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Daily Stress Processes as Contributors to and Targets for Promoting Cognitive Health in Later Life

Robert S. Stawski, PhD,

School of Social and Behavioral Health Sciences, Oregon State University, USA

Eric S. Cerino, MS,

School of Social and Behavioral Health Sciences, Oregon State University, USA

Dakota D. Witzel, BS, and

School of Social and Behavioral Health Sciences, Oregon State University, USA

Stuart W.S. MacDonald, PhD

Department of Psychology, University of Victoria, BC, Canada

Abstract

Objective: The aim of this study was to test the hypothesis that daily stress processes, including exposure and emotional reactivity to daily stressors, are associated with response time inconsistency (RTI), an indicator of processing efficiency and cognitive health. Furthermore, we considered daily stress-cognitive health associations at the level of individual differences and within-persons over time.

Methods: Participants were 111 older adults (Mean=80 years, Range=66–95) enrolled in a measurement burst study where assessments of response-time based cognitive performance, stressful experiences, and affect were administered on each of 6 days over a two-week period. This protocol was repeated every six months for 2.5 years. Multilevel modeling was used to examine frequency of stressor exposure, non-stressor affect, and affect reactivity to daily stressors as individual difference and time-varying predictors of RTI.

Results: Between-persons, higher levels of non-stressor negative affect ($b=0.41$, 95% CI: -0.01 , 0.83 , $p=.055$) and negative affect reactivity ($b=0.80$, 95% CI: 0.18 , 1.42 , $p=.012$) were associated with greater RTI. Within-persons over time, higher levels of negative affect ($b=0.20$, 95% CI: 0.06 , 0.34 , $p=.006$) and negative affect reactivity ($b=0.13$, 95% CI: 0.02 , 0.24 , $p=.018$) were associated with increased RTI among the oldest portion of the sample, while higher levels of positive affect ($b=-0.11$, 95% CI: -0.21 , -0.02 , $p=.019$) were associated with reduced RTI.

Conclusions: Negative affect reactions to daily stressors are associated with compromised RTI both between- and within-persons. Findings suggest that emotional reactions to daily stressors contribute to compromise older adults' cognitive health, while increased positive affect may be beneficial.

Corresponding Author: Robert S. Stawski, PhD, School of Social and Behavioral Health Sciences, College of Public Health and Human Sciences, Oregon State University, Corvallis, Oregon, 97331-6406 USA, Telephone: 1 541 737 9052, robert.stawski@oregonstate.edu.

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Keywords

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Stress is an important risk factor for cognitive and brain health, particularly among older adults who are at increased vulnerability (1), and there is burgeoning research interest in understanding psychosocial stress as a modifiable risk factor for age-related declines in cognition (2). Recent research has demonstrated the importance of daily stress processes (3) for predicting compromises in mental (4) and physical (5) health, as well as increased mortality (6) with a growing body of work suggesting similar compromises for cognitive health during adulthood and old age (7–9). As such, daily stress processes may be candidate intervention targets (10) for promoting cognitive health and minimizing normal and pathological age-related decline (11,12).

Daily stress research focuses on exposure, the self-reported frequency of experienced stressors, and affect reactivity, stressor-related changes in affect as primary constructs contributing to health (3). Previous research has shown that greater exposure is associated with better cognitive performance across adults aged 33–95 (8,9), but worse subjective reports of memory among adults aged 66–95 (13). Conversely, greater affect reactivity to daily stressors is associated with worse cognitive performance among adults aged 25–95 (7–9). These previous studies have exclusively employed broad, ability-level assessments of cognitive function.

Response time (RT)-based tasks, reflecting speed of information processing, are common for assessing cognitive performance. Response time inconsistency (RTI), reflecting trial-to-trial fluctuations in speeded performance, have been identified as an important and unique dimension of performance reflecting neural and processing efficiency (14) and lapses of attention (15). Recently, researchers have postulated RTI as an important and valid behavioral indicator of cognitive health (16) and discussed as an indicator of processing efficiency (17) among healthy adults (18), with elevated RTI linked to clinical subgroups including those with attention deficit hyperactivity disorder (19), multiple sclerosis (20), and depression and anxiety (21). RTI is also established as an early and sensitive indicator of normal (22) and pathological cognitive aging, including risk for incident dementia (23,24). Further, RTI is linked to increased white matter hyperintensities (25), diminished white matter integrity (26), and dopamine neuromodulation (27) further underscoring central nervous system integrity as a common factor contributing to RTI (24,28,29). Although correlated with standardized measures of neuropsychological status and cognitive ability, RTI shows unique sensitivity and clinical utility for predicting cognitive decline, cognitive impairment, and mortality (24). As such, it is potentially more sensitive for detecting subtle variations in processing efficiency, attributable to durable gradations in cognitive status and central nervous system integrity, as well as more transient fluctuations attributable to contextual influences such as daily stress processes (30–32).

Stress is thought to impact cognition through various pathways, including hippocampal and frontal lobe neurotoxicity (33,34) and decreased processing efficiency (17), both of which are reflected in RTI (28). Select empirical evidence supports a positive association between

perceptions of stress (35), chronic distress (18) and RTI. These studies, however, rely on global reports of perceived stress/distress and fail to clarify whether minor everyday stressors, and daily stress processes are associated with RTI.

While daily stress processes may be associated with increased RTI among older adults, there is insufficient evidence to assess this. One key issue concerns which component(s) of daily stress processes are associated with RTI. Affect reactions to daily stressors reflect variation in affect associated with stressor exposure. Thus, differentiating the contribution of stressor exposure, non-stressor levels of affect, and affect reactivity to stressors for predicting RTI is critical for elucidating the components of daily stress processes that contribute to compromised cognitive health (3,10,36). Additionally, while individual differences in exposure and affect reactivity to daily stressors are linked to poorer mental (4) and physical (5) health, and increased mortality risk (6), recent research has shown that older adults' affect reactions to daily stressors vary over time (37) suggesting the importance of considering daily stress-cognition associations across individuals and time. One study (38) demonstrated a within-person association between stressor exposure and compromised cognitive performance, exacerbated among older adults relative to college students, but did not examine affect reactivity. Thus, a nuanced examination of daily stress -RTI associations requires consideration of the components of daily stress processes, as well as whether individual differences (e.g., people *who* are more reactive), within-person variation (e.g., *when* a person is more reactive), or both contribute to compromised cognitive health.

The current study aimed test the hypothesis that daily stress processes contribute to compromised processing efficiency and cognitive health, evidenced as increased RTI, among older adults. Furthermore, we also aimed to examine whether such associations exist at the level of individual differences, within-persons over time, or both. Drawing on data from a measurement burst design (39,40), incorporating intensive daily assessment protocols into more traditional longitudinal assessments is essential for capturing daily stress process constructs, and for delineating the nuances of daily stress-RTI associations both between- and within-persons.

Method

Participants.

At baseline, 111 older adults were enrolled in a study of cognition, health, and aging (see 37, 38 for additional details). Participants were community-dwelling residents recruited via newspapers and senior centers ($n=65$) and residents of a senior retirement community ($n=53$). Table 1 shows descriptive characteristics of the sample. All participants were of intact mental status, having committed eight or fewer errors on the Blessed mental status exam (41).

Design and Procedure

Using a measurement burst design, participants were assessed during six sessions occurring over a 14-day period, with half of the sessions occurring in the morning (9am-12pm) and half occurring in the afternoon (1–5pm). This protocol was repeated every six months over

2.5 years, yielding up to five bursts and 30 sessions of assessment for each participant (Figure 1). For each session, participants came to the lab and completed a battery of cognitive performance tasks, and self-report assessments of affect, physical symptoms, and daily stressors (see 37,38 for additional details). Trained testers administered the entire study protocol at each session, and testers worked with the same participants over the course of the study. Additionally, once per burst of assessment, participants completed a series of questionnaires on general health and wellbeing, at home, between their second and third sessions. Ninety percent of participants completed at least four bursts, and 82% completed all five. Data collection occurred from February 2002 to February 2005, with all study procedures approved by the Syracuse University Institutional Review Board. All participants provided informed consent prior to participation.

Measures.

Response Time Inconsistency.—Participants completed a number comparison choice response time (RT) task whereby two 3-digit strings were presented on a computer screen and indicated whether the strings were the same (e.g., 692 and 269) or different (e.g., 173 and 183), regardless of digit order, via pressing one of two keyboard buttons reflecting “same” vs “different” judgements. Forty trials (10 practice followed by 30 test) were completed during each session; RTI was quantified using a residualized intraindividual standard deviation (ISD; 32). Specifically, following the partialling of key confounds (including systematic within-person trends across trials as well as between-person differences in RT), the residual scores were converted to standardized T-scores ($M=50$, $SD=10$) – a metric commonly employed in the neuropsychology and clinical literatures. Thus, the RTI metric is in T-score units, with a single point on this scale reflecting 1/10 of an SD. The residualized ISD has numerous advantages over alternative quantifications; beyond being one of the most oft-used indicators of RTI, it also statistically controls for potential confounds including learning, practice effects, and individual differences in average RT (32,42). Further, previous research has shown that the residual ISD from a choice RT task exhibits adequate reliability and predictive validity with as few as 20 trials (25) and is a valid index across adulthood and older age (43).

Daily Stressors.—Participants completed a paper-pencil version of the Daily Inventory of Stressful Events (44), indicating whether each of five events (arguments, avoided arguments, network stressors, health-related stressors, other self-identified stressors) occurred prior to their session that day. Days were coded dichotomously (1=any stressors reported; 0=no stressors reported).

Daily Affect.—Positive and negative affect were each measured with five items from the Philadelphia Geriatric Center Morale Scale (45). Participants rated how they felt *right now*, *at this moment*, using a 5-point scale (not at all, a little, moderately, quite a bit, extremely). Scores were calculated by taking the sum of the five items for positive ($\alpha=.93$) and negative ($\alpha=.84$) affect.

Covariates.—Given known age, sex, and education differences in exposure and affect reactivity to daily stressors (46–49), and cognitive function (50), these variables were

included as covariates. Further, previous research has shown daily stressors to be associated with increased physical symptoms (48,49), while affect reactivity to daily stressors is associated with worse mental (4) and physical (5) health, and general perceptions of stress (37,46). As such, daily physical symptoms, general mental and physical health, and general perceptions of stress were included as covariates. Daily physical symptoms were measured at each session using a brief checklist of 18 symptoms, covering five constellations (aches and pains, gastrointestinal, cardiovascular, upper respiratory, and self-identified symptoms), experienced over the past 24 hours (51). A symptoms score was computed as the sum of symptoms endorsed. General mental and physical health were measured using the SF-12 health survey (52), while general perceived stress was measured using the Perceived Stress Scale (53), which participants completed once per semi-annual burst.

Statistical Analysis

Computation of Daily Stress Process Indicators.—Frequency of daily stressor exposure was quantified as the proportion of stressor days reported during a given burst (range=0–1). Affect reactivity was operationally defined as the slope of the stressor-affect associations, across sessions. Daily positive and negative affect scores were each regressed on the dichotomous stressor occurrence variable for each person at each burst. Intercepts, representing affect on non-stressor days, and slopes, representing the change in affect from a non-stressor day to a stressor day, were retained as predictors reflecting affect and affect reactivity, respectively. Affect reactivity slopes were set to missing when stressor frequencies were either 0% or 100% as a reactivity slope could not be computed. Reactivity slopes were computed for 109 participants (98.1% of the sample), representing the final analytic sample. Slopes could not be derived for two participants as they completed all 30 sessions, but reported stressors on every assessment day.

Daily Stress Processes Predicting RTI.—Three-level multilevel models were employed with RTI as the outcome: assessment sessions (level 1) were nested within bursts of assessment (level 2), which in turn were nested within persons (level 3) (54). Given that our daily stress process variables were constructed for each person at each burst, exposure, non-stressor affect and affect reactivity slopes were included as time-varying predictors using person-mean centering (49). The centering approach allows for explicit estimation of associations between daily stress processes and RTI, within-persons across burst, and between-persons (i.e., individual differences). Initial models included within- (level 2) and between-person (level 3) daily stress exposure, non-stressor positive and negative affect, and positive and negative affect reactivity variables as predictors of RTI. Subsequent models were adjusted for covariates including daily physical symptoms (level 1) and general mental and physical health (level 2) as time-varying covariates, and age (in years), sex (male; female), education (in years) as time-invariant (level 3) covariates. Linear trends across sessions (level 1) and bursts (level 2) were included to account for practice-related trends in cognitive performance.

Inspection of Q-Q plots of the RTI variable revealed slight evidence of non-normality of the residuals. While no residuals had a Cook's D distance greater than 1 (the largest was 0.029), 26 observations (.84%) had values exceeding the four divided by total observations (2,965

assessments) convention. Results were unchanged with these observations removed; accordingly, we report results based on all observations. RT data was missing on 144 (4.8%) of the 2,965 assessment sessions, while daily stress and affect measures were missing on 11 (0.03%) of sessions. Analyses were conducted using SAS PROC MIXED v9.4 (55) using maximum likelihood estimation, which accommodates instances of missing data without dropping entire cases. Additionally, estimates of associations in standard deviation (SD) units were obtained by multiplying the unstandardized slope coefficient by the level-specific standard deviation (reported in Table 2), divided by the level-specific SD of the RTI outcome variable, thereby providing an approximate effect on the outcome per SD difference in a predictor variable (49).

Results

Table 2 provides descriptive statistics and the distribution of variation for the primary daily stress process and RTI variables. Results from unconditional multilevel models with no predictors or covariates revealed that there was significant variation in RTI, with 63.78% of this variance reflecting *between-person* differences and the remaining 36.22% reflecting *within-person* variation across sessions (30.69%) and bursts (5.53%) of assessment. For the daily stress process variables, stressors were reported on 47% of occasions. Average levels of positive and negative affect on non-stressor days were 17.90 and 6.12, respectively, indicating that positive affect, on average was notably higher than negative affect. For affect reactivity, positive affect significantly decreased on stressor days by .47, while negative affect increased by .59. Relative to the SD in positive and negative affect within-persons across days, these reactivity slopes represent a 0.23 SD decrease in positive affect and 0.33 SD increase in negative affect. Importantly, there was evidence of significant variability in each of the daily stress process variables both between-persons and within-persons. For frequency of exposure and non-stressor affect, the majority of variation (58.32%–80.73%) reflected between-person differences, with 19.27% to 41.68% reflecting variation within-persons across bursts. In contrast, for affect reactivity, the majority of variation (71.72%–81.20%) was within-persons across bursts, with comparatively less reflecting between-person differences (18.80%–28.28%).

Daily Stress Processes Predicting RTI

In an unadjusted model (Table 3 – Model 1), between-person differences in stressor frequency were associated with lower RTI ($b = -2.90$, $p = .005$), while higher negative affect reactivity was marginally associated with higher RTI ($b = 0.60$, $p = .077$). Within-persons, during bursts when a participant's non-stressor positive affect was higher than usual, they exhibited less RTI (-0.11 , $p = .025$). Adjusting for sociodemographic covariates (Table 3 – Model 2), all results remained the same, except that between-person differences in negative affect reactivity were associated with significantly higher RTI ($b = 0.66$, $p = .042$). After additional adjustment for daily symptoms, general mental and physical health, and global perceived stress (Table 3 – Model 3), between-person differences in negative-affect reactivity remained associated with higher RTI ($b = 0.82$, $p = .011$), but stressor frequency was no longer significantly associated with RTI. Between-person differences in non-stressor negative affect, however, were associated with marginally higher RTI ($b = 0.41$, $p = .055$).

Further, the within-person association of non-stressor positive affect and lower RTI remained. We also estimated all models predicting average RT and none of the between- or within-person daily stress process effects were significant suggesting that daily stress-RTI associations are not attributable to daily stress-related slowing of performance (see Table, Supplemental Digital Content 1). Average RT and RTI were correlated, ($r=.63, p<.001$), suggesting related, but distinct constructs (14,16), which is further underscored by the dissociative pattern of daily stress process effects in the aforementioned predictive models.

Age Differences and Sensitivity Analyses

Correlations of age with primary RT and daily stress process variables revealed greater RTI, average RT and non-stressor negative affect, as well as lower non-stressor positive affect (see Table, Supplemental Digital Content 2). Using age at baseline assessment, we examined linear age differences in the daily stress processes variables on RTI (Table 44) and three effects emerged. First, the effect of between-person differences in stressor frequency decreased with age. Simple slopes for the stressor frequency effect were derived for $-1SD$ age (73.6), mean age (80.0) and $+1SD$ age (86.4) (see top panel of Figure 2). Higher stressor frequency was associated with lower RTI at $-1SD$ age ($b=-2.89$, 95%CI: $-5.61, -0.17$, $p=.037$, SD-units= -1.03), but not for the mean ($b=-1.11$, 95%CI: $-3.08, 0.85$, $p=.26$, SD-units= -0.39) or $+1SD$ ($b=.67$, 95%CI: $-1.91, 3.25$, $p=.61$, SD-units= 0.24) ages. Second, as shown in the middle panel of Figure 2, there were age differences in the within-person non-stressor negative affect association such that reporting more negative affect than usual was associated with reduced RTI at $-1SD$ age ($b=-0.24$, 95%CI: $-0.42, -0.05$, $p=.011$, SD-units= -0.27), but increased RTI at $+1SD$ age ($b=0.20$, 95%CI: $0.06, 0.34$, $p=.006$, SD-units= 0.23). Third, there were age differences in the within-person negative affect reactivity association. When individual's negative affect reactivity was greater than usual, RTI also increased, but only at $+1SD$ age ($b=0.13$, 95%CI: $0.02, 0.24$, $p=.018$, SD-units= 0.17) as the association was not significant for either the mean ($b=0.01$, 95%CI: $-0.07, 0.10$, $p=.76$, SD-units= 0.02) or $-1SD$ ($b=-0.11$, 95%CI: $-0.23, 0.02$, $p=.100$, SD-units= -0.14) ages (see bottom panel of Figure 2). Sensitivity analyses revealed that results remained unchanged when analyses were adjusted for number of bursts completed, or restricted to participants who completed at least four assessment bursts.

Discussion

Daily stress processes were associated with higher RTI in a sample of older adults. Leveraging the novel strengths of a measurement burst design, we observed that individual differences in negative affect reactivity, and to a lesser extent, non-stressor negative affect were associated with higher RTI, whereas positive affect was associated with decreased RTI within-persons over time. Exploration of age differences in daily stress process-RTI associations revealed that the negative association between frequency of exposure and RTI was specific to the younger segment of the sample, while within-person variation in non-stressor negative affect and negative affect reactivity were associated with increased RTI, and specific to the older segment of the sample. Further, results were robust to adjustment for daily health, general mental and physical health, and perceived stress. Together, results suggest that specific dimensions of daily stress processes are candidate risk factors for

compromised cognitive health during old age, and that both *for whom* and *when* these processes are exerting influence matters.

Daily Stress Processes and RTI: Between-Person Associations

Between-person differences in frequency of exposure were associated with less RTI, suggesting that people who experience daily stressors more frequently are in better cognitive health. While seemingly counterintuitive, this result is consistent with previous research showing positive associations between individual differences in stressor frequency and cognitive function throughout midlife (8) and old age (9). While stressors may negatively influence health-related outcomes, the stressors assessed in studies of daily stress, including this study, may in part reflect social and professional engagement and a more active lifestyle (8,9). The attenuation of this association after adjustment for daily health, general mental and physical health, and perceived stress suggests that proximal and general health constraints on social engagement may explain this paradoxical association (56). Further, we observed suggestive evidence of age differences in this association such that this negative association was specific to the younger adults, who are potentially more vital and engaged. This explanation, however, assumes individual differences in daily stressor frequency reflect engagement. To our knowledge, no empirical studies have considered daily stress, engagement, and RTI simultaneously to evaluate this explanation; this is a potentially promising line of future inquiry.

We also observed positive associations between individual differences in non-stressor negative affect and negative affect reactivity and increased RTI indicating that each was associated with poorer processing efficiency. Further, we did not observe age differences in these distinct effects, suggesting that both are relevant risk factors for RTI among older adults, regardless of one's age. This is consistent with previous research showing similar associations with indices of broad fluid cognitive ability measures during midlife (8) and old age (9), and extends these findings to RTI. Previous research has suggested that stress and distress are associated with increased processing efficiency, as measured by RTI, demonstrating such associations with measures of neuroticism (18), perceived stress (35), and mild anxiety and depressive symptoms (21). Adjusting for similar constructs, daily stress processes were associated with RTI among older adults. Further, these results point to ambient and daily stressor-related increases in negative affect as plausible mechanisms contributing to decreased processing efficiency and compromises in older adults' cognitive health. Previous research has shown that neuroticism is associated with emotional reactivity to daily stressors (57) and RTI (18), and that individual differences in general levels of negative affect account for the neuroticism-RTI link. While we were unable to evaluate the contribution of neuroticism in the current study, we do acknowledge that neuroticism is a potentially important contributor to our observed negative affect reactivity-RTI association.

In contrast to daily stress process components involving negative affect, neither between-person differences in non-stressor positive affect or positive affect reactivity were associated with RTI. This is broadly consistent with previous research (8,9). One study, however, did observe greater positive affect reactivity to interpersonal tensions, specifically, and poorer cognitive function during midlife (8). Differences in these results could be due to age and

sample-size differences, as well as our dichotomous quantification of exposure, which ignores stressor type. Taken together, daily negative affect and negative affect reactivity to daily stressors are important dimensions of daily stress processes associated with individual differences in older adults' processing efficiency and cognitive health.

Daily Stress Processes and RTI: Within-Person Associations

Compared to between-person associations, within-person associations between daily stress processes and RTI were scant. One association indicated that when older adults' non-stressor positive affect was higher than usual, they exhibited less RTI. This is consistent with previous research showing positive day-to-day associations between positive affect and cognition among older adults attributed to increased motivation (58) and improved neural transmission (59). As such, our results are consistent with the health-promoting effects of positive emotions (60) and extend these findings to processing efficiency and cognitive health.

Within-person variation in non-stressor negative affect and negative affect reactivity were both associated with RTI, but the patterns differed by age. At younger ages in the current sample, higher levels of non-stressor negative affect were associated with decreased RTI, whereas the opposite was true with increasing age. From a stress-processing efficiency perspective, such transient fluctuations in negative affect could represent increased arousal that served to sharpen functioning, resulting in reduced RTI for the relatively younger portion of the sample, but compromised functioning, resulting in increased RTI among the more cognitively vulnerable, comparatively older segment of the sample. With respect to negative affect reactivity, being more reactive than usual was associated with increased RTI, but this was specific to the older segment of the sample. Taken together, transient fluctuations in positive affect appear to hold promise for promoting older adults' processing efficiency and cognitive health, while transient fluctuations in negative affect, and heightened negative affect reactivity appear to be deleterious to processing efficiency and cognitive health, particularly among older adults.

It is important to note that the age-related increase and specificity of these within-person associations among the oldest portion of our sample suggests that daily stress processes operate to create periods of risk for increased RTI. Specifically, between-person differences in negative affect reactivity emerged as a risk factor for increased RTI among older adults, regardless of chronological age. Within-persons and specifically among the oldest segment of the sample, when non-stressor negative affect and negative affect reactivity were higher than usual, RTI also increased. Thus, among older adults, there are *high risk individuals* 'who' could potentially be targeted for intervention, and particularly among the oldest old, there are *high risk periods* for 'when' individuals could be targeted for intervention to promote cognitive health.

Value of the Measurement Burst Design and RTI

The current results showcase the importance of the measurement burst design for examining the influence of daily stress processes. Without such a design, it would be impossible to differentiate between-person and within-person variation in daily stress process indicators,

as well as to consider the dissociative patterns of results observed. The results of the current study underscore the importance and value of the measurement burst design as both person and time contribute to daily stress process-RTI associations. This pattern of results is consistent with recent arguments regarding the importance of considering what, who, and when to target potential interventions for mitigating stress and promoting health (10), and suggest value for this approach for further examination of daily stress links to other dimensions of cognitive, mental, and physical health.

Additionally, RTI demonstrated considerable value as an indicator of cognitive health. Increased negative affect reactions to daily stressors were associated with greater RTI, which is consistent with theoretical accounts of stress and distress disrupting neural and processing efficiency (17,33). Furthermore, when we examined daily stress processes predicting average RT (computed from the same task), a hallmark indicator of cognitive aging (61), no significant associations emerged. This dissociative pattern of results suggests that daily stress processes do not necessarily compromise how quickly people process information, but rather how efficient that processing is. Thus, this link is particularly valuable as it provides insight into dimensions of daily stress processes that confer risk to cognitive health – and notably a specific dimension of cognitive function (i.e., processing efficiency) -- with burgeoning empirical evidence for the relevance and utility of variability in terms of functional (32,62,63), structural (26,28), and clinical (25,64,65) dimensions of cognitive health.

Limitations and Future Directions

Despite the advantages of the measurement burst design, the between- and within-person associations reported are correlational, so directionality and causation cannot be determined. In future research, it will be important to address this by integrating measurement burst and prospective longitudinal designs. The temporal resolution for affect reactivity was relatively gross where ecological momentary assessment (66) approaches could provide improved quantification of affect reactivity and allow for examining daily stress process-RTI associations over different temporal intervals. Our quantifications of exposure and affective reactivity to daily stressors was necessarily reductionist, merely distinguishing stressor from non-stressor days. Analysis of associations stratified by *stressor type* resulted in model convergence issues, largely due to restrictions in the number of observations and participants, which is commensurate with well-established sociodemographic differences in the frequency and types of daily stressors experienced (e.g., 3,8). Additional research targeting particular types of stressors and their links to RTI will help clarify the type(s) of daily stressors exerting the most potent impact on RTI. Similarly, we only examined RTI, reflecting processing efficiency, as a primary outcome. While we selected RTI as a theoretically-motivated candidate indicator of cognitive health linked to daily stress processes, future research examining additional neuropsychological and cognitive measures will help clarify the specificity, or generality, of daily stress-cognition associations. Lastly, a relatively small sample comprised of comparatively highly educated and predominantly female older adults participated in the current study. Additional research replicating these findings in more heterogeneous samples will help further evaluate generalizability.

Conclusion

Our results contribute to a growing body of literature demonstrating the importance of daily stress as a risk factor for compromised mental and physical health, extending this to cognitive health among older adults. Both individual differences and within-person variation in daily stress processes, particularly non-stressor negative affect and negative affect reactivity, predict compromised processing efficiency as measured by RTI. Thus, intervention efforts targeted toward mitigating daily stress processes must consider *what*, as well as *who*, and *when* to target (10,67). Additionally, within-person variation in positive affect appears to hold promise for promoting older adults' processing efficiency. In summary, daily stress processes appear to be candidate contributors to, and targets for, promoting cognitive health during old age.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Acronyms:

RTI	Response Time Inconsistency
CI	Confidence Interval
ISD	Intraindividual Standard Deviation
RT	Response Time

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Figure 1.
Depiction of measurement burst design protocol.

Figure 2. Individual differences in frequency of stressor exposure effect on RTI by age (Panel A). Time-varying effect of non-stressor negative affect on RTI by age (Panel B). Time-varying negative affect reactivity effect on RTI by age (Panel C). For all figures, bars represent predicted slope point estimate (and 95% CI) at select points in the age distribution (–1SD age, mean age, and +1SD age).

Table 1.

Sample Characteristics and Demographics

	Mean/%	SD	Range
Age	80.24	6.29	66–95
Education (Years)	14.97	2.43	8–22
Sex			
Female	72%		
Male	28%		
Race			
Caucasian	97%		
African American	2%		
Asian	1%		
Marital Status			
Married	43%		
Widowed	45%		
Self-Reported Health Conditions Ever Diagnosed			
Cancer	27%		
Diabetes	11%		
Heart Attack	8%		
Congestive Heart Failure	6%		
Stroke	8%		

Note. N=109 participants

Table 2.

Sample Average Estimates and Distribution of Variation from Multilevel Models of Response Time Inconsistency and Daily Stress Process Variables.

	Estimate (95% CI)	Percentage of Total Variation			
		SD(WPS)	SD(WPB)	SD(BP)	WPS WPB BP
RTI	6.73 (6.07, 7.09)	2.85	0.84	1.98	30.69% 5.53% 63.78%
Frequency of Exposure	.47 (.43, .52)	–	0.18	0.25	– 32.43% 67.57%
Non- Stressor Positive Affect	17.90 (17.34, 18.47)	–	1.46	2.99	– 19.27% 80.73%
Non- Stressor Negative Affect	6.12 (5.86, 6.38)	–	1.14	1.34	– 41.68% 58.32%
Positive Affect Reactivity	-.47 (-.64, -.29)	–	1.75	0.84	– 81.20% 18.80%
Negative Affect Reactivity	.59 (.40, .77)	–	1.44	0.90	– 71.72% 28.28%

Note. N=109 participants. RTI=Response Time Inconsistency, CI=Confidence Interval, SD=Standard Deviation, WPS=Within-Person across Sessions, WPB=Within-Person across Bursts, BP=Between-Persons.

Table 3.
Multilevel Model Estimates of Between- and Within-Person Daily Stress Process and RTI Associations

Between-Person Associations	Model 1				Model 2				Model 3			
	b	(95%CI)	p	SD-units	b	(95%CI)	p	SD-units	b	(95%CI)	p	SD-units
Frequency of Exposure	-2.90	(-4.90, -0.91)	.005	-1.03	-2.18	(-4.09, -0.26)	.027	-0.77	-1.09	(-3.10, 0.92)	.28	-0.39
Non-Stressor Positive Affect	-0.11	(-0.27, 0.06)	.22	-0.13	-0.06	(-0.22, 0.10)	.47	-0.07	-0.10	(-0.27, 0.07)	.23	-0.12
Non-Stressor Negative Affect	0.32	(-.06, 0.71)	.102	0.26	0.19	(-0.18, 0.57)	.31	0.16	0.41	(-0.01, 0.83)	.055	0.34
Positive Affect Reactivity	0.09	(-0.60, 0.79)	.79	0.06	0.29	(-0.39, 0.96)	.40	0.19	0.34	(-0.31, 0.99)	.31	0.22
Negative Affect Reactivity	0.60	(-0.07, 1.26)	.077	0.40	0.66	(0.02, 1.29)	.042	0.44	0.80	(0.18, 1.42)	.012	0.54
Within-Person Associations	b	(95%CI)	p	SD-units	b	(95%CI)	p	SD-units	b	(95%CI)	p	SD-units
Frequency of Exposure	0.06	(-0.52, 0.64)	.85	0.03	0.06	(-0.52, 0.64)	.83	0.03	0.10	(-0.50, 0.69)	.75	0.04
Non-Stressor Positive Affect	-0.11	(-0.20, -0.01)	.025	-0.14	-0.11	(-0.20, -0.01)	.023	-0.14	-0.11	(-0.21, -0.02)	.019	-0.15
Non-Stressor Negative Affect	0.02	(-0.09, 0.13)	.70	0.03	0.03	(-0.08, 0.13)	.65	0.03	0.03	(-0.08, 0.15)	.49	0.04
Positive Affect Reactivity	-0.04	(-0.11, 0.03)	.29	-0.06	-0.04	(-0.11, 0.03)	.31	-0.05	-0.03	(-0.11, 0.04)	.37	-0.05
Negative Affect Reactivity	0.02	(-0.07, 0.10)	.67	0.02	0.02	(-0.06, 0.11)	.64	0.03	0.03	(-0.06, 0.12)	.50	0.04

Note. N = 109 participants. Model 1: Unadjusted. Model 2: Model 1 + Covariate adjustment for age, sex and education. Model 3: Model 2 + Covariate adjustment for daily physical symptoms, SF-12 mental and physical health, and perceived stress scale. SD-units: slope estimate in SD-units.

Table 4.

Multilevel Model Results for Age, Daily Stress Process Variables, and their Interactions Predicting RTI.

Between-Person Associations				
	b	(95%CI)	p	SD-units
Age	0.14	(-0.59, 0.86)	.71	0.62
Frequency of Exposure	-1.11	(-0.09, 0.85)	.26	-0.39
Non-Stressor Positive Affect	-0.08	(-0.24, 0.08)	.33	-0.10
Non-Stressor Negative Affect	0.40	(-0.04, 0.83)	.075	0.33
Positive Affect Reactivity	0.18	(-0.47, 0.83)	.58	0.12
Negative Affect Reactivity	0.66	(-0.06, 1.37)	.073	0.44
Age*Frequency of Exposure	0.28	(0.00, 0.56)	.050	0.63
Age*Non-Stressor Positive Affect	-0.01	(-0.03, 0.02)	.59	-0.06
Age*Non-Stressor Negative Affect	-0.00	(-0.07, 0.07)	.93	-0.02
Age*Positive Affect Reactivity	0.07	(-0.03, 0.17)	.18	0.29
Age*Negative Affect Reactivity	0.02	(-0.06, 0.11)	.58	0.02
Within-Person Associations				
	b	(95%CI)	p	SD-units
Frequency of Exposure	0.12	(-0.46, 0.70)	.68	0.06
Non-Stressor Positive Affect	-0.15	(-0.24, -0.05)	.002	-0.19
Non-Stressor Negative Affect	-0.02	(-0.13, 0.10)	.74	-0.02
Positive Affect Reactivity	-0.07	(-0.13, 0.01)	.080	-0.09
Negative Affect Reactivity	0.01	(-0.07, 0.10)	.76	0.02
Age*Frequency of Exposure	0.06	(-0.04, 0.16)	.24	0.18
Age*Non-Stressor Positive Affect	0.00	(-0.01, 0.02)	.71	0.03
Age*Non-Stressor Negative Affect	0.03	(0.02, 0.05)	<.001	0.25
Age*Positive Affect Reactivity	0.00	(-0.01, 0.01)	.59	0.03
Age*Negative Affect Reactivity	0.02	(0.01, 0.03)	.004	0.16

Note. N = 109 participants. Adjusted for sex, education, daily physical symptoms, general mental and physical health, and global perceived stress.
SD-units: slope estimate in SD-units.