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Age, Stress, and Emotional Complexity: Results From Two Studies of Daily Experiences

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Experiencing positive and negative emotions together (i.e., co-occurrence) has been described as a marker of positive adaptation during stress and a strength of socioemotional aging. Using data from daily diary (N = 2,022; ages 33–84) and ecological momentary assessment (N = 190; ages 20–80) studies, we evaluate the utility of a common operationalization of co-occurrence, the within-person correlation between positive affect (PA) and negative affect (NA). Then we test competing predictions regarding when co-occurrence will be observed and whether age differences will be present. Results indicate that the correlation is not an informative indicator of co-occurrence. Although correlations were stronger and more negative when stressors occurred (typically interpreted as lower co-occurrence), objective counts of emotion reports indicated that positive and negative emotions were 3 to 4 times more likely to co-occur when stressors were reported. This suggests that co-occurrence reflects the extent to which negative emotions intrude on typically positive emotional states, rather than the extent to which people maintain positive emotions during stress. The variances of both PA and NA increased at stressor reports, indicating that individuals reported a broader not narrower range of emotion during stress. Finally, older age was associated with less variability in NA and a lower likelihood of co-occurring positive and negative emotions. In sum, these findings cast doubt on the utility of the PA–NA correlation as an index of emotional co-occurrence, and question notion that greater emotional co-occurrence represents either a typical or adaptive emotional state in adults.

Keywords: stress, emotional complexity, aging, co-occurrence, mixed emotions

The ups and downs of emotions are familiar. Sometimes we feel pretty good (i.e., mostly happy, content, and pleased, with low levels or the absence of sadness, frustration, or annoyance), sometimes we feel pretty bad (i.e., very disappointed, irritated, maybe somewhat afraid, and little pleasure or excitement), and sometimes we feel a mix of positive and negative emotions (e.g., bittersweet, ambivalent). This mix has been referred to as emotional complexity or mixed emotional experience (Larsen & McGraw, 2011). Intraindividual variability in emotional states is well-documented in the literature and several prominent theories describe emotional complexity, its purpose, and what produces it. The tendency to experience complexity may relate to resilience and well-being and it is theorized to exhibit age-graded changes throughout adulthood. Notably, recent work (Hershfield, Scheibe, Sims, & Carstensen, 2013) indicates that individuals who reported higher levels of mixed emotions reported fewer physical health symptoms, and that across 10 years, individuals whose levels of mixed emotions increased the most across time experienced the least increase in physical symptoms over that period. The present study examines the operationalization of emotional complexity as mixed emotions, tests predictions about when mixed emotional states will occur, and investigates age differences in mixed emotions.

Mixed emotions implies the joint experience of both positive and negative emotions; this is sometimes called covariation (Diehl, Coyle, & Labouvie-Vief, 1996; Ready, Carvalho, & Weinberger, 2008), coactivation (Larsen, McGraw, & Cacioppo, 2001), poignancy (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000; Carstensen et al., 2011), or co-occurrence (Hay & Diehl, 2011; Ong & Bergeman, 2004). In the present study, we use the term co-occurrence as it most clearly describes the phenomenon of positive and negative emotions occurring together. Given our interest in the fluctuating mix of emotions that make up mood states, we focus on emotional complexity as mixed emotions, we follow the literature and operationalize this first as covariation (i.e., correlation) and also examine discrete instances of co-occurring positive and negative emotion reports. We examine these at both the momentary and daily levels.

Emotional Complexity and Aging

Several aging theories make predictions for greater emotional complexity with advancing age. Specifically, socioemotional selectivity theory (SST) predicts that, because of awareness of limited time remaining, "emotional reactions in later life . . . are better characterized by poignancy than happiness" (Carstensen et al.,

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2000, p. 653). According to SST, older persons are expected to experience mixed emotions to a greater extent than younger persons. Differential emotions theory (Magai, Consedine, Krivoshekova, Kudadjie-Gyamfi, & McPherson, 2006) proposes that as cognitive connections become more elaborate over the life course, greater co-occurrence of positive and negative emotions are expected among older persons. Finally, according to Labouvie-Vief's dynamic integration theory (DIT; Labouvie-Vief, Chiodo, Goguen, Diehl, & Orwoll, 1995), the ability to tolerate ambiguity and conflicting information is a key feature of cognitive-emotional complexity and maturity. According to DIT, complexity is expected to be highest in middle age (Labouvie-Vief, Diehl, Jain, & Zhang, 2007).

The data on age differences in co-occurrence is mixed. Some studies have found older adults to report greater amounts of co-occurrence (Carstensen et al., 2000; Carstensen et al., 2011 longitudinally and cross-sectionally at Waves 1 and 3), another study showed older age associated with reduced co-occurrence (Ready et al., 2008), and still others found no relationship between co-occurrence and age (Carstensen et al., 2011 cross-sectionally at Wave 2; Hay & Diehl, 2011). Magai, Consedine, Krivoshekova, Kudadjie-Gyamfi, and McPherson (2006) asked young, middle, and older adults to recall and recount an experience in the last 2 years that made them feel extremely sad or angry, then asked participants to report on the emotions they felt while telling the story; the narratives were coded for affect categories and participant facial expressions were coded. All age groups showed positive-negative blends in their facial expressions, but not in the self-report or narrative data.

Are Mixed Emotions Adaptive?

Some data suggests that such an age-graded increase in the experience of mixed emotional states is adaptive. For example, in a sample of older adults, participants with less negative correlations (i.e., more co-occurrence) tended to be those who scored higher on measures of psychological resilience and lower on neuroticism and global perceptions of stress (Ong & Bergeman, 2004). Hay and Diehl (2011) suggest that this correlation is related to adaptive emotion regulation; individuals with stronger average correlations between NA and PA (stronger negative correlations interpreted as lower co-occurrence) across 30 days of diary surveys were less likely to move from a high NA state to a low NA state than those with weaker correlations. Using data from three bursts of week-long ecological momentary assessments spaced 5 years apart, Hershfield, Scheibe, Sims, and Carstensen (2013), found that more positive (i.e., less strongly negative, the average correlation was −.39) correlations were associated with reporting fewer physical health symptoms. Further, increasing levels of mixed emotions (i.e., correlations moving further from −1) across the 10 years were associated with less steep declines in physical health over this period. However, a number of studies have found that the PA–NA correlation is unrelated to an assortment of beneficial outcomes and characteristics such as subjective and psychological well-being (Grühn, Lumley, Diehl, & Labouvie-Vief, 2012), life satisfaction (Ong & Bergeman, 2004), personality (Grühn et al., 2012), cognitive-developmental complexity as an index of emotional maturity (Grühn et al., 2012), nor self-rated health (Ong & Bergeman, 2004) or reduced mortality (Carstensen et al., 2011).

This mixed set of findings may be due in part to problems in the common way to operationalize co-occurrence, the PA–NA correlation. This correlation may be influenced by response features of positive and negative emotion reports other than their co-occurrence, specifically variability. One purpose of this study is to examine the extent to which the within person correlation between PA and NA reflects reporting positive and negative emotions at the same observation. In this study, we compare results using the PA–NA correlation to data coded as mixed (i.e., positive and negative emotions endorsed at this observation) and nonmixed emotional states. Below, we describe the standard interpretations of the correlation as related to co-occurrence as well as issues which undermine this statistics' utility in this application.

Co-Occurrence as Correlation

In studies of emotional experience in daily life, co-occurrence is most often operationalized as the within person correlation between positive affect (PA) and negative affect (NA). In the literature, correlations that are more positive (or less negative) are interpreted as signifying greater co-occurrence (e.g., $r = .19$ as "blended together somewhat during the same reporting period," Ong & Bergeman, 2004, p. 119), whereas correlations closer to −1 are described as simpler and lack of evidence for co-occurrence (e.g., $r = -.35$ as "tended not to be present at the same time," Carstensen et al., 2011, p. 651). Thus, a weak negative or a positive correlation is thought to imply relative independence of positive and negative emotions. This is typically interpreted as more co-occurrence of PA and NA and, thus, greater emotional complexity (Hershfield et al., 2013).

Although a correlation reflects the magnitude of a linear relationship between two variables, it is also sensitive to the amount of variance both variables exhibit. Indeed, Grühn, Lumley, Diehl, and Labouvie-Vief (2012) and Zautra, Berkhof, & Nicolson (2002) noted that low variability can restrict the correlation to close to zero. This represents two concerns for use of the correlation as an index of emotional co-occurrence because people typically report relatively low frequency and intensity of NA during everyday life. First, it implies that weak PA and NA correlations may simply reflect floor effects of measures of NA, rather than relative independence between positive and negative emotional experiences. And second, this implies that event-related increases to the PA–NA correlation come about not by how the event alters the underlying PA–NA relationship, but by how the event alters the restriction of range that characterizes NA during uneventful times. These concerns are especially salient for understanding how stressful experiences influence the magnitude, variance and correlation of PA and NA.

Time-Scale of Emotional Co-Occurrence

The topic of mixed emotions has generated much interest at least in part because several theories (Carstensen et al., 2000; Zautra, 2003) propose that it is adaptive. The ability to experience stimuli as nuanced rather than simply good or bad is purported to provide an individual with more information from which to respond or adapt to it (Zautra, Affleck, Tennen, Reich, & Davis,

2005). Maintaining positive emotions in the presence of stressors is theorized to help "undo" the effects of stress (see Ong, 2010). These theories share a common terminology and prediction but do not inform what experiencing PA and NA together means in everyday life.

Researchers operationalize emotional co-occurrence by using self-reports of positive and negative emotions at the same observation. However, interpreting what co-occurrence means requires careful consideration of the time scale across which a mix of positive and negative emotions are reported and experienced. Specifically, the term "emotional co-occurrence" implies that positive and negative emotions are not only reported, but also *experienced* simultaneously or at least within a given temporal epoch. For example, if a person reports experiencing both happiness and sadness during the last 30 days, then one may argue that a positive and negative emotion co-occurred during the past month. Similarly, if a person reports experiencing both happiness and sadness during the last 24 hr, then there would be positive and negative emotional co-occurrence during the past day. However, retrospective reports which ask participants to describe how they feel about a specific event (e.g., a loss or an ending) or how they felt over a specified period (i.e., today, last week, in general), do not necessarily provide information about co-occurrence of *experienced* emotions. For example, an individual may feel intense NA about a negative event, such as a pet's death, but as part of thinking and talking about the event, may recall pleasant memories, consider the relief from pain and suffering, and effectively reframe the event to describe it as having both positive and negative features. This seems to more clearly describe an outcome of reappraisal some period after the event than an immediate, experiential report of current emotional state at a given time. In the interests of understanding adaptation, coping strategies such as reappraisal are of interest, of course, but specificity regarding timing is necessary in order to definitively demonstrate co-occurrence.

When participants are asked to recall the frequency of PA and NA or rate their overall mood over a prescribed period, this does not necessarily provide information about the concurrent experience of both positive and negative emotions. Even diary data can only inform as to whether or not a person has experienced positive and negative emotions on the same day, but not necessarily at the same time. A person may wake up in a good mood and be in a bad mood by the end of the workday. The person reported both PA and NA today, but may not have ever felt mixed emotions at any given moment. Diary data are subject to retrospection biases such as peak-effects (Hedges, Jandorf, & Stone, 1985) which could result in the person recalling the most positive and negative emotions experienced even if these occurred at disparate times. Both event-focused and time-aggregations—including diary data—likely involve recollection as well as reappraisal. Measurements closely tied to immediate experience, such as ecological momentary assessments (EMA), as well as creative experimental approaches (see Larsen & McGraw, 2011) provide the most relevant evidence for mixed emotional states.

Even if we make the unlikely assumption that reappraisal processes do not influence recollective reports of emotions, emotional co-occurrence during the previous day very likely means something different than experiencing both happiness and sadness at the same moment. Therefore, the current study uses data from two types of designs to examine the effects of stressful experiences and age on emotional co-occurrence. In the diary study, individuals retrospectively report on their emotions that day and whether or not stressful events occurred. In the EMA study, participants report on their current emotions and whether an event has occurred in the last 3 hr.

Emotional Complexity, Co-Occurrence, and Daily Stress

Researchers have relied on daily stress as a natural experiment for understanding the effects of context on emotional co-occurrence. A key contribution of the dynamic model of affect (DMA; Zautra et al., 2005) is pointing out that emotional experiences occur in environmental contexts. These contexts encompass a variety of stimuli, including stressful events. Zautra and colleagues describe the influence of stress on emotion in terms of complexity. Fortunately stressful events are not the modal context for emotional experiences, occurring on fewer than half of days (e.g., stressors are reported on about 40% of days; Almeida, Wethington, & Kessler, 2002; Hay & Diehl, 2010). Specifically, DMA posits that stress has two related effects on emotions. First, DMA predicts that stress can "'shrink' affective space" (Zautra, Berkhof, & Nicolson, 2002, p. 1524). Second, DMA predicts that stress results in emotional experiences becoming more bipolar, that is less mixed, which results in a "more simplified affective experience" (Zautra et al., 2005, p. 1524) and produces a "partial collapse of affective complexity" (Zautra et al., 2005, p. 1526). Researchers often examine the PA–NA correlation because it is believed to reflect the degree to which people experience both positive and negative emotions at the same time. Specifically, as reviewed in the Results above, a weak PA–NA correlation is thought to signify more co-occurrence than a stronger, more negative correlation. Because stressful or unpleasant experiences are not the norm, DMA predicts that emotional co-occurrence characterizes typical, unperturbed emotional states and that stress decreases the frequency of co-occurring positive and negative emotions.

An alternative prediction for co-occurrence can be developed from Diener and Diener's (1996) theory of subjective well-being; that is, that affect is typically positive, not mixed. Diener and Diener propose that individuals may have a slightly positive, rather than neutral, set-point as their emotional baseline and suggest that this may be adaptive in allowing for rapid detection of threats and to encourage approach and exploration tendencies. Like DMA, this theory involves both cognitive and emotional elements and uses data on reported emotional experience to support its predictions. In ecological momentary assessment studies in which individuals were signaled at random times each day to complete mood ratings, the majority of samples of college students, disabled persons, and older adults sampled randomly across the day reported currently feeling more positive than negative on more than 50% of days studied (Diener & Diener, 1996). Further, Diener and Diener review findings from other ecological momentary assessment studies across U.S. and European samples, ranging from children to college students to adults, and find that participants' typical mood report was one of higher levels of PA than NA.

According to Diener and Diener, although affect is typically positive, experiencing positive or negative events may temporarily shift an individual away from this set-point. Extensive evidence shows that daily stressors increase NA (see Almeida, 2005; Bolger, DeLongis, Kessler, & Schilling, 1989) but the influence of daily stressors on PA

is less clear (i.e., lower PA when stressors occur and for more severe stressors: Röcke, Li, & Smith, 2009; higher PA on days with a stressor: Uchino, Berg, Smith, Pearce, & Skinner, 2006; no difference in PA: Zautra et al., 2005). To our knowledge, no evidence is available on how a person's NA-response to stressors relates to his or her PA-response to stressors. Based on these findings and Diener and Diener's (1996) model, we pose an alternative prediction that in comparison to normal, nonstress periods, more co-occurrence will be observed when stressors have occurred. Further, because this model predicts that affect is typically positive, this means that there should be a relative absence of and little variability in negative emotions. This low variability in the nonoccurring emotion should result in low PA–NA correlations in nonstress times and stronger correlations in stress times because of increased occurrence and thus variability in affect. As a shorthand, we refer to this as the subjective well-being (SWB) set of predictions.

Present Study

In the present study, we examine the co-occurrence of PA and NA in daily life among adults across young adulthood, middle age, and older adulthood using diary and ecological momentary assessment (EMA) data. First, we examine how the variance in PA and NA is related to stress and age. Then, we test competing hypotheses about the role of stress in co-occurrence. The DMA hypothesis predicts low co-occurrence when stressors are reported and greater co-occurrence at nonstressor times. The alternative hypothesis is that individuals will report more co-occurrence of PA and NA when stressors have occurred and will report bipolar affect (i.e., less co-occurrence) at other times. In order to compare our results with previous research, we first examine these competing predictions for co-occurrence using the correlation between PA and NA in which a stronger negative correlation is interpreted as lower co-occurrence.

In a second set of analyses, we probe what underlies the correlation and the extent to which changes in the correlation observed in stressful and normal conditions actually represents reports of co-occurring PA and NA. We examine differences in the variances of PA and NA when stressors are present and absent as a way of examining affective space. Then, we examine co-occurrence operationalized as the presence of both PA and NA at the same observation, separate from valence. Last, we examine whether there are age differences in these results.

Method

Daily Emotional Experience: Daily Diary

Participants. Participants included 2,022 adults aged 33–84 years (M = 56.25, SD = 12.20) from the Midlife in the United States (MIDUS) II survey National Study of Daily Experiences (NSDE). The sample was primarily White (94%) and a majority was women (57%). See Almeida, McGonagle, and King (2009) for detailed description of sample and protocol.

Measures. Daily reports of negative and positive affect were assessed each day. Participants were asked how often in the last 24 hr they felt each emotion using a 0 (*none of the time*) to 4 (*all of the time*) scale (Almeida & Kessler, 1998). Negative affect items included restless or fidgety, nervous, worthless, so sad nothing can cheer you up, that everything was an effort, hopeless, lonely, afraid, jittery, irritable, ashamed, upset, angry, and frustrated. Positive affect items included in good spirits, cheerful, extremely happy, calm and peaceful, satisfied, full of life, close to others, like you belong, enthusiastic, attentive, proud, active, and confident. Daily NA and PA were calculated as the averages of the respective items.

Daily stressor exposure was assessed using the Daily Inventory of Stressful Events (DISE; Almeida et al., 2002). Participants were queried about daily stressors in the form of arguments, avoided arguments, discrimination, home stressors, network stressors (i.e., stressors occurring to a close friend or family member), work stressors, and other stressors. For the present study, the exposure variable indicates whether or not any stressor was reported that day.

Procedure. Participants completed brief telephone interviews about their daily emotions and experiences for eight consecutive evenings. Phone interviews lasted about 20 min and participants received $25 for completing the interviews and daily cortisol collection.

Momentary Emotional Experience: Ecological Momentary Assessment (EMA)

Participants. Participants included 190 adults aged 20–80 years (M = 48.86 years, SD = 19.29). The sample was primarily White (72%) and African American (18%); just over half of the participants were women (52%).

Measures. Momentary reports of negative and positive affect were assessed at each survey. Each emotion was assessed via the question, "To what extent are you ____ at the moment?" using a 0 (*not at all*) to 4 (*very much*) scale. Momentary NA was calculated as the average of a person's ratings of sad, nervous, and irritated at that survey. Momentary PA was calculated as the average of an individual's ratings of happy, excited, and alert at that survey.

Later in the survey, participants were asked about recent stressor exposure at each survey, "Did you experience a disruptive event since the last beep?" When no disruptions had occurred, participants were instructed to answer "no." In the training, participants were taught to select "yes" if an event occurred which interfered with their current plans or disrupted their daily routine, even if the problem had been resolved by the time of the survey.

Procedure. The current study utilizes from the EMA portion of a larger study of everyday problem solving, goals, and emotions across the adult life span. Participants were trained on how to complete surveys on palm-top computers. The palm-top computers beeped to remind participants to complete surveys five times each day for 10 days. Surveys took about 5 min to complete. Those who completed the full study received $100. Participants who completed less than 80% of surveys at the 3-day check-up were not invited into the next phase of the study and received prorated compensation (e.g., $30), as described in the consent. The final dataset included surveys completed within 30 min of the beep reminder (79% of observations). For a detailed description of the protocol, compliance, and exclusions, see Scott, Sliwinski, and Blanchard-Fields (2013).

Analytic Strategy

Previous studies (Carstensen et al., 2000, 2011; Grühn et al., 2012; Ready et al., 2008) that did not examine the role of daily stress operationalized co-occurrence for each person as the correlation between PA and NA across all observations. We computed these values in the current study to compare our sample to previous studies.

Our next set of analyses are comparable with several studies explicitly testing DMA's predictions regarding stress (Davis, Zautra, & Smith, 2004; Ong & Bergeman, 2004). These studies used univariate multilevel models (MLMs) in which NA is predicted from time-varying covariates daily PA, stress, and their interaction. The coefficient for this interaction between PA and stress was used to describe the difference in the association between PA and NA in the presence versus absence of stress. Zautra, Berkhof, and Nicolson (2002), however, demonstrated a more direct method using multivariate multilevel models for examining the ways in which the correlation depends on context (i.e., stress). Multivariate MLMs using SAS Proc Mixed simultaneously modeled PA and NA across stress and no stress periods, providing information about the effect of stress on affect (consistent with separate univariate models) as well as estimates of the variance of PA, NA, and the covariance of PA and NA during no-stress and stress periods, from which the correlation between PA and NA can be calculated.

We then extended previous work by conducting analyses using alternate ways of describing co-occurrence. We examined differences in the types of emotions reported, separate from intensity, by calculating the counts of positive, negative, and all emotions reported during stress and no-stress periods. Based on this descriptive data, we tested DMA and SWB predictions for co-occurrence by creating a variable coded 1 if at least one positive and at least one negative emotion was reported and 0 if only positive emotions were reported and used multilevel logistic models to model log odds of co-occurrence.

Results

Descriptive Statistics

Descriptive statistics are displayed in Table 1. The average within-person correlation between PA and NA across all observations was consistent with previous EMA and daily diary studies, (EMA study momentary $r = -.40$; diary study daily $r = -.34$). That is, on average, across stress and nonstress surveys, PA and NA were moderately and negatively correlated.

Table 2
Frequencies of Emotion Reports

	Daily data	Momentary data
	% days	% beeps
Positive emotions only	44.72	49.72
Negative emotions only	0.17	0.18
Positive and negative emotions	55.54	50.06
No emotions	0.02	0.02

Note. To code the emotion reports at each survey we counted the number of positive and negative emotions that were endorsed as nonzero. Although they differed in items and anchors, the diary and EMA data used a similar response scale, 0 to 4, in which 0 represents *not experiencing the emotion*. For the diary data, this meant the individual responded that he or she had felt the emotion more than none of the time that day; for the EMA data, this meant that the individual reported feeling the emotion greater than not at the moment. For example, if a participant reported even a very low level (e.g., rating it as 1 on the scale) of feeling sad in addition to cheerful, satisfied, and full of life, this observation was counted as evidence of co-occurring positive and negative emotions.

Emotion reports were recoded to calculate the proportions of surveys which were made up of completely negative, completely positive, or mixed emotions (see Table 2). At least one positive and one negative emotion were endorsed in just over half the surveys. Nearly as often, participants reported at least one positive emotion but no negative emotions. Less than 1% of the time, individuals reported only negative emotions or neither positive nor negative emotions. Therefore, in our analyses below (see Co-Occurrence of PA and NA section later in the article), we exclude these and focus on the 99% of observations in order to have a clear comparison between mixed emotion reports and nonmixed, purely positive reports. Stressors were reported in about 14% of momentary surveys and 39% of daily reports.

Variability in PA and NA

We used heterogeneous variance models to examine whether the amount of intraindividual variability in PA and NA depended upon stressor occurrence and age. These types of models allow inclusion of predictor variables to identify which variables are significantly related to higher or lower amount of variability (see Hoffman, 2007 for description of these types of models). We fit univariate models to examine PA and NA separately and used the local variances function in SAS proc mixed, which allowed us to examine whether, for example, older persons had less variable NA than younger persons on stress and nonstress days. These models

Table 1
Descriptive Statistics

	Daily data (N = 1,838)		Momentary data (N = 188)	
	M (SD)	Range	*M (SD)*	Range
Age	56.24 (12.20)	33–84	40.86 (19.29)	20–81
WP average NA	0.21 (.28)	0–2.54	.54 (.48)	0–2.92
WP average PA	2.72 (.72)	0.04–4.00	2.36 (.49)	1.32–3.97
WP average *r*(NA, PA)	−.34 (.45)	−1.0–1.0	−.40 (.25)	−.85–.68

Note. NA = negative affect; PA = positive affect; WP = within-person.

included stress exposure, grand mean centered age, and the stress-by-centered age interaction as predictors.

Daily data. We found that variability in daily emotions increases during stress (PA: $b = 0.326$, $SE = 0.029$, $p < .0001$; NA: $b = 1.229$, $SE = 0.029$, $p < .0001$). There was no evidence of age-related heterogeneity in daily PA ($b = -0.001$, $SE = 0.001$, $p = .369$). There was, however, age-related heterogeneity in daily NA ($b = -0.006$, $SE = 0.001$, $p < .0001$), meaning older age was associated with less variability in daily NA on nonstress days. The interaction between age and stress was not significant for PA ($b = -0.001$, $SE = 0.002$, $p = .5593$), but was significant for NA ($b = -0.012$, $SE = 0.002$, $p < .0001$). That is, older age was associated with less variability in NA on stress days. In sum, older adults reported less variable NA on both nonstress and stress days.

Momentary data. Consistent with diary data, we found that variability in emotions increases during stress (PA: $b = .550$, $SE = .083$, $p < .0001$; NA: $b = .852$, $SE = .084$, $p < .0001$). There was significant age-related heterogeneity in momentary emotion reports, which indicates that during nonstress times, older age was associated with less emotional variability (PA: $b = -0.014$, $SE = 0.001$, $p < .0001$; NA: $b = -0.012$, $SE = 0.001$, $p < .0001$). The interaction between age and stress bordered statistical significance: During stress, there was a trend for older participants to report more variable emotions (PA: $b = .006$, $SE = 0.003$, $p = .061$; NA: $b = 0.007$, $SE = 0.003$, $p = .0502$).

Correlation Between PA and NA During Stress and No Stress Periods

Daily data. Using multivariate MLMs we found that in the daily data PA and NA were correlated during nonstress periods, $r = -.28$, and during stress periods, $r = -.45$ (see Table 3). As part of this model reactivity slopes (i.e., change in PA related to stress, change in NA related to stress) were allowed to correlate and were significantly associated, $r = -.35$, $p < .0005$. In order to compare with previous studies, we also examined the stress-by-PA interaction predicting NA using MLMs. Consistent with previous work, we found that there was a significant negative interaction between stress and PA ($b = -.12$, $SE < .01$, $p < .0001$). In parallel models using NA, stress, and the stress-by-NA interaction to predict PA, we found significant effects for stress predicting daily PA ($b = -.05$, $SE < .01$, $p < .0001$) and that NA was significantly and inversely related to PA ($b = -.94$, $SE = .03$, $p < .0001$). There was a significant interaction between NA and stress predicting momentary PA ($b = -.15$, $SE = .03$, $p < .0001$).

Next, we examined stress-related increases in emotional variability as an explanation for this stronger correlation during stress periods. As shown in Table 3, within person variability in both PA and NA were higher when stressors were reported. The variance in PA increased from .02 when stressors were not present to .08 when stressors were present; variability in NA also increased when stressors were reported from .13 to .18. The contour plots in Figure 1 highlight the differences in variability and covariance for stress and no stress periods.

We examined the extent to which this greater variability in NA during stressor periods explains the stronger correlation between PA and NA during stress by using within person estimates of NA variability as predictors of the correlation between NA and PA. In this set of analyses (see Table 4), we first directly estimated the correlation between PA and NA for each individual and Fisher's z as a standardized version of this correlation, producing separate estimates for stress and nonstress observations (days) for each person. Participants who had fewer than three observations for stress and nonstress were excluded. We also calculated person-specific estimates for the variances of PA and NA during stress and nonstress surveys. Then, using a univariate model predicting this standardized version of the correlation, we first replicated the above results and demonstrated that the standardized correlation between PA and NA was significantly stronger at surveys when stressors were reported than when stressors were not reported. Lastly, we found that even when accounting for individual differences in level and variability in NA, the correlation between PA and NA was stronger when stressors were reported.

Momentary data. Using multivariate MLMs we found that in the momentary data, PA and NA were correlated during nonstress periods, $r = -.32$, and during stress periods, $r = -.63$. Individuals' PA-response to stressors correlated with their NA-response

Table 3
Positive and Negative Affect Variance, Covariance, and Correlation at Stressor and Nonstressor Observations

	Daily data		Momentary data	
	No stressor today		No stressor since last survey	
	PA	NA	PA	NA
Variance (*SE*)	.02 (.0004)	.13 (.002)	.17 (.004)	.22 (.005)
Covariance	−0.02		−0.06	
Correlation	−0.28		−0.32	
	Stressor today		Stressor since last survey	
	PA	NA	PA	NA
Variance (*SE*)	.08 (.002)	.17 (.004)	.41 (.03)	.39 (.03)
Covariance	−0.05		−0.25	
Correlation	−0.44		−0.63	

Note. NA = negative affect; PA = positive affect.

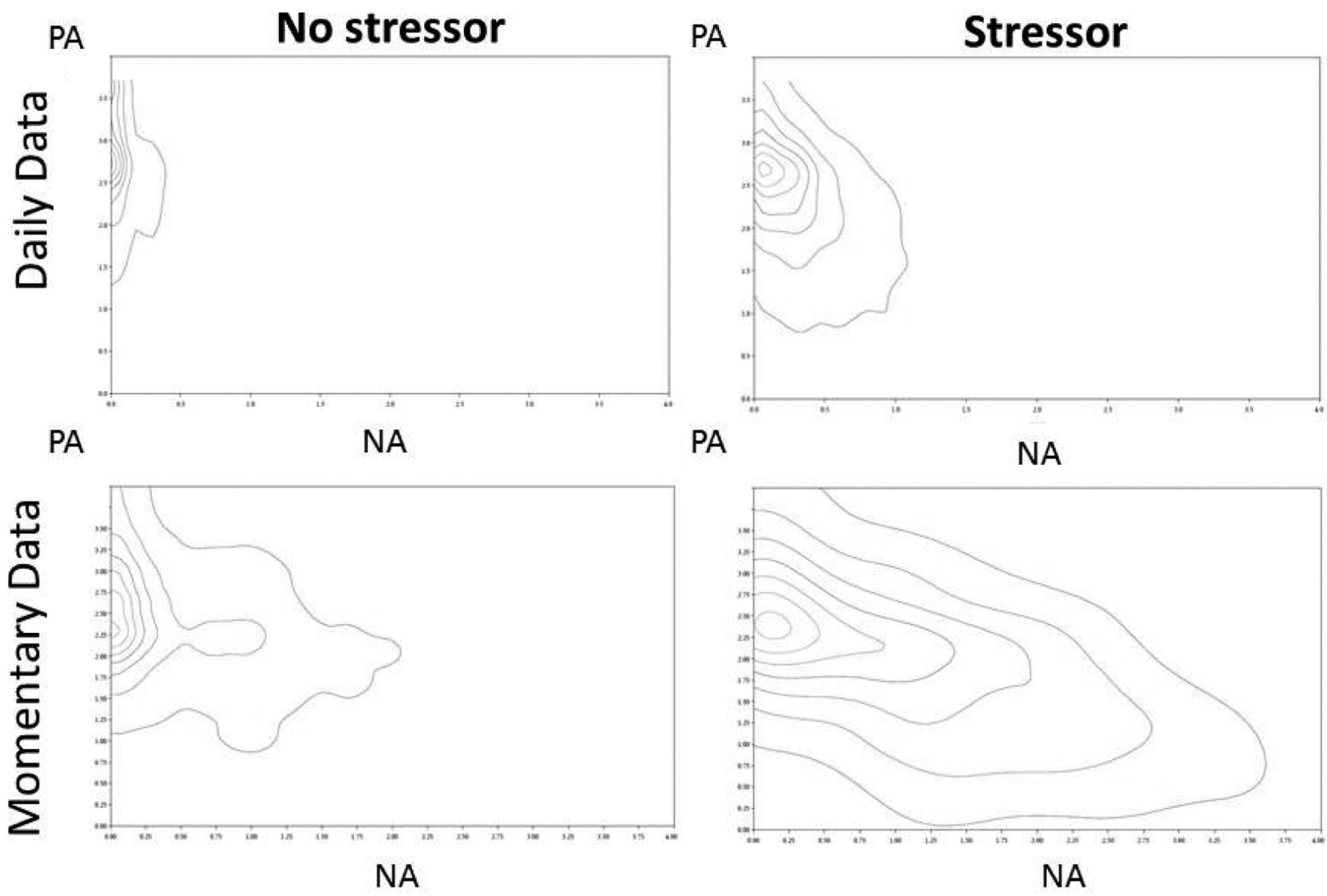

Figure 1. Contour plots of PA and NA variability at stressor and nonstressor observations.

to stressors $r = -.67$, $p = .045$. Examining the interaction between PA and stress to predict NA in univariate models described above, we also found a significant interaction between stress and PA in the momentary data ($b = -.31$, $SE = .03$, $p < .0001$). In univariate models using NA, stress, and the stress-by-NA interaction to predict PA, we found nonsignificant effects for stress predicting momentary PA ($b = -.02$, $SE = .03$, $p = .3924$) but that NA was significantly and inversely related to PA ($b = -.39$, $SE = .01$, $p < .0001$). There was a significant interaction between NA and stress predicting momentary PA ($b = -.15$, $SE = .02$, $p < .0001$).

We then examined the variance and covariance across stress and nonstress conditions in the momentary data. The variance in PA was .17 during nonstressor periods and .41 during stressor periods; variability in NA also increased when stressors were reported, from .22 to .39 in the momentary data (see Figure 1). We replicated the diary results in the momentary data in which the standardized correlation, *z*, was stronger when stressors were reported, even when accounting for individual differences in the average level and variability in NA across the study (see Table 4).

Co-Occurrence of PA and NA

Next, we examined whether this stronger negative correlation found during stress periods represents the absence of co-occurring positive and negative emotions, as it has been interpreted in the literature. We used a recoded version of the emotion data presented in Table 2, in which 1 represents an observation at which at least one positive emotion and at least one negative emotion were endorsed and 0 represents an observation at which only positive emotions were endorsed. We conducted multilevel logistic models to predict the log odds of reporting co-occurring positive and negative emotions at a given observation from whether or not the participant reported a stressor and the individual's average number of daily stressors. Due to the very few observations (see Table 2) in which no emotions or only negative emotions were reported, these were excluded from the analysis. To aid interpretation of the comparison between mixed and nonmixed emotion reports, we focused on the 99% of observations which were mixed or purely positive.

Diary data. On days when participants reported experiencing a stressor, they were three times more likely to report co-occurring positive and negative emotions ($b = 1.437$, $SE = 0.045$, $p < .0001$, odds ratio [*OR*] = 3.498, 95% CI [3.257, 3.758]). This translates to an approximate 300% increase in the chances of reporting co-occurring positive and negative emotions when stressors are reported compared with nonstress surveys.

Momentary data. At moments when stressors were reported, participants were four times more likely to report co-occurring positive and negative emotions ($b = 1.476$, $SE = .175$, $p < .0001$,

Table 4
Estimated Correlations Between Positive and Negative Affect Accounting for Current Stressor Report, and Mean and Variance of Negative Affect

	Daily data	Momentary data
Baseline model		
Intercept	−0.38 (.03)	−0.34 (.04)
Stressor exposure	−0.21 (.04)	−0.53 (.06)
Estimated correlations		
Stressor occasion	−0.53	−0.71
Nonstressor occasion	−0.36	−0.33
With NA mean		
Intercept	−0.40 (.03)	−0.38 (.04)
Stressor exposure	−0.16 (.04)	−0.44 (.07)
Average NA	−0.25 (.08)	−0.20 (.06)
Estimated correlations		
Stressor occasion	−0.51	−0.67
Nonstressor occasion	−0.37	−0.36
With NA variance		
Intercept	−0.46 (.03)	−0.42 (.04)
Stressor exposure	−0.04 (.04)†	−0.35 (.06)
Variance NA	−0.13 (.17)	−0.19 (.03)
Estimated correlations		
Stressor occasion	−0.46	−0.64
Nonstressor occasion	−0.43	−0.40
With NA mean & variance		
Intercept	−0.46 (.03)	−0.42 (.04)
Stressor exposure	−0.07 (.04)†	−0.34 (.06)
Average NA	0.37 (.10)	0.02 (.07)
Variance NA	−0.17 (.02)	−0.20 (.03)
Estimated correlations		
Stressor occasion	−0.48	−0.64
Nonstressor occasion	−0.43	−0.40

Note. All other effects significant at $p < .05$. Models were computed using Fisher's z transform of within-person correlations; correlations are presented here to ease interpretation.
† Nonsignificant coefficient.

OR = 4.378, 95% CI [3.109, 6.164]). This is approximately a 400% increase in the chances of reporting co-occurring positive and negative emotions when stressors are reported compared to nonstress times.

Co-Occurrence and Age

Then we examined the role of age in co-occurrence as operationalized by the presence of at least one positive emotion and one negative emotion at the same time. In these models, we included age, stress, the interaction between age and stress, and person-average stress as predictors.

Diary data. Using the recoded data in which 0 represents only positive emotions endorsed and 1 represents both positive and negative emotions endorsed, we found significant effects of daily stress, age, and an interaction between stress and age. Again, participants were more likely to report co-occurring PA and NA on days when they reported stressors ($b = 1.355$, $SE = 0.053$, $p < .0001$, *OR* = 3.876, 95% CI [3.494, 4.300]). With older age, individuals were slightly less likely to report co-occurring positive and negative emotions on the same nonstress day ($b = -.010$, $SE = 0.003$, $p = .0003$, *OR* = .990, 95% CI [.985, .996]). This linear effect was qualified by a quadratic age effect which indicated that the decrease in reporting co-occurring emotions slowed in advancing age ($b = .001$, $SE = 0.0002$, $p < .0001$, *OR* = 1.00, 95% CI [1.001, 1.002]). The effect of daily stress on the likelihood of co-occurrence of PA and NA was weaker with older age ($b = -.008$, $SE = 0.003$, $p = .028$, *OR* = .993, 95% CI [.986, .999]). These effects were also qualified by a daily stress by age quadratic interaction indicating that the positive association between stressor occurrence and mixed emotional states decreased as a quadratic function of age ($b = -.001$, $SE = 0.0003$, $p = .0101$, *OR* = .999, 95% CI [.999, 1.000]). That is, mixed emotional states occurred with greater frequency under stress, but this effect was not as strong in older compared to younger participants.

Momentary data. We found some similar patterns to the diary data in the momentary data for the co-occurrence of PA and NA, as indicated by at least one positive and one negative emotion endorsed at the same occasion. Co-occurrence was more likely at beeps when stressors were reported ($b = 1.708$, $SE = 0.177$, $p < .0001$, *OR* = 5.517, 95% CI [3.899, 7.804]). Older age was associated with a decreased likelihood of reporting co-occurring PA and NA ($b = -.0276$, $SE = .008$, $p = .0003$, *OR* = .973, 95% CI [.958, .988]). This was not qualified by a quadratic age effect ($p = .8042$). The interaction between momentary stress and age predicting likelihood of reporting both positive and negative emotions at the same occasion was not significant. However, there was a marginal stress by age quadratic interaction similar to that found in the daily data such that the positive association between stress and co-occurrence of emotion decreased as a quadratic function of age ($b = -.001$, $SE = 0.0004$, $p = .0512$, *OR* = .999, 95% CI [.999, 1.000]).

Discussion

Results from the analysis of diary and momentary data converge on the following conclusions: (a) consistent with previous research, the correlation between positive and negative emotions is stronger and more negative when stressors occur; (b) contrary to the notion that stress reduces the range of emotional experiences, we found increases in the variances of both PA and NA under stress which implies a broader range of emotional experiences during stress; (c) contrary to common interpretations, this stronger negative correlation is observed with more—not less—co-occurrence of mixed emotions during stress; and (d) we found that older age is associated with less intraindividual variability in momentary (i.e., PA and NA) and daily (i.e., NA) emotions and that older age was associated with a decreased likelihood of reporting co-occurring PA and NA on the daily and momentary levels. These conclusions have implications for both research and theory. Specifically, despite its common usage in research as a metric of mixed emotions, the correlation between PA and NA is not a good measure of co-occurrence or mixed emotional states; it provides no information about the simultaneous experience of PA and NA. To the extent that theories of emotional complexity make predictions about the presence of at least some positive and some negative emotions at the same time, rather than solely one or the other, emotional experience is more complex when stressors have occurred than during typical times. We discuss the implications of these findings for our understanding of daily stress, emotion, and aging.

Correlation Does Not Imply Co-Occurrence

Despite warnings (Grühn et al., 2012; Zautra et al. (2002) of the problems associated with using the correlation to index co-occurrence, it remains the most commonly used metric for studying mixed emotions in diary and EMA studies. Indeed, in their recent article Hershfield and colleagues directly state, "positive *r* values indicate that positive and negative emotions were more likely to co-occur" (Hershfield et al., 2013, p. 57). As demonstrated in our theory-based comparison of stress and nonstress periods, however, the correlation provides very little information about whether positive and negative emotions were reported at the same observation, a straightforward operationalization of co-occurrence. We recommend that future examinations of mixed emotions operationalize co-occurrence as both positive and negative emotions occurring at the same observation.

Implications for Theory

Participants in these samples reported only positive emotions on nearly half of the days and moments and a mix of at least some positive and some negative emotion in just over half of the observations. Individuals rarely—less than 1% of observations—reported feeling a complete absence of positive emotions. Therefore, the driving force that rendered episodes mixed appears to be whether or not the individual experienced negative emotions. From a public health perspective, it is reassuring to observe that among community samples spanning most of the adult life span, individuals report at least some amount of PA nearly all the time. The presence of NA, on the other hand, appears to be much more tied to events as demonstrated by this study and numerous others. Stressful events are familiar but not ubiquitous; they are reported on about one of every seven momentary surveys and a little over a third of diary days. We found that individuals' affect was typically positive and that the co-occurrence of PA and NA can be predicted by stressor exposure, consistent with SWB predictions. In contrast to the standard interpretation of mixed emotions as representing an ability to maintain PA during negative experiences, we find that in daily life mixed emotions represent the injection of negative into what is a typically positive experience.

In our samples, typical nonstress emotional experience was characterized by at least some positive emotions and no negative emotions. The complementary "all negative emotions, no positive emotions state" was rarely observed. It is possible that these bipolar, purely negative states are produced by more intense but fortunately, more rarely occurring major life events. A reviewer posed the example of receiving information that is purely negative (e.g., getting a call that your spouse has been injured in an accident, is hospitalized, and condition unknown). Timing of measurement may play an important role in whether a purely negative or mixed positive and negative emotional state is observed. That is, at the time of the call, an individual may report feeling only afraid and sad, but an hour later after visiting the stable, alert spouse in the recovery room the individual may report a mix of positive and negative emotions. We discuss timing in more detail below.

Across two studies employing different designs and emotion items, we observed the increased negative correlations between PA and NA during stress as shown in studies supporting the DMA. As indicated by the results regarding the role of unequal variances and likelihood of reporting mixed and purely positive emotions, this correlation between PA and NA is not informative as an operationalization of mixed emotional states. The DMA description of the shifts in emotional variability highlights a key component of the stress-related increases in the PA–NA correlation. The pattern of emotions reported, however, is opposite what is predicted by DMA. In typical, stress-free times, negative emotions are often not endorsed at all. A tendency to experience more PA than NA in the absence of a stressor or other strong stimulus is expected according to SWB predictions (Diener & Diener, 1996). During stressors, participants appear to maintain at least some amount of PA while also experiencing NA. The variance in both PA and NA increases during stress. That is, emotional space expands, not contracts, under adverse conditions. In sum, PA–NA co-occurrence is observed when some event occurs; in the absence of an event like a stressor occurring, emotional experience tends to be unidimensional (i.e., positive) and narrower (i.e., less variability in range of positive emotions reported).

Considering these findings, the theorized short-term benefits of mixed emotions do not appear to be the case. In over 99% of the observations, participants reported experiencing at least some PA; in nearly half of these, participants reported only experiencing PA. Compared with this alternative of purely positive emotions, the experience of complexity or poignancy is not a more pleasant contrast. Larsen, Hemenover, Norris, and Cacioppo (2003) propose that if there are benefits for experiencing PA and NA together, the optimal proportion of PA to NA that enables a person to cope likely depends on the severity of the stressor at hand. Other contextual features of the event (e.g., stressor type, previous exposure, duration) as well as the individual's response to it (i.e., specific positive and negative emotions elicited) likely also play a role in whether positive and negative emotions will co-occur and whether this is beneficial. The present study cannot address whether experiencing mixed emotions is related to long-term outcomes. Based on the pattern of findings, however, it is clear that the attention to the role of context, central to DMA, is necessary in order to progress in our understanding of what emotional complexity is and whether it matters. Future research will provide valuable insight into how co-occurring positive and negative emotions in daily life are related to characteristics of stressors, and how this may relate to who fares better or worse over the long-term.

Timing of Emotional and Stressor Reports

Because of their differing recall periods, we expected that our diary and EMA results may differ. The diary study asked participants to rate the frequency with which they experienced each emotion over the last 24 hr and report on stressors which occurred in that period. Because participants were asked to aggregate their emotional experience over the day (i.e., *none of the time* to *all of the time*) and a stressor may have occurred at any time during the day, it is possible that participants may not have been experiencing all of the emotions reported in their diary at the time of the event. Some of these emotions could have been experienced prior to or after the stressor and would still be included in the count of emotions experienced on this stress-day. We expected this scenario to be less likely in the EMA data because of emphasis on current emotional state (i.e., at the moment completing the survey) and the narrower window of time for each stressor report (i.e., since the last survey; roughly within the last 3 hr).

Overall, we found fairly consistent patterns across the two studies. However, participants reported at least one positive and one negative emotion slightly more often in the diary data (55.54% of diaries) than in the EMA data (50.06% of surveys). We observed increased NA and PA variance, covariance, and correlation during stress observations in both studies (see Table 3), but the relative increase differed across the studies. PA variability increased by four times from nonstress to stress periods in the diary data; whereas PA variability increased only by 2.4 times in EMA data. The PA–NA covariance, on the other hand, increased more steeply in the EMA data (4.17 times) than in the diary data (2.50 times). These differences appeared to offset each other, as the correlation increased by a fairly similar margin during stress in the diary (1.57 times) and EMA (1.97 times) data.

Emotional Experience and Aging

In a set of studies with participants spanning young adulthood to old age, older age was associated with less variable daily and momentary NA and less variable momentary PA. This finding is consistent with Brose, Schmiedek, Lövdén, and Lindenberger (2011), who found older adults were less variable in their NA; Röcke, Li, and Smith (2009) found older adults were less variable in both NA and PA. In follow-up work, Brose, Scheibe, and Schmiedek (2013) found evidence that this reduced emotional variability among older adults is due in part to differences life contexts. Specifically, older adults report lower frequency of stressors, less heterogeneity in stressor type, and less impact of stressors on routine. Previous work in the diary dataset used in this study is consistent with these explanations—older age was associated with fewer and less subjectively, although not objectively, severe stressors (Almeida & Horn, 2004). No age differences in frequency or severity, however, were found in the momentary data (Scott et al., 2013). In both datasets, however, we found that stress was related to increased variability in both PA and NA, consistent with Brose et al.'s explanation that contextual differences underlie differences in variability.

Older adults were less likely to report co-occurring PA and NA on a momentary and daily basis. This finding is not consistent with emotional complexity in the form of co-occurrence as an emotion regulation advantage of older compared with younger adults. This, however, it does not necessarily represent a poor outcome associated with aging either. Rather, older participants in these studies were more likely to report experiencing solely positive emotions. And, to the extent that experiencing less of an uptick in NA following a stressor is a marker of resilience as some researchers have proposed (Ong, Bergeman, Bisconti, & Wallace, 2006), in the diary data, older age was associated with being less likely to experience co-occurring positive and negative emotions on stress days. Even on days when stressors were reported, older adults were more likely to endorse solely positive emotions.

What does this indicate? Several theories (Blanchard-Fields, 2007; Charles, 2010; Heckhausen & Schulz, 1995) propose that older adults are adept at, and more frequently use, strategies such as reappraisal to deal with negative events. It may be that older adults do experience mixed emotional states when exposed to stressors but, in the minutes or hours between when the stressor occurred and when they were asked about how they felt right now or today overall, they effectively reappraised the event and reduced their NA to negligible levels. Lower likelihood of stressor-day-related co-occurrence, then, could be evidence of age differences in coping effectiveness. On the other hand, there could be age differences in response patterns, such as reluctance to endorse negative items, which could result in the greater likelihood of purely positive emotion reports from older adults.

Limitations and Future Directions

The present study presents data from both EMA and diary studies of daily stressors and emotional experiences among individuals across adulthood. It tests several theory-based predictions using several operationalizations of mixed emotional states. Several limitations of the present study have been noted above. Namely, given the novel conclusions based on this data and the lack of long-term follow-up, it is not yet possible to determine whether co-occurrence is adaptive for later outcomes. Future studies should consider these operationalizations and findings within a longitudinal framework. Second, positive events were not assessed. Positive events which occurred in the period between stressor occurrence and emotion reports could serve to increase PA in addition to the stressor-related NA. Zautra Affleck, Tennen, Reich, and Davis (2005) propose that greater emotional complexity (i.e., lower PA–NA correlation) should be observed on days with more positive events. Previous studies have found support for this prediction; however, future work should test whether these changes in the correlation represent changes in the occurrence of positive and negative emotions or are due to artifacts of the correlation. Lastly, as in all self-report data, there is the possibility of systematic differences in the way that individuals respond to positive and negative emotion questions in general, and the particular items used in these studies. The pattern of findings across the two studies using different items and recall periods, however, was remarkably consistent.

In summary, the present study provides a systematic examination of the experience of mixed emotions in adults' daily lives. Taken as a whole, the results help to shed light on some of the inconsistencies in this area. First, the PA–NA correlation is not easily interpreted as an index of emotional complexity. Specifically, small correlations are hypothesized to occur under no stress (confirmed) and to represent more unipolar emotional states/less co-occurrence (disconfirmed). Rather, blended and a more expansive range of emotional states are more likely to occur under times of stress than in more pleasant contexts. Finally, older adults are less variable in their NA and more likely to report feeling purely positive than mixed. In future work, researchers must attend to the roles of variability and context in order to understand whether, when, and for whom positive and negative emotions co-occur in daily life, and if this co-occurrence is beneficial for short- and long-term adaptation.

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