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A Prospective Study of Stress Autonomy versus Stress Sensitization in Adolescents at Varied Risk for Depression

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Abstract

This longitudinal study investigated the stress autonomy, stress sensitization, and depression vulnerability hypotheses in adolescents across six years (i.e., grades 6 through 12). Participants were 240 children (Time 1 mean age = 11.86, *SD* = 0.57) who varied in risk for depression based on their mother's history of mood disorders. All analyses were conducted as multilevel models to account for nesting in the data. Results were consistent with the stress sensitization hypothesis. The within-subject relation of stress levels to depressive symptoms strengthened with increasing numbers of prior depressive episodes. In addition, evidence consistent with the vulnerability hypothesis was found. The relation of stress levels to depressive symptoms was stronger for adolescents who were at risk for depression based on maternal depression history and for those who had experienced more depressive episodes through grade 12. These findings suggest that onsets of depression in adolescents may be predicted by both relatively stable and dynamic transactions between stressful life events and vulnerabilities such as maternal depression and youths' own history of depressive episodes.

A Prospective Study of Stress Autonomy versus Stress Sensitization in Adolescents at Varied Risk for Depression

The link between the experience of stressful life events (SLEs) and the onset of major depressive disorder (MDD) has received strong empirical support in both children and adults (Grant, Compas, Thurm, McMahon, & Gipson, 2004; Kendler, Karkowski, & Prescott, 1999), although considerable variability exists in individuals' responses to similar stressors. Diathesis-stress theories (e.g., Abramson, Metalsky, & Alloy, 1989; Abramson, Seligman, & Teasdale, 1978; Beck, 1967, 1976; Monroe & Simons, 1991) have attempted to account for this variability by proposing relatively stable individual vulnerability factors that moderate the relation between stress and depression. Current evidence suggests that the risk of having a major depressive episode (MDE) increases as a function of the number of prior episodes (American Psychiatric Association, 2000; Solomon et al., 2000). Moreover, first lifetime

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episodes of depression tend to be more strongly associated with SLEs than recurrences (e.g., Farmer et al., 2000; Lewinsohn, Allen, Seeley, & Gotlib, 1999; for a meta-analytic review see Stroud, Davila, & Moyer, 2008). Theories seeking to explain the etiological role of stressful life events in relation to MDEs need to account for changes in this relation across successive recurrences.

The present study examined several models that offer unique accounts of the dynamic relation between stress and depression. According to the stress autonomy hypothesis, the relation between stress levels and depression weakens with successive MDEs such that stressors eventually no longer trigger recurrences (see Figure 1). In contrast, the stress sensitization hypothesis asserts that with each successive MDE the level of stress capable of triggering a recurrence decreases. This may take the form of the following three submodels (described below): 'stress activation,' 'stress amplification, or 'risk saturation.' Finally, the 'vulnerability model' proposes that relatively stable individual differences are responsible for the changing relation between stress levels and depression.

Stress Autonomy

The "kindling" hypothesis has been proposed as an explanation for changes in the relation of stress to depression over time. In their review, Monroe and Harkness (2005) highlighted conceptual confusion in this literature and identified two distinct models that frequently are both referred to as "kindling." The stress autonomy model implies two parallel processes. First, the association between SLEs and onsets of depressive episodes weakens with each successive MDE, such that eventually SLEs no longer trigger MDEs. Second, MDEs become progressively decoupled from life stress, such that depressive episodes eventually emerge autonomously, without an apparent trigger. The stress autonomy model as conceptualized here (see Figure 1) asserts that stress levels and depression recurrences (i.e., number of prior MDEs) will interact such that the relation of stress levels to depressive symptoms will weaken with each successive MDE until eventually these processes are essentially independent. This interaction pattern is consistent with the stress inoculation model proposed by Rudolph and Flynn (2007) that predicts that exposure to childhood adversity will result in reduced reactivity to both major and minor stressors.

Stress Sensitization

In contrast, the stress sensitization model as conceptualized in the current study asserts that stressors become increasingly capable of triggering depressive symptoms. Thus, an individual's likelihood of developing depression increases with each successive MDE as the person becomes progressively more sensitized to SLEs. The exact form of the interaction between stress and depression recurrences (i.e., number of prior MDEs) that would support stress sensitization could occur in one of the following three ways.

The *stress activation model* (Figure 2a) predicts that the relation between stress and depressive symptoms will *strengthen* with repeated episodes such that the activation threshold is lower at both high and low levels of stress. Individuals who are more sensitized to stress maintain their ability to discriminate between stressors of different magnitudes; that is, the impact of both major and minor stressors increases with each successive MDE.

The *stress amplification model* (Figure 2b) also predicts that the relation between stress and depression will strengthen with repeated episodes; however, individuals who are more sensitized will only exhibit high levels of depressive symptoms in response to major stressors (Rudolph & Flynn, 2007). That is, differences in sensitization across individuals will be more readily observed at high levels of stress. Those who have not experienced prior MDEs will show low levels of depressive symptoms regardless of degree of stress exposure.

In contrast to these two prior models, the *risk saturation model* (Figure 2c) predicts a decreasing threshold of activation and a *weakening* of the relation between stress and depressive symptoms with repeated episodes. According to this framework, differences in sensitization between individuals will be more readily observed at low levels of stress; that is, the impact of minor stressors increases with successive MDEs, whereas the impact of major stressors remains the same. Those who experience more recurrences will appear equally responsive to stressors of high and low magnitude. [The risk saturation model describe here is similar to what Rudolph and Flynn (2007) referred to as the stress sensitization model of childhood adversity.]

Vulnerability Model

Finally, in contrast to models hypothesizing that the effects of stress change within individuals over time, thereby leading to observations that individuals become more or less vulnerable to stress as a function of prior MDEs, diathesis-stress models (i.e., vulnerability models) propose relatively stable risk factors that moderate the effect of stress on depression. Prior research has conceptualized vulnerability to depression as a biological or psychological predisposition "for the propensity to incur repeated depressions and to respond less favorably under stress" (Monroe, Kupfer, & Frank, 1992, p. 723). Although these vulnerabilities often are treated as time-invariant in statistical models, they may exhibit both stability and change over time (e.g., Caspi, Roberts, & Shiner, 2005). For example, the cognitive vulnerability to depression becomes relatively stable during early to middle adolescence compared to earlier in childhood, yet continues to change with development (e.g., Cole et al., 2001; Hankin, 2008). In the current study, vulnerability for each adolescent was operationalized with regard to two factors: (a) risk status based on maternal depression history; and (b) the total number of MDEs youth had experienced by the end of the study (i.e., 12^{th} grade). As we had information on participants only through 12^{th} grade, this construct should be considered an estimate of depression vulnerability across adolescence and not necessarily an indicator of risk beyond this developmental period.

A definition of vulnerability as "the total number of depressive episodes" can yield data consistent with either the stress autonomy or stress sensitization perspectives. According to the 'total episodes' perspective, individuals with greater vulnerability to depression will have more MDEs as compared to individuals with lower depression vulnerability. If depression-prone individuals exhibit relatively stable, enhanced sensitivity to stressors of any magnitude, this would be consistent with the stress activation model. Conversely, if such vulnerable individuals evince decreased sensitivity to stressors of any magnitude, then this would be consistent with the stress autonomy model. Failure to examine within-individual change would lead to the erroneous conclusion that the relation between stress and depressive symptoms was either strengthening or weakening, respectively, as a function of the number of prior MDEs. It is important to note that neither the stress autonomy nor the stress sensitization model is incompatible with the vulnerability model. That is, vulnerability factors may possess both relatively stable and dynamic properties.

The literature on stress autonomy and stress sensitization processes has been limited by several conceptual and methodological issues. Some studies have treated repeated measurements within individuals as independent. Doing so may lead to biased variability estimates and inflated Type I error rates. In addition, most studies have not considered subtle distinctions among the submodels of stress sensitization outlined above (for an exception, see Rudolph & Flynn, 2007). Finally, studies generally have failed to examine changes in the *impact* and *frequency* of both major and minor stressors across first onsets and recurrences (for a thorough discussion of this issue see Monroe & Harkness, 2005). In the current study, 'impact' was defined as the relation of stress *levels* to depressive symptoms, and 'frequency' was the relation of the total *number* of stressors to depressive symptoms. Previously, these constructs have been

framed in probabilistic terms; for example, frequency was defined as the probability of a stressful life event given the presence of an MDE (Monroe & Harkness, 2005). In contrast, the operationalization of frequency used here captures the prospective relation rather than the conditional probability. Moreover, we expected the association between numbers of major versus minor stressors with depressive symptoms to change with increasing number of episodes. Predictions regarding changes in the impact versus frequency of major and minor stressors across successive MDEs are presented in Table 1.

Empirical Support for Stress Autonomy, Stress Sensitization, and Vulnerability Models

Most studies investigating changes in the role of life stress across depressive episode recurrences have focused on severe stressors (i.e., major life events) and have found results consistent with the stress autonomy model as well as with two of the stress sensitization submodels: stress activation and risk saturation. Table 2 lists articles published since 1999 that have tested at least one of the models described here. For example, Kendler and colleagues (2000,2001,2004) investigated within-individual changes in the association between major life events and depression onsets and observed a decline in the depressogenic effects of stress with increasing numbers of MDEs. Studies examining less severe (i.e., minor) stressors generally have been consistent with both the stress activation and risk saturation submodels of stress sensitization. For example, Ormel, Oldehinkel, and Brilman (2001) found that more severe stressful life events were stronger predictors of first onsets than recurrences, whereas less severe stressors predicted recurrences but not first onsets. Taken together, these findings suggest that individuals may become increasingly sensitized to less severe stressors as they experience more MDEs.

Studies of early adversity offer a complementary perspective on stress autonomy and stress sensitization processes by shifting emphasis from stress-related psychopathology to the experience of stress itself. A cross-sectional study comparing nondepressed, first onset, and recurrent depressed adolescents regarding the relation of childhood abuse and neglect to stress sensitization processes found that adolescents exposed to early trauma experienced lower threat life events prior to first onsets of depression compared to adolescents never exposed to trauma (Harkness, Bruce, & Lumley, 2006). Evidence consistent with stress sensitization submodels was found in a study of children who varied with regard to their history of an anxiety disorder (Espejo et al., 2006). Consistent with the risk saturation model, children with histories of anxiety and low early adversity showed elevated depressive symptoms only at high levels of stress, whereas those who had been exposed to greater early adversity showed high levels of depressive symptoms at both low and high stress levels. Consistent with the stress amplification model, however, was the finding that children without a history of anxiety showed high levels of depressive symptoms only if they had high early adversity exposure.

Finally, Rudolph and Flynn (2007) reported an interesting sex difference in the relations among early adversity, stress, and depression. For girls, early adversity was associated with stress amplification processes during the pre-pubertal period and risk saturation processes during the pubertal period; for boys, early adversity moderated the relation of stress to depression during the pre-pubertal period in a manner consistent with the risk saturation model. Thus, stress sensitization processes may vary by sex and by exposure to early adversity.

Evidence consistent with the vulnerability model has been found in studies of offspring of depressed parents showing increased risk for depression (e.g., Beardslee, Versage, & Gladstone, 1998), increased exposure to high levels of stress (e.g., Billings & Moos, 1983), and a significant relation between stress and depressive symptoms (e.g., Langrock et al., 2002). Although parental depression can be a relatively stable risk factor for depression in children, it is by no means a homogeneous construct. Rather, parental depression can vary with regard to its severity, chronicity, subtypes, associated paternal psychopathology,

developmental timing, and interactions among these variables (Goodman & Gotlib, 1999), which then can contribute to variability in children's outcomes.

The current study examined stress autonomy and stress sensitization processes from early to middle adolescence, which is when rates of depression are known to be increasing (Hankin et al., 1998). Previous research testing these models has primarily focused on adults who may report high rates of prior MDEs (e.g., Kendler et al., 2000). Some researchers have questioned the reliability and validity of these assessments (e.g., Bromet, Dunn, Connell, Dew, & Schulberg, 1986) and their capacity to detect changes in the relation of stress to depression (cf. Monroe & Harkness, 2005). By following adolescents from 6th through 12th grade, we were able to examine changes in the relation of stress to depressive symptoms across first onsets and recurrences during a developmental epoch well-suited to the detection of stress autonomy and stress sensitization processes (Monroe & Harkness, 2005; Monroe et al., 1999).

Evidence from clinical and community samples suggests that adolescent-onset depression is associated with increased risk for recurrence in adulthood (e.g., Bardone, Moffitt, Caspi, Dickson, & Silva, 1996; Fombonne, Wostear, Cooper, Harrington, & Rutter, 2001; Lewinsohn, Rohde, Klein, & Seeley, 1999; Rao, Hammen, & Daley, 1999; Weissman et al., 1999). Among children and adolescents who develop a first onset of MDD, as many as 70% experience a recurrence within 5 years (Kovacs et al. 1984; Rao, Ryan, & Birmaher, et al., 1995); thus, the 6-year duration of the current study was well-suited for detecting differences of both statistical and clinical significance. Of particular relevance to the current study, familial transmission of depression has been associated with both earlier age of onset and greater recurrence of MDD (Weissman et al., 2006).

Current Methodological Approach

To adequately test the stress autonomy and stress sensitization hypotheses requires a prospective, within-subjects design (Hammen, 2005; Monroe & Harkness, 2005). Such a design allows for the examination of whether within individuals, the strength of the predictive association between stress and depressive symptoms changes as a function of the number of MDEs experienced. In addition, within-subjects analyses let us determine how much of the variation in depression severity can be attributed to relatively stable versus dynamic individual vulnerabilities.

Domains of Stress—In the present study, we examined within- and between-individual change with respect to several different domains of stress. Consistent with the recommendations of Monroe and Harkness (2005), we examined changes in *impact* with stressor severity levels summed across events. This approach assumes that an individual's level of stress may be affected by both the number and severity of stressors. We also examined whether the *frequency* of major and minor events changed in relation to time or number of prior MDEs, and if the association of total major or minor events to depressive symptoms varied as a function of the number of prior MDEs. Second, we conducted these analyses again separately for independent and dependent events to examine whether stress autonomy or sensitization processes remained after the potential influence of stress generation processes was controlled. Depression history has been found to predict the generation of dependent, but not independent, stressors (e.g., Cole et al., 2006).

Finally, we tested the models separately for achievement and interpersonal stressors to examine whether stress autonomy or sensitization processes were differentially related to specific categories of stress. This approach is consistent with prior research suggesting that interpersonal and achievement life events may capture meaningful individual differences in vulnerability to depression (e.g., Abramson, Alloy, & Hogan, 1997). Adolescence may be a particularly salient developmental period for interpersonal life events due to shifts in roles,

expectations, and interests (Greene & Larson, 1991). For example, stressors involving romantic upheavals have been found to be significantly related to first onsets, but not recurrences, of depression during adolescence (Monroe et al., 1999).

Measure of Depression—Whereas most prior studies of the stress autonomy and stress sensitization models have been conducted with respect to the onset of depressive disorders, the current study tested these models with regard to changes in Depression Symptom Rating (DSR) scores, which are based on the number of depressive symptoms and extent of impairment; DSR scores can range from no or few symptoms to a full diagnosis of depression, thereby providing an index of depression assessed both dimensionally and categorically. Subthreshold depression has been found to have a higher 1-month point prevalence rate in community samples than MDD (Judd, Akiskal, & Paulus, 1997), shares demographic, clinical, and neurophysiological features with MDD (Akiskal, Rosenhal, Haykal, Lemmi, Rosenthal, & Scott-Strauss, 1980; Sherbourne, Wells, Hays, Rogers, Burnam, & Judd, 1994), and meets dysfunction criteria necessary to qualify as a psychiatric disorder (Judd et al., 1997). Moreover, subthreshold depression is associated with increased prevalence of prior and future MDEs (e.g., Sherbourne et al., 1994) Examining change in DSR scores allowed for an analysis of weekly fluctuations in depressive symptoms and afforded greater variability than depression onsets alone. Throughout this paper, the terms ‘DSR scores’ and ‘depressive symptoms’ are used interchangeably.

The Present Study

The present study addressed the following primary research questions and hypotheses. First, does the within-individual relation between total stress levels and depressive symptoms change with successive episodes? We examined stress autonomy and stress sensitization processes using a cumulative total of the number of MDEs ranging from 0 to 2 or more episodes. Predictions for each model regarding changes in the impact (i.e., relation to depression) of major and minor events across episode recurrences are presented in Table 1.

Second, are changes in the impact of stressful life events on depressive symptoms better accounted for by changes in (a) the number of stressors across time, (b) the number of stressors over successive MDEs, or (c) the relation of total number of stressors to depressive symptoms? To determine whether the rate of stressors changed over time, we specified growth models predicting the number of major or minor stressors during each week of the study. To examine whether the number of life events differed as a function of depression recurrences (i.e., number of prior MDEs), we specified models predicting cumulative total of MDEs from the number of major or minor stressors. To examine whether the frequency of stressful life events prior to increases in depressive symptoms changed as a function of depression recurrences (i.e., number of prior MDEs), we tested models predicting change in level of depressive symptoms from the interaction of prior MDEs and the number of major or minor stressors. Predictions for each model are presented in Table 1.

Third, is the within-subject relation of stress levels to depressive symptoms stronger for individuals who are more vulnerable to depression? This test of the stress autonomy or stress sensitization models focused on between- rather than within-subjects differences. The depression vulnerability model specifies that relatively stable vulnerabilities (e.g., genetic, biological, and/or psychological) moderate the relation between stress levels and depressive symptoms. We hypothesized that the interaction of stress levels with risk (i.e., maternal depression history, total number of MDEs experienced through grade 12) would predict changes in depression symptoms. The form of this interaction could provide results consistent with the stress autonomy model (i.e., more vulnerable individuals appear less sensitive to stress), the stress activation model (i.e., more vulnerable individuals respond to major and

minor stressors with greater increases in depressive symptoms), the stress amplification model (i.e., more vulnerable individuals respond to major stressors with greater increases in depressive symptoms), or the risk saturation model (i.e., more vulnerable individuals exhibit high levels of depression regardless of stressor level).

Fourth, do stress autonomy or stress sensitization effects remain significant after accounting for relatively stable individual differences in vulnerability to depression? To address this question we tested an overall model including the interaction of prior MDEs with stress levels and the interaction of depression vulnerability with stress levels. We hypothesized that both between-subject (i.e., risk status based on maternal depression history or total number of MDEs) and within-subject (i.e., number of prior MDEs) factors would moderate the relation of total stress levels to depressive symptoms when contrasted within the same model.

Before addressing these primary hypotheses, we first tested the predictive relation between stress and depression severity with the expectation that total stress level would significantly predict elevations in depression severity. In addition, we examined when this predictive relation was strongest with lagged models. Finally, to examine our secondary research questions, we tested all models with regard to specific stressor domains (i.e., independent, dependent) and subtypes (i.e., interpersonal, achievement).

Method

Participants

Participants were 240 young adolescents and their mothers. Children were first assessed when they were in 6th grade (mean age = 11.86, *SD* = 0.57). The sample was 54.2% female, 82% Caucasian, 14.7% African American, and 3.3% other (Hispanic, Asian, Native American, or mixed ethnic background). Families were predominantly working (e.g., nurse's aide, sales clerk) to middle class (e.g., store manager, teacher), with a mean socioeconomic status (Hollingshead, 1975) of 41.60 (*SD* = 13.33).

Procedure

Parents of 5th grade children from metropolitan public schools were invited to participate in a study about parents and children. A brief health history questionnaire comprised of 24 medical conditions (e.g., diabetes, heart disease, depression) and 34 medications (e.g., Prozac, Elavil) was sent with a letter describing the project to over 3500 families. Of the 1495 mothers who indicated an interest in participating, the 587 who had endorsed either a history of depression, use of antidepressants, or no history of psychopathology were screened by telephone. Based on the screening calls of these 587 families, 349 had mothers who reported either a history of depression or no history of psychiatric problems. The 238 families not further screened were excluded because they did not indicate sufficient symptoms to meet criteria for a depressive disorder (38%), had other psychiatric disorders that did not also include a depressive disorder (19%), they or the target child had a serious medical condition (14%), were no longer interested (21%), the target child was in the wrong grade (6%), or the family had moved out of the area (2%).

The Structured Clinical Interview for *DSM* diagnoses (SCID; Spitzer, Williams, Gibbon, & First, 1990), a widely used, semi-structured clinical interview from which *DSM* diagnoses (American Psychiatric Association, 1994) can be made was then conducted with the 349 mothers who had indicated during the screening calls that they had had a history of some depression or had had no psychiatric problems. Inter-rater reliability was calculated on a random subset of 25% of these SCID interviews. There was 94% agreement (kappa = .88) for diagnoses of depressive disorders. The final sample of 240 families consisted of 185 mothers

who had a history of a mood disorder (high-risk group) and 55 mothers who were life-time free of psychopathology (low-risk group).

A different research assistant, unaware of the mothers' psychiatric history, administered an interview and a battery of questionnaires to the mother and adolescent separately. The present study reports the results of the annual assessments of the adolescents from 6th through 12th grade. Only those measures relevant to the current study are described here.

Measures

Depressive Symptoms and Disorders—To assess adolescents' current and lifetime history of depression, mothers and adolescents were interviewed with the K-SADS (Kaufman et al., 1997; Orvaschel et al., 1982) at the first evaluation. Interviews were conducted annually through the end of their senior year of high school using the Longitudinal Interval Follow-Up Evaluation (LIFE; Keller et al., 1987), which parallels the K-SADS and assesses disorders since the previous interview. The LIFE yields a Depressive Symptom Rating (DSR) score from 1 to 6 reflecting the extent of depressive symptoms and impairment for each week of the follow-up interval. Scores of 3 indicate fewer symptoms (e.g., 2 to 3 symptoms) than full DSM-IV criteria with mild or moderate impairment; scores of 4 indicate four symptoms with moderate to marked impairment; and scores of 5 or 6 indicate a Major Depressive Episode (MDE) with significant impairment according to DSM-IV criteria. All interviews were audio-taped. A second rater who was unaware of the ratings of the primary interviewer reviewed a random 25% of the interview audiotapes. Inter-rater reliability for depression yielded a Kappa = .81

Life Events were assessed annually with the Life Events Interview for Adolescents (LEIA; Garber & Robinson, 1997), which is based on the LEDS (Brown & Harris, 1989; Williamson et al., 1998) and the Life Stress Interview developed by Hammen et al. (1987). Mothers and adolescents were interviewed separately regarding events that had occurred for the adolescent during the previous year. The LEIA is a semi-structured interview that allows for precise dating of events and the assessment of objective consequences of events, given the particular context in which they occurred. Such interviews have been found to be superior to checklists in overcoming problems of counting, recalling, and dating of events (Duggal et al., 2000). Following the commonly used procedure regarding parent- and child-report, if either person indicated that an event had occurred, then it was rated. If their accounts of the event were very discrepant or if one person reported an event and the other did not, then the interviewer attempted to clarify the information at the time by asking each individual more questions. Interviewers first checked with the adolescent and parent separately about whether either objected to the interviewer's asking the other person about the event.

At a weekly meeting, interviewers presented to a group of trained raters information about each adolescent's life events. Based on all information from both sources, the group then rated the event with regard to the degree of objective threat the event had for the adolescent, using a scale ranging from 1 (*no threat*) to 7(*severe threat*). Raters were unaware of any information about the mothers' or adolescents' psychopathology. Inter-rater reliability of the objective stress ratings were obtained by having interviewers present the information about each event simultaneously to two different groups who then independently rated the event. A total of 3,708 events were coded in the study. Based on 202 events (5.4%), agreement among raters was 89.6% (kappa = .79).

Total stress levels were created by summing the objective threat ratings across all events for each week of the time interval. Operationalizing stress levels as the sum of objective threat ratings across all events takes into consideration that a particular stressor's impact likely is affected by the presence of other stressors at the same time. This definition is different from alternative operationalizations of stress as the objective threat rating for the most severe event

(e.g., Kendler et al., 2000) or as the presence or absence of at least one severe event (e.g., Brown & Harris, 1978).

Separate sums of weekly life event counts were created for minor stressors, defined as events that resulted in only minor disruption, threat, or change for the individual (i.e., a rating of 3 or less on the 1–7 scale); major stressors were defined as those that caused significant disruption, threat, or change for the individual (i.e., objective threat ratings greater than 3). Examples of minor stressors included: a sibling moving out of the home (rating = 1); a mild car accident (rating = 2); conflict in a romantic relationship (rating = 3). Examples of major stressors included being arrested (rating = 4); becoming pregnant (rating = 5); being the victim of a serious crime (rating of 6), and the death of a parent (rating = 7). It should be noted, however, that the rating assigned to any particular event was highly contingent upon the context in which the event occurred. For example, a car accident would be assigned a rating of 2 if it caused only minor damage to the car (e.g., bumper). However, if this was their 2nd car accident and it caused injury to the adolescent or passengers, then it may be assigned a rating of 5 or 6 depending on the extent of the injury sustained.

Events also were rated with regard to their dependence, or the extent to which the child's behaviors contributed to the occurrence of the event, on a scale of 1 (*completely independent*) to 4 (*completely dependent*). For example, a rating of 1 might be assigned to an illness in a relative; a rating of 2 might be assigned to a normative school transition; a rating of 3 might be assigned to conflict with a peer; and a rating of 4 might be assigned to getting suspended from school due to truancy. Event type (i.e., interpersonal or achievement) also was coded. Two raters independently read all of the written narratives recorded by the interviewers and coded each event regarding its independence/dependence and type: interpersonal (e.g., conflict with a friend) or achievement (e.g., failed a final exam). Inter-rater reliability was high for independence/dependence ratings (intraclass correlation coefficient: $r = .90$, $p < .001$), and for event type ratings (kappa = .86, $p < .001$).

Results

Preliminary Analyses

Of the 240 adolescents in the initial sample, 230 were administered at least one stress assessment. For these participants, the mean number of weeks spent in the study was 275 ($SD = 67$). Seven participants experienced one MDE before baseline assessment. By the end of the study, 36 participants had experienced one MDE, 27 had experienced two MDEs, 5 had experienced three MDEs, 2 had experienced four MDEs, and one participant each experienced five, six, and seven total MDEs. Descriptive statistics for the stressor measures are presented in Table 3.

To address the hypotheses regarding within- and between-individual change simultaneously, we specified a series of multilevel models using SAS PROC MIXED (SAS Institute, 1996) consisting of a within-person (i.e., level-1) submodel describing how each individual changed over time and a between-person (i.e., level-2) submodel describing how these changes varied across individuals (see Bryk & Raudenbush, 1992; Singer & Willett, 2003). Before fitting models including substantive predictors, we ran an *unconditional means model* with no predictors to describe and partition the outcome variation across participants without regard to time. This model stipulates that an individual's DSR score at a given time point deviates from their true mean by a level-1 residual, and that this true mean deviates from the population average true mean by a level-2 residual. Results revealed that DSR scores had a non-zero intercept ($B = 1.28$, $t = 40.28$, $p < .001$), and that there was significant variation in DSR scores within ($B = .56$, $z = 177.49$, $p < .001$) and between ($B = .23$, $z = 10.61$, $p < .001$) individuals. The intraclass correlation coefficient indicated that 29% of the total variation in DSR scores

could be explained by differences between participants, suggesting empirical nesting of the data.

Next, we ran an *unconditional growth model* with time (a within-subject variable indicating number of weeks in the study) as a predictor to determine whether there was significant variation in DSR scores across both individuals and time. This model stipulates that an individual's DSR score at a given time point deviates from their true linear change trajectory by a level-1 residual, and that this true linear trajectory deviates from the population average true trajectory by a level-2 residual. Results revealed that the average true change trajectory for DSR scores had a non-zero intercept ($B = 1.12$, $t = 35.07$, $p < .001$) and slope ($B = .00$, $t = 32.90$, $p < .001$), indicating that adolescents' DSR scores increased with age. Moreover, there was significant variation within individuals around their true change trajectories ($B = .23$, $z = 10.61$, $p < .001$) as well as significant inter-individual variation in slopes ($B = 0.55$), $z = 177.49$, $p < .001$.

Taken together, these results point to nesting of the data and suggest that sufficient heterogeneity existed to examine substantive level-1 and level-2 predictors. Ignoring individual characteristics that contribute to response patterns over time as well as the effects of state dependence would result in biased variability estimates and inflated Type I error rates. In this situation, a multilevel analytic approach is warranted. All time-varying predictors were person-centered (i.e., the means of these variables equaled zero for each person) for this and all subsequent analyses. This decision was made on theoretical rather than statistical grounds (Kreft, de Leeuw, & Aiken, 1995) and was intended to remove between-person variance and to prevent predictors from correlating with individual intercepts or between-person factors (Schwartz & Stone, 1998). Including person-centered predictors allows the estimate of the individual intercepts to be treated as a random effect by ensuring that the estimates of time-varying predictors represent purely within-person effects.

Descriptive statistics for predictors were as follows: week (mean total weeks in the study per participant = 299.63, $SD = 17.23$), SES ($M = 41.60$, $SD = 13.33$), sex (110 males, 130 females), risk (55 low risk, 185 high risk), Prior MDEs ($M = 0.22$, $SD = 0.53$), and Total MDEs ($M = 0.47$, $SD = 0.73$). Preliminary analyses of covariates revealed that risk correlated significantly with DSR scores ($B = .338$, $t = 4.68$, $p < .001$), and total stress level ($B = 2.11$, $t = 8.01$, $p < .001$). In addition, week (i.e., number of weeks in the study) significantly correlated with DSR scores ($B = .001$, $t = 32.90$, $p < .001$), total stress level ($B = -.001$, $t = -3.11$, $p = .002$), total major stressors ($B = -.0003$, $t = -45.30$, $p < .001$), and total minor stressors ($B = -.0015$, $t = -101.12$, $p < .001$). SES correlated significantly with total stress level ($B = -.031$, $t = -3.27$, $p = .001$); gender was not significantly correlated with any of the primary variables of interest. All covariates were included in subsequent analyses.

Is there a predictive relation between stress levels and depressive symptoms?

The specification of time-varying predictors such as lagged effects aids causal inferences by clarifying the temporal ordering of events. To test whether and to what extent stress levels predicted subsequent depressive symptoms (i.e. forward relation), we ran a series of lagged effects models varying the lag interval *n*. The full model was as follows:

$$Dep_{ti} = \gamma_{00} + \gamma_{10} Dep_{(t-n)i} + \gamma_{20} Stress_{(t-n)i} + u_{0i} + r_{ti} \quad (1)$$

In this equation, the term *Dep* denotes an individual's DSR score and *Stress* denotes that individual's total level of stress. Thus, Dep_{ti} indicates the DSR score at time *t* for person *i*. Terms with subscript $(t - n)$ were the effects of the n^{th} week prior to Dep_{ti}. To minimize the risk of Type I error, we only interpreted results significant at the $p = .01$ level.

Results indicated that the optimal lag (i.e., strongest predictive association) between total stress level and depressive symptoms was two weeks. At this interval, the effect of stress levels on depressive symptoms was estimated at 0.01 ($p < .001$). Stress remained a significant predictor of increases in DSR scores up to a lag of 25 weeks (see Figure 3). For all subsequent analyses, Level 1 predictors (i.e., stress and DSR scores) were lagged 2 weeks behind the dependent variable (i.e., DSR scores).

Does the relation between stress levels and depressive symptoms change with successive depressive episodes within individuals?

To evaluate whether, within individuals, the strength of the predictive association between stress levels and DSR scores changed as they accumulated more MDEs, we specified a model that included within-subject numbers of prior depressive episodes (i.e., defined as ≥ 5 on the DSR for at least 2 weeks) as both a main effect and moderator. Specifically, we tested whether the interaction of within-subject number of prior MDEs and stress levels incremented the prediction of change in DSR scores over and above gender, risk, SES, week, prior DSR ratings, prior stress level, and a cumulative total of the number of prior MDEs experienced by that point in time (*PriorMDEs*). The full equation was as follows:

$$Dep_{ti}=\gamma_{00}+\gamma_{01}Gender_i+\gamma_{02}Risk_i+\gamma_{03}SES_i+\gamma_{10}Week_{(t-2)i}+\gamma_{20}Dep_{(t-2)i}+\gamma_{30}Stress_{(t-2)i}+ +\gamma_{40}PrioMDEs_{(t-2)i}+\gamma_{50}Stress_{(t-2)i}\times PriorMDEs_{(t-2)i}+u_{0i}+r_{ti} \quad (2)$$

Results of this analysis showed that the *PriorMDEs* × total stress level interaction ($B = .008$, $t = 9.20$, $p < .001$) significantly predicted increases in DSR scores (see Table 4, Figure 4). Greater numbers of prior MDEs were associated with stronger predictive associations between stress and depression. Simple slope analyses revealed that the relation of total stress level to DSR scores was positive and significant at 0 ($B = .01$, $t = 6.48$, $p < .001$), 1 ($B = .01$, $t = 13.26$, $p < .001$), and 2 or more prior MDEs ($B = .02$, $t = 12.58$, $p < .001$). Exploratory analyses revealed that the interaction of number of prior MDEs and stress level also was significant for total independent stress level ($B = .01$, $t = 8.55$, $p < .001$), total dependent stress level ($B = .01$, $t = 5.57$, $p < .001$), total interpersonal stress level ($B = .01$, $t = 8.88$, $p < .001$), and total achievement stress level ($B = .01$, $t = 4.54$, $p < .001$).

Are the apparent changes in the impact of stressful life events on depressive symptoms better accounted for by changes in the frequency of major versus minor events?

To address this question we operationalized major stressors as those with an objective threat rating greater than 3 and minor stressors as those with objective threat ratings equal to or less than 3 on the 7-point stress severity scale. Two variables were created that reflected the number of weekly major or minor stressors. First, we ran a model predicting either major or minor stressors from the time variable (i.e., week) to determine whether base rates changed over the course of the study. As noted previously, the number of both major and minor stressors significantly decreased over time. Next, we ran a model predicting *PriorMDEs* from the number of stressors, controlling for week, and found that neither the number of major nor minor stressors significantly changed as the number of prior episodes increased.

Finally, we ran a model examining the interaction of stressor number and *PriorMDEs*, paralleling Equation 2, to determine whether the predictive relation of the number of major or minor stressors to depressive symptoms changed as individuals accumulated more MDEs. Results showed that the interactions of both major ($B = .22$, $t = 8.49$, $p < .001$) and minor ($B = .07$, $t = 7.90$, $p < .001$) stressors with *PriorMDEs* were significant (Table 4). Simple slope analyses revealed that the relation of major stressors to DSR scores was significant at 0 ($B = .05$, $t = 2.63$, $p = .009$), 1 ($B = .27$, $t = 9.87$, $p < .001$), and 2 or more prior episodes ($B = .49$,

$t = 9.93$, $p < .001$). The relation of minor stressors to DSR scores also was significant at 0 ($B = .02$, $t = 3.27$, $p = .001$), 1 ($B = .09$, $t = 9.67$, $p < .001$) and 2 or more prior episodes ($B = .16$, $t = 9.21$, $p < .001$). Finally, exploratory analyses revealed that the interaction of *PriorMDEs* and number of stressors was significant for independent ($B = .10$, $t = 8.19$, $p < .001$), dependent ($B = .11$, $t = 7.06$, $p < .001$), interpersonal ($B = .10$, $t = 10.01$, $p < .001$), and achievement stressors ($B = .08$, $t = 2.12$, $p = .034$).

Do relatively stable individual differences in vulnerability to depression moderate the within-subject relation between stress and depression?

To evaluate whether the strength of the association between stressful life events and DSR scores varied as a function of each individual's vulnerability to depression, we specified a model that included depression vulnerability as a main effect and moderator. Specifically, we tested whether the interaction of depression vulnerability and stress levels predicted change in DSR scores after controlling for gender, week, prior DSR ratings, prior stress level, and depression vulnerability (i.e., either the total number of MDEs experienced through grade 12 or risk based on maternal depression history). The full equation was as follows:

$$Dep_{ti} = \gamma_{00} + \gamma_{01} Gender_i + \gamma_{02} SES_i + \gamma_{03} DepVul_i + \gamma_{10} Week_{(t-2)i} + \gamma_{20} Dep_{(t-2)i} + \gamma_{30} Stress_{(t-2)i} + \gamma_{33} Stress_{(t-2)i} \times DepVul_i + u_{0i} + r_{ti} \quad (3)$$

Results of this analysis showed that the *DepVul* (total MDEs) × stress level interaction ($B = .008$, $t = 8.18$, $p < .001$) significantly predicted increases in DSR scores (see Table 4, Figure 5). Greater total MDEs were associated with stronger predictive relations of stress to depression. Simple slope analyses revealed that the relation of total stress levels to DSR scores was significant at 0 ($B = .00$, $t = 3.86$, $p < .001$), 1($B = .01$, $t = 13.19$, $p < .001$), and 2 or more total episodes ($B = .02$, $t = 12.12$, $p < .001$). The *DepVul* (risk) × stress level interaction also was significant ($B = .01$, $t = 3.85$, $p < .001$), with results basically paralleling the form of the *DepVul* (total MDEs) × stress level interaction.

Are stress autonomy or stress sensitization effects better accounted for by stable individual differences in vulnerability to depression?

To address the possibility that vulnerability to depression might account for the apparent stress sensitization effect, we specified a full model that included both prior MDEs and depression vulnerability (total MDEs or risk) as main effects and moderators of the relation between stress and depression. Specifically, we tested whether the *PriorMDEs* × stress level interaction remained significant after controlling for gender, risk, week, prior DSR ratings, prior stress level, *PriorMDEs, DepVul,* and the *DepVul* × stress level interaction. The full equation was as follows:

$$Dep_{ti} = \gamma_{00} + \gamma_{01} Gender_i + \gamma_{02} Risk_i + \gamma_{03} SES_i + \gamma_{04} DepVul_i + \gamma_{10} Week_{(t-2)i} + \gamma_{20} Dep_{(t-2)i} + \gamma_{30} Stress_{(t-2)i} + \gamma_{40} PriorMDEs_{(t-2)i} + \gamma_{50} Stress_{(t-2)i} \times PriorMDEs_{(t-2)i} + \gamma_{30} Stress_{(t-2)i} \times DepVul_i + u_{0i} + r_{ti} \quad (4)$$

The *DepVul* (total MDEs) × stress level interaction significantly predicted increases in depressive symptoms ($B = .00$, $t = 3.06$, $p = .002$). However, the inclusion of this between-subjects interaction in the model did not eliminate the within-subject interaction, which continued to significantly predict increases in depressive symptoms ($B = .01$, $t = 6.99$, $p < .001$). In addition, the *PriorMDEs* × stress level ($B = .01$, $t = 8.81$, $p < .001$) and *DepVul* (risk) × stress level ($B = .01$, $t = 2.65$, $p = .008$) interactions both significantly predicted increases in depressive symptoms. Thus, within-subject interactive effects remained significant after accounting for

interactions involving relatively stable individual differences in vulnerability to depression, conceptualized as either total MDEs or risk.

Discussion

The primary purpose of the present study was to examine the stress autonomy, stress sensitization, and depression vulnerability hypotheses. Consistent with the stress activation submodel of stress sensitization, the predictive relation of total stress levels to depressive symptoms strengthened with increasing numbers of prior MDEs; that is, both low and high levels of stress were associated with higher levels of depressive symptoms as the number of prior MDEs increased. Thus, as adolescents accumulated MDEs the relation between stress levels and depressive symptoms became stronger (i.e., youth became more sensitized to stressors), regardless of the magnitude of the stressor, and this result could not be explained by increases in the number of major or minor stressors over time. Additionally, greater numbers of both major and minor stressors were associated with increases in depressive symptoms for adolescents with 0, 1, or 2 or more prior MDEs. This is consistent with the stress activation model, which posits a greater role – early in the course of depression - for both major and minor stressors in precipitating higher levels of depressive symptoms as a function of number of prior MDEs. Regarding the depression vulnerability hypothesis, the relation of stress levels to depressive symptoms was stronger for adolescents at greater risk as defined by their total number of MDEs experienced by grade 12 (i.e., by the end of the study), or by their risk status (i.e., having a mother with a history of depression). Finally, results of the full model examining depression vulnerability concurrently with stress autonomy and stress sensitization suggest that both relatively stable and dynamic vulnerabilities may affect the relation between stress and depression.

Results of the current study are consistent with the stress activation model. In the recent literature examining stress autonomy and stress sensitization processes (Table 2), only two studies have reported results inconsistent with this model, which might have been due to their specific focus on the impact of anxiety disorders (Espejo et al., 2006) or the pubertal transition (Rudolph & Flynn, 2007). The current study found that the relation of numbers of major stressors to depressive symptoms strengthened over recurrences; this contrasts with studies that have reported a stronger relation of major stressors to first onsets than recurrences (Ormel et al., 2001), but is consistent with evidence of a significant association between major stressors and depression onsets for up to three lifetime MDEs (Monroe et al., 2007). Had we followed these adolescents into adulthood and observed more depression recurrences, we might have seen a decline in the association of number of major stressors to depressive symptoms as these events might be “double-eclipsed” by more prevalent and increasingly depressogenic minor stressors (Monroe & Harkness, 2005).

Evidence consistent with the depression vulnerability hypothesis also was found. The predictive relation of stress levels to depressive symptoms was stronger for more vulnerable adolescents (i.e., those who had had a greater number of depressive episodes through 12th grade or who had a mother with a history of depression), such that both major and minor stressors were associated with higher DSR scores. Thus, relatively stable individual vulnerabilities to depression moderated the within-individual relation between stress levels and depressive symptoms. Kendler and colleagues (2001) have proposed that the initial strength of the association between stress and depression onset varies as a function of genetic and environmental risk. That is, whereas individuals who are “pre-kindled” are at higher genetic risk for developing depressive episodes regardless of their own depression history, psychosocial stressors may be necessary to trigger depressive episodes and subsequent “kindling” in those with less genetic risk.

A secondary purpose of the current study was to examine changes in the predictive association of total stress levels to depressive symptoms using lagged effects models. The impact of both recent (i.e., precipitating) and more distant (i.e., incubating) stressors on depression has been shown to dissipate over time (e.g., Bebbington et al., 1993). In contrast to previous studies that have examined fixed risk periods, we did not make assumptions about the temporal impact of stress on depression; rather, we considered timing to be an empirical question. Our analyses revealed a predictive association of total stress levels to depressive symptoms that reached its peak at two weeks and remained significant for up to 26 weeks. This extends previous findings emphasizing the importance of acute stressors in the month prior to depression onset (Bebbington et al., 1988; Kendler et al., 1998, 1999; Surtees et al., 1986). Exploratory analyses also revealed that the relation of both total level and total number of stressors to depressive symptoms strengthened with successive MDEs in a manner consistent with the stress activation model for independent, dependent, interpersonal, and achievement events. Thus, adolescents in the current study showed higher levels of depression in relation to stressors for both independent and dependent as well as interpersonal and achievement stressors.

Although the current study found an increase in the predictive association of total stress levels to depressive symptoms as a function of the number of prior episodes, we could not determine the processess through which these changes occurred. One potential mechanism involves cognitive schema. Repeated exposures to depressive symptoms may strengthen depressive schema networks such that increasingly minor stressors are capable of triggering full MDEs (Segal et al., 1996). Other researchers have focused on the activation of gene transcription factors, speculating that neurotransmitter and peptide alterations associated with depressive episodes may leave behind “memory traces” that increase vulnerability to future episodes (Post, 1992). Another intriguing possibility is that early episodes of depression trigger corticotropin-releasing hormone (CRH) hypersecretion, indicative of enhanced stress reactivity, which may lead to an adaptive downregulation of CRH receptors such that stress reactivity diminishes over successive recurrences (Heim, Ehlert, & Hellhammer, 2000; Miller, Chen, & Zhou, 2007). Thus, stress sensitization processes may characterize early episodes of depression, whereas stress autonomy processes may gradually take hold over repeated MDEs.

The present study contributed to the literature on stress autonomy and stress sensitization models of depression in several ways. First, we showed that changes in the predictive association of total stress levels to depressive symptoms occurred within individuals as a function of their number of prior depressive episodes. That this within-subject interaction continued to significantly predict changes in depressive symptoms when included in the same model as the between-subjects interaction suggests that stress sensitization effects were not purely a result of individual differences in liability to depression. That is, an apparent reduction in the strength of the association between stress levels and depressive symptoms with increasing numbers of prior episodes could be explained without invoking within-individual change if depression onsets were dependent on SLEs in low risk individuals and independent of SLEs in those at high risk.

Second, we were able to explicitly model the hierarchical structure of the data using a multilevel analytic approach. Failure to account for the nesting of observations within individuals in longitudinal studies can result in biased estimates, smaller standard errors, inflated Type 1 errors, and spurious significance. Third, we tested the different stress hypotheses using objective, interview-based measures of stress and depressive symptoms. Fourth, we were able to examine the relation of stress levels to depressive symptoms in a fine-grained manner using weekly data across 6 years. We extended prior research in this area by reporting effect sizes quantifying *weekly* changes in the predictive relation of stress levels to depressive symptoms. Such effect sizes may be of greater relevance to the assessment and treatment of depression than measures of the relation of stress to depression over greater lags that obscure subtleties

in their variation despite producing large effect sizes. Our ability to detect these interactions given the high degree of autocorrelation among weekly ratings suggests that the findings likely are robust. Finally, this study is one of only a few to examine stress sensitization prospectively in a sample of male and female adolescents.

Limitations of the current study should be noted as they provide directions for future research. First, weekly ratings of stress levels, stressor counts, and depressive symptoms were based on annual assessments. Despite the use of objective, interview-based measures of stress and depression, these data may have been affected by participants' recall bias. Second, we conceptualized depression vulnerability as the total number of MDEs experienced through 12th grade and included it in prospective analyses although it was determined retrospectively. However, this approach has been advocated as a means of examining whether the effects of stress at the aggregate (i.e., person) and micro (i.e., momentary) levels are similar (Schwartz & Stone, 1998). If these effects differ, the intercept may not be treated as a random factor without biasing the coefficients of the within-subject predictors. Third, examining risk based on maternal depression history as a relatively stable vulnerability factor may overlook several sources of potential variability (Goodman & Gotlib, 1999). Although our statistical analyses treated depression vulnerability as a time-invariant main effect and moderator, it is likely that this vulnerability indicator exhibits properties of both stability and change. Fourth, although care was taken in the life stress interviews to determine objective severity levels for all events by combining parent- and child-reports and adopting a consensus approach to the event ratings, we cannot rule out the possibility that depressed mothers may have been negatively biased in their reporting. Finally, we specified stress autonomy and stress sensitization models predicting DSR ratings rather than depression onsets. Although this approach is consistent with dimensional conceptualizations of depression (e.g., Ruscio & Ruscio, 2000), it represents a departure from prior research examining MDEs.

In conclusion, the current study provided evidence consistent with the stress activation and depression vulnerability hypotheses using weekly data obtained from a sample of adolescents followed for six years. These findings are further strengthened by the use of a multilevel modeling approach that explicitly accounted for nesting in the data. Future research should examine the neurobiological (e.g. patterns of cortisol secretion and regulation) and cognitive (e.g. information processing and schema consolidation) correlates of stress sensitization to identify mechanisms of change. Stress sensitization processes highlight the need for prevention programs targeting at-risk youth before the onset of an MDE. In addition, intervention programs should focus on strategies for coping with stressors, given their frequency and their relation to depressive symptoms in individuals who have experienced more than one episode.

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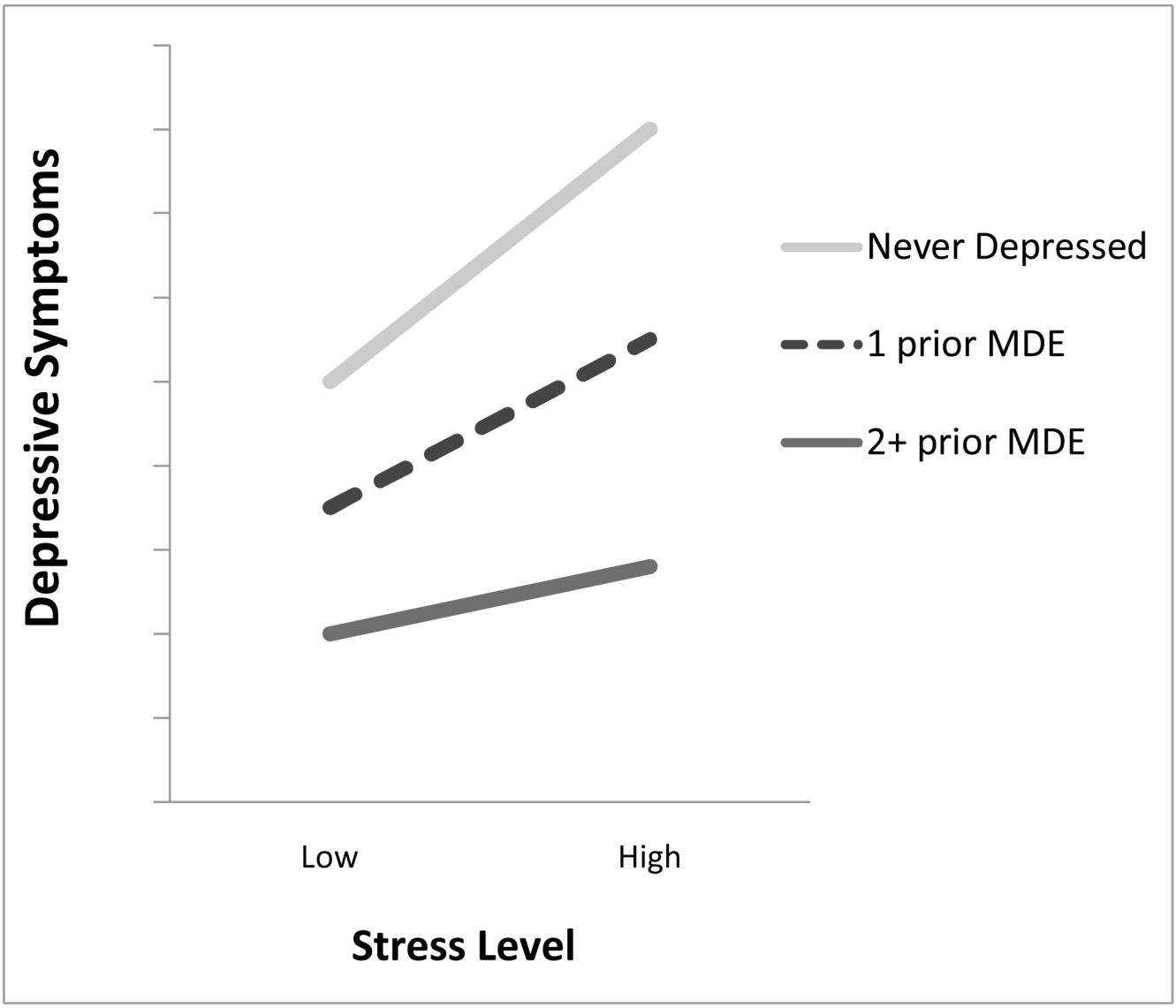

Figure 1.
Stress Autonomy Model

Figure 2a.

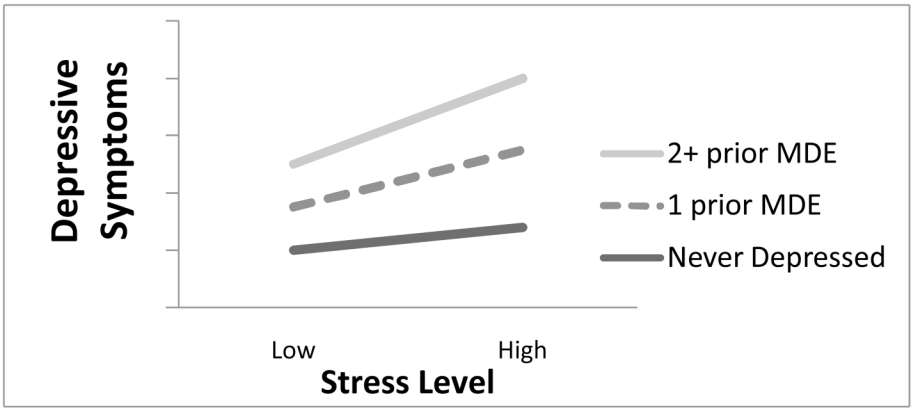

Figure 2b.

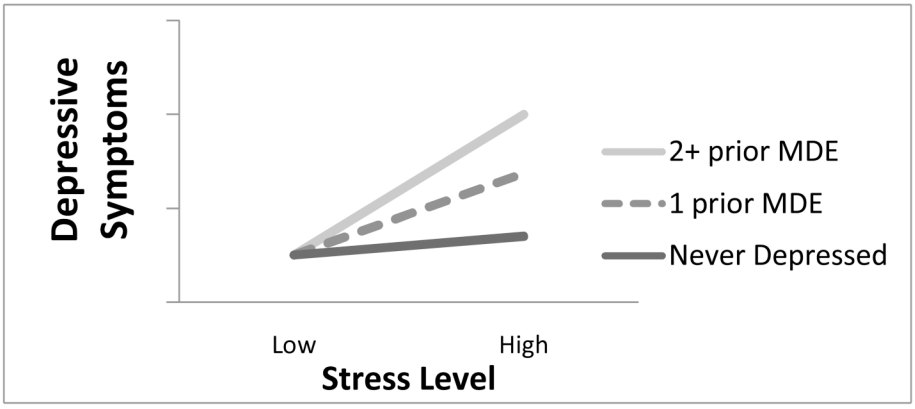

Figure 2c.

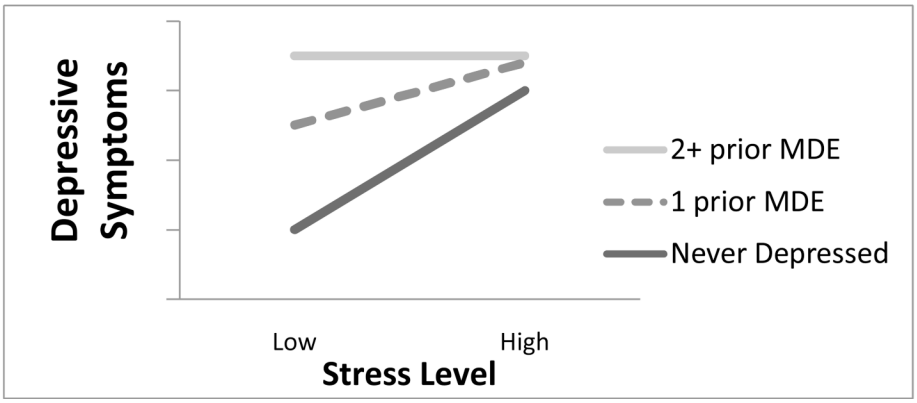

Figure 2.
Stress Sensitization Models: Stress Activation (2a); Stress Amplification (2b); Risk Saturation (2c)

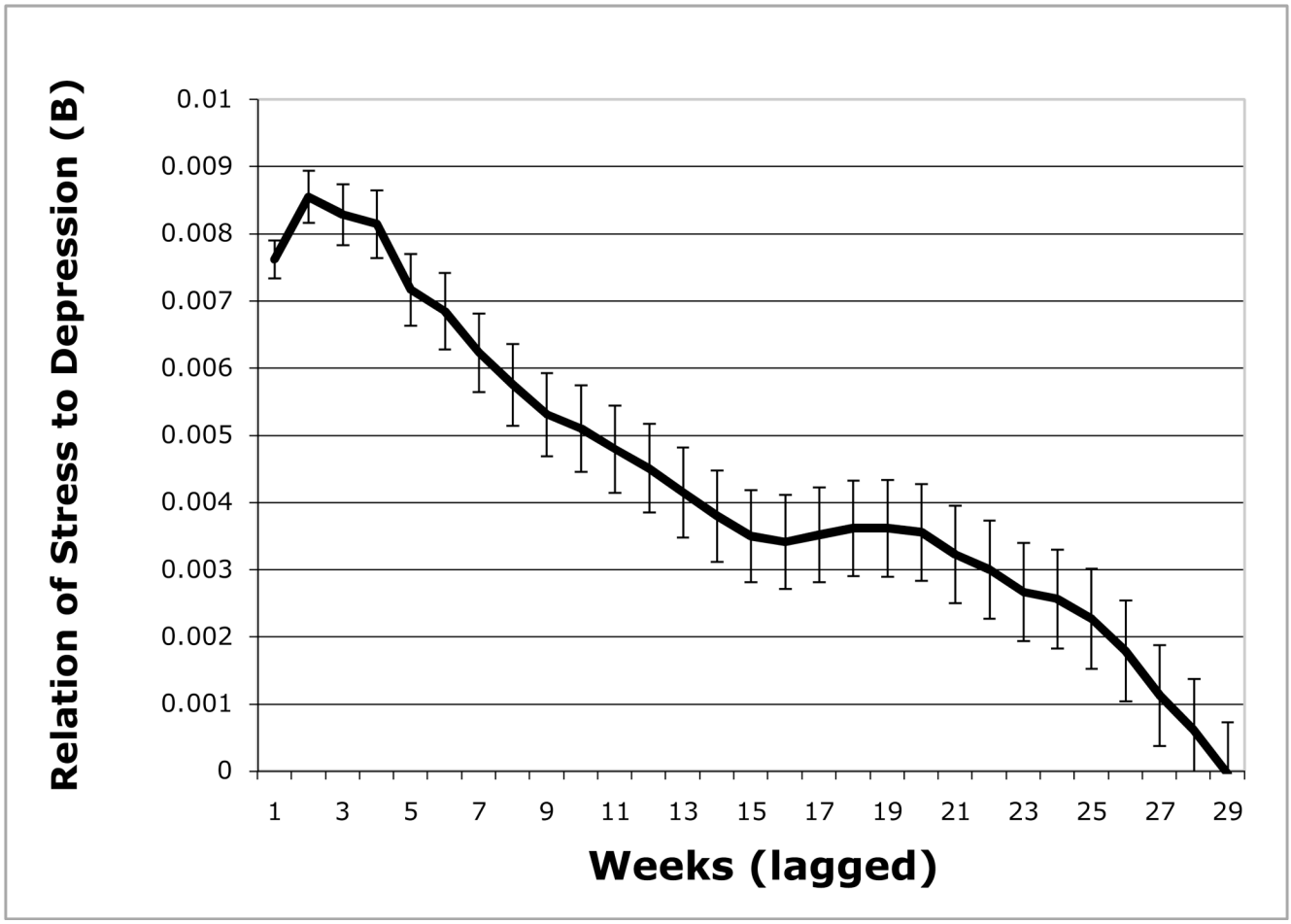

Figure 3.
Lagged Effects of Stress Level on Depressive Symptoms.

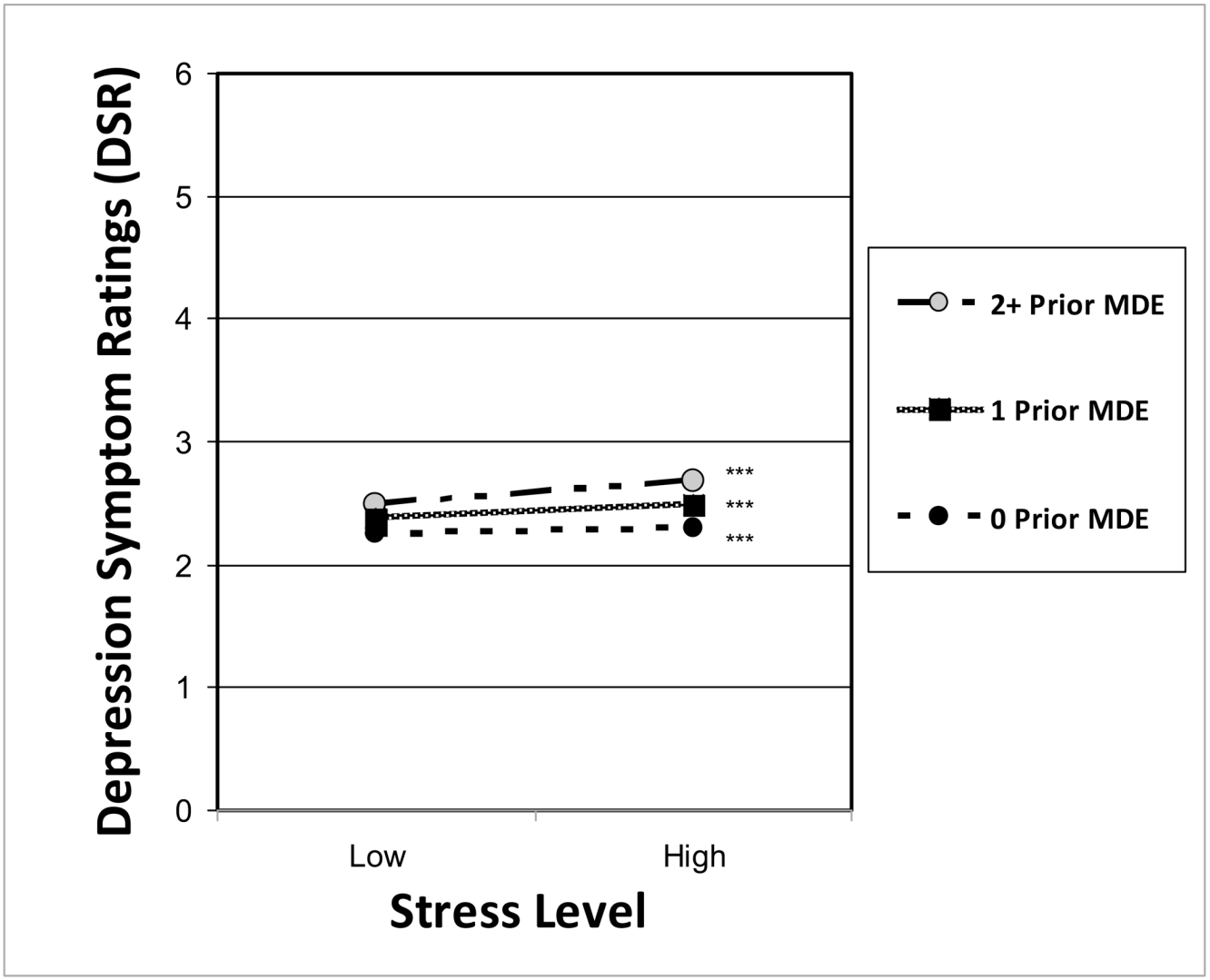

Figure 4.
Within-subject Change: Stress Level × Prior Major Depressive Episodes (MDEs). ***$p < .001$.

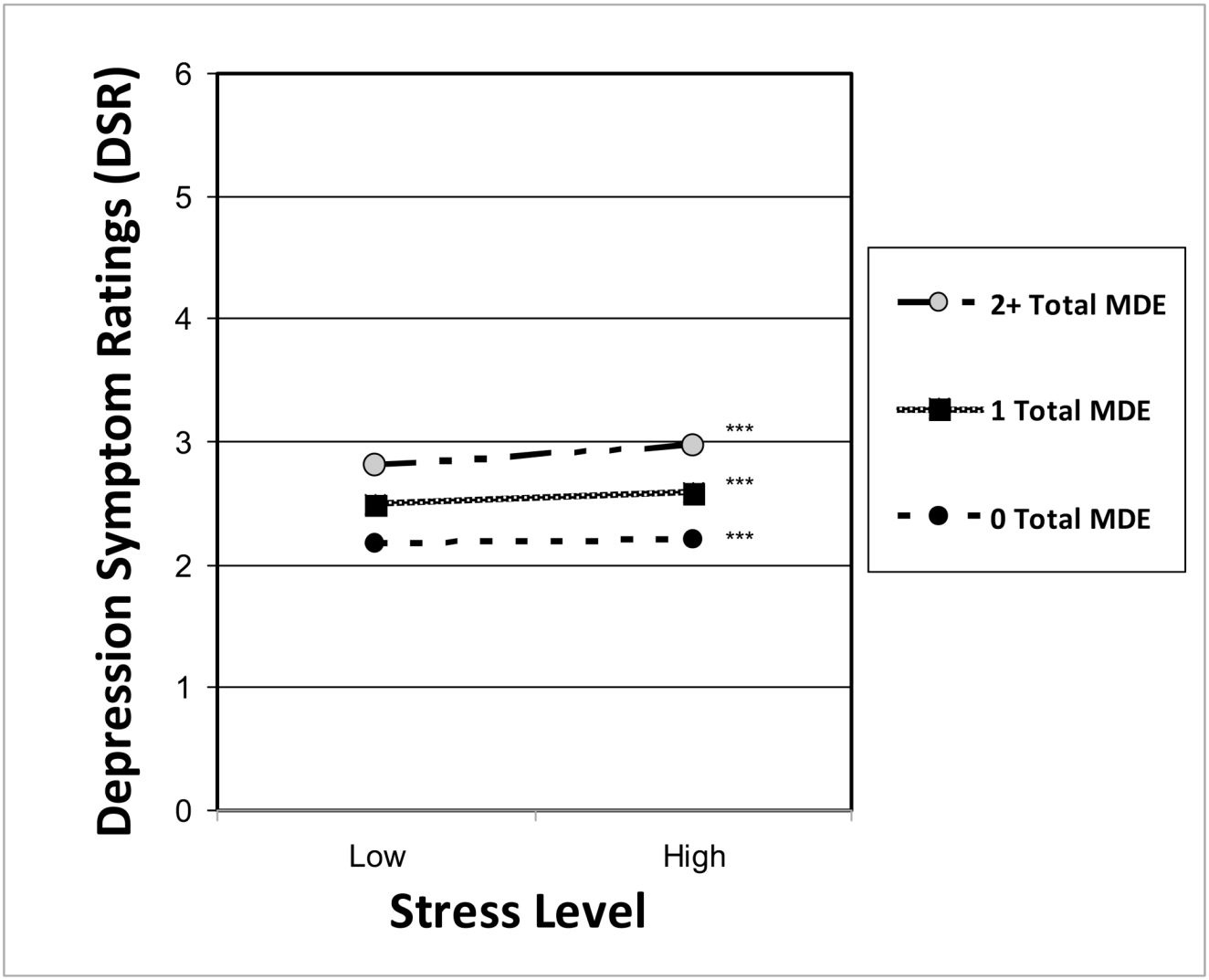

Figure 5.
Between-subject Change: Stress Level × Total Major Depressive Episodes (MDEs). ***$p < .001$.

Table 1

Stress autonomy and sensitization models: Summary of changes in impact compared to frequency (i.e., increases/decreases in regression coefficients) for major and minor life events over recurrences in relation to depression symptom rating (DSR) scores.

Role of Life Stress	Stress Autonomy	Stress Sensitization Models		
		Stress Activation	Stress Amplification	Risk Saturation
Impact				
Major Events	Decrease[a]	Increase[a]	Increase	No change[a]
Minor Events	Decrease	Increase	No change	Increase
Frequency				
Major Events				
Early MDEs	Decrease	Increase	Increase	No change
Later MDEs	Decrease	Decrease	Increase	No change
Minor Events				
Early MDEs	Decrease	Increase	No change	Increase
Later MDEs	Decrease	Increase	No change	Increase

[a]Decrease, increase, or no change in the strength of the relation of level (i.e., impact) or frequency (i.e., number) of stressors to depressive symptom rating (DSR) scores. MDEs = Major Depressive Episodes

Table 2

Studies testing the various stress models.

Study	Stress Autonomy Model	Stress Sensitization Models		
		Stress Activation	Stress Amplification	Risk Saturation
Assessed Major Stressors:				
Coyne, Thompson, & Pepper, 2004	✓	✓		✓
Farmer et al., 2000	✓	✓		✓
Kendler, Thornton, & Gardner, 2000, and Kendler, Thornton, & Gardner, 2001, and Kendler, Kuhn, & Prescott, 2004	✓	✓		✓
Kohn et al., 2001	✓	✓		✓
Lewinsohn et al., 1999, and Monroe et al., 1999	✓	✓		✓
Maciejewski, Prigerson, & Mazure, 2001	✓	✓		✓
Mitchell et al., 2003	✓	✓		✓
Monroe et al., 2007	✓	✓		✓
Assessed Minor Stressors:				
Lenze et al., 2008		✓		✓
Monroe et al., 2006		✓		✓
Assessed both Major and Minor Stressors:				
Brilman & Ormel, 2001, and Ormel, Oldehinkel, & Brilman, 2001		✓		✓
Espejo et al., 2006			✓ (ANX−)	✓ (ANX+)
Hammen, Henry, & Daley, 2000 (episodic stress) Daley, Hammen, & Rao, 2000 (chronic stress)		✓		✓ ✓
Harkness, Bruce, & Lumley, 2006 (indep events)		✓		✓
Rudolph & Flynn, 2007			✓ (pre-pubertal girls)	✓ (pubertal girls; prepubertal boys)

Table 3

Descriptive Statistics of Stress Variables.

Stressor types and domains	Total weekly stress level (per participant)	Proportion of 'stress weeks' (per participant)	Total stressors over study (per participant)
	M (SD)	*M (SD)*	*M (SD)*
Total	3.02 (1.94)	.2297 (0.13)	15.45 (8.00)
Major	--	.0003 (0.01)	1.24 (1.38)
Minor	--	.0108 (0.05)	14.20 (7.38)
Independent	2.05 (1.44)	.1506 (0.09)	15.31 (7.92)
Dependent	.87 (0.97)	.0905 (0.10)	4.78 (4.04)
Interpersonal	2.01 (1.43)	.1654 (0.12)	14.55 (8.13)
Achievement	.97 (1.20)	.0166 (0.03)	5.83 (7.58)

Major stressors: >3 and Minor stressors: ≤ 3 on 7-point objective threat scale; Total stress level (weekly) = sum of stress levels for all events each week; 'Stress weeks' = weeks a participant experienced ≥ 1 stressors.

Table 4

Multilevel Models Predicting Depressive Symptoms (DSR scores)

	Within-Individual Models			Between-Individual Models	
Predictors	Total Stress Level *B* (β)	Major Stressors *B* (β)	Minor Stressors *B* (β)	Risk *B* (β)	Total MDEs *B* (β)
Intercept	.9492 (−)***	.9253 (−)***	.9436 (−)***	.9018 (−)***	.9714(−)***
Week	−.0001 (−.0116)*	−.00004 (−.0046)	−.00004 (−.0046)	.0002 (.0267)***	.0002 (.0232)***
SES	.0020 (.0296)	.0019 (.0282)	.0018 (.0267)	.0018 (.0267)	.0013 (.0193)
Sex	.0002 (.0001)	.0020 (.0011)	−.0019 (−.0011)	.0032 (.0018)	−.0353 (−.0196)
Risk	.2867 (.1341)***	.3133 (.1465)***	.3015 (.1410)***		.1644 (.0769)*
Prior Depression	.7959 (.6631)***	.8074 (.6727)***	.8128 (.6772)***	.8150 (.6790)***	.8147 (.6788)***
Prior Stress	.0052 (.0251)***	.0533 (.2572)**	.0179 (.0864)**	.0008 (.0039)	.0034 (.0164)***
Depression-Vulnerable				.3571 (.2919)***	.3516 (.2874)***
Prior MDEs	.1571 (.0927)***	.1694 (.1000)***	.1719 (.1015)***		
Dep-Vulnerable × Stress				.0079 (.0304)***	.0077 (.0297)***
Prior MDEs × Stress	.0080 (.0421)***	.2191 (1.1526)***	.0721 (.3793)***		

*$p < .05$;

**$p < .01$;

***$p < .001$

SES = socioeconomic status; MDEs = Major Depressive Episodes; Dep = Depression