials must be retained by the PI or **faculty advisor (if the PI is a student)** for at least three (3) years after study completion. Should you have any questions or need additional information, please do not hesitate to contact me.

Sincerely,

Andrew W. Jones

Compliance Office
615-494-8918
Compliance@mtsu.edu

APPENDIX F

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Figure F1

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Figure F2

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Routledge Taylor & Francis Group

Title: A Causal Model of Adolescent Depression
Author: Diane Brage, William Meredith
Publication: The Journal of Psychology
Publisher: Taylor & Francis
Date: Jul 1, 1994

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Figure F3

Reprint Permissions for CES-D Scale (Appendix D)

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SAGE

Title: The CES-D Scale:A Self-Report Depression Scale for Research in the General Population

Author: Lenore Sawyer Radloff

Publication: Applied Psychological Measurement

Publisher: SAGE Publications

Date: 06/01/1977

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