AMERICAN PSYCHOLOGICAL ASSOCIATION

Emotion

ISSN: 1528-3542

2024, Vol. 24, No. 5, 1249–1258
https://doi.org/10.1037/emo0001333

Too Little, Too Much, and "Just Right": Exploring the "Goldilocks Zone" of Daily Stress Reactivity

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Hormetic models of stress resilience describe nonlinear relations for exposure to adversity and health outcomes, where exposure induces salutary changes up to a threshold, with changes becoming deleterious afterward. Here we apply a hormetic model of stress to reactivity to daily stressors, examining whether mental and physical health benefits arise from low-to-moderate reactivity but then decrease at higher levels. Data are from the second wave of the National Study of Daily Experiences (NSDE). Adults ($N = 2{,}022$; $M_{\text{age}} = 58.61$, $SD = 12.12$, age range: 35–86; 57% female) completed telephone interviews detailing their stressors and affect on eight consecutive evenings. A series of multilevel structural equation models estimated within-person associations between daily stressors and negative affect (i.e., stress reactivity), and between-person linear and quadratic effects of stress reactivity on mental and physical health outcomes (i.e., life satisfaction, psychological distress, and number of chronic conditions). Findings reveal a significant quadratic effect for each outcome, indicating a U-shaped pattern (inverse U for positively valenced life satisfaction), such that low and high levels of stress reactivity were associated with poorer health and well-being, whereas moderate levels of daily stress reactivity predicted better health outcomes. These findings suggest that individuals who display either very low- or very high-stress reactivity may benefit from interventions that target their emotion regulation skills and coping resources.

Keywords: stress reactivity, curvilinear, multilevel structural equation modeling, well-being

Supplemental materials: https://doi.org/10.1037/emo0001333.supp

Models of resilience often emphasize that learning how to adapt to smaller doses of stress may be helpful in the long term. In particular, models of toughening (e.g., Dienstbier, 1989; Meichenbaum, 1993), steeling (e.g., Rutter, 2006), stress inoculation (e.g., Parker et al., 2006), and hormesis (e.g., Calabrese, 2008; Epel, 2020) suggest that exposure to moderate levels of adversity, as opposed to none or high levels, can contribute to the capacity for resilience. Furthermore, there is evidence that some lifetime adversity (as opposed to none) fosters effective coping (Seery et al., 2010), bolstering arguments that focusing only on linear relations can obscure important nuances in the dose–response strengthening effects of stressor exposure (Oshri, 2023). The current study tests whether this reasoning extends not only to stress exposure but also to stress reactivity. A growing literature suggests that individuals who react more strongly to daily stressors may be more vulnerable to a variety of adverse health outcomes (Charles et al., 2013; Chiang et al., 2018; Greaney et al., 2020; Rush et al., 2019; Sin et al., 2015). To date, research in this area has focused on linear

This article was published Online First February 8, 2024.
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This study was not preregistered.This research was supported by the National Institutes of Health (Awards P01 AG020166 and U19 AG051426). The authors have no conflicts of interest to disclose. The data are publicly available at the following website: https://www.icpsr.umich.edu/web/ICPSR/series/203. In addition, a MIDUS-Colectica Portal (https://midus.colectica.org) contains rich searchable metadata, links to documentation, and the ability to download customized data sets. The analytic codes specific to the current study are available upon emailed request to the corresponding author.

Jonathan Rush served as lead for data curation, formal analysis, methodology, and visualization. Anthony D. Ong served in a supporting role for data curation, formal analysis, and methodology. Jennifer R. Piazza served in a supporting role for conceptualization and methodology. Susan T. Charles served in a supporting role for conceptualization and methodology. David M. Almeida served as lead for funding acquisition and supervision and served in a supporting role for conceptualization, methodology, and writing–original draft. Jonathan Rush and Anthony D. Ong contributed equally to conceptualization. Jonathan Rush, Anthony D. Ong, Jennifer R. Piazza, Susan T. Charles, and David M. Almeida contributed equally to writing–review and editing. Jonathan Rush, Anthony D. Ong, Jennifer R. Piazza, and Susan T. Charles contributed equally to writing–original draft.

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associations between stress reactivity and health, implying that lower levels of stress reactivity are more beneficial than moderate or higher levels of reactivity. Taking a more nuanced approach, the present study applies hormetic models to daily stressor reactivity, testing the hypothesis that relative to high or low reactivity, moderate affective reactivity to daily stressors is associated with better mental and physical health outcomes.

Hormetic perspectives on stress maintain that mild levels of adversity induce improved psychological and physical functioning, compared to the experience of no adversity or severe adversity (Dienstbier, 1989; Meichenbaum, 1993). Hormetic effects have been studied most often in the context of exposure to major events, revealing that people who experienced either high levels of lifetime adversity or none at all (defined by life experiences such as illness or injury, parental divorce or death, or stressful living conditions) had higher levels of distress, functional impairment and lower life satisfaction than people who had experienced some or a moderate amount of lifetime adversity (Seery et al., 2010). In addition, this U-shaped pattern also extended to daily stressors; when exposed to a cold-pressor laboratory stressor inducing pain, participants who reported some lifetime adversity reported less negative affect (NA) and catastrophizing compared to either none or many lifetime adversities (Seery & Quinton, 2016).

Similarly, stress inoculation is a concept that has been extensively studied in animal models, especially in rodents and primates. These studies have shown that exposure to mild or moderate stressors early in life can induce neurobiological and behavioral adaptations that enhance resistance to subsequent stressors (Lyons & Parker, 2007; Meaney et al., 1996; Parker et al., 2004). For example, rats that were handled or separated from their mothers for brief periods during the first 2 weeks of life showed lower levels of glucocorticoids, higher levels of hippocampal neurogenesis, and better performance on cognitive and emotional tasks than rats that were not exposed to such stressors (Liu et al., 1997; Meaney, 2001). Similarly, squirrel monkeys exposed to repeated social separations during infancy displayed lower levels of anxiety, exploration, and greater social dominance than monkeys not exposed to such stressors (Lyons et al., 2009; Parker et al., 2005, 2006). These animal studies suggest that stress inoculation may involve physiological and psychological mechanisms that confer resilience to future stressors.

Exposure to some lifetime adversity (as opposed to none or too much) predicts better mental health and responses to daily stressors. Experiencing mild levels of life adversities may also confer some benefits for psychological well-being, such as enhancing resilience, self-efficacy, and personal growth (Seery et al., 2010). These benefits may depend on how individuals react emotionally to daily stressors rather than how many stressors they encounter. Yet, the reaction to daily stressors themselves may also not be as linear as we have assumed. Bolger and Zuckerman (1995) define stress reactivity as an individual's unique or within-person relationship between stressful events and mood. Leading models of stress and health posit that heightened stress reactivity plays a prominent role in the development of psychiatric disorders and disease risk (Epel et al., 2018). On days stressors occur, a highly reactive individual experiences high levels of NA relative to days when stressors do not occur (i.e., they would have a strong positive within-person relationship between daily stress and NA). Existing work supports the idea that greater stress reactivity is a unique vulnerability factor for subsequent depressive symptoms (Parrish et al., 2011), mental health problems (Charles et al., 2013), chronic health conditions (Piazza et al., 2013), marital risk (Ong et al., 2020), allostatic load (Piazza et al., 2019), and even mortality (Chiang et al., 2018; Mroczek et al., 2015; Stanton et al., 2019).

The above research highlights the risk of greater reactivity to daily stressors, modeling the effects of successively greater levels of reactivity. These models illustrate the deleterious effect of high levels of reactivity but did not examine a nonlinear effect consistent with hormetic models of stress. Applying this to daily stressors, someone who was nonreactive or minimally reactive to daily stressors would experience similar levels of NA across days regardless of whether a stressor occurred or not (i.e., their within-person relationship between daily stress and NA would be close to 0). Low-stress reactivity may reflect a coping strategy involving disengaging from or minimizing the impact of stressors, which may be adaptive in the short term but maladaptive in the long term (Carver et al., 1989). Alternatively, low-stress reactivity may indicate a blunted physiological response to stressors, which may result from chronic exposure to high levels of stress or trauma (Miller et al., 2007). Blunted stress reactivity may impair the ability to mount an appropriate emotional and behavioral response to stressors and increase the risk of developing physical and mental health problems (McEwen, 2003).

This question has been examined in health psychology, where physiological responses to acute stressors provide support for nonlinear effects of stress reactivity. For example, the Dutch Famine Birth Cohort study found that increased cardiac activity to a laboratory social stressor was related to increased hypertension 5 years later (de Rooij, 2013). However, blunted cardiovascular and cortisol reactivity were also related to poorer physical and mental health 5 years later, including increased risk of depressive and anxiety symptoms, and poor lung function and cognition. Several studies have replicated this pattern, showing that both exaggerated and blunted cardiac and cortisol reactivity are related to poorer mental and physical health (Carroll et al., 2017).

Based on hormetic models of stress resilience (Epel, 2020; Oshri, 2023), we hypothesized that moderate levels of stress reactivity would be linked to more adaptive outcomes, as evidenced by U-shaped relationships between daily stress reactivity and mental and physical health. To date, most research has examined this pattern in physical responses to stressors (e.g., cardiac or cortisol reactivity) and not in affective. In addition, these prior studies examining the linear effects of stress reactivity on health outcomes have relied on a two-step analytic approach, where individual stress reactivity slopes are first estimated and exported, then included as an individual difference predictor in subsequent analyses. Using simulated data on daily stress reactivity and change in affective distress, Brose et al. (2022) demonstrated that a one-step multilevel structural equation modeling (MSEM) approach yield estimates closer to the true parameter estimates compared to a two-step approach. Importantly, daily stress reactivity and its effects on outcomes can be modeled simultaneously (cf. Rush et al., 2019; Verbeke & Davidian, 2009). Accordingly, we sought to extend research in this area by modeling random slopes and the quadratic effect of stress reactivity on mental and physical health outcomes simultaneously within a MSEM framework. Nonlinear effects were further examined using a "two-lines" approach detailed by Simonsohn (2018) to confirm the presence of a quadratic, U-shaped, association between stress reactivity and mental and physical health.

Method

Participants and Procedure

Participants were from the National Study of Daily Experiences (NSDE), a subproject of the larger publicly available Midlife in the United States (MIDUS) project (https://www.icpsr.umich.edu/web/ICPSR/series/203). A sample of 2,022 adults ($M_{\text{age}} = 58.61$, $SD = 12.12$, age range: 35–86; 57% female) responded to end-of-day telephone interviews for eight consecutive days that assessed daily experiences of stress and NA (for a detailed description of data collection, see Almeida, 2005; Almeida et al., 2009). In addition, all NSDE participants completed self-report measures of global health and well-being as part of the larger MIDUS Survey project. Daily diary data were collected on a total of 14,871 out of 16,176 possible days (completion rate = 92%). Four participants were excluded from the analysis due to missing data on study covariates, resulting in an analytic sample size of 2,018. Monte Carlo simulations confirmed that a sample size of 2,000 was sufficiently powered to detect a quadratic effect of stress reactivity on physical and mental health using an MSEM framework. Data collection procedures were approved by the Institutional Review Board of the Pennsylvania State University (PRAMS00042558).

Measures

Daily NA

Each evening of the NSDE, participants were asked to indicate how frequently they felt each of the following emotions in the past 24 hr: *fidgety*, *nervous*, *worthless*, *so sad that nothing could cheer you up*, *everything was an effort*, and *hopeless*; Mroczek & Kolarz, 1998). Responses ranged from 0 (*none of the time*) to 4 (*all of the time*). Daily NA scores were computed by averaging across the items ($M = 0.19$, $SD = 0.36$; $Mdn = 0.10$; mode = 0). Multilevel omega was used to estimate within- and between-person reliability ($\omega = .58$ and .82, respectively; see Geldhof et al., 2014).

Daily Stressors

Daily stressors were assessed using the Daily Inventory of Stressful Events (DISE; Almeida et al., 2002). The inventory consisted of six questions inquiring whether certain types of stressors had been experienced in the last 24 hr (i.e., *arguments*, *avoided arguments*, *work overloads*, *home overloads*, *network stressors*, *other*). A dichotomous variable was used to characterize days as either stress days (1 = *at least one stressor was reported*) or non-stress days (0 = *no stressor reported*). A daily stressor was reported on 40% of days (median response = 38% of days; modal responses = 25% of days).

Life Satisfaction

In the larger MIDUS survey, participants rated their satisfaction across four life domains (work, health, family, and overall) on a scale from 0 (*worst possible*) to 10 (*best possible*). The scores for each item were averaged to create an overall mean score ($M = 7.51$, $SD = 1.28$, $Mdn = 7.80$; mode = 8.00; $\alpha = .65$; Prenda & Lachman, 2001).

Psychological Distress

In the larger MIDUS survey, general psychological distress was captured by the Nonspecific Psychological Distress scale (Kessler et al., 2002). Participants reported on a 5-point scale (1 = *none of the time*; 5 = *all of the time*) how frequently over the previous 30 days they experienced each of four emotions (worthless, hopeless, nervous, restless, or fidgety) and two emotional states (felt everything was an effort; and felt so sad that nothing could cheer them up); $M = 1.49$, $SD = 0.55$, $\alpha = .85$; $Mdn = 1.33$; mode = 1.00.

Chronic Conditions

Participants reported their chronic health conditions from the past 12 months using a checklist of 30 possible health conditions (e.g., asthma, diabetes, hypertension, arthritis) in the MIDUS survey. We omitted "anxiety, depression, or some other emotional disorder" and "alcohol or drug problems" from analyses to avoid confounding psychological distress with physical health problems, and to focus on chronic conditions that are more likely to be influenced by physiological stress responses. Following previous research, the remaining 28 chronic conditions were grouped into 16 categories (Leger et al., 2018; Piazza et al., 2013), and the number of chronic condition categories reported was totaled ($M = 2.21$, $SD = 1.90$; $Mdn = 2.00$; mode = 1.00).

Covariates

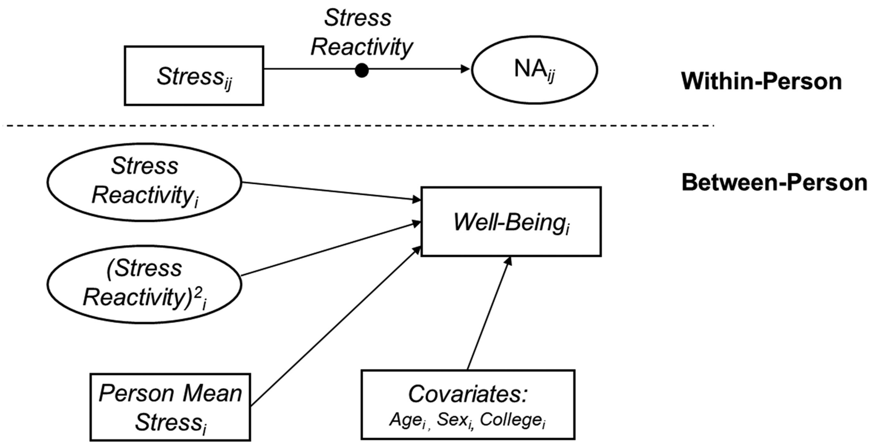
Participant age, sex, and education were included as covariates to adjust for sample heterogeneity. We included age, sex, and education as covariates in our models, as these are commonly used demographic variables that may influence health and well-being outcomes. For example, previous studies have found that older adults tend to report higher levels of life satisfaction and lower levels of psychological distress than younger adults (Diener et al., 2018), that women tend to report higher levels of NA and psychological distress than men (Matud, 2004), and that higher levels of education are associated with higher levels of life satisfaction and lower levels of chronic conditions (Ross & Wu, 1995). Age was centered at the grand mean in all statistical models, sex was coded with males as the reference category, and education was coded as a dichotomous variable (0 = *high school or less*; 1 = *some college or more*).

Analytic Strategy

MSEM analyses were used to simultaneously model the within-person association of daily stress and NA (i.e., stress reactivity), and between-person linear and quadratic effects of stress reactivity on health and well-being. These models handle the hierarchical structure of the data and permit interactions among random slope coefficients to be modeled as exogenous predictor variables. Daily measurement occasions were nested within individuals, resulting in two levels of analysis. Model specification is depicted in Figure 1.

At the within-person level, stress_{ij} for individual i on day j was included as a predictor of daily levels of NA_{ij}. The daily within-person association between stress exposure and NA (i.e., stress reactivity) was modeled as a random slope, capturing individual differences in the magnitude of affective reactivity to daily stressors (depicted in

Figure 1
Multilevel Structural Equation Model



Note. Daily assessments are nested within people. Ovals indicate variables were estimated within the model. Black dot indicates that pathway was modeled as a random slope. NA = negative affect; stress = stress day.

Figure 1 by the solid black dot). At the between-person level of analysis, the random stress reactivity$_i$ slope was modeled as a latent endogenous variable that varies across individuals. Additionally, the latent stress reactivity slope was permitted to interact with itself to estimate a latent quadratic variable (i.e., stress reactivity$_i^2$). Both stress reactivity$_i$ and stress reactivity$_i^2$ were included as predictors of the health and well-being outcomes to provide individual difference estimates of the linear and quadratic effects of stress reactivity on life satisfaction, psychological distress, and chronic health conditions, respectively. A set of observed covariates were included to adjust for the effects of age (grand-mean centered), sex, education, and person-mean stress (i.e., the proportion of stress days where at least one stressor was reported). All effects were estimated simultaneously in Mplus Version 8.7 (Muthén & Muthén, 2021), using full information maximum likelihood.

MSEMs that revealed a significant quadratic effect of stress reactivity (stress reactivity$_i^2$) were further examined using the "two-lines" approach to support the presence of the U-shaped effect (Simonsohn, 2018). Upon confirming the U-shaped effect, we applied the Johnson–Neymen (J–N) technique to identify the regions where the linear effect of stress reactivity was significantly related to well-being (Johnson & Neyman, 1936; Rast et al., 2014). This permitted the identification of an optimal zone of stress reactivity: within this zone, stress reactivity was predictive of optimal health and well-being.

Transparency and Openness

Data and documentation for all MIDUS projects are available to other researchers at the Inter-university Consortium for Political and Social Research (ICPSR: https://www.icpsr.umich.edu/web/ICPSR/series/203). In addition to the publicly available data at ICPSR, a MIDUS-Colectica Portal (https://midus.colectica.org) contains rich searchable metadata, links to helpful documentation, and the ability to download customized data sets. Analytic methods specific to the current study are available on request from the corresponding author. This study was not preregistered.

Results

Each of the health and well-being outcomes was examined in separate models. Table 1 presents the findings from the full MSEMs for each outcome (life satisfaction, psychological distress, chronic health conditions).[1] The within-person stress reactivity fixed effect was statistically significant across models, indicating that their NA was higher on days when individuals reported a stressor than on days when they did not report a stressor. Importantly, the random effect of the stress reactivity slope was also statistically different from zero, suggesting individual differences in how reactive people were to daily stressors. Figure 2 displays the distribution of estimated individual stress reactivity values across the sample. Even though most individuals showed some affective reactivity to daily stressors ($M = 0.14$), there was still considerable range in stress reactivity, with many individuals displaying little to no affective reactivity to daily stressors.

Life Satisfaction and Reactivity

Examining the quadratic effect of stress reactivity on each health and well-being outcome revealed significant nonlinear associations across all the models. Figure 3 displays the inverted U-shaped association between daily stress reactivity and life satisfaction. Individuals who were highly reactive to daily stressors (stress reactivity $> .135$) demonstrated a significant inverse association with life satisfaction, such that those with greater reactivity exhibited lower life satisfaction. Conversely, individuals who were minimally reactive to daily stressors (stress reactivity $< .07$) reported lower life satisfaction. Results from the J–N technique revealed an optimal zone of stress reactivity ranging from 0.07

[1] To account for the zero-inflated distribution of the NA data, we also estimated zero-inflated negative binomial models predicting each outcome (see Table S1 in the online supplemental materials). The results remained consistent with a significant quadratic effect of stress reactivity predicting life satisfaction, psychological distress, and chronic health conditions.

Table 1
Multilevel SEM Analyses of the Quadratic Effects of Daily Stress Reactivity on Health and Well-Being Outcomes

Variable	Life satisfaction		Psychological distress		Chronic conditions	
	Estimate (*SE*)	95% CI	Estimate (*SE*)	95% CI	Estimate (*SE*)	95% CI
Fixed effects						
Within-person variables						
NA intercept	0.134 (0.006)**	[0.122, 0.145]	0.154 (0.005)**	[0.143, 0.164]	0.139 (0.006)**	[0.127, 0.150]
Stress reactivity	0.139 (0.006)**	[0.127, 0.151]	0.135 (0.006)**	[0.124, 0.147]	0.135 (0.006)**	[0.123, 0.148]
Between-person variables predicting outcome						
Age	0.017 (0.002)**	[0.013, 0.021]	−0.001 (0.001)*	[−0.003, 0.000]	0.042 (0.003)**	[0.036, 0.049]
Female	0.059 (0.049)	[−0.038, 0.156]	0.023 (0.015)	[−0.007, 0.053]	0.414 (0.076)**	[0.266, 0.562]
College	0.284 (0.055)**	[0.176, 0.393]	−0.056 (0.017)**	[−0.090, −0.022]	−0.179 (0.084)*	[−0.343, 0.015]
Person-mean stress	−0.615 (0.098)**	[−0.808, −0.423]	0.226 (0.031)**	[0.166, 0.286]	0.684 (0.148)**	[0.393, 0.975]
Stress reactivity linear	4.418 (1.224)**	[2.020, 6.817]	−2.243 (0.167)**	[−2.571, −1.916]	−6.649 (0.423)**	[−7.477, −5.820]
Stress reactivity quadratic	−20.225 (3.246)**	[−26.59, −13.86]	11.488 (0.359)**	[10.78, 12.19]	20.813 (0.161)**	[20.50, 21.13]
Random effects						
Within-person NA	0.057 (0.001)	[0.056, 0.059]	0.062 (0.001)	[0.060, 0.064]	0.057 (0.001)	[0.055, 0.058]
Between-person						
NA intercept	0.058 (0.002)	[0.054, 0.063]	0.046 (0.002)	[0.043, 0.050]	0.056 (0.002)	[0.052, 0.060]
Stress reactivity	0.026 (0.002)	[0.021, 0.030]	0.030 (0.001)	[0.028, 0.033]	0.033 (0.002)	[0.029, 0.036]
Outcome residual variance	0.849 (0.078)	[0.695, 1.002]	0.050 (0.003)	[0.044, 0.056]	2.135 (0.114)	[1.912, 2.358]

Note. Results are based on 14,869 daily assessments ($N = 2{,}018$). Female (*male* = 0; *female* = 1). College (*high school or less* = 0; *some college or more* = 1). Person-mean stress = proportion of stress days. Estimates of fixed effects are reported as unstandardized regression coefficients. Estimates of random effects are reported as variances. SEM = structural equation modeling; CI = confidence interval; NA = negative affect.
* $p < .05$. ** $p < .001$.

to 0.13, with individuals in this moderate zone exhibiting the highest levels of life satisfaction.

To further confirm that an inverted U-shaped association accurately represented the data, we conducted follow-up analyses using the "two-lines" approach proposed by Simonsohn (2018). By demonstrating a significant direct linear association prior to the apex of the curve ($B = 5.29$, $p < .001$) and a significant inverse linear association after the apex ($B = -3.31$, $p < .001$) through a linear spline model, we can conclude that the quadratic U-shaped association was not due to misspecification (see Figure S1 in the online supplemental materials).

Psychological Distress and Reactivity

A nonlinear U-shaped effect best represented the associations between stress reactivity and psychological distress. Once again, the two-lines approach supported the presence of a U-shaped effect by establishing a significant inverse linear association prior to the apex of the curve ($B = -4.25$, $p < .001$) and a significant direct linear association following the apex ($B = 2.36$, $p < .001$; Figure S2 in the online supplemental materials). MSEM estimates were further probed using the J–N technique, indicating that individuals who were moderately reactive to daily stressors (stress reactivity between 0.08 and 0.11) reported the lowest psychological distress, whereas individuals who were either minimally reactive (stress reactivity $< .08$) or highly reactive (stress reactivity $> .11$) to daily stressors had higher levels of psychological distress (see Figure 4).

Chronic Health Conditions and Reactivity

Similarly, individuals who were either highly reactive or minimally reactive to daily stressors reported more chronic conditions, whereas those who were moderately reactive to daily stressors reported the fewest chronic health conditions. The two-lines approach also supported the U-shaped effect of stress reactivity predicting chronic conditions ($B_{prior} = -7.92$, $p < .001$; $B_{post} = 3.36$, $p < .001$). Figure 5 displays the U-shaped association and the optimal region of stress reactivity based on the J–N technique (i.e., between .13 and .18).

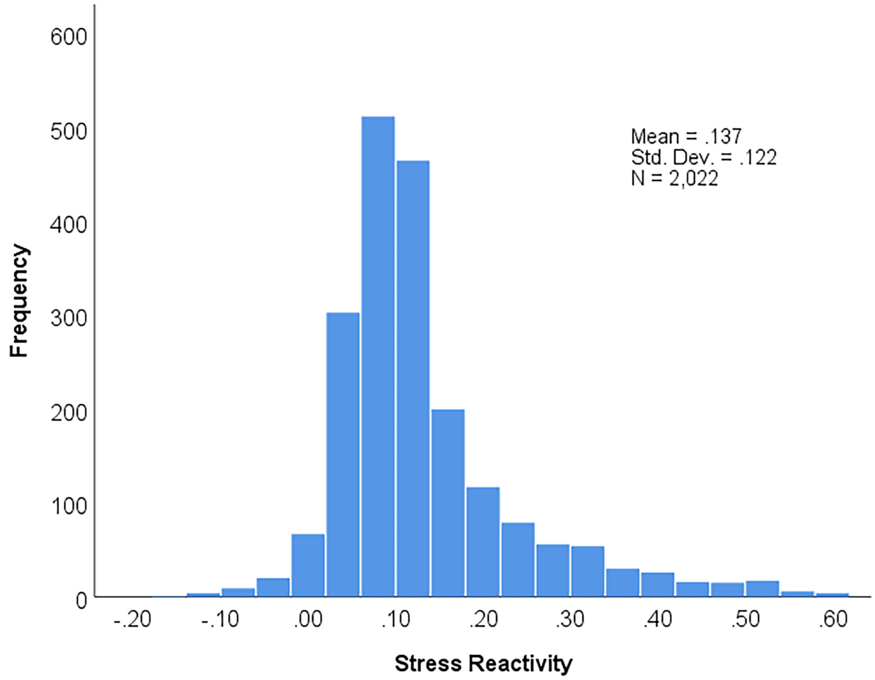
A significant linear effect of stress reactivity was also predictive of each health and well-being outcome (see Table 1). However, with the quadratic effect included in the model, the linear estimates are interpreted as the linear slope conditioned when stress reactivity is equal to zero. Thus, at low levels of stress reactivity, a significant direct association was observed with life satisfaction, and a significant inverse association was observed with psychological distress and chronic conditions. These estimates are consistent with what is displayed in Figures 3–5, where the magnitude of the linear association (i.e., the tangent to the curve) is when stress reactivity equals zero.

The covariates age and education significantly accounted for individual differences in each outcome, such that older adults reported higher levels of life satisfaction, lower psychological distress, and more chronic conditions than younger adults. Individuals with a college education reported higher life satisfaction, lower psychological distress, and fewer chronic conditions than those without a college education. Sex did not account for individual differences in life satisfaction or psychological distress; however, females did report more chronic conditions than males. Including the covariates age, sex, and education significantly improved model fit compared to models that omitted them, $\Delta\chi^2(3) = 192.54$; 26.72; 301.91, *p*s $< .001$, for life satisfaction, psychological distress, and chronic conditions models, respectively.

Discussion

The present study examined the potential hormetic, or strengthening, effects of daily stress reactivity. Results revealed hypothesized curvilinear relationships: Relative to low or high reactivity, moderate levels of daily stress reactivity were associated with lower psychological distress,

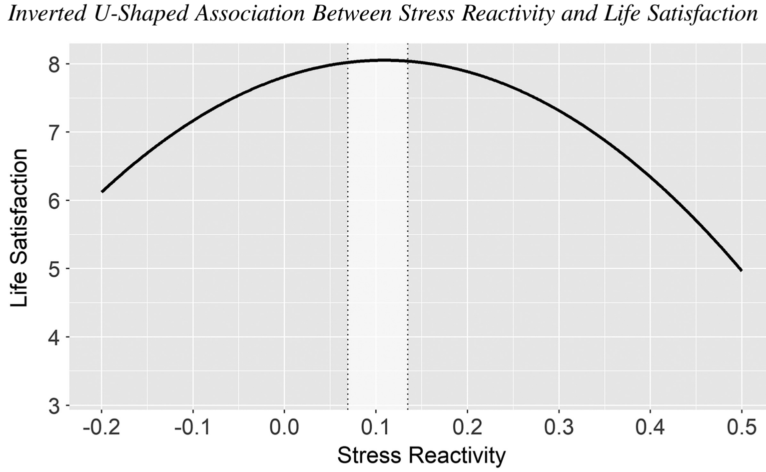
Figure 2
Distribution of Stress Reactivity



Note. Stress reactivity values are estimated from multilevel model reflecting the within-person difference in negative affect on stress days versus nonstress days. See the online article for the color version of this figure.

fewer chronic conditions, and higher levels of life satisfaction. These findings extend previous work in two important ways. First, they provide support for the view that resilient adaptation to psychological stressors is not limited to major life adversities (Seery et al., 2010), but also generalizes to minor daily stressors (Ong & Leger, 2022). Second, they provide a critical qualification to the typically observed linear relationships between daily stress reactivity and well-being identified in prior work (Charles et al., 2013; Chiang et al., 2018; Sin et al., 2015). Evidence from the current study demonstrates that the effects of daily stress reactivity on well-being take a U-shaped curve, with well-being reaching its nadir at low and high levels of reactivity.

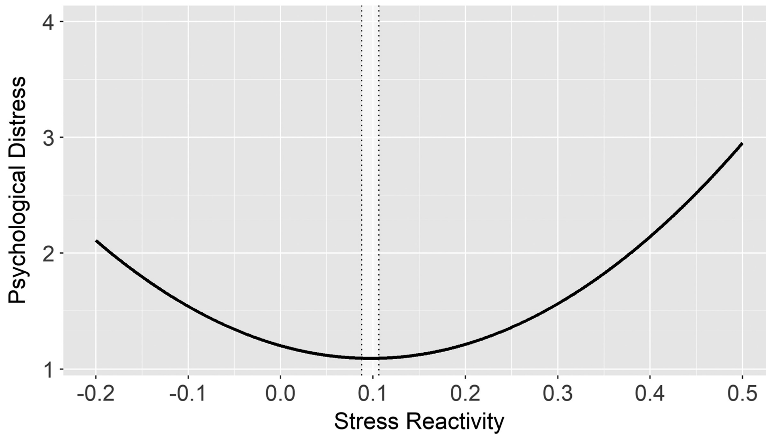
Figure 3
Inverted U-Shaped Association Between Stress Reactivity and Life Satisfaction



Note. Vertical hatched lines are the boundaries of the optimal zone of stress reactivity predicting highest levels of life satisfaction: 0.07–0.14. Stress reactivity values below and above this zone are significantly related to lower life satisfaction.

Figure 4

U-Shaped Association Between Stress Reactivity and Psychological Distress



Note. Vertical hatched lines are the boundaries of the optimal zone of stress reactivity predicting lowest levels of psychological distress: 0.08–0.11. Stress reactivity values below and above this zone are significantly related to greater psychological distress.

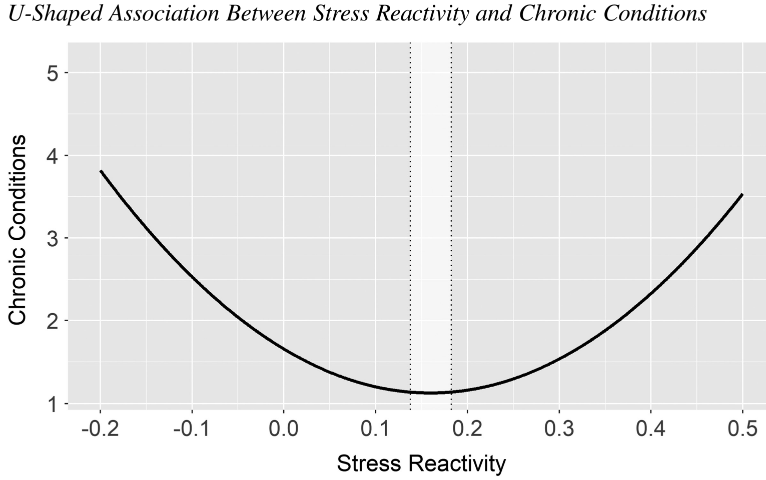
The Optimal Level of Stress Reactivity

By examining the quadratic effects of stress reactivity on well-being, the current research permits further insight into whether an optimal region of stress reactivity exists. While the results do not permit a precise cutoff for the amount of stress reactivity that is deemed optimal, it does provide support that some moderate amount of reactivity, relative to little to no reactivity or high levels of reactivity, is more beneficial.

The finding that moderate reactivity is more adaptive than high levels of reactivity is consistent with previous literature indicating that high levels of stress reactivity are associated with poorer mental and physical health outcomes (e.g., Chiang et al., 2018; Sin et al., 2015). However, why might moderate stress reactivity levels contribute to better psychological and physical health outcomes than lower levels? One possibility is that moderate reactivity facilitates effective coping by fostering greater perceptions of control and mastery in the face of everyday stressors (Seery & Quinton, 2016). Moderate stress reactivity may reflect an optimal balance between emotional sensitivity and regulation, allowing individuals to respond appropriately to stressors without becoming overwhelmed or detached (Gross & Thompson, 2007; Lazarus & Folkman, 1984). Moreover, moderate stress reactivity may indicate a history of mild adversity experiences that have inoculated individuals against future stressors, enhancing their coping skills and resources (Rutter, 1985; Seery et al., 2010). Another possibility is that low reactivity could indicate a lack of engagement with important aspects of life. Engagement with life is an important

Figure 5

U-Shaped Association Between Stress Reactivity and Chronic Conditions



Note. Vertical hatched lines are the boundaries of the optimal zone of stress reactivity predicting fewest chronic conditions: 0.13–0.18. Stress reactivity values below and above this zone are significantly related to more chronic conditions.

predictor of life satisfaction (Peterson et al., 2005) and health outcomes (Horowitz & Vanner, 2010). However, engagement of any type, particularly social, comes with an inherent risk of experiencing a stressor (Charles et al., 2021). Low reactivity may, therefore, be a proxy for limited engagement with life activities, which may be harmful to one's health and well-being.

Moderate levels of daily stress reactivity may also catalyze adaptive biological processes, such as cardiac vagal tone, that are critical to well-being (Kogan et al., 2013; Kok & Fredrickson, 2010). In fact, lack of exposure to stressors may limit the body's ability to engage in "cellular housecleaning" (Epel, 2020). Further research is warranted to determine whether psychobiological mechanisms underlie the nonlinear associations between daily stress reactivity and health and well-being.

Limitations and Future Directions

The present study has several limitations. Although it used a large national probability sample, the analyses were cross-sectional, so causal conclusions cannot be drawn. The data were collected in the context of a larger study of social, psychological, economic, and medical aspects of aging, and there was no opportunity to extend the assessments. Additional ratings of daily stressors and affect may give more reliable estimates of daily stress reactivity and capture more ecologically valid associations with health and well-being. Furthermore, ethnic and racial diversity in the MIDUS was limited, with the majority of the sample being from European American backgrounds.

Another potential limitation of this study is that all of the measures were based on self-report, which may introduce method variance and bias. Future research could use more objective measures of stress exposure and reactivity, such as physiological indicators. Similarly, future research could examine the different types of chronic conditions separately or use objective measures of physical health to provide a more nuanced investigation of the nonlinear influence of stress reactivity. The outcomes of life satisfaction, psychological distress, and chronic conditions were selected based on substantial prior empirical and theoretical work linking stress processes to mental health and well-being (Diener et al., 2018; Kessler et al., 2002), in addition to physical health outcomes (Leger et al., 2018; Piazza et al., 2013). We focused specifically on these indicators given the established associations between stress processes and both positive and negative aspects of mental health and physical well-being. For example, previous research has documented linear effects of daily stress reactivity on depressive symptoms and anxiety (Charles et al., 2013), life satisfaction (Mroczek & Almeida, 2004), and chronic conditions (Piazza et al., 2013). Based on this prior evidence, we had an a priori rationale and expectation that if daily stress reactivity showed nonlinear associations with well-being, such patterns would likely emerge across multiple aspects of mental health, life evaluation, and physical functioning. An important direction for subsequent work is to examine whether the observed nonlinear effects replicate across additional objective indicators of health and functioning beyond those studied here, such as cognitive performance or mortality. Our aim was to provide empirical support that accounting for nonlinear relations can reveal more nuanced patterns between daily stress processes and well-being. Additional research building on these findings is needed to establish boundary conditions and enhance generalization.

This study focused on individual (actor) effects of daily stress reactivity on health outcomes. Differentiating between actor (or intrapersonal) effects and partner (or interpersonal) effects using dyadic designs can elucidate how stress reactivity can spread beyond one partner to influence the health of the other (Ong et al., 2022). Finally, optimal levels of reactivity are likely to vary, not just across individuals, but also across cultures. It will be important in future research to identify systematic cultural variations in beneficial (hormetic) effects of stress reactivity.

Conclusion

Although psychological research has demonstrated that heightened reactivity to stressors may increase the risk for morbidity and mortality, evidence from the current research suggests that reactivity may be most adaptive in moderation. In particular, moderate levels of stress reactivity—relative to low or high reactivity—may reflect a Goldilocks zone or optimal degree of adaptive response to stressors. Our findings have important implications for understanding how individuals cope with daily stressors and how stress reactivity affects their well-being outcomes. Individuals who display very low- or very high-stress reactivity may benefit from interventions targeting their emotion regulation skills and coping resources. For example, individuals with low-stress reactivity may benefit from interventions that enhance their emotional awareness and expression, such as mindfulness-based therapies or expressive writing (Baikie & Wilhelm, 2005; Frattaroli et al., 2011; Gross & Thompson, 2007; Kabat-Zinn et al., 1992). Individuals with high-stress reactivity may benefit from interventions that reduce their emotional arousal and distress, such as cognitive-behavioral therapy or relaxation training (Hofmann et al., 2012). Future research should examine whether these interventions can modify stress reactivity patterns and improve well-being outcomes among individuals who display suboptimal levels of stress reactivity.

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Received May 18, 2023
Revision received October 30, 2023
Accepted November 1, 2023 ■