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Daily Emotional Stress Reactivity in Emerging Adulthood: Temporal Stability and its Predictors

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Abstract

Background & Objectives—Emotional reactivity to stress is associated with both mental and physical health and has been assumed to be a stable feature of the person. However recent evidence suggests that the within-person association between stress and negative affect (e.g. affective stress-reactivity) may increase over time and in times of high stress, at least in older adult populations. The objective of the current study was to examine the across-time stability of stress-reactivity in a younger sample—emerging adulthood—and examine neuroticism, overall stress, social support and life events as potential moderators of stability.

Design & Methods—Undergraduate students (N = 540, mean age = 18.76 years) participated in a measurement burst design, completing a 30-day daily diary annually for four years. Moderators were assessed once at every burst, while negative affect and stress were assessed daily via a secure website.

Results & Conclusions—Findings suggest a relatively high degree of rank-order and mean-level stability in stress-reactivity across the four years, and within-person changes in neuroticism and overall stress predicted concurrent shifts in stress-reactivity. Unlike older samples, there was no evidence of an overall linear change in stability over time, though there was significant variability in linear change trajectories.

Stress is one of the most impactful psychological phenomena in regards to its consequences for mental and physical health. Indeed, the damaging effects of major stressful life events (e.g. losing a loved one or unemployment; e.g. Cohen, Tyrrell, & Smith, 1993) as well as minor daily hassles (e.g. Almeida & Wethington, 2004) have been well-documented. Furthermore, whereas major life events may be relatively rare (albeit potent), daily hassles and micro-stressors are likely to be frequent, and it has been argued that due to their accumulated effects over time may be even more important for health (Zautra, 2003). Given the prevalence and effects of daily stress, the extent to which individuals are able to modulate their affective responses to daily stressors reflects a key aspect of the role that emotion regulation plays in stress management and disease prevention (Sapolsky, 2011).

For the reasons above, researchers have been concerned with the consequences of being highly stress-reactive. Indeed, consistent evidence shows that there is significant variability between persons in the intensity of affective responses to daily stressors (Almeida, 2005) and that the degree of an individual's stress-reactivity is an important feature of affective instability (Renaud & Zacchia, 2012) as well as an important indicator of psychological health. Extreme emotional reactions to daily stress have been associated with mental illness, such as psychosis (Myin-Germeys, Peeters, Havermans, Nicolson, deVries, Delespaul, van Os, 2003), depression (O'Hara, Armeli, Boynton, & Tennen, 2014; Cohen, Gunthert, Butler, O'Neill, & Tolpin, 2005), and bipolar disorder (Myin-Germeys, van Os, Schwartz, Stone, & Delespaul, 2001). However, whereas reliable differences are found between those who are relatively high or low on stress-reactivity, little is known about the extent to which reactivity to daily stressors is stable *within* the individual over time. The current research investigates the *within-person* stability of daily stress-reactivity in young adults as assessed micro-longitudinally (i.e. with daily diaries).

Examinations of daily affective stress-reactivity have typically employed a daily diary approach (e.g. Bolger, et al, 1989; Almeida, 2005), primarily because diaries effectively avoid the pitfalls of biased retrospection and other self-report errors, and also allow for the detection of responses to relatively minor or mundane stressors. Typically researchers calculate a within-person stress-affect slope derived from repeated daily or within-day observations (i.e., multiple days, weeks, or months). This approach is believed to be a more accurate reflection of individuals' levels of stress-reactivity and is thought to capture generally stable associations that are diagnostic of the person. Stated in other words, if a similar time period were to be sampled a year or multiple years from the initial data collection, similar levels of covariation between daily stress and affect within individuals would be observed. Furthermore, this daily-diary derived index of stress-reactivity has been used as a dependent variable (e.g. Bolger, et al., 1989; O'Hara, et al., 2011; Myin-Germeys, 2001; Myin-Germeys, 2003) and an independent variable (Gunthert, et al, 2005; Cohen, et al, 2005; Piazza, et al., 2013). In other words, researchers have relied on this index to contribute to our growing understanding of the importance of stress-reactivity generally.

By calculating within person slopes from daily observations of stress and affect, this method assumes that a general intrapersonal baseline stability in reactivity exists, around which people may fluctuate. Although within-person variation in stress reactivity has been documented in non-diary lab studies and is attributed to situational factors (e.g. the presence of a supportive partner; Gerin, Pieper, Levy, & Pickering, 1992), in the context of daily process studies, greater variability is assumed to occur between persons, and it is widely employed as a between-person variable and thought to be trait-like in its stability. This assumption is based on associations between the daily-process derived stress-reactivity index and other trait-like or highly stable characteristics such as socioeconomic status (Grzywacz, Almeida, Neupert, & Ettner, 2004) or neuroticism (Bolger & Zuckerman, 1995; Gunthert, Cohen, & Armeli, 1999), as well as links to genetic vulnerability (Gunthert, Conner, Armeli, Tennen, Covault, & Kranzler, 2007). However, many correlates of stress-reactivity are themselves likely to change over time—if not over the course of a day, week or month then over the course of a year or more—such as the availability of social support (Affleck, Tennen, Urrows, & Higgins, 1994), the degree of chronic pain (Affleck, et al., 1994), or

difficult circumstances at work or home (Almeida & Wethington, 2004). It is plausible that stress-reactivity as operationalized with daily-diary data fluctuates within person, and until recently, the within-person stability of daily-process derived stress-reactivity had not been tested empirically.

To explore the trait assumptions described above, multiple waves of diaries with the same sample (also known as a “measurement burst design”) are required. Sliwinski and colleagues (2009) took this approach and examined the stability of daily stress-reactivity over time in two mature samples (average ages of the samples were 47 and 80 years respectively) and employed multiple waves of diaries in both samples (two waves over 10 years and five waves over two years respectively). They examined two varieties of stability: rank-order stability (the degree to which an individual who is comparatively high in stress-reactivity in assessment 1 is also comparatively high in assessment 2) and mean-level stability (the degree to which individuals’ absolute levels of stress-reactivity remain consistent from assessment to assessment). Results indicated that stress-reactivity showed evidence of moderate to strong rank-order stability over a 10-year period, although follow up analyses showed the strength of this association was strongest among younger participants (in their 30s and 40s) with correlations in the .50–.60 range, compared to older individuals (correlations in the .30 range). Results also indicated that stress-reactivity increased with age within-person such that as individuals aged they displayed stronger positive associations between daily stress and negative affect over the course of the study (i.e., mean-level instability). Finally, results indicated that changes in mean levels of stress-reactivity were unrelated to neuroticism, but were related to relative levels of perceived stress during that period, i.e., daily stress-reactivity was stronger during observation periods characterized by higher mean levels of perceived stress.

Collectively, Sliwinski et al.’s (2009) results suggest that similar to many personality traits, stress-reactivity has features of both within-person stability and variability, and importantly argue that the stability of daily-process derived stress-reactivity is likely to vary at different points across the lifespan. This raises questions both about younger samples and which circumstances may promote stability or be responsible for fluctuations in stress-reactivity. Based on these findings, we extended this work in two central ways.

First, to our knowledge Sliwinski and colleagues (2009) are the first to examine the stability of daily process derived stress-reactivity, and this research specifically focused on mature populations. In the current study, we examine aspects of rank-order and mean-level stability in the critical years spanning from late adolescence or early adulthood, also known as “emerging adulthood” (Arnett, 2007). Emerging adulthood, typically defined as the age period between 18 and 25, is distinct from other developmental periods in several ways. For instance, it is argued to be the least structured developmental period and is likely to involve shifts in identity and independence, specifically in western cultures (Arnett, 2007). Individuals in this age bracket are continuing to develop in regards to emotion-regulation and affective characteristics (Zimmerman & Iwanski, 2014), and research has found that well-being generally improves over the course of emerging adulthood, depressive symptoms are likely to decline and self-esteem is likely to increase (Arnett, 2007). Together these findings raise the possibility that stress-reactivity may decrease or become more stable

during this period. However, it is also known to be a critical period for the development of mental illness (de Girolamo, Dagani, Purcell, Cocchi, & McGorry, 2012), which suggests that emotional dysregulation and the influence of stress may be particularly likely to change during this period. Given that this developmental stage may be uniquely associated with shifts in emotion-regulation, it is likely that the results found in aging samples may not apply this population.

Second, we aimed to explore other predictors of mean-level stability of stress-reactivity. In addition to examining variables included in previous research—neuroticism, age and global stress level (Sliwinski, et al. 2009), we also examined recent stressful life events and the availability of social support. It is possible that major life events (e.g. loss of a loved one) may affect stability differently than overall perceived stress. Additionally, social support has been shown to reduce physiological and emotional reactivity to stress in the lab (Gerin, et al., 1992; Heinrichs, Baumgartner, Kirschbaum, and Ehlert, 2003) and may also fluctuate, if not daily, then over the course of 4 years, thereby influencing the stability of stress-reactivity.

To address these issues, we used a measurement burst design in which individuals reported on their daily stress and negative mood daily for 30 days annually for up to 4 consecutive years. Across these years individuals also reported on their social support, neuroticism and negative life events in the past year, thus allowing us to examine how overall mean levels and deviations from mean levels of these contextual factors (social support and life events) and purportedly stable person factors (neuroticism) were related to changes in mean levels of daily stress-reactivity. In view of the importance of stress-reactivity for mental and physical health, establishing the parameters of its stability across the lifespan could be important for establishing norms and shaping related interventions or treatments.

Method

The methods and procedures for this research were approved by the institutional review boards of the University of Connecticut and the University of Connecticut Health Center. Participants provided their consent to participate in the study in person during the first wave of the study and online during subsequent waves.

Participants

We recruited 575 college students from the psychology participant pool and university-wide broadcast messages at the University of Connecticut to participate in a longitudinal study of daily experiences and health-related behavior. Eighty-six percent of the sample was Caucasian, and 52% of the sample was female. The majority of participants were freshmen when beginning the study (57% percent), many were sophomores (33%) and the remainder began the study during their junior or senior year. At wave one participants' average age was 18.76 years ($SD = 1.09$ years).

Procedure

In an initial assessment, participants provided demographic and personality information, and approximately two weeks later began a 30-day daily diary each year for up to four years.

Participants were staggered across the fall (61% of participants) or the spring semester in order to account for seasonal effects, and season of participation remained consistent within participant across years. During the diary period, participants accessed the survey once per day through a secure website between the hours of 2:30 pm and 7:00 pm. This time window was selected to occur at a time most college students would be available and willing to complete the survey (after classes were likely to be completed for the day but before the beginning of evening activities). All surveys were completed online, and participants were contacted and prompted by phone for each wave of the study. Participants were compensated as a function of adherence, with a maximum of \$120 for each wave of the study, and participants who completed a minimum of 25 of the 30 days were entered into a lottery to win an additional \$100.

Measures

Daily stress—Stress was assessed with a single item asking participants to “Please rate **TODAY’S** overall stressfulness by clicking the appropriate rating.” Responses were indicated on a Likert scale ranging from 1 (*not at all stressful*) to 7 (*extremely stressful*).

Daily negative mood—Negative mood was assessed daily with a combination of items selected from the Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988) and the circumplex model of emotion (Larsen & Diener, 1992). Participants were asked, “how much does each of the following words describe your mood **NOW**? Please click on the appropriate rating.” And were provided a Likert scale ranging from 1 (*Not at all*) to 5 (*Extremely*). Negative mood was assessed with the following items: Anxiety (*angry, hostile*), anger (*jittery, nervous*), and sadness (*sad, dejected*). Each set of items were averaged to create a score for the given mood. All six items were also averaged to provide an index of overall negative mood (year 1 $\alpha = .83$; year 2 $\alpha = .87$; year 3 $\alpha = .87$; year 4 $\alpha = .84$; reliability calculated by averaging the mean alpha for each study day for each year).

Neuroticism—Neuroticism was assessed annually with Costa and McCrae’s Five-Factor Inventory (NEO-FFI; 1992). Participants were asked to indicate their agreement with 12 statements and were provided a Likert scale ranging from 1 (*Strongly Disagree*) to 7 (*Strongly Agree*). Items included statements such as, “I am not a worrier,” and “I often feel tense and jittery.” Reliability coefficient $\alpha = .87$ during all four years.

Social Support—The perceived availability of social support was assessed annually with the perceived social support from friends and family scale (Procidano & Heller, 1983). The scale consists of seven parallel Likert-scale items each for friend and family support and is calculated as the mean of the responses. Items include “*My friends give me the moral support that I need*,” “*I rely on my family for emotional support*,” and “*My friends are good at helping me solve problems*,” and responses are given on a scale ranging from 1 (*Strongly disagree*) to 7 (*Strongly agree*; year 1 $\alpha = .88$; year 2 $\alpha = .88$; year 3 $\alpha = .90$; year 4 $\alpha = .89$).

Stressful Life Events—Stressful life events during the previous year were assessed annually with 25 items from the Life Events Scale for Students (LESS; Clements & Turpin,

1996) selected as unambiguously negative by Covault et al. (2007). Selected items included events such as death of a parent, a major injury or illness, and losing a job. The composite score reflected the count of items endorsed.

Results

Descriptive statistics

Participants were omitted in a given year if they did not have at least 15 days of complete diary data. This resulted in 505 individuals for year 1 (with a mean of 25.0 diary days), 451 individuals for year 2 (89% retention from year 1; with a mean of 24.5 diary days), 412 individuals for year 3 (91% retention from year 2; with a mean of 25.4 diary days), and 369 individuals for year 4 (89.5% retention from year 3; with a mean of 25.1 diary days) yielding a 73% retention rate for all four years and a total of 43,417 person days. Attrition from the study was associated with several demographic and psychological factors; however, importantly, attrition was not predictive of stress-reactivity¹. Table 1 displays the means and standard deviations for each variable for each year and correlations within-variable across years, and Table 2 displays correlations across variables within year (assessment period).

Rank order stability of stress-reactivity

Rank-order stability reflects the degree to which the individuals maintain their high or low reactivity status *relative to other individuals* over time, that is whether an individual who is high in year 1 relative to others is also likely to be high in year 2, and so on.

Stress-reactivity in any given year was operationalized as the within-person slope derived from regressing negative mood on stress. We used MPLUS software (Muthen & Muthen, 2012) to evaluate the associations among the daily stress-negative affect slopes derived from the 4 yearly daily diary assessments. Specifically, we estimated a multilevel structural equation model in which daily diary data was nested within persons and the four waves of data were modeled in a multivariate fashion (Rabe-Hesketh, Skrondel, & Zheng, 2012). For each wave, daily negative affect was regressed on daily stress, and daily stress was person mean-centered, such that the stress-negative affect slopes represent within-person associations (i.e., the degree to which daily affect changes as a function of deviations from individuals' mean levels of daily stress). Both intercepts (which correspond to mean levels of negative affect) and slopes (i.e., daily stress-negative affect associations) from the level 1 portion of the model were treated as random effects and allowed to covary within each wave. Mean level of stress was also included in the level 2 (person level) portion of the model and its associations both across contiguous time points (stability) and with the corresponding year intercepts and slopes were estimated. In order to capture rank order stability of stress reactivity, the daily stress-negative affect slopes from each wave were regressed on the previous wave's slopes.

¹The number of waves completed was higher among Caucasian (vs. others; $r = .09, p < .05$), females compared to males ($r = .16, p < .01$), and participants with higher mean levels of daily stress ($r = .09, p < .05$) and higher mean levels of social support ($r = .11, p < .01$). Number of waves completed was lower among individuals with higher mean levels of daily negative mood ($r = -.12, p < .01$) and higher mean levels of negative life events ($r = -.21, p < .01$). Importantly, results indicated no association between the numbers of waves completed and stress-reactivity, ($b = .003, SE = .003, p = .404$).

Given that not all participants completed each wave, we used multiple imputation procedures to handle missing data. Specifically, we used the Bayes estimator with the Markov Chain Monte Carlo procedure in MPLUS (Asparouhov & Muthen, 2010); in which 10 replication sets were created that included the daily and aggregated mean stress and negative mood variables in the imputation process. We present the results pooled across all 10 replications (see Table 3).²

Tests of the intercept and slope variance components indicated that each year there was significant variability in these parameters—there was significant individual differences in mean levels of negative affect and the daily stress-negative affect slopes. Of central interest, we found significant positive associations between the daily stress-negative affect slopes (i.e., stress-reactivity) across time. Stated in other words, individuals who were more "stress-reactive" (i.e., had slopes corresponding to stronger positive associations) in year 1 were also more stress-reactive in year 2, and so on to years 3 and 4. We also specified an equality constraint to evaluate whether this effect varied over time: it did not differ across years (Wald $\chi^2_{(2)} = 0.34, p = .84$), supporting the rank order stability of stress-reactivity across this time period. It should be noted that this analytic approach does not produce a standardized effect size, thus we estimated and saved stress-negative affect slopes from each year's data and calculated Pearson correlations across the waves. Stability was fairly strong as evidenced by high correlations among the slopes from adjacent waves ($r_{12} = .70, r_{23} = .70, r_{34} = .62$).³

Also shown at the top of Table 3 are the stability coefficients for mean negative affect and stress; both showed significant positive associations across time. We also found a significant positive association at all waves, except wave 4, between mean levels of daily stress and the stress-mood slopes (see bottom of Table 3), indicating that individuals with higher mean levels of daily stress in that year were more stress reactive in that year. Finally, for each year, mean levels of daily stress levels were associated with mean levels of daily negative affect (intercepts), and mean daily negative affect (intercepts) was positively associated with stress-reactivity (stress-negative affect slopes).

Mean level stability and moderators of stress-reactivity

To examine how mean levels of stress-reactivity varied within person across time we estimated a 3-level hierarchical linear model with days (level 1) nested within years (level 2) nested within persons (level 3) using HLM software (Raudenbush, Bryk, & Congdon, 2004). The HLM approach allows for missing data and estimates parameters for all 540 individuals regardless of the number of completed waves. The model predicted daily negative affect from daily stress (person-mean centered) at level 1. Level 2 included age (grand-mean centered) and yearly deviations from overall mean levels of neuroticism, mean daily stress, negative life events and social support. Level 3 included sex (coded -1 males and 1 for females) and overall mean levels (i.e., across all years) of neuroticism, mean daily stress, negative life events and social support (all grand-mean centered). Variance components for the level 1 intercepts were estimated at the year-level (level 2) and the person-level (level 3)

²Models were re-estimated using listwise deletion and the results were substantively identical.

³Pearson correlations were based on the listwise deleted sample of $N = 309$.

portion of the model. Variance components were also estimated at the person-level of the model for level 1 stress-affect slopes and for the level 2 effects of age in predicting level 1 intercepts and slopes; we focused on these variance components because they were of theoretical interest.

Table 4 shows the results of the models. The mean negative affect portion of the table corresponds to the intercepts-as-outcomes portion of the model; here we see that overall mean levels of negative affect were higher for men, individuals high in mean levels of N and daily stress. Also, mean levels of negative affect were higher on years when mean daily stress and N were relatively higher and social support was relatively lower. Age did not interact with any of the person-level predictors in predicting average negative affect.

Of greater interest to our aims is the portion of the table corresponding to the daily stress-affect slopes (i.e., the “slopes-as-outcomes” portion of the model). Here we found a significant overall within-person association between daily stress and negative affect (i.e., the intercept of this portion of the model); specifically, on days when stress was relatively high, individuals reported higher level of negative affect. These stress-negative affect slopes (i.e., stress-reactivity) were stronger in the positive direction for individuals high in mean levels of neuroticism and negative life events (i.e., means across all years). Additionally, yearly deviations from individual mean daily stress and neuroticism predicted stress-reactivity with stress-reactivity being stronger during years with relatively higher levels of mean daily stress and neuroticism. Finally, regarding possible moderators of stress-reactivity over time, the association between age and stress-reactivity (i.e., the age interactions shown at the bottom of the table) was stronger in the negative direction for individuals with higher overall mean levels of negative life events.

Regarding the variance components specified in the model, all were significant. Specifically, there was significant variation in level 1 intercepts at level 2 ($r^2 = .034$, $p < .001$) and level 3 ($U_{00} = .079$, $p < .001$). These effects indicate that there was significant variation in average levels of negative affect across years (level 2) and across individual (level 3). There was also significant person-level variation in the stress-negative affect slopes ($U_{10} = .002$, $p < .001$) as well as the effects of age on negative affect ($U_{01} = .003$, $p < .001$) and age on the daily stress-negative affect slopes ($U_{11} = .0005$, $p < .001$). The latter effect indicates that although stress-reactivity did not demonstrate an overall linear age trajectory across all participants, there was significant variation in linear trajectories across persons (i.e., some showing positive linear changes and others showing negative linear changes).

Discussion

Affective stress-reactivity is typically assessed with daily diaries and operationalized as the within-person slope between daily stress and affect; however, there is still much to be learned about the extent to which this index of stress-reactivity is stable within-person across time, particularly in young adults. In this study we found that daily process derived stress-reactivity demonstrated both rank-order stability as well as mean-level stability (individuals' actual levels of stress-reactivity are likely to remain stable across time) in an emerging adult population.

Consistent with previous research (Sliwinski et al., 2009) we found evidence of rank-order stability in stress-reactivity. Stated in other words, individuals high in stress-reactivity one year are likely to be high going forward. This finding is consistent with the conceptualization of stress-reactivity as trait-like and goes some way in legitimizing the consideration of individuals who are “high” versus “low” in emotional reactivity to daily stressors in research.

In our examination of mean-level stability we found, consistent with previous research in an older adult sample (Sliwinski, et al., 2009), that stress-reactivity was higher in years when mean levels of daily stress for that assessment period was also higher. Interestingly, while Sliwinski and colleagues found no association between neuroticism and the stability of stress-reactivity over time, we found that yearly shifts in neuroticism were associated with shifts in stress-reactivity in the positive direction. This is consistent with previous research that demonstrates the influential role neuroticism has to play in negative affectivity and stress (Lahey, 2009). The discrepancy between the current and previous research may be due to differences in the timing of assessment. Sliwinski and colleagues assessed neuroticism only once at baseline, and thus it is possible that although overall levels of neuroticism (i.e. assessed only as a between-person variable) do not affect the stability of stress-reactivity, it is sensitive to within-person shifts in neuroticism. This highlights the need to investigate these process within-person and over time and not overly rely on one time assessments. For example, stress-reactivity may be affected by within-person shifts (however subtle) in other personality traits as well, such as optimism. The measurement burst design is an effective strategy for capturing these processes that may otherwise be difficult to detect.

Additionally, we found no overall linear age effects on stress-reactivity in this younger sample. However, there was significant variability in the association between age and stress-reactivity indicating that some individuals showed positive linear age effects whereas others showed negative linear age effects. It is possible that this developmental period is relatively heterogeneous in regards to contextual change (e.g. the development of mental illness versus the formation of lasting adult friendship networks), and thus it is difficult to detect clear patterns of changes in stress-reactivity over time. In contrast, these contextual factors may be more homogenous in older adults. For example, when examining moderators of the age-reactivity association we were able to, in essence, test whether some individuals showed greater change over time than others. The only variable tested that moderated the age effect was stressful life events. Results indicated that stress-reactivity increased with age among individuals with *lower* levels of stressful life events. This finding, suggesting that individuals with fewer stressful life events would be *less* reactive over time is not in the expected direction, and should be further examined in future research. It is possible that method-based error is partially responsible for this counterintuitive finding. The LESS, is an event checklist. Although fewer than 2% of published studies of life stress have used interview-based methods to assess major life events, a considerable body of evidence demonstrates that the concordance between event checklists and life event interviews is less than .50. Monroe (2008) and others have documented this discrepancy across methods and several reviews of the life events literature (e.g., Dohrenwend, 2006) have concluded that interview-based measures are superior to event checklists, and that despite their rarity in the life stress literature (due to issues of convenience and cost), interview-based life stress measures are

the current gold standard. We urge future researchers in this area to utilize the well-established interview-based measures of life stress.

No other potential moderators examined in this study--gender, neuroticism, average daily stress and social support-- moderated the association between age and reactivity. Although not examined here, future research might investigate the roles of other factors that may account for this variability in stability, such as resilience, which has been shown to be associated with stress-reactivity (Ong, Bergeman, Bisconti, & Wallace, 2006) or even self-regulation, which has been shown to be related to but not synonymous with emotion regulation more generally (Koole, 2009).

Our study findings provide a conceptual replication of those presented by Sliwinski and colleagues (2009) in a different population (emerging adults as opposed to aging adults), with different measures of negative mood and stress, and over a different time span (yearly for four years versus twice over ten years and five times over two years) and yielded similar conclusions. However, there are limitations worth noting. First, while completion of all four waves of diaries was not associated with stress-reactivity, there were several predictors of study adherence, which limits our confidence in the generalizability of these findings.¹ It is also possible that the findings regarding the roles of neuroticism and stressful life events in regards to mean-level stability may not hold in a design with assessment schedules more similar to those used in the previous research. Similarly, although four years of data collection allowed us to examine possible changes in reactivity that might be undetectable over a shorter time frame (e.g. a one month period), relative to a lifespan four years is a brief period and thus our findings may not reflect patterns typical of individuals in their thirties or in middle adulthood. Traits have been shown to change (either increase or decrease) over the life course (Roberts, Walton, & Viechtbauer, 2006), and stress-reactivity may also change over longer or even shorter periods of time at different stages of the lifespan or under different circumstances. Emerging adulthood may be an overall period of stability in regards to reactivity, but it could shift with major milestones, such as the entering of the workforce, transition to parenthood, retirement, or simply with aging, as suggested by the previous research (Sliwinski, et al., 2009), or, as stated above, it may be less stable in a less homogeneous environment (outside the context of a four-year university). Additionally, we assessed daytime stress and emotions associated with that stress in the afternoon. While this timing likely minimized missing data by avoiding times when participants would be engaged in social activities, it also means we did not capture end of the day or total-day reactivity. Future research—ideally work that can assess reactivity at multiple times of day or work that retrospectively covers previous evening's mood and stress—is needed to rule out any time-of-day effects regarding the stability of stress reactivity and to better capture a whole day's reactivity.

Although future research should examine both person-level and situational predictors of changes in stress-reactivity, overall the findings presented here suggest that stress-reactivity is relatively stable within person—we found no clear trajectories or patterns of change in reactivity, at least over a four-year span in young adulthood. In combination with previous findings, we can claim with greater confidence that the snap shots of stress reactivity that we are taking of individuals with brief diaries are likely to reflect relatively stable processes.

Furthermore, recognizing that stress-reactivity has a substantial degree of stability within person suggests that our efforts to mitigate the effects of stress, whether in personal relationships or in clinical therapeutic settings, may be better spent on more malleable or situationally-influenced factors and strategies, such as the availability of social support (Thoits, 1986) or mindfulness interventions (Britton, Shahr, Szepeswol, & Jacobs, 2012), which may help individuals achieve their personal “low” in regards to stress and their reactions to it.

Finally, Almeida remarked that “stress is a process that occurs within individual, and research designs need to reflect this fact” (Almeida, 2005, pp 66). Our research contributes to our understanding of what it means for stress reactivity to be an intrapersonal process. Using diaries to investigate stress is a first step in meeting this call; however, continuing to expand the time frames in which we investigate stress processes, looking at a variety of populations in a variety of circumstances and using that data to further examine the dynamics of stress-reactivity will provide us with a more complete understanding of how stress functions intrapersonally and inform how we treat stress-related illnesses in therapeutic settings.

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References

- Affleck G, Tennen H, Urrows S, Higgins P. Person and contextual factors of daily stress reactivity: Individual differences in relations of undesirable daily events with mood disturbance and chronic pain intensity. *Journal of Personality and Social Psychology*. 1994; 66:329–340. DOI: 10.1037/0022-3514.66.2.329 [PubMed: 8195989]
- Almeida DM. Resilience and vulnerability to daily stressors assessed via diary methods. *Current Directions in Psychological Science*. 2005; 14:64–68. DOI: 10.1111/j.0963-7214.2005.00336.x
- Almeida DM, Wethington E, Kessler RC. The daily inventory of stressful events: An interview-based approach for measuring stressors. *Assessment*. 2002; 9:41–55. DOI: 10.1177/1073191102091006 [PubMed: 11911234]
- Arnett JJ. Emerging adulthood: What is it and what is it good for? *Child Development Perspectives*. 2007; 1:68–73. DOI: 10.1111/j.1750-8606.2007.00016.x
- Asparouhov, T., Muthen, B. Multiple imputation with Mplus. 2010. www.statmodel.com
- Britton WB, Shahr B, Szepeswol O, Jacobs WJ. Mindfulness-based cognitive therapy improves emotional reactivity to social stress: Results from a randomized controlled trial. *Behavior Therapy*. 2012; 43:365–380. DOI: 10.1016/j.beth.2011.08.006 [PubMed: 22440072]
- Bolger N, DeLongis A, Kessler RC, Schilling EA. Effects of daily stress on negative mood. *Journal of Social and Personality Psychology*. 1989; 57:808–818. DOI: 10.1037/0022-3514.57.5.808
- Bolger N, Zuckerman A. A framework for studying personality in the stress process. *Journal of Personality and Social Psychology*. 1995; 69:890–902. DOI: 10.1037/0022-3514.69.5.890 [PubMed: 7473036]
- Clements K, Turpin G. The Life Events Scale for Students: Validation for use with British Samples. *Personality and Individual Differences*. 1996; 20:747–751. DOI: 10.1016/0191-8869(96)00005-0
- Cohen LH, Gunthert KC, Butler AC, O’Neill SC, Tolpin LH. Daily stress reactivity as a prospective predictor of depressive symptoms. *Journal of Personality*. 2005; 73:1687–1714. DOI: 10.1111/j.0022-3506.2005.00363.x [PubMed: 16274450]

- Cohen A, Tyrrell DAJ, Smith AP. Negative life events, perceived stress, negative affect, and susceptibility to the common cold. *Journal of Social and Personality Psychology*. 1993; 64:131–140. DOI: 10.1037/0022-3514.64.1.131
- Costa, PT., Jr, McCrae, RR. Revised NEO Personality Inventory (NEO-PI-R) and NEO Five-Factor Inventory (NEO-FFI) professional manual. Odessa, FL: Psychological Assessment Resources; 1992.
- Covault J, Tennen H, Armeli S, Conner TS, Herman AI, Cillessen AHN, Kranzler HR. Interactive effects of the serotonin transporter 5-HTTLPR polymorphism and stressful life events on college student drinking and drug use. *Biological Psychiatry*. 2007; 61:609–616. DOI: 10.1016/j.biopsych.2006.05.018 [PubMed: 16920076]
- Gerin W, Pieper C, Levy R, Pickering TG. Social support in social interaction: a moderator of cardiovascular reactivity. *Psychosomatic Medicine*. 1992; 54:324–336. [PubMed: 1620808]
- de Girolamo G, Dagani J, Purcell R, Cocchi A, McGorry PD. Age of onset of mental disorders and use of mental health services: Needs, opportunities, and obstacles. *Epidemiology and Psychiatric Sciences*. 2012; 21:47–57. DOI: 10.1017/S2045796011000746 [PubMed: 22670412]
- Dohrenwend BP. Inventorying stressful life events as risk factors for psychopathology: toward resolution of the problem of intracategory variability. *Psychological Bulletin*. 2006; 132:477–95. DOI: 10.1037/0033-2909.132.3.477 [PubMed: 16719570]
- Grzywacz JG, Almeida DM, Neupert SD, Ettner SL. Socioeconomic status and health: A micro-level analysis of exposure and vulnerability to daily stressors. *Journal of Health and Social Behavior*. 2004; 45:1–16. DOI: 10.1177/002214650404500101
- Gunther KC, Conner TS, Armeli S, Tennen H, Covault J, Kranzler HR. Serotonin transporter gene polymorphism (5-HTTLPR) and anxiety reactivity in daily life: A daily process approach to gene-environment interaction. *Psychosomatic medicine*. 2007; 69:762–768. [PubMed: 17942837]
- Gunther KC, Cohen LH, Armeli S. The role of neuroticism in daily stress and coping. *Journal of Social and Personality Psychology*. 1999; 77:1087–1100. DOI: 10.1037/0022-3514.77.5.1087
- Heinrichs M, Baumgartner T, Kirschbaum C, Ehler U. Social support and oxytocin interact to suppress cortisol and subjective responses to psychosocial stress. *Society of Biological Psychiatry*. 2003; 54:1389–1398. DOI: 10.1016/S0006-3223(03)00465-7
- Koole SL. The psychology of emotion regulation: An integrative review. *Cognition and Emotion*. 2003; 23:4–41. DOI: 10.1080/02699930802619031
- Lahey BB. The public health significance of neuroticism. *American Psychologist*. 2009; 64:241–256. DOI: 10.1037/a0015309 [PubMed: 19449983]
- Larsen, RJ., Diener, E. Promises and problems with the circumplex model of emotion. In: Clark, MS., editor. *Review of Personality and Social Psychology*. Newbury Park: Sage; 1992. p. 25-59.
- Monroe SM. Modern approaches to conceptualizing and measuring human stress. *Annual Review of Clinical Psychology*. 2008; 4:33–52. DOI: 10.1146/annurev.clinpsy.4.022007.141207
- Muthen, L., Muthen, B. *Mplus user's guide*. 7. Los Angeles, CA: Muthen & Muthen; 2012.
- Myin-Germeys I, van Os J, Schwartz JE, Stone AA, Delespaul PA. Emotional reactivity to daily life stress in psychosis. *Archives of General Psychiatry*. 2001; 58:1137–1144. DOI: 10.1001/archpsyc.58.12.1137 [PubMed: 11735842]
- Myin-Germeys I, Peeters F, Havermans R, Nicolson NA, deVries MW, Delespaul P, van Os J. Emotional reactivity to daily life stress in psychosis and affective disorder: An experience sampling study. *Acta Psychiatrica Scandinavica*. 2003; 107:124–131. doi:10.1034/j.1600-0447.2003.02025.x. [PubMed: 12534438]
- O'Hara RE, Armeli S, Boynton MH, Tennen H. Emotional stress-reactivity and positive affect among college students: The role of depression history. *Emotion*. 2014; 14:193–202. DOI: 10.1037/a0034217 [PubMed: 24274764]
- Ong AD, Bergeman CS, Bisconti TL, Wallace KA. Psychological resilience, positive emotions, and successful adaptation to stress in later life. *Journal of Personality and Social Psychology*. 2006; 91:730–749. [PubMed: 17014296]
- Piazza JR, Charles ST, Sliwinski MJ, Mogle J, Almeida D. Affective reactivity to daily stressors and long-term risk of reporting a chronic physical condition. *Annals of Behavioral Medicine*. 2013; 45:110–120. DOI: 10.1007/s12160-012-9423-0 [PubMed: 23080393]

- Procidano ME, Heller K. Measures of perceived social support from friends and from family: Three validation studies. *American Journal of Community Psychology*. 1983; 11:1–24. DOI: 10.1007/BF00898416 [PubMed: 6837532]
- Rabe-Hesketh, S., Skrondel, A., Zheng, X. Multilevel structural equation modeling. In: Hoyle, RH., editor. *Handbook of Structural Equation Modeling*. Guilford Press; 2012. p. 512-531.
- Raudenbush, SW., Bryk, AS., Congdon, R. HLM 6 for Windows [Computer software]. Skokie, IL: Scientific Software International, Inc; 2004.
- Renaud SM, Zaccchia C. Toward a definition of affective instability. *Harvard Review of Psychiatry*. 2012; 20:298–308. [PubMed: 23216067]
- Roberts BW, Walton KE, Viechtbauer W. Patterns of mean-level change in personality traits across the life course: A meta-analysis of longitudinal studies. *Psychological Bulletin*. 2006; 132:1–25. DOI: 10.1037/0033-2909.132.1.1 [PubMed: 16435954]
- Salovey P, Stroud LR, Woolery A, Epel ES. Perceived emotional intelligence, stress reactivity, and symptom reports: Further explorations using trait meta-mood scale. *Psychology and Health*. 2002; 17:611–627. DOI: 10.1080/08870440290025812
- Sapolsky, R. Stress, stress-related disease, and emotion regulation. In: Gross, J., editor. *Handbook of Emotion Regulation*. 1. New York, NY: Guilford Press; 2007.
- Sliwinski MJ, Almeida DM, Smyth J, Stawski RS. Intraindividual change and variability in daily stress processes: Findings from two measurement-burst diary studies. *Psychology of Aging*. 2009; 24:828–840. DOI: 10.1037/a0017925
- Thoits PA. Social support as coping assistance. *Journal of Consulting & Clinical Psychology*. 1986; 54:416–423. DOI: 10.1037/0022-006X.54.4.416 [PubMed: 3745593]
- Watson D, Clark LA, Tellegen A. Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*. 1988; 54:1063–1070. DOI: 10.1037/0022-3514.54.6.1063 [PubMed: 3397865]
- Zautra, AJ. *Emotions, Stress, and Health*. New York, NY: Oxford University Press; 2003.
- Zimmerman P, Iwanski A. Emotional regulation from early adolescence to emerging adulthood and middle adulthood: Age differences, gender differences, and emotion-specific developmental variations. *International Journal of Behavioral Development*. 2014; 38:182–194. DOI: 10.1177/0165025413515405

Table 1

Descriptive statistics for variables by year and correlations within variable across years.

<u>Daily Stress</u>				
Mean (SD)	Year	1	2	3
3.25 (.97)	1			
3.29 (.92)	2	.61		
3.33 (.99)	3	.65	.73	
3.23 (.94)	4	.57	.62	.73
<u>Daily Negative Mood</u>				
Mean (SD)	Year	1	2	3
1.38 (.36)	1			
1.41 (.42)	2	.67		
1.39 (.39)	3	.62	.74	
1.34 (.34)	4	.51	.65	.80
<u>Neuroticism</u>				
Mean (SD)	Year	1	2	3
42.53 (12.51)	1			
42.68 (12.01)	2	.68		
42.38 (11.91)	3	.59	.71	
41.01 (11.73)	4	.61	.64	.70
<u>Social Support</u>				
Mean (SD)	Year	1	2	3
5.39 (.92)	1			
5.35 (.89)	2	.64		
5.28 (.98)	3	.58	.70	
5.31 (.94)	4	.58	.64	.74
<u>Life Events</u>				
Mean (SD)	Year	1	2	3

Daily Stress				
Mean (SD)	Year	1	2	3
4.45 (2.96)	1			
3.88 (3.20)	2	.43		
3.67 (2.98)	3	.43	.44	
3.43 (2.72)	4	.43	.39	.47

Note. All values presented have a *p*-value of < .001. Daily variables were averaged first within year and then correlated across years.

Table 2

Correlations among variables within year.

	<u>Year 1</u>			
	1.	2.	3.	4.
1. Daily Stress				
2. Negative mood	.39***			
3. Neuroticism	.25***	.21***		
4. Social Support	-.10*	-.14**	-.29***	
5. Life Events	.08	.09*	.18***	-.18***
	<u>Year 2</u>			
	1.	2.	3.	4.
1. Daily Stress				
2. Negative mood	.29***			
3. Neuroticism	.30***	.37***		
4. Social Support	-.06	-.25***	-.33***	
5. Life Events	.10*	.07	.25***	-.21***
	<u>Year 3</u>			
	1.	2.	3.	4.
1. Daily Stress				
2. Negative mood	.29***			
3. Neuroticism	.27***	.36***		
4. Social Support	-.07	-.25***	-.42***	
5. Life Events	.05	.16**	.23***	-.21***
	<u>Year 4</u>			
	1.	2.	3.	4.
1. Daily Stress				

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	<u>Year 1</u>			
	1.	2.	3.	4.
2. Negative mood	.33 ***			
3. Neuroticism	.29 ***	.38 ***		
4. Social Support	-.16 ***	-.27 ***	-.42 ***	
5. Life Events	.12 *	.26 ***	.32 ***	-.17 ***

Note.

*
 $p = .05$,
**
 $p = .01$,

 $p = .001$.

Daily variables were averaged first within year and then correlated across years.

Table 3

Multilevel SEM results

	Year 1			Year 2 ^a			Year 3 ^a			Year 4 ^a		
	B	SE		B	SE		B	SE		B	SE	
Stability coefficients												
Mean daily negative affect (Intercepts)	-	-		.796**	.061		.716**	.067		.697**	.063	
Stress-Negative affect association (Slopes)	-	-		.545**	.108		.501**	.095		.529**	.103	
Mean Daily stress	-	-		.581**	.039		.777**	.038		.693**	.036	
Variances ^b												
Negative affect	.123**	.015		.081**	.014		.070**	.014		.035**	.006	
Daily Stress	.929**	.052		.522*	.042		.451**	.039		.417**	.031	
Stress-Negative affect Slopes	.004**	.001		.004**	.001		.003**	.001		.002**	.000	
Covariances												
Intercepts-Slopes	.008**	.002		.005**	.002		.007**	.002		.003**	.001	
Mean Daily Stress-Intercepts	.012**	.004		.006*	.003		.008**	.003		.002	.003	
Mean Daily Stress-Slopes	.127**	.018		.051**	.015		.043**	.012		.037**	.007	

Note. B = unstandardized regression coefficient; Cov = covariance;

^aPrediction of year from previous year for stability coefficients.

^bResidual variances at years 2–4.

**
p<.01,

*
p<.05

Table 4

Multilevel regression assessing changes in stress reactivity over time

Predictor	Mean Negative Affect ^a			Daily Stress-Affect Slopes ^b		
	b	SE	p	b	SE	p
Intercept	1.392	.014	<.001	.078	.002	<.001
Mean Neuroticism (N)	.008	.001	<.001	.001	.000	<.001
Sex	-.061	.015	<.001	.002	.003	.411
Mean Daily Stress	.120	.019	<.001	.004	.004	.272
Mean Life Events	.004	.007	.559	.004	.001	.002
Mean Social Support	-.032	.020	.106	-.001	.004	.848
Age	-.008	.006	.132	-.002	.002	.296
Yearly N	.004	.001	<.001	.001	.000	.035
Yearly Daily Stress	.081	.012	<.001	.015	.004	<.001
Yearly Life Events	.003	.004	.449	.000	.001	.930
Yearly Social Support	-.032	.013	.017	-.001	.005	.895
Age × Mean N	.001	.001	.265	.000	.000	.164
Age × Sex	-.003	.006	.570	.000	.002	.938
Age × Mean Daily Stress	-.003	.007	.650	-.001	.002	.575
Age × Mean Life Events	.001	.003	.745	-.002	.001	.013
Age × Mean Social Support	.008	.008	.290	-.003	.002	.147

Note. B = unstandardized regression coefficient.^aIntercepts-as-outcomes portion of the model (Intercept = mean Negative Affect levels);^bSlopes-as-outcomes portion of the model (Intercept = average Daily Stress-Negative Affect slope)