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Age differences in emotional responses to daily stress: The role of timing, severity, and global perceived stress

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Abstract

Research on age differences in emotional responses to daily stress has produced inconsistent findings. Guided by recent theoretical advances in aging theory (Charles, 2010) that emphasize the importance of context for predicting when and how age is related to affective well-being, the current study examined age differences in emotional responses to everyday stressors. The present study examines how three contextual features (e.g., timing of exposure, stressor severity, global perceived stress [GPS]) moderate age differences in emotional experience in an ecological momentary assessment study of adults aged 18–81 (N=190). Results indicated older adults' negative affect (NA) was less affected by exposure to recent stressors than younger adults, but that there were no age differences in the effects of stressor exposure three to six hours afterward. Higher levels of GPS predicted amplified NA responses to daily stress, and controlling for GPS eliminated age differences in NA responses to stressors. No age differences in NA responses as a function of stressor severity were observed. In contrast, older age was associated with less of a decrease in PA when exposed to recent stressors or with more severe recent stressors. There were no age differences in the effect of previous stressor exposure or severity on PA, nor any interactions between momentary or previous stress and GPS on PA. Together, these results support the notion that chronic stress plays a central role in emotional experience in daily life. Implications of these results for emotion theories of aging are discussed.

Keywords

strength and vulnerability integration theory; overpowering hypothesis; emotions; daily stress; global perceived stress; age

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Stressors are familiar, if unpleasant, occurrences in life across the lifespan, but it is not clear whether older and younger people are equally affected by these events. Daily stress studies, in particular, have produced inconsistent findings. Some studies showed reduced (Brose, Schmiedek, Lövdén, & Lindenberger, 2011; Rook, 2003; Stawski, Almeida, Lachman, Tun, & Rosnick, 2010; Uchino, Berg, Smith, Pearce, & Skinner, 2006), another demonstrated amplified (Mroczek & Almeida, 2004), age-related responses, and yet others found no age differences in negative emotional response to stress (Röcke, Li, & Smith, 2009).

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Socioemotional theories of aging (Carstensen, Fung, & Charles, 2003) explain how adults maintain emotional well-being as they age, but provide less detail about the boundary conditions under which such age-related preservation and enhancement in emotional experience would (and would not) be observed. Recent theories (Charles & Piazza, 2009; 2010; Wrzus, Müller, Wagner, Lindenberger, & Riediger, 2013) clarify these inconsistent findings by specifying boundary conditions under which older age would be associated with better or worse emotional well-being. These provide *a priori* predictions for the conditions under which older age will be related to impaired, preserved, and enhanced emotional experience.

Strength and Vulnerability Integration theory (SAVI; Charles, 2010) draws from existing theory on age-based strengths in avoiding and diffusing stressful experiences. It also incorporates age-related vulnerabilities in physiological flexibility (e.g., reduced heart rate variability resulting in sustained physiological arousal following stressors) which may cause older adults to report similar or worse levels of well-being than younger adults. Thus, SAVI acknowledges that older adults can exhibit enhanced emotional experience (i.e., lower Negative Affect [NA]) compared to younger persons but proposes boundary conditions for this age advantage, emphasizing that it is “only by understanding the context of daily life can we predict when and how age is related to affective well-being” (Charles & Piazza, 2009, p. 711). The Overpowering Hypothesis (Wrzus et al., 2013) also provides specific predictions about how particularly demanding stressors can overwhelm older adults’ resources and put them at increased risk for the negative effects of stress. Guided by these notions, the current ecological momentary assessment (EMA) study examines how three contextual features (e.g., timing of exposure, stressor severity, individual differences in global perceived stress) moderate age differences in emotional experience. The present study aims to clarify the inconsistent findings in previous research for age differences in emotional response to stress by testing predictions in a sample of young, middle, and older adults surveyed repeatedly throughout the day for more than a week.

In the next section, we elaborate on predictions from SAVI, the Overpowering Hypothesis, and other theories on each of these features and how we operationalized them in this study. Predictions from SAVI and the Overpowering Hypothesis regarding in which contexts age differences in emotional well-being will occur are specifically for NA. We, therefore, do not pose predictions for PA but examine parallel models in order to provide informative data from which future predictions can be made.

Timing: When Age-Related Strengths Will Matter

According to several emotion regulation theories of aging (Blanchard-Fields, 2007; Carstensen et al., 2003; Charles, 2010; Heckhausen & Schulz, 1995), older adults use attentional strategies (Charles, Mather, & Carstensen, 2003; Mather & Carstensen, 2005), reappraisals (Shiota & Levenson, 2009; Wrosch, Heckhausen, & Lachman, 2000), and behavior (Coats & Blanchard-Fields, 2008) more frequently and effectively than younger adults in order to de-escalate negative events or avoid them entirely. Older adults’ strengths in strategy use are hypothesized to produce age-related advantages in emotional experience when they are observed. As Isaccowitz and Blanchard-Fields (2012) recently noted, however, direct evidence linking age differences in some of these strategies (e.g., attention) to emotion regulation is lacking.

One of the most innovative features of SAVI is in its attention to time as a context for emotional experience. SAVI outlines specific points in the stream of everyday emotional experiences at which age differences will and will not be present (see Charles, 2010, Figure 1) and implies that the ability to benefit from strategies depends, in part, upon temporal proximity to stressful events. Specifically, in the absence of stressors, SAVI predicts age benefits (i.e., older age associated with lower negative affect); age benefits are also predicted in general by Socioemotional Selectivity Theory (SST; Carstensen et al., 2003), though without a specification of the boundary conditions of these advantages. When a stressful event occurs, however, SAVI predicts that the age benefits seen in emotional well-being "will be attenuated or may even disappear entirely" (Charles, 2010, p. 1069). Charles states, "as a result of an inability to use thoughts and behavior to escape the situation, subjective emotional reports will be more similar across age groups" (2010, p. 1076). However, SAVI posits that given time after a stressor to engage their strengths such as reappraisal, older adults will again display enhanced emotional well-being compared to younger persons. That is, age-benefits in emotional well-being "will begin to emerge and will become greater as time from the event passes" (Charles & Piazza, 2009, p. 718).

Previous research

SAVI's predictions use time relative to event to divide emotional experiences as those occurring in the absence of stressors, reports occurring in the proximal period of stressors, and reports after stressors. Similar divisions also appear in laboratory stress studies. Experimenters expose participants to standard stressors under controlled laboratory conditions and observe emotional and physiological responses before, during, and after the stressor. Physiological and emotional reactivity is then calculated by comparing an individual's change in the outcome when the stressor is present to the baseline pre-stress period; recovery is the duration of this response (Linden, Earle, Gerin, & Christenfeld, 1997).

Analysis of data from daily diary and ecological momentary assessment (EMA) studies, however, often conflates these periods. Most of these naturalistic stress studies conceptualize and analyze the repeated measures data not as a sequence of experiences ordered in time (e.g., series of observations of an individual with attention to event-chronology: pre-stress, pre-stress, stress-event, post-stress, post-stress) as implied by SAVI but as a set of independent observations of stress and non-stress days or beeps (e.g., series of observations of same individual without attention to chronology: no stress, no stress, stress-event, no stress, no stress) within persons. That is, most analytic approaches that examine only the concurrent effects of stress on emotion (e.g., Sliwinski, Almeida, Smyth, & Stawski, 2009; Sliwinski, Smyth, Hofer, & Stawski, 2006) treat all non-event measurements as equivalent, whether or not they occurred immediately prior to or following the experience of a stressful event.

If age differences in emotional reports are contextualized by the timing of a stressful experience relative to the assessment emotions (e.g., specifically that older adults will fare as poorly or worse than younger adults during an event but that they will regain their enhanced emotional well-being as time passes) and different patterns regarding age differences are expected across these periods, lumping pre- and post- stress experiences together is problematic. One way to address the difference between pre- and post-event affect is through the use of lagged analysis, as were used in previous research which did not focus on age differences (Johnson et al., 2008; Ong, Bergeman, Bisconti, & Wallace, 2006; van Eck, Nicolson, & Berkhof, 1998) and employed in the current study. Lags allow for direct tests of whether age differences in emotional reports are contextualized by the timing (i.e., no stressor, current or recent stressor, stressor a few hours ago) of stressful experiences relative to their effects on emotion.

Predictions

To date, age differences in response to stressors have mostly been examined over months (i.e., Hart & Charles, 2012) and days (i.e., Charles, Piazza, Luong, & Almeida, 2009), the current study proposes to shift this to a more micro-level time scale (see also Wrzus et al., 2013) by examining age differences in lagged effects across hours. Guided by Charles (2010, Figure 1), we operationalize predictions related to time as follows. *In the absence of stress:* Older age will be associated with lower average levels of NA when stressors are not reported (i.e., the effect of age on level of NA when all other predictors, including stressor exposure, are zero). This prediction follows SAVI and SST. *During a stressful experience:* When reporting their emotions in the proximal period after stressors, older adults will be unlikely to benefit from their strengths at post-event reappraisal and will show similar increases in NA compared to younger persons; as predicted by SAVI. This will be evident in a non-significant age-by-recent stressor interaction. *After a stressor has passed:* Older adults' strengths at reappraisal will result in stressor effects being relatively short-lived compared to younger people. That is, older age will moderate the effect of previous stressor on current NA. Based on SAVI, older adults' mood will be less affected by stressors a few hours ago. This will be evident in a significant age-by-lagged stressor interaction.

Intensity: Situations in which Vulnerabilities Are Observed

Several recent theories propose that the intensity of the demands of a stressor are key determinants of whether older age will be associated with better emotional functioning. The intensity of the threat a stressor presents has been operationalized in numerous ways (Almeida, Wethington, & Kessler, 2002; Holmes & Rahe, 1967; Wrzus et al., 2013). In SAVI, physiological arousal is used in the model to index the intensity, challenge, or threat posed by a stressful experience. Specifically, SAVI states "in situations eliciting low physiological reactivity and…that dissipate quickly, [older] age may be related to better outcomes" (Charles, 2010, p. 1078). In contrast, "during exposure to a stressor that creates high levels of physiological arousal, no age-related benefits [are expected] in emotion regulation" (Charles & Piazza, 2009, p. 718). Charles (2009) suggests that these could be manifest in several systems, including cardiovascular and neuroendocrine. Factors other than age may also play key roles in these physiological reactions, as in the example of cortisol in which higher output is usually associated with acute stress, but the long-term effects of chronic stress can lead to lower cortisol output (Miller, Chen, & Zhou, 2007). Given that chronic stress can suppress physiological activity (Fries, Hesse, Hellhammer, & Hellhammer, 2005), using additional indices (e.g., subjective severity) to characterize stressor intensity is advisable, especially in groups of people that are hypothesized to be especially susceptible to the effects of chronic stress (e.g., older adults).

Wrzus and colleagues' (2013) Overpowering Hypothesis shares considerable similarity with SAVI's predictions regarding the demands a stressor poses. According to the Overpowering Hypothesis, age differences in emotional response will be apparent in situations with high demands that overwhelm older adults' resources. The Overpowering Hypothesis draws both from SST and Dynamic Integration Theory (DIT; Labouvie-Vief, 2003). Similar to SAVI, the Overpowering Hypothesis uses SST to outline the strengths of aging, predicting that older adults' motivation may enable them to maximize their emotional well-being, at least in low-demand situations. The influence of DIT forms the complement to the vulnerabilities outlined in SAVI. DIT suggests that declines in cognitive capacities in older age may result in older adults being less able to respond to the demands of situations and, thus, less effective emotion regulation (Labouvie-Vief, 2003).

In the current study, we use a more conventional approach (Almeida et al., 2002; Stawski, Sliwinski, Almeida, & Smyth, 2008) to characterize stressor intensity: subjective ratings of severity. Subjective appraisals of event severity are central to stress theory (Lazarus & Folkman, 1984) and frequently collected in stress studies. Little information, however, is available on how severe events need to be to produce immediate or persistent effects on mood. If the intensity of the threat or demands from a stressor influences the way an individual responds to it, as implied by theory, then investigating the role of stressor severity is a useful approach.

Previous research

Wrzus et al. (2013) tested predictions about the role of stressor demands in two experience sampling studies of participants ranging from adolescence to old age. Consistent with the Overpowering Hypothesis and SAVI, when exposed to demanding (e.g., complex events that affected multiple life domains) events, older age was not related to lower NA. Indeed, older age was associated with larger increases in high-arousal NA and decreased heart rate variability. For less demanding events (i.e., circumscribed stressors affecting a single life domain), Wrzus et al. found no age differences in NA responses and that older age was associated with less of a decrease in heart rate variability. Thus, there is some support for the prediction, posited by both SAVI and the Overpowering Hypothesis, that the demands of a stressor serve as a moderator of age differences in emotional responses to stressors.

Predictions

We operationalize predictions from SAVI and the Overpowering Hypothesis as follows. In *non-stressful conditions* (i.e., no event has occurred or an event occurred but is rated as not at all stressful), older age will be associated with less stressor-related NA. Whereas in *stressful conditions* (i.e., events reported and severity rated higher than not at all), this advantage will vanish and older adults will show more of an increase in NA. This difference will be evident in a significant age-by-severity interaction. These will be tested in both concurrent and lagged effects.

Chronic Stress: A Context for Daily Stressors

SAVI and SST point to older adults' strengths in selecting social environments in order to prevent negative experiences. According to SAVI, under situations of chronic stress (e.g., functional impairment, spousal caregiving) older adults' strengths in emotion regulation abilities will decrease or disappear. Complementary, a relative absence of chronic stress among healthy older adults may foster age benefits in responding to daily stressors. That is, the maturational changes in motivation posited by SST (Carstensen, 1995) may provide older adults with more positive psychosocial environments within which to respond to events.

Previous research

There is some support for the hypothesis that chronic stress may undermine age-advantages in emotional well-being. van Eck and colleagues (1998) found individual differences in reports of the global perceptions of the stressfulness (GPS) of life over the last month moderated the association between stressors and current NA as well as NA 90 minutes later, as well as concurrent event-related positive affect (PA). Stawski, Sliwinski, Almeida, and Smyth (2008) also found no age differences in NA response to daily stressors, however, older adults exhibited larger negative responses to daily stress when adjusting for individual differences in global perceived stress. That is, for a given level of GPS, older adults exhibited more stress-related NA than younger adults. Sliwinski and colleagues (2009) found average reactivity to daily events increased longitudinally across months and years and that the extent to which an individual's NA was tied to events depended on his or her current levels of global perceived stress.

Predictions

SAVI predicts that the "constant demands created by chronic, uncontrollable, unpredictable, and pervasive stressors override age-related strengths in emotion regulatory abilities" (Charles, 2010, p. 1081). Indeed, the global perceived stress measure (Cohen, Kamarck, & Mermelstein, 1983) used in the above studies (e.g., Sliwinski et al., 2009; Stawski et al., 2008; van Eck et al., 1998) aligns well with SAVI's definition of chronic stress: prolonged circumstances (i.e., reference period over the last month), with no means of escape (i.e., items reflecting lack of control, inability to cope successfully, unpredictability in life situation) which is distressing (i.e., items including nervousness, feeling 'stressed') and pervasive (i.e., items regarding day-to-day problems and annoyances, the most important things currently happening in life, and the way participants spend their time).

We operationalize chronic stress as GPS in this study and predict that individuals reporting higher levels of GPS will respond more strongly to stressors. This will be evident in a positive and significant interaction between recent stressor and GPS. Following van Eck et al., we also expect that negative emotional responses to stressors will persist longer for people experiencing higher levels of GPS. This will be evident in a positive and significant interaction between lagged stressor and GPS. Finally, we expect that controlling for individual differences in GPS will eliminate any age benefit in emotional responses to stress. This is because equating older and younger people on level of stressfulness of life in the last month removes one of the strengths of older adulthood, life situations selected and structured to enhance emotional experience (Carstensen et al., 2003).

Method

Participants

Participants included 190 adults ranging from young adulthood to old age (mean age = 48.86 years; range 20–81 years). Participants were recruited from an existing database of persons who had previously participated or expressed interest in the lab's research. Additional young and middle-aged males were recruited through a postcard mailing to a list of names purchased from an advertising agency. Participants who referred additional participants to the study received $25.

The sample is representative of the Atlanta Metropolitan area in terms of gender, SES, racial and ethnic diversity. The sample was 52% female and primarily Caucasian (72%; African American 18%; Other 10%); similar gender and racial distribution was achieved across the young, middle, and older portions of the sample. Participants were excluded from the study if they did not have a minimum of a high school education and did not speak English in their homes. Participants were also excluded if it was a non-typical week (i.e., death in the family, surgery), they were using anxiety or depression medications, or had schedules that would interfere with data collection (i.e., shift work). In order to achieve sufficient observations for other components of the larger study, the data from some persons were excluded after they had begun the protocol as described below; similar participants (e.g., age, gender, race) were later resampled in order to achieve the desired representation in terms of age, gender, and race.

Measures

Current affect—The affect items were developed for this study; the selection of items was influenced by several published studies of emotion and aging (Charles & Piazza, 2007; Charles, 2005; Magai, Consedine, Krivoshekova, Kudadjie-Gyamfi, & McPherson, 2006; Mikels et al., 2005; Tsai, Knutson, & Fung, 2006). Current negative and positive affect at the time of the survey were assessed via composites of three items each. Participants responded on a 0 (not at all) to 4 (very much) scale to the question, “To what extent are you sad at the moment?” The same question was asked for nervous and irritated. Momentary NA was created from a sum of these three items. For PA, a composite was created from the sum of items happy, excited and alert using the same question wording and response options. We calculated between and within person reliabilities for the affect measures (Cranford et al., 2006). Between person reliability was R_{1F} = .78 for NA and R_{1F} = .77 for PA; within person reliability was R_C = .65 for NA and R_C = .65 for PA.

Stressor events & severity—Stressor events were assessed at each survey by the question “Did you experience a disruptive event since the last beep?” Participants were instructed to select “yes” if something occurred which interfered with their current plans or disrupted their daily routine. Participants were instructed to respond “yes” even if the obstacle or problem had been resolved by the time of the beep. If multiple disruptions had occurred since the last survey, participants were instructed to respond to the questions regarding the most disruptive event. When events occurred, participants were then asked “how stressful was it?” and used a 1 (not at all) to 5 (very much) rating scale.

Global perceived stress (GPS)—Overall perceptions of current life stress were assessed using the 10-item Perceived Stress Scale (PSS; Cohen et al., 1983; Cohen & Williamson, 1988). The PSS was designed to assess the degree to which individuals appraise the situations in their lives to be unpredictable, uncontrollable, and overloaded. Participants are asked to reflect over the last month and report the frequency of agreement on a 1 to 5 scale (never, almost never, sometimes, fairly often, always). α = 0.88.

Procedure

The present study focuses on the data from the 10 days of momentary surveys and individual difference measures from a larger project on everyday problem solving, goals, and emotions. Participants attended a 1–3 hour training session in the lab on the use of the Palm Pilot Tungsten T2 (Palm, Inc., 2003) and instructions for the study. Prior to the training session, they received demographic and other paper and pencil individual difference surveys which they completed and brought to the lab session. Data collection began the following day. Participants were “beeped” to respond to the Palm Pilot surveys five times each day, within 15 minutes of 9:00 am, 12:00 pm, 3:00 pm, 6:00 pm, and 9:00 pm. Participants reported on emotional states at the time of the survey, as well as the occurrence of disruptive events in the period since the last beep; surveys took about 5 minutes to complete. Research assistants conducted follow-up calls with participants at the end of the first day to ensure that they understood the protocol. After three days, participants returned to the lab for a 15 minute checkup session in which research assistants downloaded the survey data and checked compliance. Participants who responded to 80% of the beeps were asked to continue in the study for another 7 days, for a total of 10 days. Upon completion, participants returned their Palm Pilots and completed paper and pencil surveys in the lab. Participants who completed all parts of the study received $100. Those who did not complete 80% of surveys at the three day check-up exited the study at this time and received pro-rated compensation (e.g., $30), as described in the informed consent. Of the 246 recruited for the study, 45 (18%) exited at the check-up session; the most common reason for participants electing to drop out of the study was that the protocol was too time intensive; they did not differ from the final sample on demographics or GPS. These were resampled in order to meet the planned age, gender, and racial diversity of the design, with a planned enrollment of approximately 180 in total. Data from 10 participants who completed the entire protocol were omitted from this analysis because they met study exclusion criteria during the study period. Data from a total of 190 participants was included in the study.

Participants completed 79% of surveys within 30 minutes of the beep prompt; surveys which were answered more than 30 minutes after being beeped were excluded. In five of these observations, participants responded to the beep within 30 minutes but the palm pilot crashed and no data was recorded on the variables of interest. A total of 8892 observations were used in the analysis. Due to a computer error, the scheduled beep times for five individuals were not recorded. Because of the high compliance in the verified times, we decided to include these individuals in the analysis. Due to the same error, the scheduled beep times for 696 observations were not recorded; because of the high compliance in the verified times, we chose to retain these observations. Analyses were conducted with and without these observations. The pattern of results held across all models with the exception of NA Model 1; the event-by-age effect was in the same direction and nearly the same size but was not significant when these observations were excluded.

Analytic Strategy

We used multilevel linear models (Snijders & Bosker, 1999) to examine SAVI predictions regarding age differences in the recent (i.e., concurrent) and previous (i.e., lagged) stress slopes on momentary NA and PA. We first test the effect of concurrent and lagged stressor exposure without reference to severity (see Model 1 in Tables 2 and 4). Lags represented responses at previous beep and were not carried across days; therefore, the first lagged observation of the day was always set to missing. Then, we model stressor exposure and severity simultaneously using the combined exposure and severity variable discussed above. We then examined age and finally GPS as moderators of these effects (Models 3–4). Linear and nonlinear age effects were tested; we divided the sample into quintiles in order to allow for non-symmetric nonlinearities across the lifespan. Nonlinear effects did not alter the central findings except where noted below. Person mean stress (e.g., the proportion of an individual’s observations which were stress events; individual’s average severity rating) were included to control for individual differences in event frequency and severity. We centered the lagged predictors (including the lagged versions of NA and PA) in order to account for the bias due to individual differences in this nested data. Person-day centering was used to account for the dependency in the lagged data. Observations close in time may be similar not solely because they are from the same person but because they occurred on the same day (for example, due to day of week effects) In the example of NA, each momentary NA report was subtracted from the person’s average NA for that particular day. Grand mean centered age and GPS were entered as moderators. Random day-level and person-level effects were included for intercepts and concurrent stress. Random effects were also included for lagged emotion and stress variables when this addition improved model fit.

Results

The Results section is presented in three parts. First, we present descriptive statistics and correlations for the stress and affect variables with age and GPS. Second, we present multilevel models examining the associations between age and GPS associations with momentary event-related and severity-related NA. These associations indicate the extent to which the relationship between, for example, being exposed to a stressor and reporting more NA depends on the age of the individual. Third, we present analyses examining these associations for momentary PA.

Descriptive statistics

Momentary measures (PA, NA, stressor frequency and severity) were averaged across all measurements to compute the between person correlations in Table 1. Age was negatively correlated with average momentary NA, indicating that older persons tended to report lower levels of NA. Age was also negatively associated with GPS ($r(186) = -.15$, $p<.05$, but unrelated to momentary PA, stressor exposure, stressor severity. Associations between the momentary stressor variables and NA were moderate (ranging from .17 to .27); stressor severity but not exposure was related to PA. GPS was unrelated to stressor exposure and PA, but positively associated with severity and NA. Average momentary NA and PA reports across stress and non-stress beeps were moderately associated.

Negative affect

Preliminary models used categorical coding of stress incorporating exposure and severity (e.g., 0: no stressor occurred, 1: stressor occurred but rated not at all stressful, 2: stressor occurred and rated 2, etc., 5: stressor occurred and rated 5 very stressful). We tested whether these ratings differed from each other in predicting NA; results are displayed in Figure 1. Indeed, compared to each other, each of the severity ratings 1–5 predicted significantly higher NA. Levels of NA for severity rating 0 (no event reported), however, and severity rating 1 (event reported but rated not at all stressful) did not differ from each other. Therefore, in all subsequent models, we used coded no stressor and stressors rated not at all stressful as 0 and each of the severity ratings 1 to 4 and modeled them as continuous predictors of momentary emotional experience (see Models 2–4). For consistency, we used the same coding for lagged stressor effect in the results presented in the tables. Based on a reviewer's suggestion, we did a follow-up analysis for the lagged stress effect and found that only lagged stressors rated 5 (very stressful) produced significant increases in current NA compared to non-stressors. All other levels of lagged severity (1: stressor occurred but rated not at all stressful to severity rating 4) did not differ from no lagged stressor reported; see Figure 2.

Timing—We tested the prediction that age-related strengths in emotion regulation depend on the timing of stressful events by examining the effects of concurrent (i.e., stressor reported at same survey as NA report) and previous (i.e., stressor reported at previous survey) stressor exposure, see NA Model 1 in Table 2. Because participants responded to beeps approximately every three hours and reported on stressors occurring any time in the three hours since the last beep, lagged effects refer stressors occurring as little as three (e.g., at the time of the previous survey) and as long as six (i.e., the three hour period leading up to the previous survey) hours ago. Older age was associated with less of an increase in NA in response to concurrent events ($est = -0.0108$, $SE = 0.00524$, $p < .04$) but these age benefits dissipated over time. Three to six hours after an event, older and younger individuals did not differ in the effect of exposure to a previous stressor on NA ($est = 0.000132$, $SE = 0.003085$, $p = .97$).

Severity—Using a separate model, we tested the prediction that age benefits depend on the severity of the stressor and included lagged effects to examine recent and previous stressor experiences, see NA Model 2 in Table 2. When differences in the severity of stressors are accounted for, no age differences are observed in the effect of concurrent ($est = -0.00183$, $SE = 0.001867$, $p = .32$) or previous stress ($est = -0.00016$, $SE = 0.001158$, $p = .88$). That is, older and younger adults exhibited similar increases in NA as a function of the severity of the stressful event.

GPS—Building from NA Model 1 and 2, we examined chronic stress as a condition which SAVI predicts would undermine age benefits. When individual differences in global perceptions of stress (GPS) are included, the age benefits observed in NA Model 1 for recent stressor exposure are no longer apparent ($est = -0.00828$, $SE = .005318$, $p = .12$), see NA Model 3 in Table 3. Further, individuals reporting high levels of GPS were more affected by recent ($est = .04823$, $SE = 0.01698$, $p < .01$) and previous stressor exposure ($est = 0.02705$, $SE = 0.01037$, $p < .01$). The role of GPS as an amplifier of stress-related NA was also observed for severity of recent events (*est* = 0.01257, *SE* = 0.006178, $p < .05$), see NA Model 4 in Table 3; no age differences were found.

We tested whether linear age moderated the effect of GPS on recent or lagged stress but none of the three-way interactions were significant. There was a significant interaction between lagged stress, GPS, and nonlinear age in which the effect of GPS was more strongly related to previous stressor severity in middle aged adults (i.e., 43–56 year old category in this sample) compared to the reference group of the oldest adults (70–81 year olds). The other age groups did not differ from the reference group for this effect. With this significant three way interaction in the model, the recent stressor severity by GPS interaction was not significant. The age differences in the intercept of NA found in Models 1–4 appear to be driven by differences between the youngest (20–26 year olds) and oldest participants in the sample. The other age groups did not differ from the oldest adults in average NA.

Positive affect

We explored parallel models for interactions between age and concurrent and previous stress on momentary PA. These are summarized in Tables 4 and 5. Contrary to the NA results, an age advantage (i.e., older age associated less of a decrease in PA when exposed to recent stressors or with more severe recent stressors) was observed across all models. There were no age differences in the effect of previous stressor exposure or severity on PA. Chronic stress, as assessed by GPS, was unrelated to the effect of recent or previous stress on PA. Three-way interactions between stress, GPS, and linear age were not significant.

Examining nonlinear age effects with quintiles, we found that the two youngest groups in the sample, which spanned ages 20–42, reported significantly larger decreases in PA for recent stressors than the oldest participants did. This difference was apparent between 26–42 year olds and the oldest adults in the sample when examining nonlinear age effects on severity-related PA. A nonlinear effect was found in which 57–70 year olds' stressor-related PA was more affected by GPS than the oldest participants in the sample. GPS as a moderator of previous stressor severity on PA was significant when nonlinear age effects were included in the model. Further, the three-way interaction between age quintiles, GPS, and previous severity was significant; relative to the oldest persons in the sample, all other age groups reported significantly larger reductions in PA related to the effect of GPS on lagged severity.

Discussion

Findings that older adults report lower levels of negative affect have been interpreted to be a result of the motivational shifts toward emotion regulation goals outlined in SST (Charles, Reynolds, & Gatz, 2001). Recent theoretical developments (Charles, 2010; Wrzus et al., 2013) posit that there are boundaries for these age advantages in emotional experience. Specifically, SAVI predicts that time, intensity, and chronic stress serve as moderators of age differences in emotional experience. The Overpowering Hypothesis also predicts that the features of the stressor may determine whether or not age differences will be observed. The present study is the first to examine how time since stressor, severity, and GPS relate to age differences in daily emotional well-being. Below, we discuss the results of the present study in light of these theories of adult age differences in emotion regulation abilities.

Age Differences in Emotional Response to Events

In this study, older adults' NA was less affected by the recent occurrence of a stressor. Older adults, however, do not experience this advantage when severity ratings or psychosocial conditions (e.g., global perceived stress) are taken into account. Age differences in social contexts are implied by SST but their impact on emotion regulation may be underappreciated. Specifically, individual differences in emotional responses to stress may reflect the influence of age differences in motivations that shape the broader psychosocial context within which daily life transpires. By extension, the age differences examined here and in previous studies cannot be properly understood without a good assessment of broader life context because 1) we expect there to be age differences in social context (Carstensen et al., 2003) and 2) context shapes how we respond to stress (Charles & Piazza, 2009; Pearlin, 1989; Wheaton, 1996).

Timing—Drawing from research on older adults' strengths at reappraisal and other post-event processing, SAVI predicts that older adults would be disadvantaged during a negative event but that older age would be associated with better emotional well-being as time passes from the event. We found that time did play an important role in age differences in response to event exposure, but not in the expected direction. Instead, older adults' NA was less affected by exposure to recent events than younger people (i.e., NA Model 1), but three to six hours after an event there were no age differences in NA-response to event exposure.

One possible explanation for this result is in the speed at which regulation to daily events unfolds. None of the theories we examined specify the time period over which individuals regulate and recover from stressors in daily life. It may be that the window of observations in this study, did not match the nuances of emotion regulation *invivo*. One possibility is that the spacing between observations (several hours) was too coarse to observe age-related vulnerabilities in emotion regulation that is concurrent with a stressful event. That is, it is possible that by the time participants were prompted to report an event, sufficient time had already passed for age-related strengths in emotion regulation to re-emerge. Alternatively, a few hours may be insufficient time and it may require days, not hours, to observe the re-emergence of age-related strengths in emotion regulation.

This attention to the timing of events and emotional states is extremely important for advancing theory. The emotional effects of stress persist for people of all ages, as indicated in the lagged effects for NA, and there are individual differences (e.g., global perceived stress) in the strength of these enduring effects. A better understanding of age differences in emotional responses to daily stress requires explicit attention to the time course of events and consequent affective states (Charles, 2010).

Severity—SAVI and the Overpowering Hypothesis propose that older adults may be more vulnerable to events which are more intense, demanding, or complex. In this study, we indexed intensity via severity ratings. We did not find strong support for this prediction, in the form of an interaction between severity and age. However, we did find that although older adults exhibited smaller negative emotional responses to mere stressor exposure, this advantage did not extend to stressor severity. That is, older adults were just as affected by increasing stressor severity as younger adults.

It is possible that the lack of age differences in response to events which are more severe, as well as the absence of age differences in how participants rated the severity of the events, may be due to the timing of measurement in this study. End-of-day reports in diary studies may be detecting older adults' use of their skills at reframing to downplay the severity of events when recalling their stressors at the end of the day, but when reporting severity at more proximal periods of stressors – as used in this study – these strategies may not have yet taken effect. In contrast to our results, Wrzus and colleagues (2013) found that older adults were more negatively affected by more complex events, where complexity was defined by the whether an event affected a single or multiple domains. Future research should examine how age differences depend upon different measures of stressor intensity (e.g., subjective ratings, physiological reactions, event complexity).

GPS—Previous work shows that the amount of global perceived stress moderates the effects of momentary stress on negative mood both at cross-section (van Eck et al., 1998) and longitudinally (Sliwinski et al., 2009). Further, there is some work that suggests that younger adults experience more perceived stress and that this difference can influence the magnitude and direction of the relationship between age and the effects of daily events (Stawski et al., 2008). Consistent with this work, we found that individual differences in perceived stress moderate the effect of recent and previous stressor exposure on NA. As mentioned above, the finding that those individuals experiencing high levels of chronic stress also report prolonged emotional responses to daily events is an important target for intervention.

Further, we found that statistically controlling for individual differences in perceived stress eliminates the age advantage in NA response to stressor exposure. The age benefit initially observed for stressor exposure may be due to older adults living in more favorable and less stressful psychosocial environments. Age differences in chronic stress in the form of the ongoing stressfulness of life (e.g., GPS) could result from the antecedent emotion regulation strategies predicted by socio-emotional selectivity theory (Carstensen, 1995) in which, with decreasing amounts of time left to live, older adults structure their lives to prioritize emotional goals (Carstensen, Isaacowitz, & Charles, 1999; Carstensen, 2006) and invest in valued and rewarding social relationships. The age advantage observed in NA Model 1, then, may result from older adults living in more favorable, or less adverse, environments than younger adults, which may afford them more resources to respond to disruptive events as they appear. This study and others (Charles et al., 2009; Stawski et al., 2008) highlight the nature of the psychosocial contexts in which stressors occur often favors older adults. When involved in a conflict that may generate a stressful event like an actual argument, if the argument is avoided, older adults have less of a negative mood response to this potential stressor than younger persons (Charles & Piazza, 2009). However, they are just as affected as younger persons by arguments which do occur. When controlling for individual differences in GPS in the present study, age provides no advantage in responding to events and may actually be disadvantageous (Stawski et al., 2008). Therefore, it appears that when older adults are exposed to unavoided stressors, in the form of equivalently severe daily events or similarly stressful and uncontrollable psychosocial conditions, they are as affected as younger persons by everyday stressors.

Positive Affect—SAVI addresses subjective emotional reports broadly, but the specific hypotheses are most clearly articulated for NA. The Overpowering Hypothesis focused on NA and physiological responses. Therefore, our analyses of PA responses to daily stress were exploratory and were presented to provide needed data from which future predictions will be developed. Using parallel models from our NA analyses, we found a different pattern of effects suggesting that regulating positive emotions in the face of daily stressors may work differently. We found consistent age benefits in the form of higher PA following recent stress, both as indexed by exposure and severity. Older adults reported less of a reduction in PA at surveys in which an event had recently occurred and for events which were more severe. The time period over which PA is regulated, however, may also be shorter than the window available in this study, as by three to six hours later there were no age differences in the effect of stress on PA. This is somewhat consistent with Hart and Charles' (2012) study of colorectal patients; they found no age differences in level of positive emotions and no change in PA across more than a year regardless of age. Further GPS, as an index of chronic stress, did not moderate either the immediate or lagged effects of stress on PA. In light of the current findings, future theoretical developments may generate more specific and separate hypotheses for positive and negative emotions.

Additional Findings: Severity and Age

In addition to the theoretical predictions examined, the study also provided useful information on key topics for which is there is not yet much theory. Although severity ratings are commonly collected in daily stress research and have a central role in stress and coping theory, relatively less attention has been paid to how severity operates. In light of well-known and important concerns about subjective appraisals (Monroe & Kelley, 1997), the data presented in Figure 1 provides some new perspective. Specifically, it is interesting to observe that when participants in this study reported an event that they rated as not at all stressful, their NA is indistinguishable from times when no stressors had occurred. For recent events which were rated at least some level of stressfulness, NA was significantly higher than non-stressor times. Further, it appears that the extent to which stressors earlier in the day still affect mood later is driven by events rated the most severe. This may be common sense, but to our knowledge, this is the first data to demonstrate that the extent to which a stressor’s effect on mood endures across the day depends on how severe the event was. Finally, theory regarding age differences in emotional responses to stressors is silent on how middle aged adults will respond. Most examinations, like ours, have focused on linear effects of age or compared extreme age groups. In follow-up analyses, we found some evidence for nonlinear effects but given the absence of theory or a clear pattern of findings, we await further data to understand whether these are maturational shifts, differences in psychosocial contexts, or specifics of the sample.

Limitations and Conclusions

Several limitations of the study must be noted. First, testing for age moderation of lagged stressor effects may not provide the most sensitive test of SAVI’s prediction of age differences increasing as time from the event passes. Currently, we know little about the time course of emotional responses to daily events. Researchers have found stress related-NA and -depressed mood persisting for up to two days in a diary study (Ong et al., 2006) and 90 minutes (van Eck et al., 1998) to six to nine hours (Johnson et al., 2008) later in EMA studies; event severity predicted decreased PA up to three to six hours (Johnson et al., 2008). None of these studies, unfortunately, examined age differences in these lagged effects. If, as SAVI predicts, age differences will appear “immediately after appraisal mechanisms are employed” (Charles & Piazza, 2009, p. 718) and the implementation of these reappraisals happens later (e.g., more than nine hours later or the next day), we would not be able to detect the age differences in our single lag analyses. Second, in this study, composites of items were used for NA (e.g., sad, nervous, irritated) and PA (e.g., happy, excited, alert). To the extent that there may be differences in, for example, depressive, anxious, and angry responses to stress, it would be helpful in future studies to include multiple items for each of these components of NA. Third, this study showed that for equal levels of stressor severity, there is little evidence for age differences in emotional responses to stressors. This study does not address, however, the hypothesized strength of aging in the form of appraising the same event as less stressful than younger people. Stress and coping theory (Lazarus & Folkman, 1984) proposes that the way an individual appraises the event influences his or her emotional response to it. As this study examined naturally-occurring, self-rated stressors, we could not investigate age differences in appraisals of the same type of stressors. Finally, data loss due to compliance issues and equipment malfunctions limited the available observations for these analyses. Although those observations lost to malfunctions were unretrievable, we took a conservative approach of also excluding any observations for which participants did not respond within 30 minutes of the beep.

Despite these limitations, this study tested a set of predictions based on recent theory regarding age differences in emotional experience in the recent and extended period following a daily stressor. As additional tests of these theories appear in the literature, there will be a stronger evidentiary basis on which to refine the theory and provide a principled account of the ways in which regulation of NA and PA may differ as well as the time course over which age benefits may appear and how this may depend on the immediate (e.g., timing, severity) and broader psychosocial stress (e.g., GPS, other chronic stressors) context. As demonstrated here and asserted in the title of a paper introducing SAVI, for “age differences in affective well-being, context matters” (Charles & Piazza, 2009, p. 711). In order to better understand when and how age differences in emotional well-being and regulation unfold, future studies of daily stress and emotions should incorporate this perspective.

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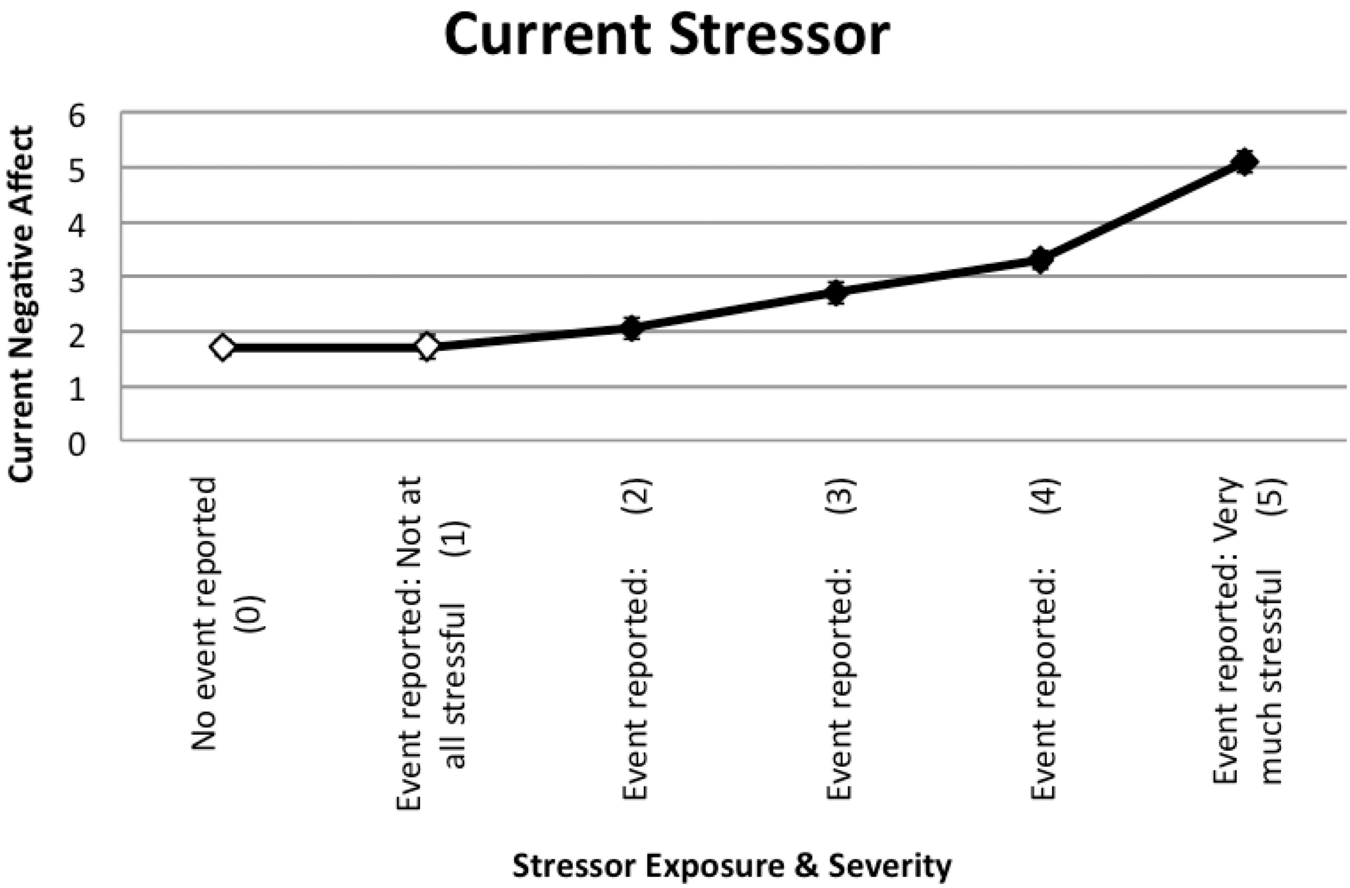

Figure 1.
Estimated current negative affect (NA) for each level of current stress. Self-reported severity ratings for events appear in parentheses. When no event was reported, severity was coded 0. Current stressor: Stressor reported at current survey (i.e., occurred in last 0–3 hours). Filled points: significantly different from NA when no event was reported (category 0), $p < .01$. Open points: nonsignificant difference from NA when no event was reported.

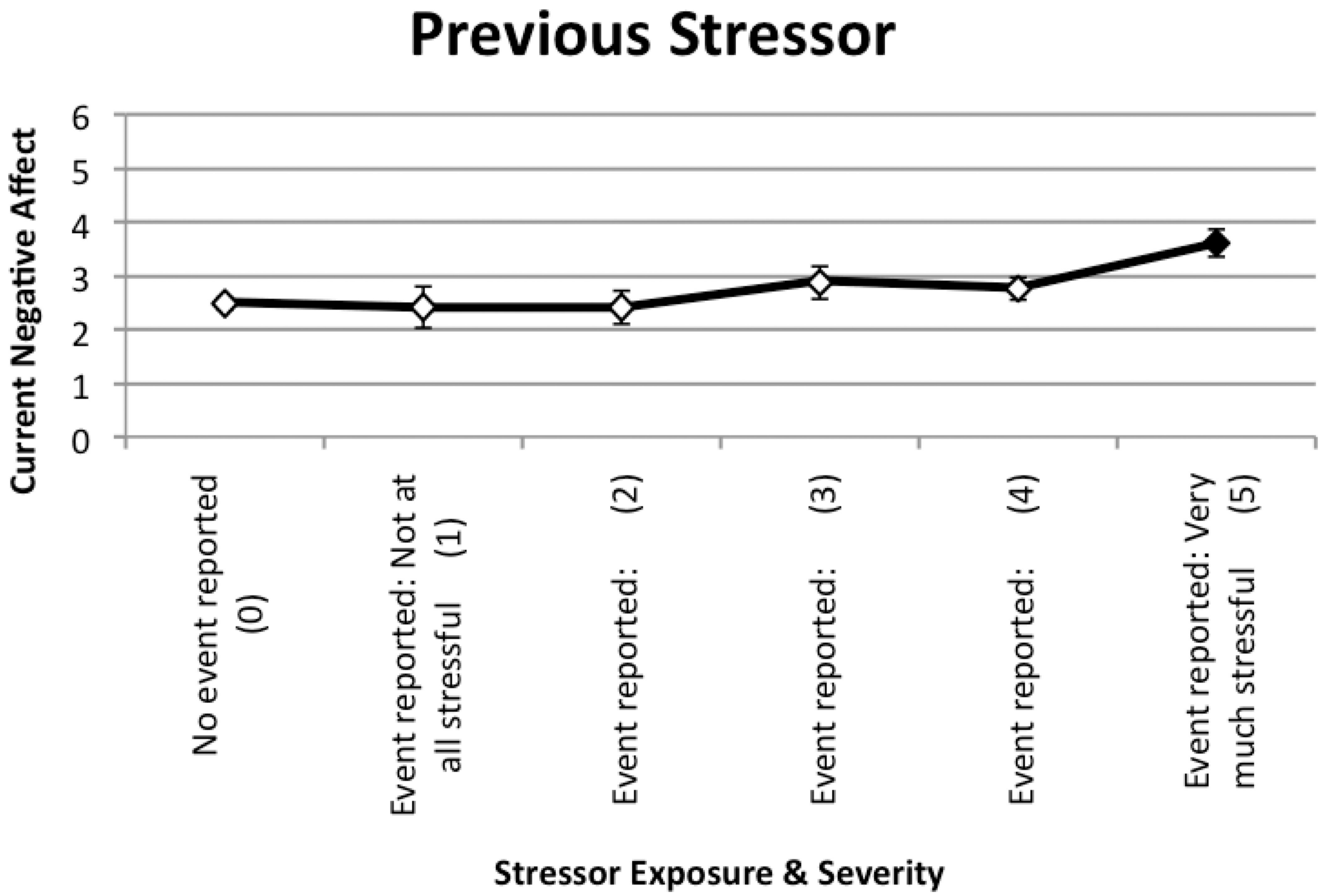

Figure 2.
Estimated current negative affect (NA) for each level of previous stressor. Self-reported severity ratings for events appear in parentheses. When no event was reported, severity was coded 0. Previous stressor: Stressor reported at current survey (i.e., occurred in last 3–6 hours, lagged effect). Filled points: significantly different from NA when no event was reported and every other severity level (categories 0–4), $p < .01$. Open points: nonsignificant difference from NA when no event was reported and every severity level except "very much stressful" (category 5).

Table 1

Descriptive Statistics and Correlations Among Age, Momentary Stress, Global Perceived Stress, and Daily Affect

Variable	***M***	***SD***	**1**	**2**	**3**	**4**	**5**
1. Age	48.86	19.29	-				
2. Stressor event[a, b]	0.13	0.09	−.02	-			
3. Stressor severity[a, c]	0.29	.25	−.10	.87**	-		
4. Global Perceived Stress[d]	22.68	6.07	−.15*	.11	.22*	-	
5. Negative affect[a]	1.65	1.46	−.27**	.17*	.30**	.35**	-
6. Positive affect[a]	7.09	1.48	.13	−.13	−.18*	−.34	−.40**

[a] Mean value reflects average taken across days and beeps for each individual.

[b] Stressor event: No = 0, Yes = 1.

[c] Stressor severity: 0: No event reported, event reported as not at all stressful, 1 – 4: Severity rating of event.

[d] Four participants provided momentary and age data but were missing on GPS.

* $p < .05$.

** $p < .01$.

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Table 2

NA Model 1: Age & Exposure			*NA Model 2: Age & Severity*		
Variable	***Estimate***	***SE***	**Variable**	***Estimate***	***SE***
Fixed Effects			Fixed Effects		
Intercept	1.2446	0.1633**	Intercept	1.394	0.1561**
Age	−0.01898	0.005139**	Age	−0.0187	0.005062**
Previous NA (WP)	−0.1565	0.01694**	Previous NA (WP)	−0.1744	0.01668**
Stressor (BP)	1.4834	0.1003**	Severity (BP)	0.6469	0.2954*
Recent Stressor (WP)	1.4834	0.1003**	Recent Severity (WP)	0.6465	0.03586**
Previous Stressor (WP)	0.3029	0.06079**	Previous Severity (WP)	0.1413	0.02338**
Recent Stressor X Age	−0.0108	0.00524*	Recent Severity X Age	−0.0018	0.001867
Previous Stress X Age	0.000132	0.003085	Previous Severity X Age	−0.0002	0.001158
Variance Components			Variance Components		
Between person			Between person		
Intercept	1.781	0.1922**	Intercept	1.7218	0.186**
cov(Int, Stressor)	0.04294	0.1443	cov(Int, Stress)	−0.0416	0.0488
Stressor	0.5178	0.1824**	Stress	0.04051	0.02159*
cov(Int, Previous NA)	−0.03239	0.02361	cov(Int, Previous NA)	−0.0327	0.02284
cov(Stressor, Previous NA)	0.02523	0.02105	cov(Severity, Previous NA)	0.00674	0.007433
Previous NA	0.01479	0.004247**	Previous NA	0.0044	0.004218
Within person			Within person		
Intercept	0.333	0.03258**	Intercept	0.3694	0.03246**
cov(Int, Stressor)	0.176	0.08372*	cov(Int, Severity)	0.03442	0.03004
Stressor	2.0361	0.2643**	Severity	0.2537	0.03583**
Residual	1.6515	0.03632**	cov(Int, Previous NA)	−0.0025	0.0122
			cov(Severity, Previous NA)	0.00674	0.01502
			Previous NA	0.04984	0.009723**

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NA Model 1: Age & Exposure			*NA Model 2: Age & Severity*		
Variable	***Estimate***	***SE***	**Variable**	***Estimate***	***SE***
			Residual	1.5221	0.03553**

* $p < .05$.

** $p < .01$.

Note: Between person (BP) refers to Level 3 (i.e., persons); within person (WP) refers to Levels 2 (i.e., days) and 1 (moments).

Table 3

NA Model 3: Age, Global Perceived Stress, & Exposure			*NA Model 4: Age, Global Perceived Stress, & Severity*		
Variable	***Estimate***	***SE***	**Variable**	***Estimate***	***SE***
Fixed Effects			Fixed Effects		
Intercept	1.2914	0.1571**	Intercept	1.2244	0.1509**
Age	−0.01411	0.00504**	Age	−0.01417	0.004982**
Previous NA (WP)	−0.1529	0.01711**	Previous NA (WP)	−0.1722	0.01683**
Stressor (BP)	0.8381	1.0327	Severity (BP)	0.4143	0.2878
Recent Stressor (WP)	1.4697	0.9958**	Global Perceived Stress (GPS)	0.06395	0.0159**
Previous Stressor (WP)	0.2905	0.06201**	Recent Severity (WP)	0.6366	0.03655**
Recent Stressor X Age	−0.00828	0.005318	Previous Severity (WP)	0.1344	0.0241**
Previous Stress X Age	0.001345	0.003216	Recent Severity X Age	−0.00121	0.001922
Global Perceived Stress (GPS)	0.06578	0.01594**	Previous Severity X Age	0.000102	0.001197
Recent Stressor X GPS	0.04823	0.01698**	Recent Severity X GPS	0.01257	0.006178*
Previous Stressor X GPS	0.02705	0.01037**	Previous Severity X GPS	0.006653	0.00384
Variance Components			Variance Components		
Between person			Between person		
Intercept	1.6169	0.1773**	Intercept	1.5737	0.173**
cov(Int, Stressor)	−0.06468	0.1352	cov(Int, Severity)	−0.06624	0.0467
Stressor	0.4438	0.1813**	Severity	0.03935	0.02209*
cov(Int, Previous NA)	−0.04189	0.02241	cov(Int, Previous NA)	−0.03962	0.0217
cov(Stressor, Previous NA)	0.02156	0.02051	cov(Severity, Previous NA)	0.005543	0.007464
Previous NA	0.01473	0.00428**	Previous NA	0.004866	0.004277
Within person			Within person		
Intercept	0.3257	0.0327**	Intercept	0.3611	0.03265**
cov(Int, Stressor)	0.1609	0.08441	cov(Int, Severity)	0.02635	0.03024
Stressor	2.0747	0.2724**	Severity	0.2536	0.03649**
Residual	1.6555	0.03677**	cov(Int, Previous NA)	0.000487	0.01214

NA Model 3: Age, Global Perceived Stress, & Exposure			*NA Model 4: Age, Global Perceived Stress, & Severity*		
Variable	***Estimate***	***SE***	**Variable**	***Estimate***	***SE***
			cov(Severity, Previous NA)	0.007615	0.015
			Previous NA	0.04615	0.009678**
			Residual	1.5346	0.03616**

* $p < .05$.

** $p < .01$.

Note: Between person (BP) refers to Level 3 (i.e., persons); within person (WP) refers to Levels 2 (i.e., days) and 1 (moments).

Table 4

PA Model 1: Age & Exposure			*PA Model 2: Age & Severity*		
Variable	***Estimate***	***SE***	**Variable**	***Estimate***	***SE***
Fixed Effects			Fixed Effects		
Intercept	7.3988	0.1729**	Intercept	7.4349	0.1674**
Age	0.00546	0.00553	Age	0.00501	0.00548
Previous PA (WP)	−0.1772	0.01629**	Previous PA (WP)	−0.179	0.0159**
Stressor (BP)	−0.6413	1.1144	Severity (BP)	−0.3031	0.3162
Recent Stressor (WP)	−1.2177	0.08799**	Recent Severity (WP)	−0.5057	0.32037**
Previous Stressor (WP)	−0.27	0.06469**	Previous Severity (WP)	−0.0829	0.02469**
Recent Stressor X Age	0.01693	0.00458**	Recent Severity X Age	0.00596	0.00167**
Previous Stress X Age	0.00201	0.00343	Previous Severity X Age	0.00088	0.00126
Variance Components			Variance Components		
Between person			Between person		
Intercept	2.0204	0.2204**	Intercept	1.9761	0.2153**
cov(Int, Stressor)	−0.228	0.1409	cov(Int, Severity)	−0.0691	0.05299
Stressor	0.2575	0.1366*	Severity	0.02467	0.01767
cov(Int, Previous PA)	−0.0028	0.02549	cov(Int, Previous PA)	−0.0051	0.02473
cov(Stressor, Previous PA)	−0.0128	0.0175	cov(Severity, Previous PA)	0.00204	0.0064
Previous PA	0.01236	0.00423**	Previous PA	0.00805	0.00442*
Within person			Within person		
Intercept	0.5323	0.04437**	Intercept	0.5082	0.04279**
cov(Int, Stressor)	−0.2023	0.09219*	cov(Int, Severity)	−0.0476	0.03346
Stressor	1.6138	0.2526**	Severity	0.1555	0.03192**
Residual	1.9759	0.04399	cov(Int, Previous PA)	0.00142	0.0137
			cov(Severity, Previous PA)	−0.0226	0.01339
			Previous PA	0.01391	0.0077*
			Residual	1.9774	0.04509**

* $p < .05$.

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* $p < .01$.

Note: Between person (BP) refers to Level 3 (i.e., persons); within person (WP) refers to Levels 2 (i.e., days) and 1 (moments).

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Table 5

PA Model 3: Age, Global Perceived Stress, & Exposure			*PA Model 4: Age, Global Perceived Stress, & Severity*		
Variable	***Estimate***	***SE***	**Variable**	***Estimate***	***SE***
Fixed Effects			Fixed Effects		
Intercept	7.3234	0.1655**	Intercept	7.3184	0.1616**
Age	0.00263	0.00544	Age	0.00258	0.00539
Previous PA (WP)	−0.1767	0.01647**	Previous PA (WP)	−0.1795	0.01615**
Stressor (BP)	0.00692	1.078	Severity (BP)	−0.0113	0.308
Recent Stressor (WP)	−1.225	0.08934**	Global Perceived Stress (GPS)	−0.0777	0.01723**
Previous Stressor (WP)	−0.2716	0.06601**	Recent Severity (WP)	−0.508	0.03298**
Recent Stressor X Age	0.01603	0.00474**	Previous Severity (WP)	−0.0876	0.0255**
Previous Stress X Age	0.00257	0.00348	Recent Severity X Age	0.00571	0.00173**
Global Perceived Stress (GPS)	−0.079	0.0172**	Previous Severity X Age	0.00091	0.0013
Recent Stressor X GPS	−0.0234	0.01515	Recent Severity X GPS	−0.0041	0.00555
Previous Stressor X GPS	−0.0033	0.01115	Previous Severity X GPS	0.00172	0.00411
Variance Components			Variance Components		
Between person			Between person		
Intercept	1.8243	0.2024**	Intercept	1.7939	0.1987**
cov(Int, Stressor)	−0.2925	0.1359*	cov(Int, Severity)	−0.0818	0.05135
Stressor	0.2627	0.1367*	Severity	0.02748	0.01813
cov(Int, Previous PA)	0.0034	0.02405	cov(Int, Previous PA)	0.000073	0.02354
cov(Stressor, Previous PA)	−0.0152	0.01768	cov(Severity, Previous PA)	0.00086	0.00652
Previous PA	0.01235	0.00425**	Previous PA	0.00817	0.00448*
Within person			Within person		
Intercept	0.5369	0.04496**	Intercept	0.5144	0.04345**
cov(Int, Stressor)	−0.2157	0.09263*	cov(Int, Severity)	−0.0534	0.03348
Stressor	1.5977	0.2544**	Severity	0.1483	0.03156**
Residual	1.9745	0.04438**	cov(Int, Previous PA)	−0.0014	0.0139

PA Model 3: Age, Global Perceived Stress, & Exposure			*PA Model 4: Age, Global Perceived Stress, & Severity*		
Variable	***Estimate***	***SE***	**Variable**	***Estimate***	***SE***
			cov(Severity, Previous PA)	−0.0193	0.0133
			Previous PA	0.01405	0.00784*
			Residual	1.9766	0.04552**

* $p < .05$.

** $p < .01$.

Note: Between person (BP) refers to Level 3 (i.e., persons); within person (WP) refers to Levels 2 (i.e., days) and 1 (moments).