The Effect of Daily Stress, Personality, and Age on Daily Negative Affect

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ABSTRACT The current study examined whether stress reactivity becomes stronger or weaker with age. Daily stress and daily negative affect were modeled using 1,012 subjects from the National Study of Daily Events (NSDE), an 8-day daily diary study. Age ranged from 25 to 74. Data were modeled using within-person HLM techniques. Daily stress and neuroticism interacted in their effect on daily negative affect. There was a stronger association between daily stress and negative affect for persons high in neuroticism as compared to those low on the trait. In addition, daily stress and age interacted in their effect on daily negative affect. There was a stronger association between daily stress and negative affect for older as compared to younger adults. Results suggest heightened reactivity to stressors in older adulthood, perhaps due to kindling effects. Changes in the aging brain may explain this effect. Our investigations illuminate the complexities that characterize the set of associations among negative affect, stress, personality, and age, and point to potential aging or cohort effects.

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Nearly everyone experiences psychological distress, or negative affect, in response to actual or perceived stress. Yet people vary widely in the amount of negative affect reported in response to stress, as well as the amount of stress to which they are exposed. This type of systematic within-person variation is known as intraindividual variability (Nesselroade, 1988), and it is essential for integrating process and trait approaches to personality (Fleeson, 2001). The personality trait neuroticism plays a major role in determining individual differences in the intraindividual stress-affect association, but, undoubtedly, other variables moderate the daily stress-affect association. This paper considered the role of age, one such moderator.

Recent findings have highlighted the importance of developmental factors in understanding emotion and well-being (Carstensen, Pasupathi, Mayr & Nesselroade, 2000; Charles, Reynolds, & Gatz, 2001; Lang & Heckhausen, 2001; Mroczek & Kolarz, 1998; Smith, Fleeson, Geiselmann, Settersten, & Kunzmann, 1999; Wrosch, Heckhausen, & Lachman, 2000), raising questions about the role of age in daily stress and affect processes. Such developmental considerations led to the central questions of this paper. Are older adults more or less reactive to daily stress than younger adults? Additionally, what role does neuroticism play in this relationship? Are high-neuroticism older adults more or less reactive to daily stress than high-neuroticism younger adults?

Neuroticism as a Moderator of the Stress-Negative Affect Association

Neuroticism and stress are both strongly associated with negative affect (Almeida & Kessler, 1998; Costa & McCrae, 1980; Diener, Suh, Lucas, & Smith, 1999; Suls, Green, & Hillis, 1998; Watson & Clark, 1992). When people high in neuroticism encounter stressful events, they tend to experience them as more aversive and react with higher levels of negative affect than those low in this trait (Bolger, 1990; Bolger & Schilling, 1991; Bolger & Zuckerman, 1995; David & Suls, 1999; Gunthert, Cohen, & Armeli, 1999). Suls (2001) calls this process "hyper-reactivity," or a large change in negative affect in response to a stressor (Suls et al., 1998).

The theoretical underpinnings of neuroticism as a moderator are fourfold. First, persons high in this trait report larger numbers of stressful events in their lives, implying greater exposure to stress or even the creation of stressful situations (Bolger & Zuckerman, 1995; Ormel & Wohlfarth, 1991). Second, persons high in neuroticism may be more likely to appraise stressors as threats instead of as challenges, increasing the probability of feeling negative affect as a response (Lazarus & Folkman, 1984; Suls, 2001). During the appraisal process, persons high in neuroticism tend to focus more on the negative features of stressful events than people low in neuroticism (Hemenover, 2001). Third, after an event has occurred, persons high in neuroticism are more likely to remember events as stressful than people low in neuroticism; in essence, they encode life events differently (Larsen, 1992). Fourth, persons high in neuroticism may employ less productive coping strategies, especially emotion-focused coping (Bolger, 1990; David & Suls, 1999), or utilize strategies that are unproductive for neurotics in particular (Bolger & Zuckerman, 1995).

The Effect of Age on Stress Reactivity

Much of the aforementioned empirical work on the moderating role of neuroticism in the stress-affect association used samples that contained young, midlife and older adults. Yet no study examined age differences in the effects of stress and neuroticism or their interaction. There is good reason to consider age, as it has a well-documented effect on negative affect. Specifically, older adults report less negative affect than midlife and younger adults (Charles, Reynolds, & Gatz, 2001; Eid & Diener, 1999; Magai, 2001; Mroczek, 2001; Mroczek & Kolarz, 1998). Declines in the intensity of emotional reactions also have also been documented among older adults (Diener, Sandvik, & Larsen, 1985; Leventhal & Prohaska, 1986; Leventhal, Patrick-Miller, Leventhal, & Burns, 1997). However, no study has examined whether the effect of stress and neuroticism on negative affect varies across different ages. Do adults of varying ages show differential levels of reactivity?

Arguments for lessened reactivity in older adulthood. Some perspectives suggest that older adults are less reactive to stress than younger adults. Diehl, Coyle, and Labouvie-Vief (1996) found that

older adults displayed greater impulse control than did younger adults when dealing with stressors. This indicates that as we age we may cope with stress better and perhaps even become less reactive to stress. These findings are consistent with a growing body of literature suggesting that we regulate our emotions more effectively with age. Lawton (1996) and Schulz (1982) suggested that repetition of negative affect states over many years might decrease the likelihood of triggering such states in the future. Such increases in the threshold for experiencing negative affect due to repeated activation are known as "dampening" effects (Diener, Colvin, Pavot, & Allman, 1991).

Certain lifespan theories of emotion regulation are also consistent with the idea of lessened reactivity to stress as we age (Carstensen, 1995; Carstensen, Isaacowitz, & Turk-Charles, 1999; Labouvie-Vief, & DeVoe, 1991; Lang, Staudinger, & Carstensen, 1998). These theories posit better regulation of emotion among older adults and suggest that this is a key aspect of optimal aging (Baltes & Baltes, 1990; Baltes, Lindenberger, & Staudinger, 1998; Magai, 2001; Heckhausen & Schulz, 1995).

Arguments for heightened reactivity in older adulthood. Another set of perspectives suggests that the same process—repeated activation of negative affect—may actually *increase* reactivity in older adulthood. Repetition of negative affect activation, rather than causing habituation or dampening, may lead to sensitization. Several theoretical perspectives give rise to this idea. First, changes in the aging brain may alter the way we experience emotion, especially negative affect. The structures in the brain that mediate the experience of negative affect, the amygdala and limbic system, become more sensitive as we age (Adamec, 1990; Panksepp & Miller, 1996). Such heightened sensitivity may lead to easier activation of negative affect when a stimulus such as stress is encountered. These neurophysiological changes make it conceivable that negative affect is more likely to become activated as a consequence of frequent activation. Reactivity to stress may increase as we grow older due to a lifetime of repeated activations of the neural systems that mediate negative affect.

These heightened sensitivities are akin to "kindling effects," a process in which repeated exposure to some stimulus causes sensitization (Gilbert, 1994; Kendler, Thornton, & Gardner, 2001;

van der Kolk, 1996, 1997; Woolf & Costigan, 1999). Kindling effects have been observed with respect to chronic pain, drug abuse, epilepsy, traumatic stress, anxiety, and depressive episodes. For example, depressive episodes are frequently triggered by stressful life events. However, after repeated depressive episodes the likelihood increases that a person will spontaneously slip into a depressive episode without the trigger of a stressful life event (Kendler, Thornton, & Gardner, 2001). An individual in a kindled state is also more sensitive to the stimulus. Not only are depressive episodes (or epileptic seizures or drug abuse relapses) more likely to occur spontaneously, they are also more likely to be triggered when a stressful life event takes place—the stimulus threshold has lowered. Similarly, kindling effects occur in chronic pain. Many people become more sensitive to pain rather than developing tolerance over the long term (Woolf & Costigan, 1999). Kindling is a relatively permanent state of heightened susceptibility (Gilbert, 1994).

Kindling effects result from neuroplasticity, the ability of groupings of neurons to change and realign themselves in response to repeated exposure to stimuli. Neural networks that govern some process (the sensation of pain, an epileptic seizure, feelings of depression or negative affect) can itself become molded by the stimulus, causing these networks to become even more sensitive to the stimulus and to sometimes occur spontaneously (van der Kolk, 1996, 1997; Woolf & Costigan, 1999). We suggest that persons high in neuroticism may become similarly molded over time, resulting in hypersensitivity to stress. Thus, older adults high in neuroticism should display greater reactivity to stress. Specifically, we should observe a stronger association between daily stress and daily negative affect among high-neuroticism older adults.

Current Study

Self-reports of emotion vary with the time interval used to frame the report (Winkielman, Knauper, & Schwarz, 1998). Daily reports are a product of both personality and contextual variables, whereas global reports are mainly a product of personality traits. To acquire a reading of negative affect that reflects both personality and context (e.g., stress), we utilized a daily experience design (Tennen, Affleck, Armeli, & Carney, 2000). Assessing both affect and stressors at the daily level allows us to get closer to the emotions people of different

ages and different levels of neuroticism feel when a stressor actually happens (Almeida & Kessler, 1998; Larsen, 1987), permitting a more "micro" account of negative affect.

The present study tested the hypothesis that the association between daily stress and affect covaries with both age and neuroticism. Specifically, we predicted heightened stress reactivity among high-neuroticism older adults as compared to high-neuroticism younger adults. We therefore tested a three-way interaction between daily stress, neuroticism, and age on daily negative affect. We also tested the two-way interactions among the three explanatory variables.

METHOD

Sample and Procedure

Data came from the National Study of Daily Experiences (NSDE; Almeida, Wethington & Kessler, in press; Almeida, MacDonald, & Wethington 2001). Respondents were 1,012 adults (54.5% women, 45.5% men) all of whom had previously participated in the Midlife in the United States Survey (MIDUS), a nationally representative telephone and mail survey of 3032 people aged 25 to 74 carried out in 1995–1996 by the John D. and Catherine T. MacArthur Foundation Network on Successful Midlife Development. Respondents in the NSDE were randomly selected from the MIDUS sample and received $20 for their participation in the project. Over the course of eight consecutive evenings, respondents completed short telephone interviews about their daily experiences.

The NSDE data collection spanned an entire year (March 1996 to March 1997) and consisted of 40 separate "flights" of interviews with each flight representing the 8-day sequence of interviews from approximately 38 respondents. The initiation of interview flights was staggered across the day of the week to control for the possible confounding between day of study and day of week. The daily telephone interviews took place in the evening of each study day. Of the more than 1200 MIDUS respondents who were contacted, 83% agreed to participate. Respondents completed an average of seven of the eight interviews, resulting in a total of 7221 daily interviews. Respondents were on average 48 years old. Seventy-seven percent of the women and 85% of the men were married at the time of the study, and 47% percent of the households reported having at least one child. Average household income was between $50,000 and $55,000.

Measures

Daily negative affect. Our analyses made use of daily assessments of negative affect. We used an inventory of 10 items that was built using Item Response Theory (Kessler et al., 2002). This negative affect scale was developed using a national sample and a large pool of items taken from the following well-known and valid instruments: The Affect Balance Scale (Bradburn, 1969), the University of Michigan Composite International Diagnostic Interview (Kessler et al., 1994), the Manifest Anxiety Scale (Taylor, 1953) and the Center for Epidemiological Studies Depression Scale (Radloff, 1977). Kessler et al. (2002) developed 6- and 10-item versions of the scale using Item Response Theory to choose items that represented the full range of negative affect or psychological distress.

The items asked if in the past 24 hours one felt: ''depressed,'' ''nervous,'' ''so nervous nothing could calm you down,'' ''restless or fidgety,'' ''so restless you could not sit still,'' ''that everything was an effort,'' ''worthless,'' ''hopeless,'' and ''so sad nothing could cheer you up.'' This scale is a mix of depression, anxiety, and appraisals (hopeless, worthless), and can be labeled either ''psychological distress'' or ''negative affect,'' as most distress measures that include a mix of anxiety and depression are strongly correlated with explicitly negative affect measures (Watson & Tellegen, 1985; Watson & Clark, 1992). Respondents indicated how much of the day they experienced each negative affect item on a 0 to 4 point scale. The 5 response options were *none of the time*, *most of the time*, *some of the time*, *a little of the time*, and *all of the time*. For each day in the daily study, we took the mean of these 10 negative affect items. This yielded an average of 7 daily negative affect measurements for each of the 1012 respondents. The daily-level alpha reliabilities ranged from .75 to .85 across the 8 days.

Daily stress. Daily stress was assessed via the semi-structured Daily Inventory of Stressful Events (DISE; Almeida, et al., 2002). This instrument consists of 7 stem questions that ask if certain stressors have occurred within the past 24 hours. These were: (1) having had an argument or disagreement with someone, (2) almost having had an argument or disagreement but having avoided it, (3) a stressful event at work or school, (4) having had a stressful event happen at home, (5) having experienced race, gender, or age discrimination, (6), having had something bad happen to a relative or close friend, and (7) having had anything else bad or stressful happen in the past 24 hours.

For these seven stressors, respondents rated the severity of each, using a 1 to 4 scale where 1 meant it was *not at all stressful* and 4 meant it was *very stressful*. Total daily stress was computed by summing the severity

scores for each stressor for each day. Hence, the daily stress variable reflected both the number of stressful events reported (exposure) and the rating of the stressfulness of each event (severity). For example, if someone said they had three stressors on a given day, and rated the first a 1, the second a 3 and the third a 2, then the daily stress score for that day would be 6. Obviously, another way to obtain a stress score of 6 is by experiencing six stressors, but rating each of them "not at all" stressful. We were concerned that combining exposure and severity would lead to a loss of information. However, the correlation between exposure (number of stressors on a given day) and the severity ratings was very high ($r = .94$), indicating little loss of information. The daily stress variable ranged from 0 to 18 across the 7,221 days, although by far the most frequent score was zero (62%), indicating that no-stress days were quite common.

Neuroticism. A short measure of neuroticism consisting of four items was created for the MIDUS (Lachman & Weaver, 1997), using adjectives culled mainly from Goldberg's (1992) big-five markers. Neuroticism was assessed on the MIDUS, the base sample from which the NSDE participants were recruited. As such, neuroticism was assessed several months to a year prior to the commencement of the NSDE. This was desirable because it maintained a degree of independence between the neuroticism and negative affect assessments. The MIDUS was a product of an interdisciplinary effort, in which psychologists, sociologists, anthropologists, physicians and epidemiologists competed for limited space on the survey instrument. Thus, the neuroticism measure needed to be kept short, ultimately to four items.

The four neuroticism items were "moody," "worrying," "nervous," "and "calm" (reversed). Participants responded to the stem question "Please indicate how well each of the following describes you" and rated themselves on each item using a 0–3 response scale where 0 meant *not at all* and 3 meant *a lot*. The mean was then taken for these items (leaving out those who did not respond to one or more items). Coefficient alpha was .79 in the current sample.

This scale has been used in a number of published reports that have documented its construct validity. In these studies it was negatively correlated with subjective physical health and global well-being (Staudinger, Fleeson, & Baltes, 1999), as well as social support, future-oriented life planning, perceived control, and life satisfaction (Prenda & Lachman, 2001). It was positively correlated with 1-month negative affect and global reports of physical health (Mroczek & Kolarz, 1998), as well as stressful life events over the course a year (Prenda & Lachman, 2001). These previous studies document the construct validity of this 4-item

scale. However, its temporal stability has not yet been assessed—a limitation of the scale. Nevertheless, it was derived from a set of adjective markers of neuroticism known to have high stability (Goldberg, 1992) and was strongly correlated (in a German sample) with the NEO-PI scale of neuroticism, also known to have high stability (Staudinger, Fleeson, & Baltes, 1999).

Data Analysis

We used mixed models to analyze these data (Bryk & Raudenbush, 1992; Kenny, Bolger, & Kashy, 2002; Nezlak, 2001). Data were arranged in "person-days," nesting stress and affect within persons. Thus stress and affect could vary over days within persons. Most participants had between 6 and 8 (average of 7) measurements of stress and affect over an 8-day period. A small number had fewer than 6 days of data. These persons were used, although their small *N* gave them less weight in the analyses.

At Level 1 we modeled the within-person stress-affect association, and at Level 2 we introduced between person variables, such as neuroticism. Our Level 1 and 2 models for the initial analyses were:

$$\text{Level 1}: \quad NA_{ij} = B_{0j} + B_{1j}\,(\text{Stress}_{ij}) + e_{ij} \tag{1}$$

$$\begin{aligned} \text{Level 2}: \quad B_{0j} &= \tilde{a}_{00} + \tilde{a}_{01}\,(\text{Neuroticism}) + u_{0j} \\ B_{1j} &= \tilde{a}_{10} + u_{1j} \end{aligned} \tag{2}$$

At Level 1, the outcome, NA_{ij} is the amount of negative affect on day *i* for person *j*. It is a function of B_{0j}, the person's own intercept, and B_{1j}, the person's own slope which characterizes the association between stress and negative affect for that individual. Stress_{ij} is amount of stress on day *i* for person *j* and e_{ij} is a within-person error or residual term. We centered stress around the person's mean for the 8-day period, so B_{0j} is the person's predicted level of negative affect on an average day. At Level 2, B_{0j} is expressed as a function of the between-persons intercept ($\tilde{a}_{00}$), the effect of the between-persons variable Neuroticism ($\tilde{a}_{01}$), and a between-persons error term (u_{0j}). The within-persons slopes, B_{1j}, are a function of the mean slope between persons ($\tilde{a}_{10}$) and between-persons error term (u_{1j}) that captures individual differences in the stress-NA slopes. In subsequent models we added age and the various two- and three-way stress, neuroticism, and age interaction terms to the Level 2 equations.

These within- and between-person equations are solved simultaneously (Raudenbush & Bryk, 2002, p. 70), and can be expressed in a single equation, hence the term mixed model. Following Raudenbush and

Bryk (2002, p. 76), such a combined equation may be expressed as:

$$NA_{ij} = \tilde{a}_{00} + \tilde{a}_{01}\,(\text{Neuroticism}) + \tilde{a}_{01}\,(\text{Stress}) + u_{0j} + u_{1j}\,(\text{Stress}) + e_{ij} \quad (3)$$

Equation 3 shows negative affect for a given person and day as a function of within- and between-person variables, as well as within- and between-person errors. All models were implemented using Proc Mixed in SAS (SAS Institute, 1999) in the current study.

It was possible that the raw version of the within-person daily stress variable might yield a biased estimate of the stress-affect association (the intercept and slope estimates may become artificially and negatively correlated; Raudenbush & Bryk, 2002, p. 33). Thus, we centered daily stress around each person's mean across the 8 days and then created a between-person daily stress score that represented each person's mean stress across all their daily observations (e.g., Hofmann & Gavin, 1998; Schwartz & Stone, 1998). The between-person stress score captures the individual differences in daily stress (the between-person effect), while the person-centered stress score captures deviations from the mean (the within-person effect). We also included previous-day negative affect to control for the possibility that daily stress on a given day was due to one's negative affect on the prior day. Finally, we centered the three between-person variables (neuroticism, mean daily stress and age) around their respective means, a procedure known as grand mean centering (Raudenbush & Bryk, 2002).

RESULTS

Table 1 shows correlations among the key study variables, along with their means and standard deviations. Note that age is inversely correlated with daily negative affect, daily stress, and neuroticism. Leaving aside the within-person relationship between daily stress and negative affect, younger adults report more daily stress and daily negative affect than older adults, and have higher levels of neuroticism. The association between age and negative affect are consistent with several recent findings (Charles, Reynolds, & Gatz, 2001; Mroczek, 2001; Mroczek & Kolarz, 1998). The association between age and neuroticism is also consistent with modest declines in neuroticism documented by previous research (Caspi & Roberts, 1999; Costa & McCrae, 1992, 1994; Costa, Herbst, McCrae, & Siegler, 2000). Neuroticism is also positively correlated with daily stress, a finding consistent with prior studies that show that people

Table 1
Correlations Among Study Variables

Variable	1.	2.	3.	4.
1. Daily Negative Affect	1.00			
2. Daily Stress	.35	1.00		
3. Neuroticism	.30	.14	1.00	
4. Age	− .08	− .14	− .17	1.00
Mean	0.17	1.47	1.22	47.95
Standard Deviation	0.36	2.35	0.67	13.15

Note. All correlations are significant at the .0001 level. Correlations based on variables 1 and 2 used aggregate daily values.

high in this trait report greater exposure and severity of stress (Bolger & Schilling, 1991; Bolger & Zuckerman, 1995).

Neuroticism, Stress, and Daily Negative Affect

Mixed models (Raudenbush & Bryk, 2002; Kenny et al., 2002; Kreft & de Leeuw, 1998; Nezlak, 2001; Snijders & Bosker, 1999) were used to determine whether daily negative affect rises with daily stress and neuroticism, covarying mean daily stress (a between-person variable) and previous day negative affect. As shown in Table 2, all variables in the model were significant. The top of the table shows fixed effects (pooled intercepts and slopes for the sample). The intercept represents the predicted amount of daily negative affect on an average stress day, because daily stress was person-centered. The coefficient for daily stress represents the amount of daily negative affect over one's average amount of daily negative affect that is associated with a one-unit increase in daily stress. The coefficient for neuroticism represents the association between neuroticism and negative affect on average stress days. It is the association between neuroticism and the negative affect intercepts. Random effects are also shown in Table 2, indicating that the relationship between daily stress and negative affect varied significantly across persons.

To replicate the stress-by-neuroticism interaction, we estimated a model where negative affect on a given day was a function of daily stress, neuroticism, and the interaction of daily stress and neuroticism (in addition to mean daily stress and previous day negative

Table 2
Daily Negative Affect as a Function of Daily Stress and Neuroticism

Fixed Effects	Estimate (se)
Intercept	.117 (.006)***
Person-Centered Daily Stress	.030 (.003)***
Mean Daily Stress	.051 (.004)***
Previous Day NA	.235 (.011)***
Neuroticism	.086 (.009)***
Random Effects	**Estimate (se)**
Intercept	.023 (.002)***
Person-Centered Daily Stress	.002 (.000)***
Residual	.042 (.000)***

Note. ***$p < .001$; all between-person predictors (mean daily stress and neuroticism) are centered around the sample mean for that variable.

affect). Table 3 shows that the daily stress by neuroticism interaction was significant, indicating that the magnitude of the daily stress-negative affect association depended on level of trait neuroticism. This is graphically depicted in Figure 1. The association between

Table 3
Daily Negative Affect as a Function of Stress, Neuroticism and Interactions

Fixed Effects	Estimate (se)
Intercept	.117 (.006)***
Person-Centered Daily Stress	.028 (.002)
Mean Daily Stress	.051 (.004)***
Previous Day NA	.233 (.011)***
Neuroticism	.089 (.008)***
Person-Centered Daily Stress X Neurot.	.023 (.003)***
Random Effects	**Estimate (se)**
Intercept	.023 (.002)***
Person-Centered Daily Stress	.002 (.000)***
Residual	.042 (.000)***

Note. ***$p < .001$; all between-person predictors (mean daily stress and neuroticism) are centered around the sample mean for that variable.

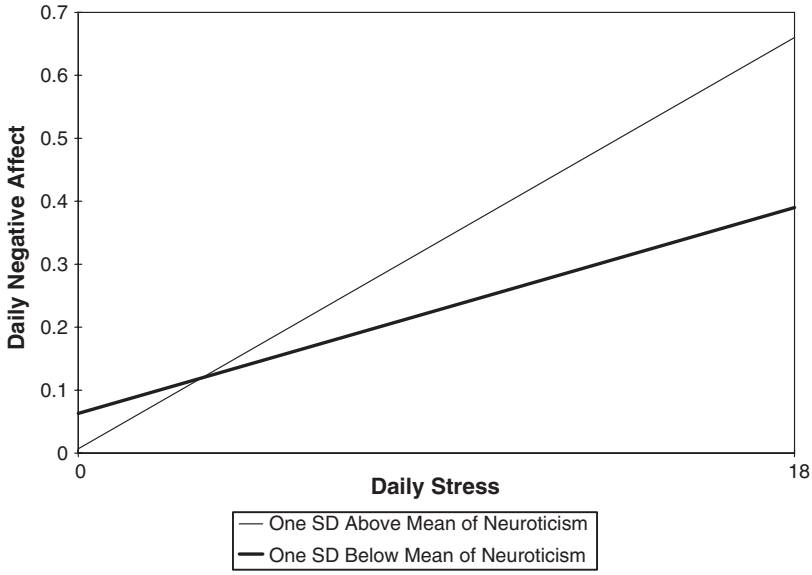

Figure 1
Neuroticism moderates the association between daily stress and daily negative affect.

amount of stress on a given day and negative affect was smaller for persons lower in trait neuroticism (1 standard deviation below the mean of neuroticism) than those higher in neuroticism (1 standard deviation above the mean). As shown in Figure 1, the slope of the line defining the stress-affect association was steeper among persons high in neuroticism than those low on the trait. This replicates previous findings that documented the stress-by-neuroticism interaction on daily distress (Bolger & Schilling, 1991; Bolger & Zuckerman, 1995; Gunthert et al., 1999; Suls, 2001).

The addition of the daily stress by neuroticism interaction also reduced the variance of the stress-negative affect associations. The random effect for daily stress represents the individual differences in the stress-negative affect associations across the participants. The absolute values of the variances are small, and in the tables they are taken out to only 3 decimal places. However, what matters is the proportion of one to the other, allowing an assessment of effect size (Raudenbush & Bryk, 2002). Adding the daily stress-by-neuroticism interaction decreased the variance of the stress-negative affect slopes by 10.7%, a considerable amount.

Age, Daily Stress, Neuroticism and Daily Negative Affect

Having established the stress-by-neuroticism interaction in the current sample, we added age to our models. We entered the three-way interaction between stress, neuroticism, and age, as well as all two-way interactions among these three variables. The three-way interaction between daily stress, neuroticism, and age was not significant.[1] However, 2 of the 3 two-way interactions were significant: daily stress interacted with age, $t(5115) = 3.12$, $p < .01$, and neuroticism $t(5115) = 7.16$, $p < .0001$.

Table 4 shows the model that includes these two interactions, which are graphed in Figure 2. We used the upper and lower values of our age range, 25 and 74, as well as values one standard deviation above and below the mean of neuroticism, to produce the functions depicted in Figure 2. The daily stress-by-neuroticism interaction is observable via the thick vs. thin lines. The thick lines represent persons low in neuroticism, and the two thin lines represent persons high in neuroticism.

The daily stress-by-age interaction is observable via the dashed vs. solid lines. The dashed lines represent older adults. Note that older adults are characterized by a stronger relationship between daily stress and negative affect regardless of level of neuroticism. That said, high-neuroticism older adults indeed displayed the strongest association, but even low-neuroticism older adults showed a stronger stress-NA relationship than was observed among younger adults.

Younger adults (solid lines), by contrast, show a less strong association between daily stress and negative affect. In essence, younger adults are in general less reactive to daily stress than older adults. This heightened reactivity is consistent with the kindling hypothesis (van der Kolk, 1996, 1997; Woolf & Costigan, 1999), but the kindling phenomenon appears to apply to older adults in

1. The three-way interaction was significant when stress severity was not included as part of the daily stress variable. When days were coded dichotomously as stress days or nonstress days, the significant three-way interaction indicated that stress-affect association was strongest among high-neuroticism older adults but was weakest among low-neuroticism older adults. These differences in results, depending on how we conceptualize the stress variable (incorporating severity or not), may be due to age differences in how severity is perceived and subjectively rated.

Table 4
Models of Daily Negative Affect as a Function of Age, Stress and Neuroticism and Interactions

Fixed Effects	Estimate (se)
Intercept	.117 (.006)***
Person-Centered Daily Stress	.029 (.002)**
Mean Daily Stress	.053 (.004)***
Previous Day NA	.235 (.011)***
Neuroticism	.092 (.009)***
Age	.001 (.000)*
Person-Centered Daily Stress X Neuroticism	.025 (.003)***
Person-Centered Daily Stress X Age	.001 (.000)**
Random Effects	**Estimate (se)**
Intercept	.023 (.002)***
Person-Centered Daily Stress	.002 (.000)***
Residual	.042 (.001)***

Note. *$p<.05$. **$p<.01$. ***$p<.001$; all between-person predictors (mean daily stress, neuroticism, and age) are centered around the sample mean for that variable.

general, not just those high in neuroticism (although high-neuroticism older adults do display the strongest stress-NA relationship). The addition of the two interactions reduced the individual differences in the stress-negative affect slopes (the variance of the slopes) by 4.7%. This is a nontrivial effect size.

DISCUSSION

In this study, we asked if the association between daily stress and negative affect (reactivity) was moderated by age as well as neuroticism. In particular, our study tested the hypothesis that high-neuroticism older adults should display amplified stress reactivity. Using mixed models to test the effect of a within-person factor (daily stress) and two between-persons factors (neuroticism and age), we found a general amplification or kindling effect. The association between daily stress and negative affect was stronger among older than younger adults, although high-neuroticism older adults displayed the greatest stress reactivity (Figure 2). On days

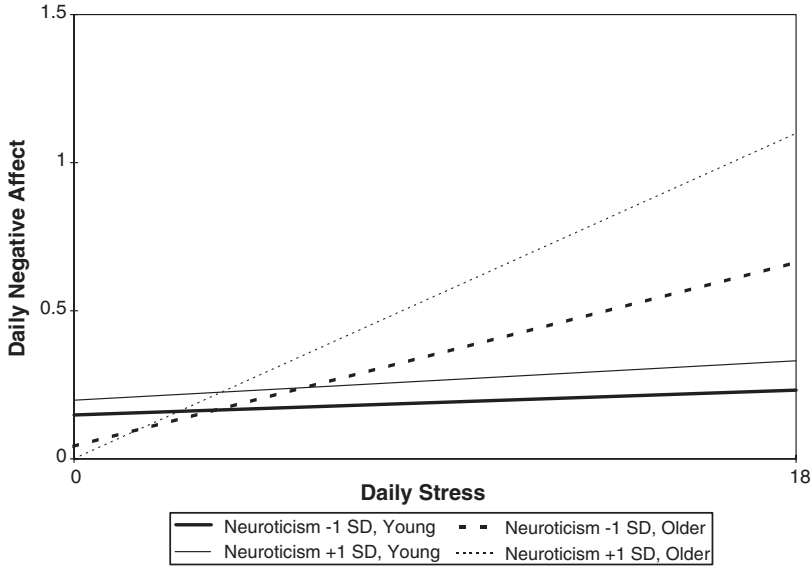

Figure 2
Age and neuroticism moderates the association between daily stress and daily negative affect.

when stress was high, older adults in general reported higher levels of negative affect than did younger adults. This was over and above the stress-by-neuroticism interaction that was also replicated (Bolger & Schilling, 1991; Bolger & Zuckerman, 1995; Gunthert et al., 1999; Suls, 2001). Barring a cohort effect, older adults appeared more prone to experiencing negative affect when they encountered stress than did younger and midlife adults. Why would older adults show such heightened reactivity?

As discussed earlier, the answer may lie in amount of neural activation. Over time, the repeated activation of neural pathways in the amygdala and limbic system, may cause sensitization (Gilbert, 1994; Kendler et al., 2001; Panksepp & Miller, 1996; van der Kolk, 1996, 1997; Woolf & Costigan, 1999). Sensitization in the neural pathways that govern negative affect may undergird the phenomenon described in this study. This may be similar to the way the physical experience of chronic pain can hypersensitize an individual to feeling pain (Woolf & Costigan, 1999), or the way prior depressive episodes leads to heightened susceptibility to depression-inducing stimuli and to spontaneous episodes (Kendler et al.,

2001). A lifetime of frequent activation of the neural pathways associated with negative affect may bring about such sensitization, causing heightened susceptibility to stimuli that produce negative affect, including daily stress. Figure 2 showed that high-neuroticism older adults displayed the greatest amount of heightened reactivity. Yet even low-neuroticism older adults show levels of reactivity that are higher than among comparably low-neuroticism younger individuals. If a kindling effect explains these findings, then it seems to be a broad phenomenon that happens to older adults in general, not only to high-neuroticism older adults.

The Paradox of Lower Daily Stress, Negative Affect, and Neuroticism but Higher Stress Reactivity Among Older Adults

Paradoxically, heightened stress reactivity among older adults coexists with lower overall levels of daily negative affect, daily stress, and neuroticism. Age was negatively correlated with all three of these variables. Older adults experience less daily stress and less daily negative affect and are lower on neuroticism. Yet on those occasions when stress does occur, they react with greater levels of negative affect than their younger counterparts. One explanation for this paradox may lie in the typical daily experiences of older adults and their level of exposure to stressors. Older adults are more likely to be retired or semi-retired and to have children who have left the home, both of which are key sources of daily stress for midlife and younger adults. Our older adults, like the majority of older persons in the United States, also tend to be relatively financially secure. Perhaps retirement, the empty nest, and financial security mean fewer opportunities for older adults to deal with daily stressors, putting them "out of practice," so to speak. This interpretation is an alternative to the kindling explanation phenomenon and explains the effect in terms of age-related differences in exposure to daily stress rather than age-related neurological changes.

Similarly, the phenomenon of lower daily stress may underlie the decline in neuroticism with age that we found. However, other explanations are plausible. For instance, those who are high in neuroticism may not live as long as other people, meaning fewer high-neuroticism individuals within the population of older adults. Or the age-related decline in neuroticism may result from a cohort effect. People of the current generation of older adults may have

lower lifelong levels of neuroticism than more recent generations. Without long-term longitudinal data on multiple cohorts, we cannot determine which of these explanations is correct.

Limitations

Our findings are subject to a number of limitations. One shortcoming stems from the cross-sectional nature of our sampling. Our oldest respondents may differ in important ways from our midlife or younger respondents. They have survived to older adulthood, necessarily leaving out anyone from that generation who may have died during young or in middle adulthood. There may be important differences in affect, neuroticism, or stress reactivity among those who survive to older age and those who do not.

Again, we must also raise the possibility of cohort effects. Our older adults are part of the cohort that came of age during the Depression, WWII, and the early years of the Cold War. Our midlife respondents, by contrast, are mainly comprised of baby boomers. Our youngest adults were those who generally came of age in the 1980s. Generational differences due to historical events may be responsible, in part, for our findings. Without multigenerational longitudinal data (a cross-sequential design) there is no way of separating cohort from aging effects.

Another limitation centers on encoding of stressful events. The NSDE respondents were interviewed in the evening, often many hours after reported stressful events had taken place. Many factors, particularly personality traits, influence how these stressors are encoded into memory and remembered later. People high in neuroticism may selectively encode events as more stressful than those low in neuroticism (Larsen, 1992). These influences could have distorted our findings in that the same event was remembered as stressful to one person but not to another. Hence the former individual reported a stress event, but the latter did not, even if their objective experiences were identical. Further, our measure of neuroticism may have distorted the findings. We used a short (4-item) index of this trait that had a reasonable reliability and good construct validity, but was nonetheless a shadow of the larger scale it was taken from (Goldberg, 1992). The stability of this measure is unknown as well, even though it was derived from a stable measure. It thus may not have yielded the best possible measurements of trait neuroticism.

Finally, our most important limitation centers on what we did not measure. We have drawn upon theory and research involving sensitivity changes in neural pathways (kindling) to explain our findings. Yet we relied exclusively on circumstantial evidence. We did not measure neural sensitivity and did not directly measure any of the underlying mechanisms specified in our hypotheses. As such, we cannot rule out that nonphysiological mechanisms have influenced our results. For example, it is conceivable that over the lifespan some people (especially those high in neuroticism) may shift toward coping strategies (e.g., emotion-focused) that heighten the effect of neuroticism on negative affect. Similarly, perceptions and appraisals of stressors may change with age. This may alter the effect of neuroticism on stress, as we know that appraisals are one of the ways neuroticism impacts the stress-affect association. There is some evidence for this as perceptions and appraisals include sense of control, which has been shown to interact with life events in predicting affect in older adults (Lang & Heckhausen, 2001). Whether age-graded changes in coping strategies, perceptions of control, or stress appraisals account for our findings or whether they were due to heightened neural sensitivity requires further investigation. Such future studies need to delve deeper, using (1) indices of affect regulation, (2) neurophysiological assessments, (3) assessments of coping strategies, (4) measurements of stressor appraisals, and (5) cognitive schemata that may govern interpretations of stressors and how they are encoded in memory.

Conclusion

To restate our central findings, both age and neuroticism moderated the relationship between daily stress and negative affect. The older one was, the stronger the relationship between daily stress and negative affect, except when daily stress was very low. Older adults reported more negative affect on days when stress was high as compared to younger adults, essentially displaying greater stress reactivity. Additionally, persons high in trait neuroticism showed a stronger relationship between daily stress and negative affect, replicating previous findings (Bolger & Zuckerman, 1995; Suls, 2001). Changes in neurophysiological sensitivity may explain these results, but other explanations (cohort effects, changes in coping strategies or appraisals of stress) are plausible as well. Regardless of

the reason for these results, our investigations have illuminated some of the complexities that characterize the associations among negative affect, stress, personality, and age.

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