THE GERONTOLOGICAL SOCIETY OF AMERICA®

Journals of Gerontology: Psychological Sciences
cite as: *J Gerontol B Psychol Sci Soc Sci*, 2020, Vol. 75, No. 3, 494–503
doi:10.1093/geronb/gby046
Advance Access publication April 20, 2018

OXFORD

Original Research Report

Daily Stress Reactivity Across the Life span: Longitudinal and Cross-Sectional Effects of Age

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Received: October 20, 2017; Editorial Decision Date: March 29, 2018

Decision Editor: Shevaun Neupert, PhD

Abstract

Objective: Exploration of development requires the use of research designs and process-oriented methodologies that can capture daily fluctuations within individuals, systematic changes within individuals, and differences between individuals. We examine the stress–affect relationship in this way to assess how the relationship between daily stress and negative affect (NA) as well as the relationship between daily stress and positive affect (PA) differs between individuals and changes over time depending on age and stress differences.

Method: Participants (N = 966) completed daily "burst" assessments of stress, NA, and PA. Three-level multilevel models depicted how cross-sectional age, within-person age changes, and global stress differences impact the daily stress–affect relationship.

Results: Findings illustrate that cross-sectional age and the aging process uniquely buffer the stress–NA relationship whereas global stress exacerbates it. Furthermore, older adults as well as adults with low global stress experience a weaker relationship between daily stress and PA as they age, but midlife adults and adults with high global stress experience a stronger relationship.

Discussion: These results depict differences in aging trajectories for both midlife and older adults and thus inform intervention and preventative care strategies aimed toward promoting stress regulation.

Keywords: Affect, Daily stress, Intraindividual variability, Longitudinal age, Multilevel modeling

Individuals illustrate a great deal of heterogeneity in the aging process (Baltes, 1987); as such, when studying developmental processes such as emotion regulation, researchers must account for between-person differences, within-person fluctuations, within-person change, and the relationships among them (Nesselroade, 1991). Specifically, *intraindividual variability*, or fluctuations in short-term within-person emotion states, must be understood in the context of *intraindividual change*, defined as the long-term systematic changes with development. Furthermore, individuals may change in different ways, both in terms of short-term variability and longer-term patterns of change, so *interindividual differences*, or trait-like differences between people must also be considered (Nesselroade, 1991; Ram & Gerstorf, 2009). In general, theories and research on aging suggest that emotional regulation improves with age (Carstensen et al., 2011; Charles & Carstensen, 2007; Urry & Gross, 2010). Further research shows that older adults differ in their experience and perceptions of stress (Almeida, 2005; Charles et al., 2010; Folkman, Lazarus, Pimley, & Novacek, 1987; Neupert, Almeida, & Charles, 2007; Stawski, Sliwinski, Almeida, & Smyth, 2008), highlighting the need to study the relationships between stress and affect longitudinally to show how the relationship changes within and differs between individuals.

The Daily Stress–Affect Relationship

An abundance of research indicates that greater daily stress relates to greater negative affect (NA; Bolger, DeLongis, Kessler, & Schilling, 1989; Montpetit, Bergeman, Deboeck, Tiberio, & Boker, 2010; Scott, Sliwinski, & Blanchard-Fields, 2013; Stawski et al., 2008; Zautra, Johnson, & Davis, 2005) and lower positive affect (PA; Blaxton, Bergeman, Whitehead, Braun, & Payne, 2015; Stawski et al., 2008). Specifically, research shows significant within-person and between-person relationships between stress and NA (Blaxton et al., 2015; Sliwinski, Almeida, Smyth, & Stawski, 2009) as well as daily stress and PA (Blaxton et al., 2015; Stawski et al., 2008). Further research shows that a more coupled relationship between daily stress and daily NA indicates greater stress reactivity, whereas a less coupled relationship indicates greater stress resistance (Montpetit et al., 2010). Almeida (2005) presents a model that depicts several contextual factors that either exacerbate or mitigate the relationship between daily stress and well-being outcomes, including sociodemographic influences, psychosocial factors, health variables, stressor characteristics, subjective appraisals, and aspects of daily well-being. Although the model illustrates the effects of cross-sectional age on stress, the longitudinal effects of age are not described. For the purposes of the current study, we will focus on how age, assessed both cross-sectionally and longitudinally, and global perceptions of stress relate to differences in the stress–affect relationship.

Age Differences and Changes

When considering the effects of age on developmental processes, researchers can assess both cross-sectional age differences as well as the within-person aging process. In terms of cross-sectional age differences, research has shown that individuals become more heterogeneous as they age (Baltes, 1987; Baltes, Reese, & Nesselroade, 1988), indicating that between-person differences may be more pronounced in older samples. One reason for this is that individuals can take many different paths throughout development, illustrating a great deal of plasticity (Baltes, 1987). These age-related changes suggest that individuals may change in how they experience day-to-day and year-to-year processes, indicating the need to examine within-person fluctuations and changes over time. In addition, cross-sectional age differences may relate differently to within-person aging processes. Specifically, research indicates that individuals of different starting ages may change differently over time (Baltes, 1987), indicating cohort effects. Consequently, when examining developmental processes, researchers must not only consider cross-sectional age differences and within-person age-related changes, but also the relationship between age differences and age-related changes. In this way, researchers can better elucidate the possible cohort differences, idiographic trajectories of change irrespective of cross-sectional age, and idiographic trajectories within each cohort that are associated with developmental processes.

Theoretical and empirical research indicates that there are age differences in emotional experiences (Baltes, 1987; Carstensen et al., 2011; Charles & Piazza, 2009; Hay & Diehl, 2011; Stawski et al., 2008; Urry & Gross, 2010) and stressful experiences (Almeida, 2005; Charles, Piazza, Mogle, Sliwinski, & Almeida, 2013; Folkman et al., 1987; Lazarus & Delongis, 1983; Neupert et al., 2007; Stawski et al., 2008). In terms of emotional regulation, Urry and Gross (2010) suggest that as older adults' cognitive, physical, and social resources decline, they place more emphasis on successful emotional regulation, and select strategies that allow them to optimize their emotional regulating to enhance their quality of life and life satisfaction, which compensates for the increase in losses that they experience. Empirical research shows that older adults tend to focus more on emotional salient information and, within that emotional salient information, focus more on positive affectively toned information rather than negatively toned information (Charles & Carstensen, 2007). Further research shows a positivity effect among older adults in day-to-day life. For example, older adults tend to reminisce more on positive memories rather than negative ones (Charles & Carstensen, 2007), illustrating effective optimization strategies. Similarly, another study revealed that age positively related to maintaining a low NA state, and positively related to moving from a high NA state to a low NA state (Hay & Diehl, 2011). At the daily level, older adults reported less daily NA and greater daily PA compared to younger adults (Stawski et al., 2008). These findings illustrate that older adults tend to have better emotional experiences, but few studies have examined the longitudinal effect of age on emotional experience.

When it comes to stress, younger individuals experience more hassles involving finance, work, family, friends, home maintenance, and personal life (Folkman et al., 1987) whereas older adults reported less daily stressors (Almeida, 2005; Charles et al., 2010; Neupert et al., 2007; Stawski et al., 2008; Stefaniak, Blaxton, & Bergeman, 2018) and less daily perceived stress severity compared to midlife and young adults (Almeida, 2005; Blaxton et al., 2015; Stefaniak et al., 2018). These differences may contribute to age differences in the stress–affect relationship. For example, when comparing older and younger adults, Stawski et al. (2008) found that, although older adults experienced less daily stressors than younger adults, daily stress related to lower PA among only the older adults, suggesting that older adults' levels of PA may be more affected by daily stress fluctuations than younger adults' levels. Conversely, in one wave of participants from the Notre Dame Study of Health & Well-Being (NDHWB), older adults experience a more buffered relationship between daily stress and PA as well as daily stress and NA compared to midlife adults (Blaxton et al., 2015). Furthermore, one study showed that the number

of stressors on a given day as well as the severity of that stress positively related to NA for younger adults, but not for older adults (Stawski et al., 2008). Similarly, another study revealed that older age buffered the relationship between interindividual stressor-related intrusive thoughts and NA, intraindividual unspecific intrusive thoughts and daily NA, and stressor-related intrusive thoughts and daily NA (Brose, Schmiedek, Lövdén, & Lindenberger, 2011). Scott et al. (2013) revealed that midlife adults experienced the most exacerbated relationship between previous stress severity and NA. Conversely, another study revealed that older age related to a stronger relationship between daily stress and daily NA (Mroczek & Almeida, 2004). These conflicting results, along with the sparsity of research exploring how the daily stress–affect relationship changes longitudinally, indicates a need for further research.

Global Stress Perceptions

Greater overall stress not only contributes to greater future stress (Pearlin & Skaff, 1995), but also amplifies the association between daily stress and NA (Almeida, 2005; Bolger et al., 1989; Hay & Diehl, 2011; Scott et al., 2013; Sliwinski et al., 2009). Pearlin and colleagues describe a *stress proliferation process*, in which previous stressors may continue to impact the individual, resulting in the development of new stressors or chronic stress (Pearlin, Aneshensel, & Leblanc, 1997; Pearlin & Skaff, 1995). When examining a model relating daily stressors to negative mood, considering whether a stressor had occurred previously significantly improved model fit (Bolger et al., 1989). Further research shows that high global perceptions of stress exacerbated the relationship between recent experience of a stressor and NA as well as recent stress severity and NA (Scott et al., 2013; Sliwinski et al., 2009), and between-person stress, or greater average levels of stress, related to a more intensified relationship between weekly stress and NA (Zautra et al., 2005). In addition, participants with on-going stressors reported more affective distress in response to daily stressors than participants who did not report on-going stressors (Almeida, 2005), suggesting that chronic stress enhances individuals' sensitivity to daily stress.

In examining how age moderates the relationships among global stress, daily stress, and emotions, researchers found that global perceptions of stress strengthened the relationship between daily stress and NA for younger adults, but not for older adults (Stawski et al., 2008). These findings suggest that older adults may be less affected by global perceptions of stress compared to younger adults. Interestingly, when global stress was included in the model, the inverse relationship between age and number of stressors disappeared (Stawski et al., 2008), suggesting that global stress perceptions may account for the mitigating effects of age and daily stress. In addition, although within-person unspecific intrusive thoughts and stressor-related intrusive thoughts exacerbated the relationship between daily stress and NA, the effect of stress-related intrusive thoughts was smaller for older adults (Brose et al., 2011), suggesting that older adults may resist the effects of stress more than younger adults. These findings illustrate that age differences moderate the relationships among global stress, daily stress, and daily NA, raising the question of whether longitudinal age changes would also influence this relationship. Researchers did not find significant relationships when PA was used as the dependent variable (Stawski et al., 2008).

The Current Study

Although researchers can capture intraindividual variability on much shorter timescales, capturing intraindividual change requires studying longer periods of time. Thus, different developmental processes and different aspects of those processes might best be captured using different metrics to represent the cadence and direction of change. Bergeman and colleagues explain that different developmental processes fluctuate and change at different speeds. Consequently, researchers must use different timescales to fully understand developmental processes. For example, capturing daily fluctuations in stress across multiple years can elucidate how daily relationships between stress and affect relate to long term outcomes such as mental and physical health (Charles et al., 2013; Piazza, Charles, Sliwinski, Mogle, & Almeida, 2012). By using multiple timescales, the current project explores intraindividual variability in the daily stress–affect relationship in a context of intraindividual change and interindividual differences to understand how individuals are not only different from each other, but how they, themselves, change over time.

Aim 1 of the study is to understand how cross-sectional differences in age as well as longitudinal age changes relate to interindividual differences and intraindividual variability in the daily stress–affect relationship. We hypothesize that cross-sectional age as well as longitudinal age changes will relate to a buffered daily relationship between stress and NA as well as stress and PA. We also explore whether there is a cohort effect that relates to different trajectories in how individual experience the daily relationship between stress and affect. Aim 2 of the study is to assess the between-person effect of stress on the daily stress–affect relationship. As indicated by previous studies, we hypothesize that greater global stress perceptions will relate to an exacerbated daily relationship between stress and NA. We also explore whether greater global stress perceptions relate to differences in the daily stress–PA relationship, and whether the relationship among global stress, daily stress, and daily affect changes as individuals get older.

Method

Participants

The participants included 966 individuals from the NDHWB, a 10-year longitudinal study that includes both 56-day daily "burst" diaries assessed once every 2 years as well as global questionnaires assessed yearly. The current

study used data from the midlife and later life cohorts collected at Waves 1, 3, 5, 7, and 9 because these waves included the daily "burst" assessments. The design of the NDHWB involved sampling with replenishment, so new participants could join the study at different waves, even if they had not been present at Wave 1. In addition, some participants missed entire waves, but returned to the study at later waves. Twenty-six percent of participants completed all 5 years of data, 24% of participants completed 4 years, 14% completed 3 years, 12% completed 2 years, and 25% completed 1 year. Because there were 966 participants and five waves of data, there were 4,830 possible bursts of data. We collected 2,769 total bursts of data, so 42.7% of the data were missing, but 16.6% of that missing data were planned missing data, meaning the participants came into the study at a later time point and stayed in the study, but missed earlier waves. Participants completed 86% of the daily questionnaires during Wave 1, 91% during Wave 3, 90% during Wave 5, 91% during Wave 7, and 93% during Wave 9. There were no age, gender, education, income, race, or marital status differences among the participants based on the number of days they completed in the study. Participants at Wave 1 ranged in age from 31 to 90 (M = 59.00, SD = 9.71). See frequencies for the sample on gender, race, education, marital status, and income in Supplementary Table 1.

Procedure

Participants completed the global questionnaire at all waves, which included questionnaires regarding demographic information. After completing the global questionnaire, participants were invited to participate in the daily "burst" assessments. They were instructed to complete their daily diary at the end of each day and mail the diaries back at weekly intervals over the course of 8 weeks. The daily diaries included measures assessing NA as well as daily stress levels. Participants received $10 in compensation after each week of completing the diaries for a total of $80 across the 56 days. In order to ensure that participants completed daily diaries each evening, we did not penalize them for missed days. If they had not filled out their diary 1 day, we asked them to leave that diary blank. During Waves 5, 7, and 9 for midlife and Waves 7 and 9 for later life, the participants received a bonus of $20 (during Year 5 for midlife) or $30 (during Years 7 and 9) if they completed all eight weeks of the daily diaries.

Measures

Positive and negative affect schedule (PANAS)

Participants reported daily NA and daily PA using the NA and PA subscales respectively from the PANAS (Watson, Clark, & Tellegen, 1988), by indicating the extent to which they felt each of 10 emotions on a scale ranging from 1 to 5 (not at all, a little, moderately, quite a bit, extremely). Sample emotions of NA included "ashamed," and "afraid," whereas sample emotions for PA included "inspired," and "strong." A 20% missing data rule was applied to incomplete responses on the measure, so that if participants did not answer at least eight of the questions for either NA or PA, the data for that day were not counted. Otherwise, the mean response was substituted for missing data. Cronbach's α in the present sample on Wave 1 Day 1 is .87 for NA and .88 for PA.

Perceived stress scale

Participants reported daily stress levels by completing the Perceived Stress Scale (Cohen & Williamson, 1988). The current study modified 10 of the items to assess perceived levels of stress over the course of 1 day. Response options ranged from 1 to 4 (strongly disagree, disagree, agree, strongly agree). The measure includes items such as "Today I was upset because of something that happened unexpectedly," or "Today I felt difficulties were piling up so high that I could not overcome them. A 20% missing data rule was applied to incomplete responses on the measure, so that if participants did not answer at least 20% of the questions for that day, the data were not counted. Otherwise, the mean response was substituted for the missing data. Cronbach's α in the present sample on Wave 1 Day 1 is .88.

Analytic Approach

Three-level, multilevel models were used in order to assess daily intraindividual variability (Level 1), intraindividual change across waves (Level 2), and interindividual differences (Level 3; see Equation 1 for the full model). The first set of models uses NA as the dependent variable, and the second set uses PA as the dependent variable. The models were built sequentially, by first exploring the main effects, then the two-way interactions, and then the three-way interactions. Income (in the NA model) and education (in the PA model) were included at Level 3 to control for their effects because they were related to both dependent and independent variables. The data were analyzed using the SAS Proc Mixed procedure with Maximum Likelihood estimation, so missing data was assumed to be missing at random or missing completely at random (Fitzmaurice, Laird, & Ware, 2012).

The main effects model included day as a Level-1 (daily level) covariate, which controlled for systematic changes in daily stress over the course of the 56 days (Wang & Maxwell, 2015). Person-mean centered daily stress ($[\text{Stress}_{ijk} - \text{Stress}_{\cdot jk}]$) was included as a Level-1 predictor; Stress_{ijk} represents the observed daily stress score of person k in wave j at day i and $\text{Stress}_{\cdot jk}$ is person k's average stress score averaged across the days in wave j. β_{2jk} measures the within-person effect of daily stress on daily affect for person k in wave j. At Level 2 (wave level), for the β_{0jk} equation, we included wave (0 for Year 1, 2 for Year 3, etc.) to assess the effect of aging on affect (γ_{01k}) and $[\text{Stress}_{\cdot jk} - \text{Stress}_{\cdot\cdot k}]$ to

control for the effect of yearly fluctuations in the wave-level average stress on affect (γ_{02k}) for person k. Finally, at Level 3 (person level), for the γ_{00k} equation, we included Income (δ_{003}) as a covariate, Age at Time 1 to assess the effect of cross-sectional age differences on affect (δ_{002}), and $\text{Stress}_{..k}$ to access the between-person effect of stress on affect (δ_{001}), quantifying how individual differences in overall stress levels impact overall levels of affect. In contrast, δ_{200} measures the average within-person effect of daily stress on daily affect averaged across the waves and persons.

Next, we added in the two-way interactions. Specifically, Wave_{jk} was added to the β_{2jk} equation at Level 2, where γ_{21k} measures how the daily (within-person) stress–affect relationship changes with the aging process for person k (correspondingly, δ_{210} measures the average aging effect in the daily relationship averaged across persons). At Level-3, Age at Time 1 was added to the γ_{20k} equation to test whether cross-sectional differences in age relate to between-person differences in the daily stress–affect relationship at Wave 1 (δ_{201}). In addition, global stress, measured by $\text{Stress}_{..k}$, was added to the Level-3 γ_{20k} equation to examine whether the Wave-1 daily stress–affect relationship depended on overall global stress perceptions (δ_{202}).

The three-way interaction between Level 3 age, Level 2 wave, and Level 1 daily stress tested whether individuals of different starting ages show different within-person age-related changes in daily stress–affect fluctuations (δ_{211}). The three-way interaction between Level 3 age, Level 3 global stress, and Level 1 daily stress indicated whether the hypothesized exacerbating effect of global stress perceptions on the daily stress–affect relationship differed according to age differences (δ_{203}). The three-way interaction between Level 3 stress, Level 2 wave, and Level 1 daily stress tested whether individuals with different global stress levels differentially experience yearly changes in the daily stress–affect relationship (δ_{212}). In order to allow both models (for NA and PA as the separate dependent variables) to converge, some of the Level-3 effects were included as fixed effects only (Baird & Maxwell, 2016). The model with PA as the dependent variable was built the same way except we controlled for education at Level 3 instead of income. The final model (shown with NA as the dependent variable) is:

Level 1 (daily level):

$$\text{NA}_{ijk} = \beta_{0jk} + \beta_{1jk}(\text{day} - 1) + \beta_{2jk}(\text{Stress}_{ijk} - \text{Stress}_{.jk}) + e_{ijk}$$

Level 2 (wave level):

$$\beta_{0jk} = \gamma_{00k} + \gamma_{01k}(\text{wave}_{jk}) + \gamma_{02k}(\text{Stress}_{.jk} - \text{Stress}_{..k}) + \gamma_{03k}[\text{wave}_{jk} * (\text{Stress}_{.jk} - \text{Stress}_{..k})] + u_{0jk}$$

$$\beta_{1jk} = \gamma_{10k} + u_{1jk}$$

$$\beta_{2jk} = \gamma_{20k} + \gamma_{21k}(\text{wave}_{jk}) + u_{2jk}$$

Level 3 (person level):

$$\gamma_{00k} = \delta_{000} + \delta_{001}(\text{Stress}_{..k}) + \delta_{002}(\text{Age}_k) + \delta_{003}(\text{Income}_k) + \upsilon_{00k}$$

$$\gamma_{10k} = \delta_{100} + \upsilon_{10k}$$

$$\gamma_{20k} = \delta_{200} + \delta_{201}(\text{Age}_k) + \delta_{202}(\text{Stress}_{..k}) + \delta_{203}(\text{Age}_k * \text{Stress}_{..k}) + \upsilon_{20k}$$

$$\gamma_{01k} = \delta_{010} + \upsilon_{01k}$$

$$\gamma_{02k} = \delta_{020} + \upsilon_{02k}$$

$$\gamma_{03k} = \delta_{030}$$

$$\gamma_{21k} = \delta_{210} + \delta_{211}(\text{Age}_k) + \delta_{212}(\text{Stress}_{..k}) \quad (1)$$

Results

Descriptive Statistics

Descriptive statistics for the person means of stress, NA, and PA are presented in Supplementary Table 2. The number of waves participants completed, gender, and race were not related to the average levels of the variables of interest. Participants reported differences in average levels of NA associated with income ($F_{6, 935} = 7.54$, $p < .001$). Participants differed in their reports of PA based on education ($F_{7, 955} = 2.51$, $p = .015$) and race ($F_{5, 953} = 2.52$, $p = .028$). Participants reported significant differences on global stress according to education ($F_{7, 945} = 3.70$, $p < .001$) and income ($F_{6, 935} = 8.31$, $p < .001$). Compared to those with higher incomes, those with lower incomes reported greater average NA ($F = 30.82$, $p < .001$) and greater global stress ($F = 38.28$, $p < .001$). Compared to those with lower levels of education, those with higher levels of education reported greater PA ($F = 8.57$, $p = .003$) and less global stress ($F = 7.97$, $p = .005$). Because income related to both the NA and independent variables and education related to both PA and independent variables, we controlled for them in the respective analyses.

Analytic Results on NA

The results of the final model including all interactions (Equation 1) are presented in Table 1. Because daily NA was highly skewed (see Supplementary Table 2), we followed a reviewer's suggestion to use the log of daily NA as the dependent variable (Singer & Willett, 2003). The main effects model revealed that greater levels of daily stress positively relate to daily NA intraindividually ($\hat{\delta}_{200} = 0.03$, $p < .001$) and greater yearly fluctuations in wave average stress positively relate to NA ($\hat{\delta}_{020} = 0.03$, $p < .001$). Aging negatively related to NA ($\hat{\delta}_{010} = -0.03$, $p = .020$). The between-person effects of stress ($\hat{\delta}_{001}$) and cross-sectional age ($\hat{\delta}_{002}$) on NA were not significant.

Table 1. Effects Among Stress, Wave, and Cross-sectional Age on the log of Negative Affect

	Main effect estimates	Two-way interactions estimates	Three-way interactions estimates	*SE*	*t* value
Fixed Within Effects Estimates					
$\hat{\delta}_{000}$ (intercept)	1.93***	1.91***	1.91***	0.04	43.57
$\hat{\delta}_{100}$ (Day)	-0.00***	-0.00***	-0.00***	0.00	-13.43
$\hat{\delta}_{200}$ (Daily stress)	0.03***	0.01***	0.01***	0.00	3.54
$\hat{\delta}_{010}$ (Wave)	-0.00*	-0.00*	-0.00*	0.00	-2.28
$\hat{\delta}_{020}$ (Wave stress)	0.03***	0.03***	0.03***	0.00	14.39
$\hat{\delta}_{210}$ (Daily stress × Wave)		-0.00***	-0.00*	0.00	-2.33
Fixed Between Effects Estimates					
$\hat{\delta}_{001}$ (Global stress)	0.01	0.00	0.07*	0.00	1.00
$\hat{\delta}_{002}$ (Age)	-0.00	-0.00*	-0.03*	0.00	-2.28
$\hat{\delta}_{003}$ (Income)	-0.01***	-0.01***	-0.01	0.00	-1.28
Cross-Level Interactions					
$\hat{\delta}_{201}$ (Daily stress × Age)		-0.00***	-0.00	0.00	-1.42
$\hat{\delta}_{202}$ (Daily stress × Global stress)		0.00***	0.00***	0.00	6.45
$\hat{\delta}_{203}$ (Daily stress × Age × Global stress)			0.00	0.00	0.42
$\hat{\delta}_{211}$ (Daily stress × Wave × Age)			0.00	0.00	0.46
$\hat{\delta}_{212}$ (Daily stress × Wave × Global stress			0.00	0.00	1.25

Note: Standard errors and *t*-values are shown for the three-way interactions estimates.
*$p < .05$, ***$p < .001$.

All of the two-way interactions were significant, supporting our hypotheses. The Level 2 wave by Level 1 daily stress interaction revealed that the daily stress–NA relationship becomes weaker over years ($\hat{\delta}_{210} = -0.001$, $p < .001$; Supplementary Figure 1). Similarly, the Level 3 age by Level 1 daily stress interaction revealed that the daily stress–NA relationship is stronger for midlife adults compared to older adults ($\hat{\delta}_{201} = -0.0002$, $p < .001$; Supplementary Figure 2). Finally, the Level 3 global stress by Level 1 daily stress interaction revealed that individuals with high global stress had stronger daily stress–NA relationship compared to individuals with low global stress ($\hat{\delta}_{202} = 0.001$, $p < .001$; Supplementary Figure 3).

The final model that included the three-way interactions revealed that none of the three-way interactions were significant.

Analytic Results on PA

The results of the final model including all interaction terms are presented in Table 2. The main effects model revealed that greater levels of daily stress ($\hat{\delta}_{200} = -0.53$, $p < .001$) and greater yearly fluctuations in wave average stress ($\hat{\delta}_{020} = -0.89$, $p < .001$) inversely relate to PA at the intraindividual level. Aging (getting older) positively relates to PA ($\hat{\delta}_{010} = 0.12$, $p < .01$). The between-person effects of stress ($\hat{\delta}_{001}$) and cross-sectional age ($\hat{\delta}_{002}$) on PA were not significant. In addition, none of the two-way interactions were significant. The three-way interaction between Level 1 daily stress, Level 2 wave (getting older), and Level 3 cross-sectional age was significant ($\hat{\delta}_{211} = 0.001$, $p < .001$), indicating that the process of getting older relates to a weaker negative relationship between daily stress and daily PA for the adults in later life whereas for adults in midlife, aging relates to an enhanced negative relationship between daily stress and daily PA (Figure 1). The interaction between daily stress, wave, and global stress was also significant ($\hat{\delta}_{212} = -0.001$, $p = .02$), indicating that, for adults with high global stress, the daily inverse relationship between stress and PA is stronger with aging whereas for adults with low global stress, the daily inverse relationship between stress and PA is less related to aging (Figure 2).

Discussion

The NDHWB provides a unique opportunity for research on the stress–affect link given the extensive, longitudinally-assessed information available for tracking consistency and change in stress over time, as well as five bursts of 56-day diary data. The ability to detect the ebb and flow of short- and long-term adversity and the sporadic perturbations in stress over time that might be especially taxing illustrate the idiographic nature of the relationship between stress and affect. Specifically, we situate the stress–affect relationship in the confluence of individual differences, within-person fluctuations, and within-person long-term change. By including the effects of age at Time 1 and overall average stress levels, we demonstrate interindividual age and stress differences respectively, by assessing the relationship between daily stress and daily NA over 56 days, we show daily intraindividual variability, and by repeatedly assessing it every 2 years we illustrate age-related intraindividual change. The findings support previous research but uniquely add to the literature by showing that both

Table 2. Effects Among Stress, Wave, and Cross-sectional Age on Positive Affect

	Main effect estimates	Two-way interactions estimates	Three-way interactions estimates	*SE*	*t* value
Fixed Within Effects Estimates					
$\hat{\delta}_{000}$ (intercept)	44.28***	44.21***	44.20***	1.43	30.80
$\hat{\delta}_{100}$ (Day)	-0.01**	09.01**	-0.08**	0.00	-3.24
$\hat{\delta}_{200}$ (Daily stress)	-0.53***	-0.61***	-0.53***	0.06	-8.83
$\hat{\delta}_{010}$ (Wave)	0.11**	0.12**	0.12**	0.04	2.61
$\hat{\delta}_{020}$ (Wave stress)	-0.89***	-0.89***	-0.89***	0.06	-15.13
$\hat{\delta}_{210}$ (Daily stress × Wave)		0.00	-0.02**	0.01	-2.88
Fixed Between Effects Estimates					
$\hat{\delta}_{001}$ (Global stress)	0.07	0.07	0.07	0.07	1.12
$\hat{\delta}_{002}$ (Age)	0.05	0.05	0.05	0.02	1.94
$\hat{\delta}_{003}$ (Education)	0.25***	0.25***	0.25	0.06	4.41
Cross-Level Interactions					
$\hat{\delta}_{201}$ (Daily stress × Age)			-0.00	0.01	-0.55
$\hat{\delta}_{202}$ (Daily stress × Global stress)			-0.00	0.00	-0.21
$\hat{\delta}_{203}$ (Daily stress × Age × Global stress)			0.00	0.00	0.48
$\hat{\delta}_{211}$ (Daily stress × Wave × Age)			0.00***	0.00	4.61
$\hat{\delta}_{212}$ (Daily stress × Wave × Global stress			0.00***	0.00	3.43

Note: Standard errors and *t*-values are shown for the three-way interactions estimates.
$^{**}p < .01$, $^{***}p < .001$.

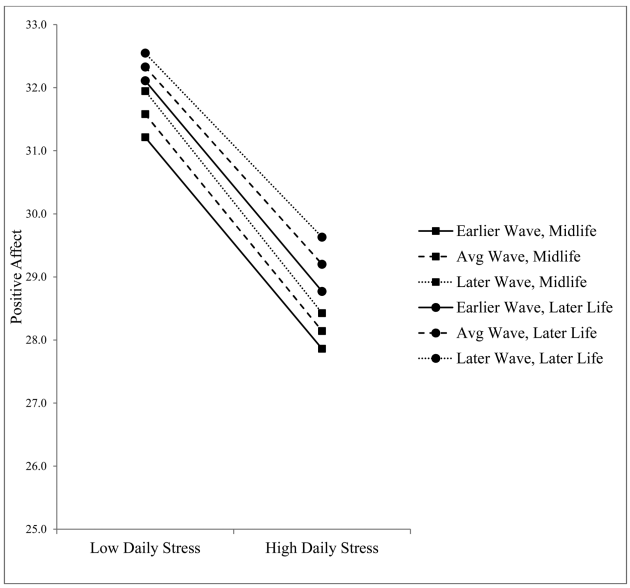

Figure 1. The interaction between daily stress, wave, and cross-sectional age on positive affect, plotted 1 *SD* below and above the mean for wave ($M = 3.53$, $SD = 2.80$), daily stress ($M = 0$, $SD = 3.11$), and cross-sectional age at Wave 1 (midlife = 50.07 years; later life = 68.85 years).

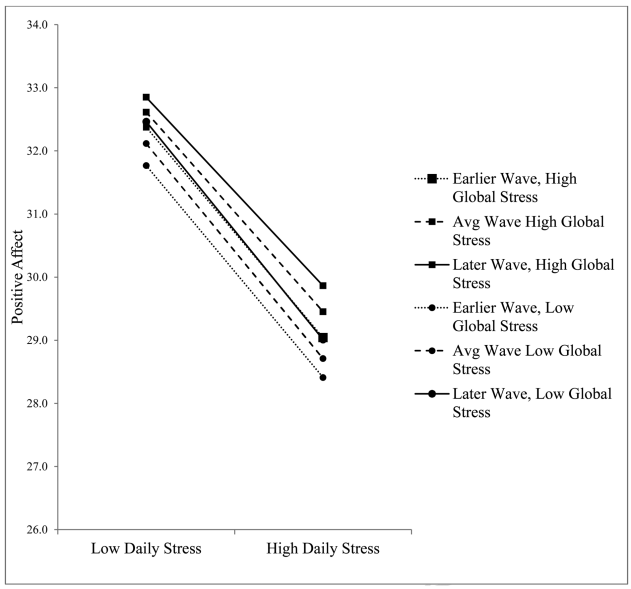

Figure 2. The interaction between daily stress, wave, and global stress on positive affect, plotted 1 *SD* below and above the mean for wave ($M = 3.53$, $SD = 2.80$), daily stress ($M = 0$, $SD = 3.11$), and global stress ($M = 18.53$, $SD = 4.18$).

the stress–NA relationship and the stress–PA relationship change differently and in unique ways for individuals of different starting ages.

The findings effectively tease apart the effects of aging within individuals and cross-sectional age differences between individuals by examining both wave (as an indicator of longitudinal age change) and age at Time 1 (as an indicator of cross-sectional age differences). Because both the two-way interactions between cross-sectional age and daily stress as well as wave and daily stress on NA were significant, we see that both age differences and the aging process uniquely impact the stress–NA relationship. These findings not only support previous research indicating age differences in stress reactivity (Brose et al., 2011; Scott et al., 2013; Stawski et al., 2008), but also add to the literature by indicating that adults tend to become less reactive to stress as they get older. Consequently, the aging process buffers the daily stress–NA relationship above and beyond the effects of cross-sectional age differences.

Moreover, the three-way interactions revealed that the process of getting older differentially relates to the daily stress–PA relationship depending on cross-sectional age. These findings illustrate the influence of cohort effects both in the current study and previous research. Specifically, we illustrate that older adults experience the buffering effect of time to a greater degree than midlife adults. The results revealed that older adults experience a weaker association between PA and stress over time, whereas midlife adults experience a stronger relationship as they get older. Thus, the findings suggest that as older adults age their PA levels become less affected by stress, but as midlife adults age they reflect greater stress effects on their PA. These findings highlight the importance of targeting interventions and preventative care strategies aimed at disrupting the daily stress–affect relationship toward adults in midlife, as they have a more coupled relationship between daily stress and affect. They further illustrate the importance of continuing to provide stress regulation strategies aimed at promoting greater positive emotions to midlife adults as they age.

The results also indicate that individuals with high global stress perceptions experience a stronger relationship between daily stress and NA, which supports previous research emphasizing that high global stress makes the effect of daily stress on NA worse (Almeida, 2005; Bolger et al., 1989; Hay & Diehl, 2011; Scott et al., 2013; Sliwinski et al., 2009). Conversely, the results of the three-way interaction on PA show that adults with typically stressful lives experience a stronger relationship between PA and daily stress as they age when compared to individuals with low global stress. Thus, interventions aimed at promoting stress regulation strategies that work to enhance PA may be particularly helpful to adults with greater global stress.

Researchers link daily affective experiences to emotional and physical well-being (Charles et al., 2013; Ong, Bergeman, & Bisconti, 2004; Piazza et al., 2012). In terms of psychological well-being, Ong et al. (2004) illustrate a relationship between low daily PA and depression. Further research indicates that the daily stress–NA relationship predicts long-term mental and physical well-being as much as 10 years later (Charles et al., 2013; Piazza et al., 2012). Thus, exploring how the daily stress–affect relationship changes within individuals and differs between them can illustrate where, how, and toward whom intervention and preventative care resources should be targeted. Although subjective ratings of stress do overlap with NA, using within-person assessments of stress perceptions allows us to control for each individual's unique perspective, as we are comparing individuals to themselves. Because the PSS is continuous, we can also assess the daily interface between stress and affect on a continuum to provide illustrative information about emotional regulation. By capturing the daily relationship between stress and affect multiple days over multiple years, we highlight how individuals fluctuate on a day-to-day basis, how they gradually change over time, and how they change differently depending on cross-sectional age. Future research can continue to situate the daily stress–affect relationship in an even broader context, exploring relationships between this relationship and other contextual factors. Furthermore, we do not explore how these relationships among cross-sectional age, aging, daily stress, and affect predict long-term mental and physical well-being. Consequently, an important next step is to link these dynamic relationships to macro outcomes, such a mental and physical health, to better understand the course by which daily processes impact long-term health.

In sum, the current project depicts the daily stress–affect relationship from an idiographic perspective, capturing intraindividual variability, intraindividual change, and interindividual differences. We not only illustrate how differences between individuals impact this relationship, but also how these processes unfold over time and how this development differs according to changes and differences in age and stress. Specifically, we demonstrate that both cross-sectional age and longitudinal age buffer the stress–NA relationship. Moreover, adults of different starting ages experience the daily relationship between stress and PA differently as they get older, suggesting an influence of cohort effects. Further, we show that global stress perceptions negatively impact the daily stress–affect relationships. The study indicates that targeting intervention and prevention care strategies at the daily level can promote better stress regulation. Specifically, we see that midlife adults and adults with greater global stress perceptions are most in need of these interventions, and encouraging these adults to maintain PA in the face of daily stress can be particularly beneficial. By exploring different components related to daily stress and affect multiple times across the years, the current study ultimately allows us to parse longitudinal age change from between person cross-sectional age differences and provide an illustrative picture of the dynamic daily stress reactivity process.

Supplementary Material

Supplementary data is available at *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences* online.

Funding

This work was supported by a grant from the National Institute of Aging (1 R01 AG023571-A1-01 to C. S. Bergeman).

Conflict of Interest

None reported.

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