

Linear and Nonlinear Models of Vulnerability to Depression: Personality and Postpartum Depression in a High Risk Population

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ABSTRACT - Although nonlinear effects have sometimes been detected in depression research, they have been seldom considered at the empirical and conceptual levels. The current study explored the nonlinear relations between Self-Criticism and Dependency personality vulnerabilities to depressive symptoms (Blatt, 1974; 1991) in both low and high stressful life conditions. A prospective investigation of post-delivery depressive symptoms in high- and low-risk pregnancy (HRP and LRP) samples was conducted. It was hypothesized that HRP (i.e., gestational diabetes mellitus), as a highly stressful life context, would interact with personality vulnerabilities to depression, resulting in nonlinear threshold effects on outcomes. Hierarchical Multiple Regression analyses (HMR) indicate nonlinear relationships between depression and both Self-Criticism and Dependency in the HRP group ($N = 100$). In contrast, the relationship among these variables remained linear in the LRP group ($N = 109$). Multiple groups Structural Equation Model (SEM) indicated significant stress \times personality interaction; for the high risk group the relations between the personality variables and depression are cubic but only linear for the low risk group and these differences are significant. Overall, the results are consistent with the notion of stress thresholds and the findings underscore the general need to examine non-linear effects in research on personality and depression. In addition, the findings support the assumed importance of the balance between the personality dimensions of relatedness and self-definition.

"For a smart material to be able to send out a more complex signal it needs to be nonlinear. If you hit a tuning fork twice as hard it will ring twice as loud but still at the same frequency. That's a linear response. If you hit a person twice as hard they're unlikely just to shout twice as loud. That property lets you learn more about the person than the tuning fork."

-Neil Gershenfeld, 1999

The transition to motherhood is a time of stress when issues of interpersonal relations, identity, and self-esteem come to the fore, imposing a reassessment of the woman's autonomy and close interpersonal relationships (Besser & Priel, 2003a; O'Hara, 1986; Ruble et al., 1990; Terry, Mayocchi, & Hynes, 1996; Whiffen, 1992). Moreover, since parenthood mandates negotiations of commitments to self and to others, issues of autonomy and affiliation are highlighted during this transition (Fedele, Golding, Grosman, & Pollak, 1988). Accordingly, the prenatal period and the transition to motherhood provide a unique opportunity for the study of personality vulnerabilities to depressive symptoms.

Blatt and colleagues proposed that normal developmental processes are characterized by an interweaving of self-definition and relatedness. The self-definition process relates to "... the development of a realistic, essentially positive and increasingly integrated self-definition and self-identity" (Blatt, 1991, p. 453). The interpersonal relatedness process is defined as "... the capacity to establish increasingly mature, reciprocal and satisfying interpersonal relationships" (Blatt, 1991, p. 453). According to their theory, an adequate balance between interpersonal relatedness and self-definition is thought to reduce stress and lead to psychological well-being (Blatt & Zuroff, 1992). Overemphasis on self-definition or relatedness motives results in dysfunctional cognitions and is assumed to constitute self-critical and dependency vulnerabilities to depression, respectively. Overemphasis on the relatedness dimension—Dependency—is characterized by an excessive preoccupation with the availability of love, nurturance, and support, and by a heightened need for closeness and interpersonal support. Exaggerated preoccupation with issues of self-definition—Self-Criticism—associates with harsh standards, heightened strivings for mastery and achievement, and a marked need for acknowledgment.

The concepts of Dependency and Self-Criticism have been validated empirically using the Depressive Experiences Questionnaire (DEQ). The DEQ includes items chosen to represent common experiences of depressed individuals (Blatt, D'Affliti, & Quinlan, 1976). The first DEQ factor, Dependency, included concerns about abandonment, helplessness and loneliness, and the need for close and dependent interpersonal relationships. The items loading on the second DEQ factor, Self-Criticism, reflected a continuous preoccupation with failure, ambivalent feelings about self and others, and a self-critical stance (Blatt et al., 1976). In a recent review, Zuroff, Mongrain, and Santor (2004) concluded that Blatt's concepts are continuous, nearly orthogonal dimensions that can be identified and measured independently from neuroticism, depression, and social context.

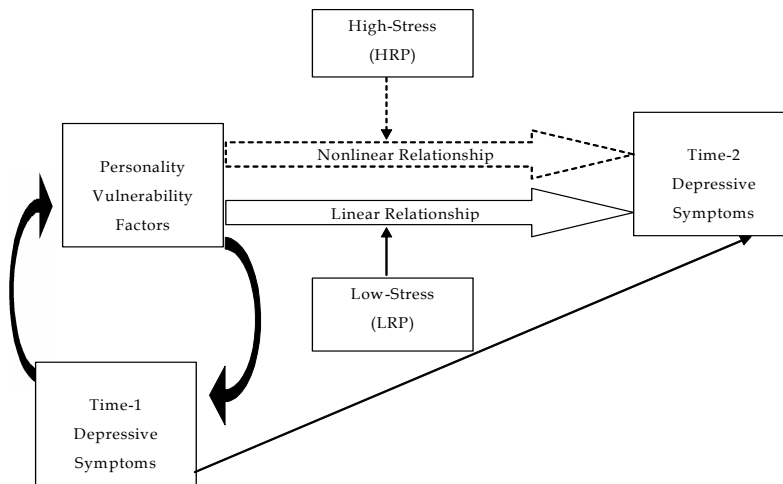
Recently, an important difference between Self-Criticism and Dependency has emerged in the research literature. While the association between Self-Criticism and dysphoria has been corroborated repeatedly in different contexts, Dependency sometimes appears as a vulnerability factor primarily under conditions of interpersonal loss and rejection (Priel & Shahar, 2000; Whiffen, Aube, Thompson, & Campbell, 2000), but evidence is accumulating that Dependency may be adaptive and may promote resilience in some interpersonal contexts (Mongrain, Vettese, Shuster, & Kendal, 1998; Santor, Pringle, & Israeli, 2000; Vettese & Mongrain, 2000). It seems that dependent individuals tend to activate their social environments to cope with stress.

The transition to motherhood is one specific context in which Dependency has been found to play a significant protective role. Recent prospective studies have shown that while high Self-Criticism measured during pregnancy predicts depressive symptoms after childbirth, Dependency is associated negatively with postpartum depressive symptoms (Besser & Priel, 2003a; Priel & Besser, 1999, 2000). In the transition to motherhood, Dependency was also found to relate to specific and global measures of social support; the association between Dependency and low levels of depression after childbirth is mediated by these measures of social support (Priel & Besser, 2000). In addition, in a longitudinal study

of pregnant women, Self-Criticism was linked with maladaptive coping strategies, while Dependency was correlated with adaptive coping strategies involving approach and low emotional-avoidance (Besser & Priel, 2003a). Thus, the Dependency construct involves aspects of both vulnerability and resilience (Blatt, Zohar, Quinlan, Zuroff, & Mongrain, 1995; Bornstein, 1992; Whiffen et al., 2000).

It is important to note that in the above reviewed studies only *linear* associations between Dependency and outcomes were investigated. Moreover, these associations have been studied mainly under *low-stress* conditions. In the present study, we sought to explore *nonlinear* relations between both Self-Criticism and Dependency personality vulnerabilities to depressive symptoms in both low and *high-stress* conditions.

Figure 1
***The Theoretical Model of Personality-Depression Relationships:
Linear and Nonlinear "Diathesis-Stress"***



Note: Figure 1 shows the conceptual model that underlies this current study. The figure outlines a model which assumes that *personality vulnerability* factors affect postpartum depression and that these effects are affected by stress i.e. stress shaping the personality vulnerabilities-depression associations. In other words, the contextual factor (stress) was assumed to qualify the effect of personality vulnerability factors (predictors) on postpartum depression (outcome) beyond levels of depression in pregnancy; nonlinear relationships between personality vulnerability factors and postpartum depression were assumed to be detected under high stress (HRP) while the associations under low stress (LRP) were assumed to remain linear.

The hypothesis that the depressogenic cognitions associated with personality vulnerability factors are intensified and further activated as a result of a highly stressful life event (Miranda, Persons, & Byers, 1990) constitutes an important advance for the study of the direction of the effects of personality

vulnerabilities. In addition, according to the state-trait vulnerability model, individuals do not differ in terms of the presence of negative cognitive schemas but with respect to the 'availability' or 'accessibility' of latent cognitive schemas (Zuroff et al., 1999). In the current study, a longitudinal design that controlled for baseline levels of depression was used to explore the link between personality vulnerability factors and depression. In addition, these associations were compared under high and low levels of stressful life circumstances. Assuming stability of personality vulnerabilities, and following the above state-trait vulnerability model and Miranda et al.'s (1990) formulation, we examined the role played by levels of a highly stressful life event in amplifying the activation and magnifying the 'accessibility' of the underlying latent personality vulnerabilities, and thus shaping the personality vulnerabilities-depression associations (see Figure 1).

Searching for Nonlinearity

The move toward more complex explanations of individual reactions under conditions of heightened stress has taken many different directions (Monroe & Simons, 1991), including the investigation of polynomial nonlinear threshold effects (Cortina, 1993; Ganzach, 1995, 1997, 1998; Veiel, 1987). For instance, Lazarus and Folkman (1984) concluded that nonlinear, interactive hypotheses regarding the content and patterning of daily experienced stress yield a better understanding of how and why people or groups respond to stress than linear hypotheses, and these hypotheses might allow the planning of better interventions to facilitate more effective coping. Likewise, Kessler, Magee, and Nelson (1996) described the need to distinguish nonlinearities and linear interactions in nonlinear models, and differentiating vulnerability from differential exposure to stressors. Finally, Aldwin and Stokols (1988) argued that linear models of the impact of stress are insufficient for understanding outcomes and discussed the need for nonlinear models for the relationship between stress and negative outcomes. Empirical research has supported these arguments. For instance, Brown and Harris (1978) established that three or more severe life events, was a cutoff point that demarcated elevated risk for depression. More recently, it was found in an adolescent sample that three or more life events served as a stress threshold for depression in adolescents without a history of major depression (Lewinsohn, Allen, Seeley & Gotlib, 1999). Finally, another study showed that it is the children with high pre-existing stress who tend to display an amplified physiological response in diastolic blood pressure when exposed to laboratory stressors (Matthews, Gump, Block, & Allen, 1997).

The possible existence of nonlinear effects is suggested by theory and research on the accentuation principle (see Block, 1982; Elder & Caspi, 1990). Several authors have used the accentuation principle to explain discontinuities during life transitions and the tendency for stress to have a much greater impact for certain individuals (see Caspi & Moffitt, 1993; Rutter, 1994, 1996). The accentuation principle is derived from the Piagetian notion of assimilation. Specifically, during transitions that involve substantial threat and challenge, people will turn to already established response patterns and enduring dispositions; that is, existing actions and response tendencies will be accentuated and become even more deeply ingrained, stable, and predominant. Presumably, when accentuation takes place, people who are characterized by personality vulnerabilities and are prone to psychological distress should be particularly likely to have an adverse reaction (see Caspi & Moffitt, 1993; Rutter, 1996). Accentuation has been implicated in various life transitions, including the transition to adolescence (Caspi & Moffitt, 1991) and the transition to parenthood (Cowan, Cowan, Hemming, & Miller, 1991). In these instances, pre-existing problems and tendencies become magnified and exacerbated.

The viability of nonlinear models of vulnerability and resilience was also considered by Gore and Eckenrode (1994). They suggested that protective factors might contribute in non-additive ways to the

explanation of the relationships between individual differences and outcomes. Gore and Eckenrode recommended the insertion of normative or scheduled transitions by taking the context as representing a situational variable that alters the psychological significance and social demands of particular life events. They also recommended studying high-risk or vulnerable populations in addition to low-risk groups. Accordingly, the present study investigates non-additive models of vulnerability to depression in high-risk pregnancy (HRP) and low-risk pregnancy (LRP) groups.

The current study investigated the possibility that chronic high-stress conditions and associated demands and threats involved in a highly stressful condition tend to influence the linearity of the association between levels of personality vulnerabilities and depressive symptoms. We maintain that the level of personality vulnerability may determine its relation to depression. We assume that it would be theoretically important and empirically possible to distinguish the following groups from each other: (a) individuals who report low levels of the DEQ factors (Self-Criticism and Dependency); (b) individuals who report high levels of the DEQ factors; and (c) individuals who report moderate levels of the DEQ factors¹. We propose that under chronic high-stress conditions that place great demands on the self, very high levels of Dependency might increase vulnerability, while moderate levels of Dependency may constitute a factor of resilience that associates with low depression scores. We also propose that under chronic high-stress conditions, the repeatedly corroborated association between Self-Criticism and depression may be nonlinear as well; that is, at extreme levels, the increase in levels of Self-Criticism may exponentially augment depression outcomes. It is possible, for instance, that experience of Type II gestational diabetes mellitus (GDM) could result in an increased sense of self-focused attention that would amplify negative self-evaluative tendencies at high levels of depressive symptoms. The proposed theoretical model is represented in Figure 1.

High-Risk Pregnancy as a High-Stress Condition

High-risk pregnancy (HRP) is defined as any pregnancy, in which there is a factor—maternal or fetal—that may potentially exert an adverse effect on the outcome (Queenan, 1985). While normal or low-risk pregnancies are associated with *moderate* levels of stress, pregnancies medically defined as “high risk” (Pritchard & MacDonald, 1980) involve *severe* levels of stress. In the present study, the high-risk pregnancy sample included women diagnosed with GDM, that is, women who developed first-time diabetes during pregnancy. Women with GDM are expected to follow a specific eating plan and to test their blood glucose frequently, as well as take insulin (either via injection or in the form of oral agents). These demands and the increased risk to the mother and fetus considerably *increase* the stress of pregnancy, which may add to the risk of adverse birth outcomes (Rini, Dunkel-Schetter, Wadhwa, & Sandman, 1999). Lawson and Rajaram’s (1994) review indicated that GDM had a profound impact on pregnant women in terms of increased dysphoria and anxiety, and personal disruption involving the “diabetic regimen” (Lawson & Rajaram, 1994). Although depressed mood is common in normal pregnancy, during the third trimester, the levels of depressive symptoms among high-risk women may be significantly higher than among low-risk women (see Besser, Priel & Wiznitzer, 2002; Mercer & Ferketich, 1988). The need for research on GDM is underscored by evidence indicating that, relative to nondiabetic women, pregnant women with GDM report more negative emotions and fewer positive emotions during the pregnancy period (see Levy-Shiff, Lerman, Har-Even, & Hod, 2002).

¹ Given the measure of personality used in this study and the contingent nature of these variables, it should be noted that we explored the effects of continuous individual differences in levels of personality and did not categorize individuals. In other words, we took into account the whole range of the variance in Self-Criticism and Dependency rather than assigning arbitrary cutoff points.

The Present Study

The present study examined linear and nonlinear models of Self-Criticism and Dependency as personality vulnerabilities to depression among LRP and HRP participants. We assumed that linear associations are characteristic of low stress contexts, whereas under high stress these associations are non-linear. It is assumed that high levels of stress accelerate the activation of latent dependent and self-critical cognitive schemas, and thus contribute to a non-linear association between personality vulnerabilities and depression; we posit that the development of depressive symptoms under high stress would not rise continuously with rising levels of personality vulnerability, with higher levels of stress producing increasingly severe depressive symptoms. Rather, we assumed that under high-stress conditions, small changes in personality levels would be associated with large changes in the severity of depressive symptoms (Brown & Harris, 1978).

This perspective suggests that there may be *thresholds* for personality variables; that is, certain levels of these variables may effect a change in the direction of the effects or in the rhythm of symptom increase (Kobasa, 1987, 1990; Kobasa & Puccetti, 1983; Krause & Stryker, 1984). The proposed model implies that in highly stressful life circumstances, the effect of a given increase in Dependency or Self-Criticism on depressive symptoms will depend on whether the personality vulnerability levels are above, below, or at critical thresholds. This model emerges from a “person-situation” perspective that defines personality in terms of the individual’s active transactions with important components of the environment (Cantor, 1990), and a view which suggests that the experience of additional stress on individuals who are already prone to stress may exponentially increase their levels of psychological distress. To our knowledge, the current study is the first to investigate the possibility of nonlinear associations between these personality vulnerability factors and depressive symptoms.

The Proposed Model Specifications

We assumed nonlinear increases of depression levels at the higher levels of both Self-Criticism and Dependency under high-stress conditions (see Figure 1). We made this assumption essentially because of the depletion of resources likely to occur in all cases under such circumstances (Helgeson, 1994; Helgeson & Fritz, 1998; Lazarus, 1999; Lazarus & Folkman, 1984; Monroe, 2002).

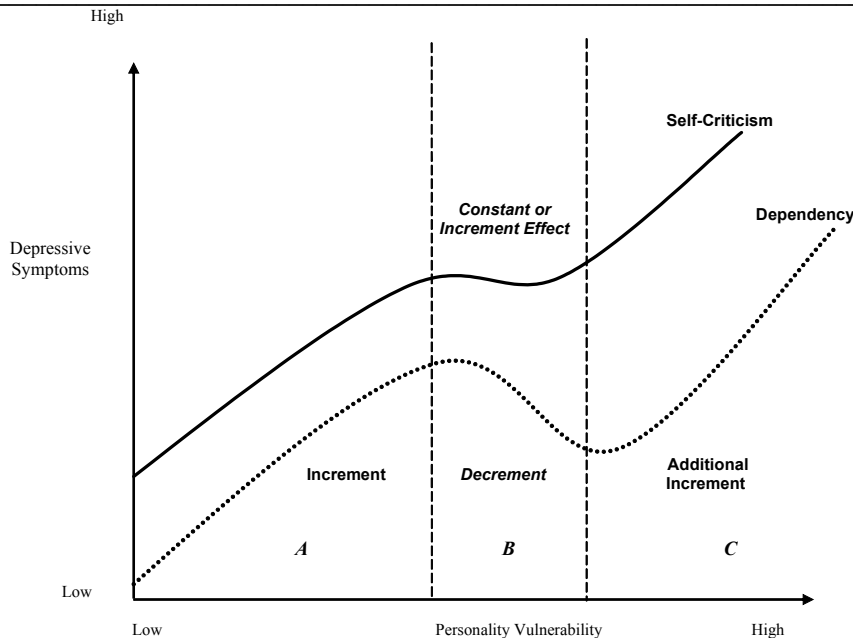
Following previous research findings (e.g., Besser & Priel, 2003a, b; Mongrain, 1998; Priel & Shahar, 2000), we expected that Dependency would not be a vulnerability factor for depression under low stress conditions; in fact, Dependency has been found to be significantly negatively associated with postpartum depression in low stress pregnancies. However, under high stress levels, we assumed that very low levels of Dependency would imply vulnerability because of the relative neglect of interpersonal resources implied. Nevertheless, once Dependency reaches a certain range under high-stress conditions, it might serve as a resilience factor, thus associating with lower levels of depression. We called this range the optimal level threshold; it is shown as the range between TH1 and TH2 in Figure 2. On the other hand, when Dependency rises above the optimal level threshold (above TH2), the excessive preoccupation with relationships may accelerate resource depletion, leading to a rapid increase in depressive symptoms. With regard to Self-Criticism under high-stress conditions, we expected that it would associate linearly with depression given past findings (Besser & Priel, 2003a, b; Priel & Besser, 1999, 2000). However, at higher levels of Self-Criticism, we hypothesized an acceleration in the increase of depressive symptoms. That is, when Self-Criticism rose above the threshold (above TH2), the preoccupation with self-definition and a preponderance of negative self-thoughts (i.e., high negative and low positive self-thoughts) was expected to effect a rapid increase of depressive symptoms. This is in

keeping with past observations that extreme levels of depression are characterized by self-schemas that are dominated by highly negative cognitions about the self (see Ruehlman, West, & Pasahow, 1985).

To sum up, under conditions of high stress, we expected that Dependency and Self-Criticism vulnerabilities would underlie processes that are highly nonlinear. A constant effect was predicted for moderate levels of Self-Criticism, whereas a decrement was predicted for moderate levels of Dependency.

Figure 2

The Theoretical Cubic Model: Self-Criticism and Dependency as Personality Vulnerability Factors and Depressive Symptoms Under High-Stress (HRP) Conditions



Note: As shown in Figure 2, the hypothesis is that among high-risk pregnancy participants, depression levels increase nonlinearly at lower levels of Dependency (A). When Dependency reaches a protective/resilience level (the range of the optimal level threshold), levels of depression decrease (B). However, when Dependency rises above the optimal level threshold (C), depression levels increase rapidly. For Self-Criticism, at low levels there is a nonlinear increase in depression levels (A). Then, at intermediate levels, depressive symptoms may continue to nonlinearly increase or might remain more or less constantly high (B). However, at high levels, when Self-Criticism reaches a vulnerable level (above the threshold), the increase in depressive levels rapidly (nonlinearly) accelerates (C).

Operatively, for Dependency, a *cubic polynomial* term was hypothesized—an *N-shaped* pattern: $Y = B_0 - B_1X + B_2(X)^2 + B_3(X)^3$ (see Figure 2)—that examines the extent to which the effect of X on Y depends on the level of X . The slope of the X, Y regression line is a function of X , as can be seen in Figure 2, which presents the cubic nonlinear theoretical model of Dependency and Self-Criticism as vulnerability to depression factors under high-stress (HRP) conditions. Such polynomial terms are used

to examine effects beyond and above linear effects. As shown in Figure 2, the hypothesis is that among high-risk pregnancy participants, depression levels increase nonlinearly at lower levels of Dependency (*A*). When Dependency reaches a protective/resilience level (the range of the optimal level threshold), levels of depression decrease (*B*). However, when Dependency rises above the optimal level threshold (*C*), depression levels increase rapidly.

For Self-Criticism, we also proposed a *cubic exponential* model [$Y = B_0 + B_1X + B_2(X)^2 + B_3(X)^3$], meaning that at low levels there is a nonlinear increase in vulnerability (*A*). Then, at intermediate levels of Self-Criticism, depressive symptoms may continue to nonlinearly increase or might remain more or less constantly high (*B*). However, at high levels, when Self-Criticism reaches a vulnerable level (above the threshold), the increase in depressive levels rapidly (nonlinearly) accelerates (*C*).

Tests of polynomial (curvilinear) and interactive effects for Self-Criticism (SC) and Dependency (DP) on depression were conducted separately for HRP and LRP women using Hierarchical Multiple Regressions (HMR). We judged that a cubic (i.e., third-order) model with interactions was the most complex model that could make a substantive contribution; so we set this as a practical limit on model complexity. Therefore, for LRP and HRP we considered three possible models:²

Linear: $b_0 + b_1(SC) + b_2(DP) + b_3(SC \times DP)$

Quadratic: $b_0 + b_1(SC) + b_2(DP) + b_3(SC \times DP) + b_4(SC)^2 + b_5(DP)^2$

Cubic: $b_0 + b_1(SC) + b_2(DP) + b_3(SC \times DP) + b_4(SC)^2 + b_5(DP)^2 + b_6(SC)^3 + b_7(DP)^3$

In brief, assuming higher levels of depressive symptoms under HRP, the following hypotheses were explored:

Hypothesis 1 (H1): Greater increases in depressive symptoms between Time 1 (pregnancy) and Time 2 (postpartum) would be found among HRP than among LRP participants, linking levels of naturally occurring stress to postpartum depressive symptoms.

Hypothesis 2 (H2): No differences in Dependency and Self-Criticism mean scores between LRP and HRP would be found, indicating that these groups do not differ regarding vulnerability factors.

Hypothesis 3 (H3): A reiteration of the Self-Criticism and Dependency linear relationships with postpartum depressive symptoms was expected among LRP women.

Hypothesis 4 (H4): In the HRP group, nonlinear vulnerability personality models were expected to fit better than linear models; different non-linear relations with depression were assumed for Dependency and Self-criticism. While only non-optimal thresholds of Dependency were assumed to constitute vulnerabilities to depression, levels of Self-criticism were assumed to exponentially affect depression levels.

Hypothesis 5 (H5): We suggest that levels of stress interact with personality vulnerabilities affecting depression; the different effects of personality vulnerabilities on depression relate to the different stress levels (HRP vs. LRP conditions).

Method

Participants

Initially, we approached 267 first time naturally conceived (e.g., in vitro fertilization IVF were not recruited) pregnant women (130 LRP and 137 GDM HRP women) making the transition to motherhood. Participants were Israeli, White, Jewish, married women, without a previous history of diabetes or other

² A model selection process in which one continues to add polynomial terms as long as they meet conventional significance criteria was likely to produce unreplicable, uninterpretable, and unnecessarily complex models. Based on our theoretical hypothesis, we concluded that a cubic model with an interaction was the most complex model that could make a substantive contribution.

mental or physical illness (according to their medical file). Ten Well Baby Clinics serving urban lower-middle-class neighborhoods participated in this study. All participants were routinely administered a 50-g oral glucose load at 24-28 weeks of gestation. Women having normal fasting values and two abnormal glucose tolerance tests (at 1 and 3 hours) were designated as GDM High Risk Pregnancies (O'Sullivan & Mahan, 1964), and were transferred to the High Risk Gynecology Unit for follow-up examinations. LRP women continued to attend the Well Baby Clinics for routine monitoring.

Of the 130 LRP and 137 HRP women who were contacted, 113 LRP (87%) and 110 HRP (80%) agreed to take part in this study. The final sample included only those who subsequently experienced normal childbirth and had healthy babies. An APGAR score of eight or higher was set as a criterion for normality in the newborns' health status (Nelson, 1987). Ten participants were excluded from the HRP sample because they had miscarriages ($n=6$), delivered prematurely ($n=3$), or the baby had an abnormal APGAR ($n=1$). Four LRP participants were excluded: three had miscarriages and one participant moved. Thus, our final sample included 100 HRP and 109 LRP participants. Mean age was 27.54 years ($M = 25.31$, $SD = 3.51$ and $M = 29.97$, $SD = 5.09$ for LRP and HRP, respectively). All participants were in the same regional hospital and released after two regular days of hospitalization. Participants had 10-20 years of formal education with $M = 13.35$, $SD = 1.79$ (10 to 19 years, $M = 13.34$, $SD = 1.70$ and 11 to 20 years $M = 13.41$, $SD = 1.93$, for LRP and HRP, respectively).

Measures

The Depressive Experiences Questionnaire (DEQ). The DEQ is a 66-item scale devised to evaluate patterns of experiences that constitute a predisposition to depressive states and therefore are appropriate for a non-clinical population. The DEQ Dependency factor reflects preoccupation with abandonment and separation, feelings of being unloved and fear of loss. The Self-Criticism factor reflects introjective concerns with failure and guilt, and inability to meet high standards. Intratest homogeneity and test-retest reliability for the DEQ are adequate (Blatt et al., 1982). The Israeli version of the DEQ (Priel, Besser & Shahar, 1998) has adequate reliability for many different samples, including those of pregnancy and postpartum research (Besser, 2004; Besser, Flett, & Davis, 2003; Besser & Priel, 2005a; Besser & Priel, 2003a, b; Priel & Besser, 1999, 2000). According to Blatt and colleagues (1976), each of the 66 items' standardized scores should be multiplied by the factor weight coefficient obtained in the normed sample for the loadings on both Self-Criticism and Dependency. In this unit weight scoring system, all 66 items, relative to their factor weight coefficients, contribute to form the final scores of *both* Dependency and Self-Criticism. Thus, internal consistency reliability coefficients are reported only for the entire DEQ questionnaire. Previous studies used the DEQ in pregnancy and postpartum research reported Cronbach's α of .90 and higher (e.g., Besser & Priel, 2003a; Priel & Besser, 1999, 2002). The Cronbach's α internal consistency coefficients for DEQ scores in the present study were .92 and .90 for the LRP and HRP samples, respectively.

The Center for Epidemiological Studies Depression Scale (CES-D). The CES-D (Radloff, 1977) was used to measure depressive symptoms during pregnancy and eight weeks after delivery. This 20-item scale assesses current levels of depressive symptoms in the general population. Extensive evidence in a variety of samples attests to the psychometric properties of the CES-D. Eaton et al. (2004) observed recently that there are over 900 papers in the published literature that have involved the CES-D (Eaton, Muntaner, Smith, Tien, & Ybarra, 2004). This scale has been shown to be valid and reliable for many different samples, including studies of depression in pregnancy and postpartum that reported Cronbach's α of .85 and higher (see, e.g., Besser et al., 2002; Besser & Priel, 2003a, b; Fleming, Ruble, Flett, & Van Wagner, 1990; Priel & Besser, 1999, 2000, 2002, 2003a). The Cronbach's α internal consistency

coefficients in our study were .85 and .88 for Time 1 and .87 and .86 for Time 2 for LRP and HRP, respectively. The CES-D was included because it focuses on affective and psychological symptoms and does not have somatic symptoms that could be influenced unduly by medical conditions.

Procedure

Two waves of measurements were obtained as part of a longitudinal project on depressive symptoms after childbirth. This part of the project was designed specifically to compare linear and nonlinear relationships among Dependency, Self-Criticism, and depression in LRP versus HRP women³. Participants who fulfilled the demographic and clinical criteria completed the self-report measures during the last trimester of pregnancy, $M = 27.28$ weeks, $SD = 7.16$ ($M = 26.56$ weeks, $SD = 6.32$ and $M = 28.09$, $SD = 7.93$ weeks, for LRP and HRP, respectively), and eight weeks after childbirth. Participants completed the CES-D and DEQ at Time 1, and the CES-D at Time 2.

Results

Statistical analyses (Analyses of Variance, Correlational, and HMR analyses) were performed using SPSS for Windows (Norusis, 1993; Version 12.0; SPSS Inc, Chicago, IL). Statistical significance was set at two-tailed $p < .05$ for all analyses.

Comparison of LRP and HRP Samples

Demographic and personality variables. To explore possible differences between the LRP and HRP samples for the study variables, a one-way MANOVA was performed, with the two stress groups as the independent variable and gestational age, participants' age, formal education, Self-Criticism and Dependency scores as the dependent variables. One-way ANOVAs showed that the groups were not significantly different with regard to gestational age, participants' education, Self-Criticism, and Dependency. However, a significant difference was found between groups regarding participants' age ($F [1,207] = 60.15$, $p < .0001$). HRP participants were significantly older. Consequently, in subsequent analyses, we included participants' age as a covariate. Means, SDs, and the 95% Confidence Intervals are presented in Table 1.

Depressive symptoms. The CES-D norms established in community samples indicate 16 as the cutoff point for the presence of at least mild depressive symptoms; 32% of the LRP and 29% of the HRP pregnant women and 40.4% of the LRP and 47% of the HRP mothers had scores above 16, so the overall level of distress in this sample was elevated. These high levels of distress are likely a reflection of numerous general factors involving ongoing concerns about physical safety in Israel. These results are not significantly different from results obtained in previous Israeli pregnant and postpartum samples of women (e.g., Besser & Priel, 2003b; Priel & Besser, 1999, 2000; Priel, Besser, & Wiznitzer, 2002).

CES-D scores were analyzed in terms of a two-way ANCOVA with stress (high vs. low) as a between-subjects factor, depression scores (Time 1 vs. Time 2) as a within-subjects repeated factor and participants' age as a covariate. A significant time effect was obtained ($F [1,207] = 14.59$, $p < .0001$). An

³ The current study builds on previous findings regarding the associations between Self-Criticism, Dependency and postpartum depression in low-risk pregnancies, as reported Besser and Priel (2003a), and Priel and Besser (1999, 2000). This study is the first to explore the associations between Self-Criticism, Dependency and postpartum depression in an HRP sample, and was designed specifically to compare linear and nonlinear relationships of Dependency, Self-Criticism, and depression in low-risk versus high-risk samples, using a new sample of LRP women and more informative or more precise/specific methodologies.

increment in Time 2 depressive symptoms was found ($M = 12.47$, $SD = 6.59$ and $M = 14.41$, $SD = 7.28$ for Time-1 and Time-2 depression respectively). A Time \times Group significant interaction effect was obtained ($F [1,207] = 5.73$, $p < .01$). Planned comparisons revealed a significant Time 2 depressive symptoms increment for the HRP group ($F [1,207] = 18.50$, $p < .0001$) but not for the LRP group ($F [1,207] = 1.06$, $Ns.$). Furthermore, CES-D2 scores were found to be significantly higher among the HRP participants ($F [1,207] = 5.49$, $p < .02$). (Means and Standard Deviations for CES-D1 and CESD-2 for LRP and HRP are presented in Table 1).

Table 1
Comparing HRP and LRP for the Study Variables: Means, SDs, and the 95% Confidence Intervals for Means

Variable	LRP		HRP		95% Confidence Intervals for Means			
	M	SD	M	SD	LRP		HRP	
					Lower	Upper	Lower	Upper
1. Age	25.28	3.49	29.97	5.09	24.61	25.94	28.96	30.98
2. Education	13.32	1.70	13.35	1.89	12.99	13.64	12.97	13.73
3. Gestational Age	26.48	6.21	28.09	7.94	25.30	27.66	26.52	29.66
4. Self-Criticism	-.57	.98	-.55	1.02	-.76	-.39	-.75	-.34
5. Dependency	-.03	.95	-.16	.99	-.21	.15	-.35	.04
6. CES-D 1 ^a	12.55	5.92	12.39	7.28	11.43	13.68	10.95	13.83
7. CES-D 2 ^b	13.29	6.68	15.63	7.73	12.03	14.56	14.10	17.16

Note. $N=100$ HRP above the diagonal; $N= 109$ LRP below the diagonal. ^a CES-D 1 = Depression measured at Time 1. ^b CES-D 2 = Depression measured at Time 2.

Table 2
Correlations: Personality and Depressive Symptoms Variables in LRP and HRP Samples

Variable	1	2	3	4	5	6
1. Age	---	.17	-.06	-.05	-.00	-.05
2. Education	.24**	---	-.11	.03	.00	.17
3. Self-Criticism	.04	-.13	---	-.25**	.16	.43***
4. Dependency	-.03	.22*	-.07	---	-.13	-.26**
5. CES-D 1 ^a	-.16	-.13	.17	-.07	---	.43***
6. CES-D 2 ^b	-.07	-.18	.49***	-.24**	.38***	---

Note. $N=100$ HRP above the diagonal; $N= 109$ LRP below the diagonal (two-tailed tests).

^a CES-D 1 = Depression measured at Time 1.

^b CES-D 2 = Depression measured at Time 2.

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

Correlational Analyses

Table 2 displays the correlations among age, education, Self-Criticism, Dependency, and assessments of depression before and after birth for the HRP and LRP groups. Correlations were compared using Fisher's z test. As the table indicates, Self-Criticism and Dependency are negatively associated for the HRP sample; Self-Criticism and Dependency are not associated in the LRP sample. A statistical test confirmed that these correlations are significantly different. In addition, in both samples, measured at Time 2, depression was associated positively with Self-Criticism and negatively with Dependency but statistical analysis showed that these correlations are not significantly different. The moderate correlations between depressive symptoms measured at Time 1 and Time 2 were .38 ($p < .001$) and .43 ($p < .001$) for LRP and HRP, respectively, indicating a significant consistent level of depressive

symptoms during pregnancy and after birth in both samples but the difference between these correlations is not statistically significant. The other correlations did not reach statistical significance either and differences between the two samples correlations were nonsignificant. However two nonsignificant correlations suggested different patterns of associations in each sample: the correlation between Education and CES-D1 for the HRP group is .00, while for the LRP group is -.13 and the correlation between Education and CES-D2, the HRP group is 0.17, while the LRP group is -.18. Statistical comparisons of the correlations obtained in each sample indicated that only the Education and CES-D2 correlations are significantly different ($p < .013$). Accordingly, in the subsequent analysis, we controlled for Education levels.

Testing Linear and Nonlinear Vulnerability Effect Models

As a means of evaluating the contributions of linear and nonlinear effects of Dependency and Self-Criticism to the prediction of postpartum depression (CES-D2), we used a polynomial hierarchical regression procedure (Cohen & Cohen, 1983) separately for each of the HRP and LRP samples to examine the shape of the relation between personality vulnerability traits and depressive symptoms. The DEQ factor scores, their interaction term, and their second- and third-degree power polynomials (i.e., the quadratic and cubic component terms) were entered sequentially as predictors of depressive symptoms. This approach permitted, beyond a first test for the existence and strength of linear association, a subsequent test of whether quadratic and/or cubic nonlinear components added significant or incremental variance. We controlled for age and education in the first step of the regression (covariates). We entered CES-D1 in the second step of the regression. This enabled us to control for participants' baseline levels of depression, thus eliminating confounding effects when interpreting significant associations between independent and dependent variables. In the following steps (step 3, 4, and 5), the competing models for the associations between personality vulnerability factors and Time-2 depression were entered:

First the *Linear* model [in Step 3] $b_0 + b_1 (SC) + b_2 (DP)$; then the *Quadratic* component [in Step 4] $b_0 + b_1 (SC) + b_2 (DP) + b_3 (SC \times DP) + b_4 (SC)^2 + b_5 (DP)^2$, and finally the *Cubic* model component was entered [in Step 5]: $b_0 + b_1 (SC) + b_2 (DP) + b_3 (SC \times DP) + b_4 (SC)^2 + b_5 (DP)^2 + b_6 (SC)^3 + b_7 (DP)^3$

The interactive effect (i.e., the Self-Criticism \times Dependency product term) is a nonzero exponential function of itself. Such terms are also nonlinear, and therefore also examine non-additive effects (Cortina, 1993; Ganzach, 1995, 1997, 1998; MacCallum & Mar, 1995; Veiel, 1987). Accordingly, this effect was included and estimated with the Self-Criticism and Dependency quadratic [step 4] and cubic [step 5] nonlinear effects.

According to Ganzach (1997), true nonlinear relationships emerge only from a full model, which includes linear, nonlinear, and interaction effects as in the final step of the regression model. Significant nonlinear effects obtained in the final step indicate that these effects are above and beyond the others as if they were entered into the equation last. The HMR steps allowed the linear, quadratic and cubic functions for competition with one another to empirically assess which function best characterizes the higher order relation between the predictor set and Time 2 depression.

Nonlinear Model in the Low-Stress Condition (LRP)

As Table 3a indicates, the test of the nonlinear model in the LRP sample age and education, entered in the first step, was not significant. CES-D1 entered in the second step explained 13% of the total variance. In the third step, personality linear effects added another 21% to the explained variance. The β value for Dependency indicates a negative significant linear association between Dependency and depressive symptoms when controlling for the common variance with Self-Criticism and CES-D1

effects. The β value for Self-Criticism indicates a positive significant linear association between Self-Criticism and depressive symptoms when controlling for the common variance with Dependency and CES-D1 effects. Neither nonlinear (quadratic or cubic) nor interaction effects were found. As can be seen in the final step of the regression [Step 5], three predictors reached significance beyond and above the covariates and the other variables participated in the model: CES-D1 ($\beta = .28, p < .001$), Self-Criticism ($\beta = .39, p < .01$), and Dependency ($\beta = -.31, p < .04$). The complete model explained 39% of the variance of LRP CES-D2 symptoms.

Table 3a
Hierarchical Multiple Regression Analysis of Time 2 Depressive Symptoms for LRP

<i>Predictor variable</i>	<i>Multiple R</i>	<i>R²</i>	<i>F-change</i>	<i>Overall F</i>	<i>df</i>	<i>β</i>
<i>Step 1</i>	.18	.03	1.75 n.s	1.75 n.s	2,106	
<i>Covariates</i>						
Age						-.03 n.s
Education						-.17 n.s
<i>Step 2</i>	.40	.16	15.86***	6.62***	3,105	
<i>Time 1 depressive symptoms</i>						
Age						.02 n.s
Education						-.14 n.s
+Time 1 depressive symptoms						.36***
<i>Step 3</i>	.61	.37	17.45***	12.20***	5,103	
<i>Personality linear effect terms</i>						
Age						-.03 n.s
Education						-.04 n.s
Time 1 depressive symptoms						.28***
+Self-Criticism						.43***
+Dependency						-.19*
<i>Step 4</i>	.62	.39	.82 n.s	7.89***	8,100	
<i>Personality quadratic effect terms</i>						
Age						-.03 n.s
Education						-.04 n.s
Time 1 depressive symptoms						.28***
Self-Criticism						.40***
Dependency						-.23*
+Self-Criticism \times Dependency						-.02 n.s
+(Self-Criticism) ²						-.03 n.s
+(Dependency) ²						-.12 n.s
<i>Step 5</i>	.63	.39	.30 n.s	6.29***	10,98	
<i>Personality cubic effect terms</i>						
Age						-.03 n.s
Education						-.04 n.s
Time 1 depressive symptoms						.28***
Self-Criticism						.39**
Dependency						-.31*
Self-Criticism \times Dependency						-.03 n.s
(Self-Criticism) ²						.01 n.s
(Dependency) ²						-.10 n.s
+(Self-Criticism) ³						.05 n.s
+(Dependency) ³						.11 n.s

Note. $N = 109$ (two-tailed tests). β 's are standardized regression coefficient estimates.

+ indicates the variables added in each step

* $p < .05$, ** $p < .01$, *** $p < .001$. n.s = non-significant

Table 3b***Hierarchical Multiple Regression Analysis of Time 2 Depressive Symptoms for HRP***

<i>Predictor variable</i>	<i>Multiple R</i>	<i>R²</i>	<i>F-change</i>	<i>Overall F</i>	<i>df</i>	<i>β</i>
<i>Step 1</i>	.19	.04	1.81 n.s	1.81 n.s	2,97	
<i>Covariates</i>						
Age						-.08 n.s
Education						.19 n.s
<i>Step 2</i>	.47	.22	22.97***	7.33***	3,96	
<i>Time 1 depressive symptoms</i>						
Age						-.08 n.s
Education						.19*
+Time 1 depressive symptoms						.43***
<i>Step 3</i>	.62	.39	12.66***	7.67***	5,94	
<i>Personality linear effect terms</i>						
Age						-.07 n.s
Education						.27**
Time 1 depressive symptoms						.36***
+Self-Criticism						.36***
+Dependency						-.14 n.s
<i>Step 4</i>	.68	.46	3.79**	5.64***	8,91	
<i>Personality quadratic effect terms</i>						
Age						-.03 n.s
Education						.26**
Time 1 depressive symptoms						.35***
Self-Criticism						.21*
Dependency						-.33**
+Self-Criticism × Dependency						-.22*
+(Self-Criticism) ²						-.12 n.s
+(Dependency) ²						-.17 n.s
<i>Step 5</i>	.73	.51	3.57*	4.91***	10,89	
<i>Personality cubic effect terms</i>						
Age						.00 n.s
Education						.27**
Time 1 depressive symptoms						.34***
Self-Criticism						.09 n.s
Dependency						-.63***
Self-Criticism × Dependency						-.31**
(Self-Criticism) ²						.04 n.s
(Dependency) ²						-.05 n.s
+(Self-Criticism) ³						.33*
+(Dependency) ³						.50**

Note. $N = 100$ (two-tailed tests). β s are standardized regression coefficient estimates.

+ indicates the variables added in each step

* $p < .05$; ** $p < .01$; *** $p < .001$. n.s = non-significant

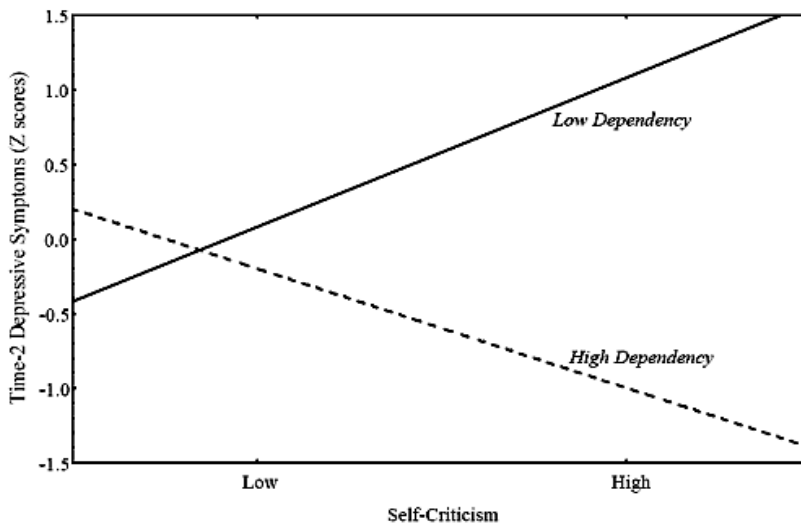
Nonlinear Model in the High-Stress Condition (HRP)

The test of the nonlinear model in the HRP sample (see Table 3b) shows that age and education, entered in the first step, did not add significantly to explanation of the variance. CES-D1 was entered in

the second step and it explained 18% of the total variance. In the third step, personality linear effects added an additional 17% to the explained variance. The β value for Self-Criticism indicates a positive significant linear association between Self-Criticism and depressive symptoms when controlling for the common variance with Dependency and CES-D1 effects. In Step 4, the Self-Criticism \times Dependency interaction and the quadratic effects of Self-Criticism and Dependency were entered and accounted for an additional 7% of the variance. Results indicated a significant β value only for the Self-Criticism \times Dependency interaction with non-significant quadratic effects. This interaction is represented in Figure 3.

Figure 3

The Product (Interaction) Term Effect: The Association Between Self-Criticism and Time 2 Depressive Symptoms for High (+SD) and Low (-SD) levels of Dependency for the HRP Sample

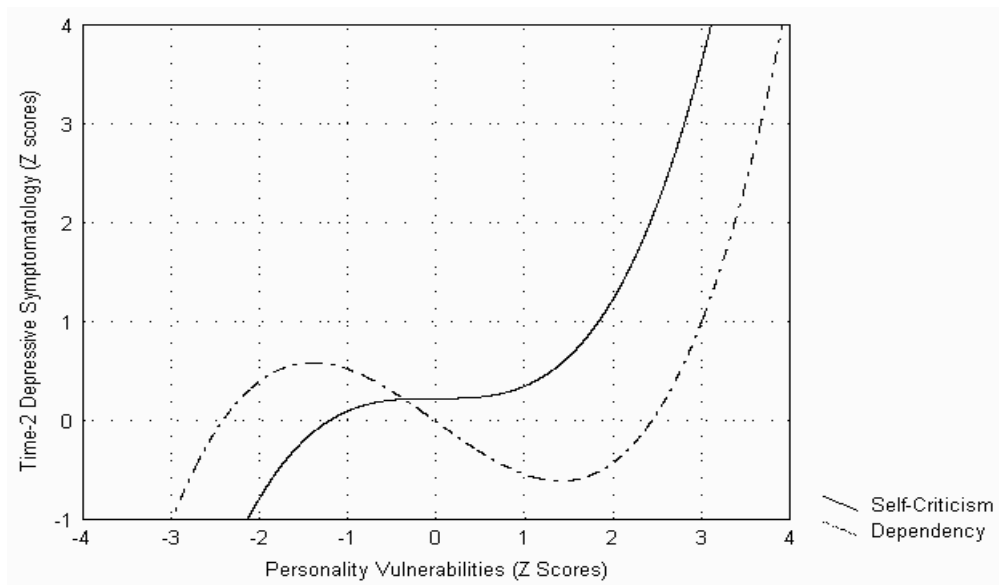


Note: As can be seen in Figure 3, the levels of Dependency moderate the associations between Self-Criticism and depression, with significantly stronger self-critical vulnerability (positive association) found under low Dependency than under high Dependency levels.

As shown in Figure 3, under high stress (among HRP), Dependency moderates the effects of Self-Criticism on depressive symptoms scores. As can be seen in Figure 3, the levels of Dependency moderate the associations between Self-Criticism and depression, with significantly stronger self-critical vulnerability (positive association) found under low Dependency than under high Dependency levels. In the final step (Step 5), the cubic effects of Self-Criticism and Dependency were entered and predicted an additional 5% of the variance. The β value for the Dependency cubic exponent indicates a positive significant nonlinear association between Dependency and depressive symptoms when controlling for the common variance with the remaining personality and CES-D 1 effects. For Self-Criticism, the β value of

the nonlinear cubic exponent term indicates a positive significant nonlinear association among Dependency

Figure 4a
Regression Curves of the Empirical Best Fit for the Empirical Nonlinear Regression Model of Dependency and Self-Criticism Predicting Time 2 Depressive Symptoms Under High-Stress Conditions (HRP)



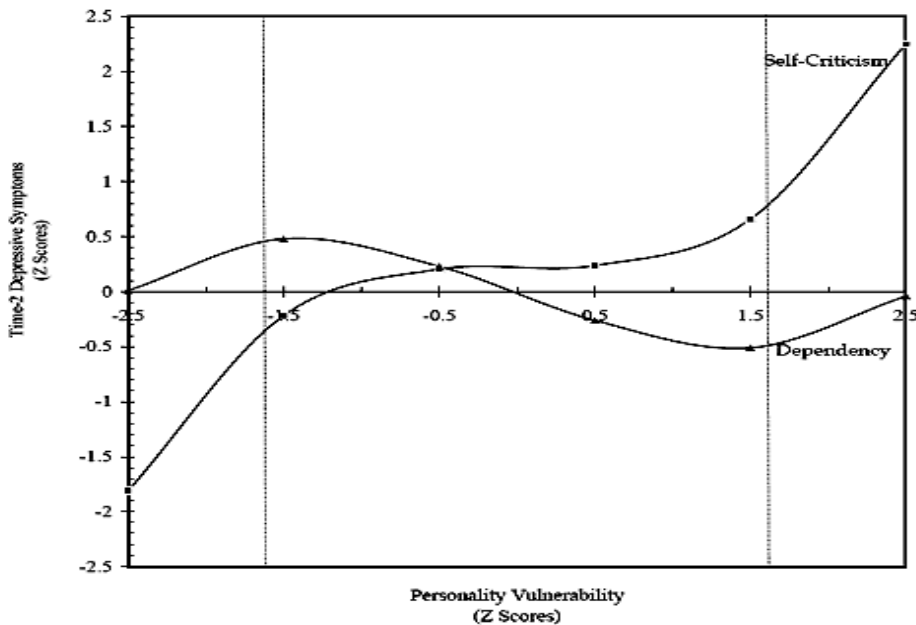
Note: *Empirical fit*: Regression curves describing the HRP nonlinear relationships between personality vulnerability levels and postpartum depression. Nonlinear functions curves were scattered using the following loss function: $(Observed - Expected)^2$. This figure shows the regression curves best fit for the empirical nonlinear regression model (raw data) of Dependency and Self-Criticism predicting Time 2 depressive symptoms under high-stress conditions (HRP). It is important to note that a Z score of zero represents the sample mean score, which, for HRP, is very close to 16 ($M=15.63$, $SD=7.73$), the cutoff point for clinical depressive symptoms. Thus, according to the regression curves best fit for the empirical nonlinear regression model, low Dependency (-2.5 SDs) provokes the mean level of depression. Depression levels rise to +0.5 SD above the mean when Dependency levels are -1.5 SDs, indicating vulnerability for low levels of Dependency. For Self-Criticism, approximately mean levels of depressive symptoms were predicted among women whose Self-Criticism was greater than 1.5 SDs above mean; levels of depressive symptoms greater than 0.5 SD above the mean were predicted only among women whose Self-Criticism scores were at least 1.5 SDs above the mean.

and depressive symptoms when controlling for the common variance with the other personality and CES-D 1 effects. As can be seen in the final step of the regression [Step 5], six predictors reached significance above and beyond the covariates and the other variables participated in the model: CES-D1 ($\beta = .34$, $p < .0001$), Dependency ($\beta = -.63$, $p < .0001$), the Self-Criticism \times Dependency interaction ($\beta = -.31$, $p <$

.003), the Self-Criticism cubic effect ($\beta = .33, p < .05$) and the Dependency cubic effect ($\beta = .50, p < .01$). The complete model explained 51% of the variance of HRP depressive symptoms at Time 2. The final⁴ nonlinear personality vulnerability equations predicting Time 2 depressive symptoms under high stress condition are represented by the following polynomial: $CES-D2 = \beta_1 (Self-Criticism)^3 + \beta_2 (Self-Criticism) + \beta_3 (Dependency)^3 - \beta_4 (Dependency) + \beta_5 (Self-Criticism \times Dependency)$.

Figure 4b

Mathematical (Estimated Values) Fit Simulation: Time 2 Depressive Symptoms as a Function of Cubic Nonlinear Terms Representing Dependency and Self-Criticism Levels



Note: This figure shows the mathematical fit simulation (estimated values) for the HRP regression curves model. Significant equations of nonlinear regression estimations effects are graphically represented according to the method described by Aiken and West (1991). Vertical lines represent the boundaries of the empirical thresholds' range of intensity, ($Z = -1.5 \pm .05$ and $Z = 1.5 \pm 1.0$). It is important to note that a Z score of zero represents the sample mean score, which, for HRP, is very close to 16 ($M=15.63, SD=7.73$), the cutoff point for clinical depressive symptoms. Thus, according to the mathematical simulation, low Dependency (-2.5 SDs) provokes the mean level of depression. Depression levels rise to +0.5 SD above the mean when Dependency levels are -1.5 SDs, indicating vulnerability for low levels of Dependency. For Self-Criticism, approximately mean levels of depressive symptoms were predicted among women whose Self-Criticism was greater than 1.5 SDs above mean; levels of depressive symptoms greater than 0.5 SD above the mean were predicted only among women whose Self-Criticism scores were at least 1.5 SDs above the mean.

As shown in Tables 3a and b, the nonlinear model for LRP did not provide any significant contribution to the CES-D2 prediction, while the model for HRP was found to incorporate significant nonlinear terms with an improvement in the HMR R^2 .⁵

⁴ Significant terms in final step

⁵ A power analysis was performed to determine the chances for replicability from a pragmatic perspective. The power analysis

Figure 4a shows the regression curves best fit for the empirical nonlinear regression model, and Figure 4b is a graphic illustration of the mathematical regression equation of Dependency and Self-Criticism predicting Time 2 depressive symptoms under high-stress conditions (HRP). Although the mathematical simulation (estimated values) presented in Figure 4b is informative, interpretations should convey mainly through the obtained fitting to the actual empirical raw data as presented in Figure 4a.

Regression Diagnostics

Although results of Power for polynomial regression tests of the null hypotheses indicated that the N we used is sufficient to guarantee adequate statistical power, results of complex, higher-order models are notoriously difficult to replicate. It is therefore imperative to conduct analyses of outliers and influential data points to determine whether the higher-order effects found in the HRP sample hold up when such observations are dropped or recoded to less extreme values.

There is a type of regression known as "robust" regression⁶ that can be used to limit the effect of outliers. The idea is to assign a weight to each point so that outliers are given reduced weight. This makes the results less sensitive to the presence of outliers. The weighting is done automatically and iteratively as follows. In the first iteration, the fit is an ordinary least squares fit with each point having the same weight. Then new weights are computed to give lower weight to points that are far from their predicted values, and the fit is repeated using these weights. The process continues until it converges. Following Chen (2002), we used Robust Regression and Outlier Detection with the ROBUSTREG procedure (SAS/STAT version 9.1) The ROBUSTREG procedure provides resistant (stable) results in the presence of outliers by limiting the influence of outliers. ROBUSTREG procedure acts as an integrated tool for *outlier detection* and *robust regression*. Based on Robust Mahalanobis Distance, Robust MCD Distance, and Standardized Robust Residual the program detect and prints high leverage or outlier points -- outlying observations whose presence might have affected the strength and significance of these complex regression analyses, these outliers were identified in five participants, though. How do those outliers might affect the preset study's obtained results?

To examine this question, we used a robust regression that uses iteratively re-weighted least squares to estimate both the regression coefficients and the standard errors. The procedure assigns weights to each of the observations. Those observations with high leverage or influence receive lower weights. Whereas robust regression methods like Huber M -estimators (Huber 1973) reduce the influence of outliers only (compared to least-squares), resistant regression methods like LMS (Least Median of

focuses on the increment for the set of interest over and above any prior variables (i.e. 7 variables yielding an increment of .23 for LRP and 7 variables yielding an increment of .29 for the HRP). Using Power and Precision for polynomial regression (Version 2.0; Borenstein, Rothstein, & Cohen, 2001), with the given sample sizes (109 and 100 for LRP and HRP respectively) and alpha set at .01, the study has power of 0.94, and it is 0.99 if alpha is set at .05 for LRP and power of 1.00 for the HRP. This analysis indicates that the N used in the LRP and HRP samples in the present study guarantees sufficient power of the tests.

⁶ Robust regression is a term used to describe model fitting procedures that are insensitive to the effects of maverick observations. There is a family of robust regression analysis that replaces the sum of squared errors as the criterion to be minimized with one less influenced by outliers. Least median of squares (Rousseeuw, 1984) is one member of this family. The term "robust regression" can be used to mean two slightly different things. The first usage should really be called regression with robust standard errors. In regression with robust standard errors the estimates of the regression coefficients are the same as in the standard OLS linear regression but the estimates of the standard errors are more robust to failure to meet assumptions concerning normality and homogeneity of variance of the residuals. The second way the term robust regression is used involves both robust estimation of the regression coefficients and the standard errors. This approach is useful in situations where there are large outliers and observations with large leverage values.

Squares) can completely disregard influential outliers (sometimes called *leverage points*) from the fit of the model. Rousseeuw (1984) has proposed calculating a distance measure based on LMS regression and using it to identify outliers with respect to the LMS regression. These observations are set aside and least squares regression is fit to the rest of the data. The result is called re-weighted least squares regression.

Use of this method with our data showed that the respective regression coefficients or their significance were not changed, indicating that the different, partial, linear and higher order non-linear regression coefficients were not artifacts of influential outliers⁷.

Regression Models Comparison: High- and Low- Situational Stress × Personality Interaction

As shown in Tables 3a and b, the nonlinear model for LRP did not provide any significant contribution to the CES-D 2 prediction, while the model for HRP was found to incorporate significant nonlinear terms. However, although an improved in the high-stress HMR R^2 was found it would not estimate whether the differences between the parameter estimates for high stress (HRP) vs. low stress (LRP) are essentially statistically significant. In order to compare the groups and estimating the role of stress in the associations between personality vulnerabilities and depression (Group × personality variable interaction), a multiple-group approach using Structural Equation Modeling (SEM; Hoyle & Smith, 1994) was used in which the relations between the predictors and outcome are estimated separately for the multiple groups. Specifically, an unconstrained model was compared with a constrained model (in which the paths are constrained to be equal across groups). If the unconstrained model is a better fit to the data there is evidence of different relations between the predictor and outcome across groups. We used the χ^2 statistic as a fit index to evaluate the probability value associated with the differences. Path models were performed using AMOS 4.0, which is based on the variance-covariance matrix (AMOS 4.0, Arbuckle, 1999), we tested the fit of the structural models to the empirical data, using maximum likelihood estimations. We defined a model in which CESD 1, Self-criticism, Dependency, the Self-Criticism × Dependency interaction, and the Self-Criticism and Dependency quadratic and cubic effects served as the predictors and CES-D 2 as the criterion. We delineated all the intercorrelations among predictors and their effect on Time 2 depression. Results indicated significant group differences with a significantly better fit for the unconstrained model ($\Delta\chi^2 [N = 209, df = 6] = 18.02, p < .006$). We assumed that HRP, implying a significant increment of stress, would interact with personality vulnerabilities to depression, resulting in nonlinear threshold effects on outcomes. The obtained SEM results indicated that the unconstrained model is a better fit to the empirical data; thus, there is evidence of a moderational effect (interaction) for Stress condition in the association between personality vulnerability and depression with low stress conditions seeming to mitigate the effect of personality vulnerabilities effects on depression.

In sum: Linear personality vulnerability remains as the LRP Time 2 best depressive symptoms predictor. For the HRP sample (high stress), the nonlinear model fits the data significantly better than the linear one and these estimates are significantly different from those estimated for the LRP group (low stress).

⁷ To further test the possibility that nonlinear relationships are produced by skewed distributions of scores, we transformed Self-Criticism, Dependency and depression scores using Blom's (1958) transformation. Differences between the results of the analyses using the untransformed and transformed depression or personality variables were nonsignificant. In addition, we performed a test of the floor/ ceiling effects for the frequencies distributions of all the 66 items of the DEQ and 20 items of the CES-D. We did not find significant floor or ceiling effects.

Summary of Results

1) Gestational age, formal education, and mean scores of personality vulnerability factors were not significantly different in the two samples.

2) Controlling for age differences, a significant Time 2 depressive symptoms increment was found for the high stress group. In addition, among the high stress participants, Time 2 depressive symptoms were found to be significantly higher than among the low stress participants, indicating significant distress among highly stressed women.

3) Correlational analyses revealed that in the high stress sample, Self-Criticism and Dependency were significantly negatively associated. In addition, in both samples, a significant positive correlation was found between Self-Criticism and depressive symptoms, and a significant negative correlation was found between Dependency and depressive symptoms. Finally, the correlations between assessments of depressive symptoms indicated a significant moderately constant level of depressive symptoms during pregnancy and after birth in both samples.

4) Controlling for Time 1 depression scores among the high stress participants, Self-Criticism was found to associate positively and Dependency was associated negatively with Time 2 depressive symptoms, indicating a significant superiority for the linear over the quadratic or cubic models. In the HRP sample, the linear model was confirmed and a Self-Criticism \times Dependency interaction was revealed in which Dependency was found to moderate the effect of Self-Criticism on postpartum depression. However, a cubic curvilinear relation between Self-Criticism and Dependency and postpartum depression offered the best mathematical and empirical fit. Finally, results confirmed our assumption that stress conditions interact with personality vulnerabilities to depression, resulting in nonlinear threshold effects on outcomes, while low stress levels significantly mitigate these adverse effects.

Discussion

The current study represents a first attempt to examine simultaneously both linear and nonlinear models of Self-Criticism and Dependency as vulnerabilities to depression under high- and low-stress conditions. The HRP and LRP samples were not significantly different in their levels of both self-critical and Dependency vulnerabilities; differential outcomes can therefore be attributed to the different life experiences and associated stressors in mothers with or without a high-risk pregnancy.

Although the women in the groups did not differ in several personal attributes, it was found statistically that the HRP group was significantly older in chronological age. Also, education was associated with less postpartum depression in the LRP sample but greater postpartum depression in the HRP sample. The age difference is not entirely unexpected; demographic factors such as older age, ethnicity, and obesity are established predictors of GDM (see Casey, Lucas, McIntire, & Leveno, 1997; DiCianni et al., 2003; Lauszus, Paludan, & Klebe, 1999; Svare, Hansen, & Molsted-Pederson, 2001). These differences are important to recognize because variance attributable to these demographic factors should obviously be controlled statistically. However, to the extent that advanced age and obesity are recognized by the pregnant women themselves as factors that may have contributed to the GDM, this could serve to heighten their sense of personal responsibility and self-consciousness in a manner that might have contributed to the results of this investigation.

Clearly, our main findings add to the literature on differences between Dependency and Self-Criticism as vulnerability factors. The obtained linear model results support a view of childbirth as a normal transition that seems to affect primarily self-critical women preoccupied with issues of identity and self-esteem. The results of the present study are also congruent with those of Fedele et al. (1988)

who found that pregnancy and the postpartum period create significant distress among autonomous but not among affiliative women. Results regarding the Self-Criticism vulnerability might suggest that the demands and restrictions entailed by having a new baby are probably onerous to a woman who is high in Self-Criticism, and may even be overwhelming within the context of a medical problem.

Recently, Self-Criticism in women was found to be associated with insecure attachment that mediated its effect on depression (Besser & Priel, 2005b). Thus, it is important to note here that our results regarding the vulnerability of self-critical women to postpartum depression are also in line with complementary work demonstrating that insecure attachment styles are associated with vulnerability to onset of postnatal depression (eg., Bifulco et al., 2004), severity of depressive symptomatology (Simpson, Rholes, Campbell, Tran, & Wilson, 2003; West, Rose, Spreng, Verhoef, & Bergman, 1999), and with persistent and more severe depression symptoms at 12 months postpartum (McMahon, Barnett, Kowalenko, & Tennant, 2005).

As shown in previous longitudinal studies in the context of the transition to motherhood among LRP women (Besser & Priel, 2003a; Priel & Besser, 1999, 2000), Dependency does not seem to constitute a vulnerability to postpartum depression. Moreover, while controlling for depressive symptoms during pregnancy, we found that high Self-Criticism and low Dependency were both associated with postpartum depression (see Tables 3a). To some extent, at least, Dependency seems to protect well-being at childbirth. The capacity of highly dependent women (Priel & Besser, 2002) and women high in communion (Helgeson, 1994; Helgeson & Fritz, 1998) to enlist social support and to use more adaptive coping strategies (Besser & Priel, 2003a) may be the core of their relative resilience before and after childbirth. The possible role of coping and help-seeking should be explored further in subsequent research. Whereas new mothers with at least moderate levels of dependency may derive some benefits, highly self-critical women may not engage in help seeking because they do not want to reveal their imperfections and self-perceived inadequacies.

The current findings are noteworthy in that they qualify past research which led to the conclusion that the diagnosis and subsequent medical implications of GDM has little psychological impact beyond ephemeral increases in state anxiety (see Daniells et al., 2003; Spirito et al., 1989). The current data suggest that the experience and impact of GDM will have a differential impact depending on pre-existing personality vulnerability factors.

The findings of the present study concerning nonlinear personality vulnerability effects corroborate a transactional perspective on the relations between personality vulnerabilities and degree of situational stress (Lazarus, 1999): The absolute magnitudes of situational demands do not determine by themselves the experience of symptoms of stress, because there are significant individual differences in the stress experience, coping abilities, and vulnerabilities among people faced with the same demands, and in keeping with the accentuation principle, personality vulnerabilities may have a magnified impact among individuals making difficult life transitions. Our findings are in line with an approach that underscores continuous interactions and adjustments between the environment and the person as an active agent. The nonlinear model findings suggest that at moderate or intermediate levels, Self-Criticism vulnerability effects remain relatively constant while Dependency is transformed from a vulnerability into a resilience factor.

It seems conceivable that in stressful life contexts, very low and very high levels of Dependency inhibit the ability of dependent women to enlist and maintain social support and their effective use of adaptive coping strategies (Besser & Priel, 2003a). Low Dependency involves an unhealthy lack of connectedness and meaningful involvement with others, while high Dependency may result in unreasonably high demands for care and in extreme neediness that leads to interpersonal conflict and

increases dependent individuals' vulnerability. It seems that among high-risk pregnant women, moderate levels of Dependency are associated with the ability to efficiently use social support, which facilitates adaptive uncertainty management (Cohen, 1993).

For both LRP and HRP self-critical women, pregnancy and infant care entail compromises about autonomous functioning that may be especially difficult for self-critical women who define themselves in terms of competence. These participants may experience a sense of loss of identity and self-worth during pregnancy and childbirth because of their preoccupation with these issues (Ussher, 1992). It seems that the demands of high-risk conditions exaggerate these women's demonstrated vulnerability such that any increment in Self-Criticism results in rapid increment in depressive symptoms. Highly self-critical HRP women might experience their situation as reflecting a personal failure that activates negative self-evaluative biases, thus increasing distress and diminishing the effectiveness of any available environmental support. Intermediate levels of Self-Criticism in the HRP, on the other hand, were found to associate with relatively stable levels of depressive symptoms (see Figure 4). Hence, in the current study, Dependency appears as a vulnerability factor only when it is too low or too high; Self-Criticism seems always to be a problem, but it is particularly problematic when it is too high.

Results regarding the Self-Criticism vulnerability suggest that the demands and restrictions entailed by having a new baby are deleterious to a mother who is especially high in Self-Criticism, but may be particularly overwhelming within the context of a medical problem. Why did more moderate levels of Self-Criticism not lead to higher levels of depression in the women with GDM? Although admittedly speculative, possible explanations are provided by the literature on how depression is related to the self and cognition. Ruchman et al. (1985) surveyed available studies on schematic processes involving the self and suggested that nondepressed individuals have a positive self-evaluation bias, but mildly and moderately depressed individuals are characterized by both positive and negative tendencies, and severely depressed people have an entirely negative self-evaluation bias. Also, research on attributional complexity has found curvilinear effects such that mild depression is associated with complex attributions of blame to self and others, but severe depression involves an exclusive focus on self-blame (for a review, see Vredenburg, Flett, & Krames, 1993). Thus, perhaps the deleterious effects of self-criticism among women with GDM are mitigated somewhat at moderate levels of depression by the presence of positive self-thoughts

and a more mixed attributional style that includes factors outside the self. This mitigation does not occur at extreme levels of depression where self-criticism may take on a more extreme form akin to the abject self-hatred expressed by some depressed people. Whatever the case, the negative impact of excessive self-criticism is clearly illustrated.

Our results regarding the role of high situational stress in shaping the associations between personality vulnerabilities and depression go well together with the state-trait vulnerability model (Zuroff et al., 1999). It seems that high stress interferes in magnifying the 'accessibility' of dependent and self-critical vulnerabilities cognitive schemas thus high stress serves as a vulnerability "accelerator", resulting in nonlinear increased depression; Self-critical and dependent cognitive schemas associations with vulnerability to depression seems to be associated linearly with depression until interacted with higher stress. This interpretation is congruent with the assumption that dysfunctional cognitions associated with the personality vulnerability factors are present but under a *stressful life event* to be further or fully activated (Miranda et al., 1990). Thus based on the state-trait model our study indicates that the role of stress is in interacting with and accelerate the activation of vulnerability schemas.

In the present study, an unanticipated Self-Criticism \times Dependency interaction was also found, but only in the high-stress condition. Women with HRP reported greater depression if they were

characterized jointly by high Self-Criticism and low Dependency. It seems that Dependency operated as a resilience factor that buffered the effect of a harsh self-orientation, but only among the high-risk group. One possibility is that the GDM diagnosis is salient to significant others, and this increases their willingness to provide various forms of social support, especially among women who have expressed their dependency needs. Accordingly, future research in this area should include measures of social support.

In sum, the use of linear and nonlinear models allowed for the exploration of Dependency vulnerability when exceeding the optimal range, and pointed to the role of high stress in enhancing the importance of the balance between relatedness (Dependency) and self-definition (Self-Criticism) personality dimensions for the prevention of clinical depression. Our results also explain the different roles played by Dependency in the prediction of depression among HRP and LRP women. Under low-stress conditions, Dependency associates negatively with depressive symptoms after childbirth. Under high-stress conditions, too-low and too-high levels of Dependency constitute vulnerabilities to depression; on the other hand, optimal levels of Dependency prevent depression under high stress. In addition, Dependency moderates the negative effects of Self-Criticism under high-stress conditions. A major thrust of the present study's findings is that the association between personality and depression is much more complex than previously understood.

Limitations of the Current Study

The limitations of this study must be acknowledged. First, this study was based solely on self-report measures, which may lead to a confounding between personality and distress variables. Although the possibility of confounding was partially addressed by controlling for Time 1 distress and other shared variances using rather conservative regressions, further improvement could be achieved by including measurements of personality vulnerability also at Time 2. Another recommendation for future research might be to include a measure at Time 2 to assess frequency and strength of occurrences of specific thoughts and behaviors presumed to arise from the influence of the constructs of interest (e.g., "After the birth of our child I just couldn't do anything for myself," "After my baby was born it seems like I was berating myself about everything I did," etc). Also, the present study distinguished high- and low-risk pregnancies assuming higher levels of stress among HRP women. Since people differ greatly in how they evaluate stress, further research should take into account participants' subjective assessments and appraisals of stress and the availability of resources (Lazarus, 1999). Clearly, some of the women in the LRP group may have been experiencing life events that were quite stressful, and these individual differences in stress exposure and reactivity should be evaluated in future research. We have tested our model in the context of a particular type of stress (GDM). It would be of interest for further studies to examine thresholds for vulnerabilities to depression in other high risk pregnancy contexts – e.g. conception through IVF, history of prior pregnancy loss, socio-economically deprived circumstances etc. On a related note, in future research, it would be helpful with women with GDM to obtain assessments of glycemic control to both establish whether poorer control is linked with depression, and personality vulnerabilities, but also determine whether self-critical women are hypersensitive to evidence suggesting that they are not doing a good job in controlling their gestational diabetes. Finally, it would have been useful to obtain follow-up assessments to evaluate the persistence of the effects found in the current study. One study found that women with GDM had health concerns that were still detectable five years later in the form of chronic anxiety about the impact on their health and their child's health (Feig, Chen, & Naylor, 1998); perhaps women with personality vulnerabilities would be less resilient and would continue to experience distress.

The findings of the current study underscore the level of complexity that should be considered and represented in models of personality vulnerability in natural contexts. The results suggest that vulnerability traits are not the endpoint in a linear progression from non-vulnerability to vulnerability (Maher, 2002) but seem to have thresholds that determine the strength and even the direction of these traits effects. Moreover, diverse vulnerability traits seem to have different patterns of nonlinear relations with external factors. Finally, a general area for future personality research is to expand investigations to include theoretically derived nonlinear effects. Though finding a linear relationship does not prohibit more complex relationships (Ganzach, 1998; MacCallum & Mar, 1995; Monroe & Simons, 1991), few personality research efforts predict or test for nonlinear effects, and this is an issue that warrants additional investigation. Given the results found in the current study, it seems likely that the quality of personality trait vulnerabilities to depression relationship under high stress situations may exhibit nonlinear relationships with other individual outcome variables including interpersonal relationships, psychological adjustment, and interpersonal behaviors. The addition of nonlinear analytic strategies to the study of person-environment transactions seems an appropriate approach to the complexity of the investigation of personality traits within naturally occurring phenomena.

Author Note

We are very grateful to the Public Health Nursing Staff of the Israel Ministry of Health, Southern District, for their cooperation in making this study possible. We thank Dr. Jeremy Miles of University of York, UK, for his constructive suggestions. We also thank Dr. Vicki Helgeson for her constructive suggestions. Gordon Flett was supported by a Canada Research Chair in Personality and Health.

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