The Pennsylvania State University
The J. Jeffrey and Ann Marie Fox Graduate School

STRESSOR FREQUENCY, SEVERITY, AND VARIABILITY IN SEVERITY AND THEIR ASSOCIATIONS WITH DAILY MEMORY LAPSES

A Thesis in

Human Development and Family Studies

by

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Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Science

December 2024

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ABSTRACT

Long-term negative impacts of stress on memory have been well established; however day-to-day associations between stressors and memory, such as specific manifestations of stressors that may degrade daily memory, have not been fully examined. Data from an 8-day diary study in the Midlife in the United States study (n=1,800) were used to conceptualize three patterns of daily stressors: frequency, severity, and variability. Potential differences by age in these associations were also examined. Participants reported 7 types of stressors (e.g., home-related, discrimination) they encountered, which were summed daily (frequency). On days when a stressor was encountered, they reported how stressful it was (severity). Individual standard deviation of stressor severity across the week (variability) was also calculated. Memory lapses were reported with 9 items each day. After controlling for sociodemographic and health covariates, results from multi-level modeling revealed that participants reported more memory lapses on days when they had greater frequency (B=.14, SE=.01, p <.001) and higher severity (B=.06, SE=.01, p <.001) of stressors. Participants with greater frequency (B=.79, SE=.04, p <.001) and higher severity (B=.21, SE=.02, p <.001) of stressors and greater variability in stressor severity also reported more memory lapses on average. Age moderated the within-person association of stressor frequency, such that on days when older individuals reported encountering more stressors, they reported less memory lapses compared to younger individuals. These findings highlight that even short-term stressor exposure, particularly frequent or high-severity stressors, may have negative associations with day-to-day memory, while these associations may become weaker with advancing age.

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ACKNOWLEDGEMENTS

Use of Midlife in the United States (MIDUS) data: Publicly available data from the MIDUS study was used for this research. Since 1995 the MIDUS study has been funded by the following: John D. and Catherine T. MacArthur Foundation Research Network, National Institute on Aging (P01-AG020166), and National institute on Aging (U19-AG051426).

Chapter 1

Introduction

Daily Stressors and Memory

Experiencing stressors is an inevitable part of life, yet both human and animal models have gathered extensive evidence that indicates high levels of stress can have a negative impact on cognitive function. Though some cases stress, such as those caused by life-threatening events or brief, moderate stress, may have enhancing effects on memory, these positive effects are more prominent in the process of encoding information surrounding the event more so than ability to retrieve that information later (Joëls et al., 2006; Roozendaal, 2002; Vogel & Schwabe, 2016). In contrast, other studies demonstrate that stress may interfere with the formation of memories around the time of the stressful event and can be a hinderance when information needs to be recalled later (Klier & Buratto, 2020; Pitman et al., 2012; Wolf, 2009) – even if the disruption is just for a few moments. Much like encountering stressors, moments of forgetfulness are also a common occurrence for most individuals, and often these moments seem to be more frequent when under high levels of stress.

The Easterbrook Hypothesis (Easterbrook, 1959) proposes that when under stress or in high states of arousal, our attention tends to narrow onto the source of and information directly relevant to the stressful situation. This survival mechanism may be intended to help better cope with stress, but in the modern world, this phenomenon can manifest in disruptive ways. Attention that would otherwise be dedicated to minute, day-to-day things such as where you

placed your keys or completion of a task get overshadowed by the stressor. This information therefore may not be encoded properly or at all, resulting in memory lapses when the information needs to be recalled later. Although these moments of forgetfulness may seem trivial in most cases, frequent memory lapses may be source of stress for some individuals by invoking concerns about their memory or by interfering with daily tasks such as work performance (de Souza-Talarico et al., 2020) and healthcare routines. In turn, this stress may lead to even more instances of memory lapses, thus kickstarting a vicious cycle.

The long-term impact of chronic stress on various aspects of memory has been extensively explored in the literature (Öhman et al., 2007; Peavy et al., 2009; Shields et al., 2017), but gaps still exist regarding how short-term fluctuations in daily stressors may impact day-to-day memory. Studies regarding the relationship between acute stress and memory performance typically investigate these associations in controlled laboratory settings and evaluate memory using cognitive tests such as recalling a list of words presented by the researcher or details of a picture. Though this approach is useful in assessing an individual's capacity to encode and recall information in a highly controlled environment, less is known whether and how these associations may translate into a person's natural lived environment where one's attention is constantly pulled in different directions. The current study utilized a Daily Diary design that collects ecologically valid (Lischetzke, 2014) data on stressors and incidents of forgetfulness over several consecutive days to examine how daily stressors that occur in a person's lived setting are associated with the experience of memory lapses.

When examining stress and stressors, it is important to keep in mind that not all stress is created equal. Stressors can originate from numerous sources throughout the day, can vary in

severity, and the frequency and severity of stressors may fluctuate from day to day. Though high levels of chronic stress can interfere with memory (Öhman et al., 2007), it is also possible that individuals may build up resilience from exposure to repeated, low-intensity stressors (Gerra et al., 2001; Grissom & Bhatnagar, 2009; Rankin et al., 2009), which may paradoxically be helpful to recall of memories instead of harmful. On the other hand, this repeated exposure may lead to a pileup of stress, and consequently may lead to perceiving higher frequency and severity of stressors, especially if the individual perceives their life to be highly stressful overall (Stawski et al., 2008).

There is also evidence to support that age plays a role in how we perceive and experience stress. Older adults tend to report less frequent daily stressors (Stawski et al., 2008; Stefaniak et al., 2022) and generally rate stressors as less severe than their younger counterparts despite no significant differences being found in the severity of the stressors as rated by a third party (Almeida & Horn, 2004). Compared to younger age groups, they also tend to experience less stress from daily hassles such as traffic jams or malfunctioning appliances and rate negative experiences as more neutral (Stawski et al., 2008; Stefaniak et al., 2022). However, there also is evidence to indicate that the opposite is plausible. The Strength and Vulnerability Integration (SAVI) theory (Charles & Piazza, 2024) predicts that even though they may encounter stressors less frequently due to selective engagement and disengagement in activities, when older adults do encounter stressors, they may be more physiologically reactive (e.g., increased heart rate), indicating a stronger underlying response. Additionally, older adults have more difficulty suppressing thoughts unrelated to the current task, or cognitive interference, than younger age groups (Stawski et al., 2011). This interference may act as a distractor and disrupt the encoding of memories associated with a task (such as putting your keys on the table) or making the

information harder to find when it needs to be recalled later, thus resulting in more memory lapses. As higher perceived stress is associated with greater cognitive interference both at the within-person and between-person level (Stawski et al., 2011), having more frequent and severe stressors may exacerbate occurrences of memory lapses. We do not yet know how memory lapses change in response to daily stressors in older adults (who may be more prone to memory lapses) compared to younger adults.

Current Study

This study aimed to extend the current literature on stress and memory by investigating day-to-day associations between different characteristics of stressors (i.e., frequency, severity, and variability in severity) and memory lapses in participants' lived settings. We hypothesized at the within-person level that on days when participants reported greater frequency and higher severity of stressors, they would report more memory lapses than their average. We also hypothesized at the between-person level that those who, on average, report greater frequency, higher severity, and greater variability in severity of stressors would also report more memory lapses on average. We also examined potential age differences in these associations. Due to lack of research on this topic, however, we did not form a priori hypothesis and explored whether age moderated the associations of stressor frequency, severity, and variability in severity with memory lapses.

Chapter 2

Methods

Data and Participants

A combined sample of the third wave of data collection from the Midlife in the United States (MIDUS) study (2017 – 2019) and the MIDUS Refresher sample (2012 – 2014), which was used as a way to replenish the core MIDUS sample, was used for this analysis (Ryff et al., 2017, 2019). The MIDUS study is a longitudinal study that sampled adults from various regions across the contiguous United States to create a nationally representative sample of middle-aged and older adults. These waves of data collection were used due to questions regarding daily memory lapses only being introduced in 2012 with the Refresher sample data collection. The respective Milwaukee project samples, which oversampled Black adults in the Milwaukee metropolitan area to increase racial/ethnic diversity, were included. Sociodemographic variables and self-rated health were collected in a self-administered questionnaire (SAQ), and variables regarding stressors and memory lapses were collected via telephone interview from the National Study of Daily Experiences (NSDE) subproject of the MIDUS study (Ryff & Almeida, 2017). The MIDUS studies were approved by the University of Wisconsin-Madison Institutional Review Board (IRB), and written informed consent was received for all MIDUS participants. Due to the use of publicly available, de-identifiable MIDUS data, the current study was exempt from an IRB review.

Out of 7,768 participants who were included in either the third wave of MIDUS data collection from the core sample (n = 3,683) or the Refresher sample (n = 4,085), a total of 2,018 participants (26.0%) also responded to the NSDE subproject. Each participant was contacted via telephone for 8 consecutive days and asked about their experiences from the past 24 hours. These

interviews included whether they encountered various stressors, how severe they felt each stressor was, and whether they experienced any lapses in their memory regarding daily tasks such as the placement of an object, important information, or why they entered a room. Further details on the procedures for the NSDE project can be found in previous literature (Radler, 2014).

Participant compliance was generally high with 95.2% of all diary days completed, and 1,430 (70.9%) participants completing all 8 days. There were 146 (7.2%) of the NSDE respondents who had less than 4 valid days (i.e., less than half) of stressor or memory lapse data, and an additional 72 (3.6%) participants did not provide complete sociodemographic or self-rated health data and were thus excluded from this study. A total of 1,800 (89.2%) participants provided valid and complete data for stressful experiences, stressor severity, and memory lapses for at least 4 of the 8 days as well as sociodemographic and self-rated health covariates. Figure 2-1 shows a flow chart describing the steps leading to a final analytic sample. There were no significant age or sex differences between participants who were included in the final sample (n = 1,800) and those were excluded (n = 318); however, those excluded were slightly less educated and more likely to be non-white and/or Hispanic.

Measures

Stressors (predictor): Each evening over the 8 consecutive days, participants responded to the Daily Inventory of Stressful Events (DISE) questionnaire (Almeida et al., 2002) where they were asked if they experienced the following stressful events at any time over the past 24 hours or since the previous interview: “Did you have an argument or disagreement?”, “Did you avoid a disagreement?”, “Did anything happen at work or school?”, “Did anything happen at home?”, “Did you experience discrimination due to your race, sex, or age?”, “Did a stressful event happen

to close friend or relative that affected you?", and "Did anything else stressful happen to you?". The response to each question was dichotomized (yes = 1, no = 0). If the respondent answered "yes" to any of the stressful experiences, they were then asked to rate how stressful the experience was on a Likert scale from "Not at all" (0) to "Very" (3).

Stressor frequency was determined by the total number of "yes" responses to whether they encountered a stressor (0 – 7) each day. **Stressor severity** was calculated as the sum of stressor severity (0 – 3) for each of the reported stressors that day (e.g., a stressor with a severity of 3 and a different stressor with a severity of 1 on the same day would score as a 4 for that day). On days when participants indicated they did not encounter a stressor, severity was entered as 0 for that stressor. **Variability in stressor severity** was calculated as the standard deviation of stressor severity score over the 8-day period for each participant. Variability in stressor severity was used to better capture variability in how much stress the person experienced across days regardless of how many sources it came from. Higher variability in stressor severity may represent inconsistency in experiences of stressors, which may be more difficult to become habituated to or build up resilience against. Additional sensitivity analyses were conducted for stressor severity and variability in severity where only days when at least one stressor was experienced (i.e., they were asked to rate the level of severity for any stressor) were included.

Memory lapses (outcome): Over 8 consecutive days, participants were asked whether they had at least one incident of forgetting each of the following 9 things in the past 24 hours or since the last interview: an errand or chore, a word, an appointment, someone's name, important information, where something was placed, why they entered a room, to take a medication, or to finish something they started. A sum of the total "yes" responses was calculated for each day with a higher score indicating more memory lapses.

Age (moderator): Age was calculated as the difference between date of birth and interview date, in years. Continuous age was used for both interaction effects and as a covariate in main-effects models.

Covariates: Each model was controlled for sociodemographic variables such as sex (1 = female, 0 = male), race/ethnicity (1 = non-Hispanic White, 0 = all other races/ethnicities), education (scale of 12 = Ph.D., MD, or other professional degree to 1 = no school or some grade school; further details outlined in Table 3-1), self-rated health (Likert scale from 1 – 5 where 1 = poor and 5 = excellent), and employment status (1 = currently employed, 0 = not currently employed). Race/ethnicity was dichotomized into non-Hispanic White and "all other races/ethnicities" due to low response rate of individuals who did not identify as non-Hispanic White. We also controlled for weekends (Saturday or Sunday) vs. weekday (Monday – Friday) (1 = weekday, 0 = weekend) as a daily level covariate.

Statistical Analyses

Descriptive statistics and correlations were used to examine sample characteristics and univariate associations between main variables. Multi-level modeling (PROC MIXED) in SAS version 9.4 was used to test the independent associations of stressor frequency, severity, and variability of severity with daily memory lapses. This model allowed for analysis at the within-person (comparing changes in an individual from day-to-day) and between-person (comparing participants to each other) level. Within-person stressor frequency and severity were centered at the person mean, and between-person stressor frequency, severity, and variability in severity were centered at the grand mean. Each stressor characteristic (i.e., frequency, severity, and variability) was included in separate models along with covariates. Additional sensitivity

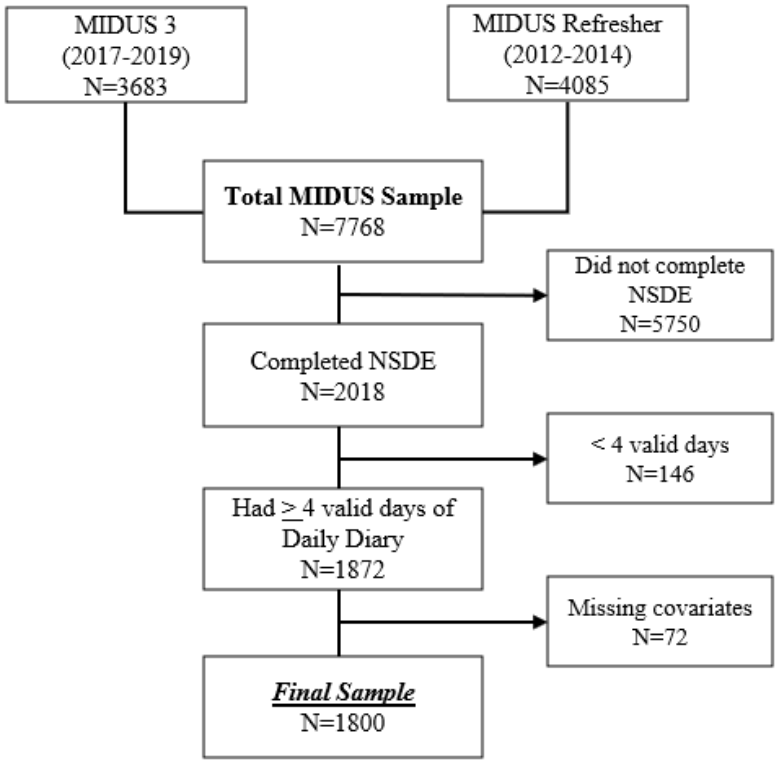
analyses were conducted to examine stressor severity and variability in stressor severity for only days when at least one stressor was reported.

Moderation analyses were conducted by adding continuous age (in years) as an interaction term in PROC MIXED models at both the within-person level for stressor frequency and severity, and at the between-person level for stressor frequency, severity, and variability in stressor severity. Simple slope tests and the Johnson-Neyman technique (Johnson & Fay, 1950; Johnson & Neyman, 1936) were used to further examine the nature of any interactions significant at $\alpha = .05$.

Supplemental Analyses

In supplemental analyses, we examined the core MIDUS sample (n = 1,124) and the Refresher sample (n = 676) separately to investigate possible differences in the associations between daily stressors and memory lapses in these samples. On average, the Refresher sample was younger in age, ranging from 25 – 75 years (M = 48.3, SD = 12.8) compared to 43 – 90 years (M = 62.43, SD = 10.2) in the core sample, and data was collected approximately five years earlier (2012 – 2014) than the core sample (2017 – 2019). The Refresher sample also had a larger proportion of participants who were employed, were more educated on average, and were in better physical health, but had a similar proportion of male/female participants to the core sample. Age moderation was not repeated with the separated core and Refresher samples due to differences in the age distribution between them, which limits comparability of the results.

Figure 2-1



Note: Flowchart of participant exclusion for combined MIDUS 3 and Refresher samples. MIDUS = Midlife in the United States study; NSDE = National Study of Daily Experiences

Chapter 3

Results

Sample Characteristics and Descriptive Statistics

Table 3-1 shows demographic characteristics of the analytical sample. The sample of 1,800 adults had slightly more females than males (56.1%; *n* =1,008), were majority non-Hispanic White (82.2%; *n* =1,480), and fairly well-educated (completed 3 or more years of college, no degree). The sample ranged from 25 – 90 years in age with an average of 57.1 years (*SD* = 13.2). Participants reported encountering an average of 0.51 (*SD* = 0.43) stressors per day and had an average stressor severity rating of 2.2 (*SD* = 1.0) on a scale of 0 – not at all severe to 3 – very severe on days when stressors were encountered. Participants also reported an average of 0.70 (*SD* = 0.81) on a scale of 0 to 8 memory lapses per day. The majority of individual stressor variables were slightly to mildly correlated (*r* = .02 to .13) other stressors, except for "something stressful at home," which was not significantly correlated to the other stressors (Table 3-2). Similarly, individual memory lapse variables were also slightly to mildly correlated (*r* = .04 to 0.23). Older adults (age 65 years and older) reported a lower frequency of stressors, lower severity of stressors, and lower variability in stressor severity compared to participants younger than 65. Contrary to expectation, older individuals did not differ in the number of memory lapses reported compared to younger individuals in this sample (*W* = 504414.0, *z* = -1.31, *p* = 0.10).

Stressors and Daily Memory Lapses

Stressor frequency

Results from multilevel-models (Table 3-3) revealed significant within-person and between-person associations between stressor frequency and number of daily memory lapses after adjusting for sociodemographic covariates and self-rated health. At the within-person level, on days when participants reported a higher number of stressors, they also reported more memory lapses compared to their average (B = 0.14, SE = .01, p <.001). At the between-person level, participants who reported a higher number of stressors on average also reported a higher number of memory lapses (B = 0.79, SE = .04, p <.001) on average. Random effects estimates indicated that there was significant variance in the random intercept (B = 0.45, SE = .02, p <.001), slope (B = 0.09, SE = .01, p <.001), covariance (B = 0.04, SE = .01, p <.001), and residual (B = 0.57, SE = .01, p <.001) meaning that both the intercept and slope of this relationship varied across participants, and that those with a higher frequency of stressors on average also tended to have a steeper slope for memory lapses.

Stressor severity

The relationship between stressor severity and number of daily memory lapses was significant at the within-person and between-person levels after adjusting for covariates (Table 3-3). On days when participants reported higher stressor severity, they also reported more memory lapses on that day compared to their average (B = 0.07, SE = .01, p <.001), and participants who reported a higher stressor severity on average also reported a higher number of memory lapses on average (B = 0.37, SE = .02, p <.001). Random effects estimates indicated that there was significant variance in the random intercept (B = 0.45, SE = .02, p <.001), slope (B = 0.02, SE =

.002, p <.001), covariance (B = 0.02, SE = .004, p <.001), and residual (B = 0.58, SE = .01, p <.001), meaning that both the intercept and slope of this relationship varied across participants, and, similar to that of stressor frequency, those with a higher severity of stress on average also tended to have a steeper slope for memory lapses. Similar results were obtained from sensitivity analyses considering only days when any stressor was reported at the within-person level (B = 0.06, SE = .01, p <.001), between-person level (B = 0.21, SE = .02, p <.001), and in random effects (intercept: B = 0.59, SE = .03, p <.001; slope: B = 0.03, SE = .01, p <.001; covariance: B = 0.02, SE = .01, p = .015; residual: B = 0.81, SE = .02, p <.001), though with slightly smaller effect sizes.

Variability in stressor severity

Results from mixed models examining the relationship between variability in stressor severity and number of memory lapses (Table 3-3) revealed that greater variability in stressor severity was associated with more memory lapses, but this relationship did not reach significance when controlling for covariates and personal mean of stressor severity across all valid days (B = 0.07, SE = .04, p = .09). However, this relationship did reach significance in sensitivity analyses considering stressor severity only on days when at least one stressor was experienced (B = 0.17, SE = .04, p < .001), such that higher variability in stressor severity on stressor days was associated with more memory lapses after controlling for covariates and personal mean of stressor severity on stressor days.

Moderation By Age

Moderation analyses showed that age had significant interaction with the relationship between stressor frequency and memory lapses at the within-person level (Table 3-4) only. The positive relationship between within-person stressor frequency and memory lapses was less pronounced for older individuals compared to those at younger ages (Figure 3-1). Specifically, on days when older participants reported a higher frequency of stressors, there was less of an increase in memory lapses that day compared to younger individuals (B = -0.002, SE = .001, p = .04). Further probing of this interaction using the Johnson-Neyman technique indicated that at older ages, the association between within-person stressor frequency and memory lapses was attenuated, and this relationship was no longer significant at age 84 years and older (Figure 3-2). There was no significant interaction effect of age on between-person stressor frequency (B = -0.001, p = .81), stressor severity (B_{within} = -0.001, p_{within}= .12; $B_{between}$ = -0.001, $p_{between}$= .27), or variability in stressor severity (B = -0.002, p = .47). Sensitivity analyses using only days when stressors were reported also did not indicate any significant interaction with stressor severity at the within-person (B = -0.001, p = .31) or between-person level (B = -0.003, p = .10), nor was there significant interaction with variability of stressor severity on stressor days (B = -0.002, p = .41).

Supplemental Analyses

Refresher sample participants reported higher stressor frequency, higher stressor severity, higher variability in stressor severity, higher variability in stressor severity on stressor days, and more memory lapses on average, but had similar stressor severity on stressor days only. Further details on sample comparisons are displayed in Table A-2. In the separated core and Refresher samples, we observed patterns in the respective relationships between stressor frequency,

severity, variability in stressor severity on all days, and variability in stressor severity on stressor days and memory lapses that were consistent with the combined sample in both directionality and magnitude (Table A-3). However, the Refresher sample had slightly higher beta values compared to the combined sample, and the core sample had slightly lower beta values compared to the combined sample.

Table 3-1: Descriptive statistics of analytical sample (N = 1800)

	***Mean* (*SD*) or *n* (%)**
Demographic	
Male	792 (44.0%)
Non-Hispanic White	1480 (82.2%)
Age	57.1 (13.2)
Education	7.9 (2.43)
Self-rated health	3.57 (1.00)
Not working for pay	939 (52.2%)
Stressor	
Frequency	0.51 (0.43)
Severity	0.92 (0.89)
Severity (stressor days)	2.18 (1.0)
Variability	1.08 (0.71)
Variability (stressor days)	1.03 (0.74)
Memory	
Memory lapses	0.70 (0.81)

Note: education on scale of 1 – 12: 1- no school or some grade school; 2- 8th grade or junior high school; 3- high school (no diploma); 4- GED; 5- graduated from high school; 6- 1 or 2 years of college (no degree); 7- college 3 years or more (no degree); 8- graduated from 2 year college, vocational school; 9- graduated from 4 or 5-year college; 10- some graduate school; 11 - Master's; 12 - postgraduate or professional degree. Self-rated health on a scale of 1 – 5 where 1= poor and 5= excellent

Table 3-2: Correlation of individual stressor and memory lapse variables (n = 1,800)

Stressor	**1**	**2**	**3**	**4**	**5**	**6**		
Disagreement	-							
Avoid disagreement	**0.13**	-						
Work or school	**0.03**	**0.04**	-					
Home	0.01	0.01	0.00	-				
Discrimination	**0.06**	**0.06**	**0.03**	0.01	-			
Friend	**0.03**	**0.03**	0.01	**0.04**	**0.05**	-		
Anything else	-0.01	0.01	**0.02**	**0.03**	**0.02**	0.02		
Memory lapse	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Errand	-							
Medication	**0.04**	-						
Finish task	**0.23**	**0.09**	-					
Appointment	**0.10**	**0.04**	**0.06**	-				
Why entered room	**0.09**	**0.06**	**0.17**	0.01	-			
Person's name	**0.07**	**0.04**	**0.10**	**0.02**	**0.12**	-		
Where put something	**0.11**	**0.09**	**0.20**	**0.03**	**0.27**	**0.14**	-	
A word	**0.11**	**0.05**	**0.14**	**0.04**	**0.17**	**0.28**	**0.18**	-
Important info	**0.14**	**0.05**	**0.18**	**0.07**	**0.09**	**0.10**	**0.14**	**0.13**

Note: bold significant at $\alpha = .05$

Table 3-3: Daily and between-person associations between **s**tressor frequency, severity, and variability in severity and memory lapses

	B	***SE***	***p-value***	***95% CI***	
Fixed main effects					
Within-person					
Stressor frequency	0.14	0.01	**<.001**	0.11	0.17
Stressor severity	0.07	0.01	**<.001**	0.05	0.08
Stressor severity (stressor days)	0.06	0.01	**<.001**	0.03	0.08
Between-person					
Stressor frequency	0.79	0.04	**<.001**	0.70	0.87
Stressor severity	0.37	0.02	**<.001**	0.33	0.41
Stressor severity (stressor days)	0.02	0.02	**<.001**	0.16	0.26
Variability in severity	0.07	0.04	0.09	-0.01	0.15
Variability in severity (stressor days)	0.17	0.04	**<.001**	0.10	0.24
Random effects					
Stressor frequency					
Intercept	0.45	0.02	**<.001**	-	-
Slope	0.09	0.01	**<.001**	-	-
Covariance	0.04	0.01	**<.001**	-	-
Residual	0.57	0.01	**<.001**	-	-
Stressor severity					
Intercept	0.45	0.02	**<.001**	-	-
Slope	0.02	0.002	**<.001**	-	-
Covariance	0.02	0.004	**<.001**	-	-
Residual	0.58	0.01	**<.001**	-	-
Variability in severity					
Intercept	0.45	0.02	**<.001**	-	-
Residual	0.62	0.01	**<.001**	-	-
Stressor severity (stressor days)					
Intercept	0.59	0.03	**<.001**	-	-
Slope	0.03	0.01	**<.001**	-	-
Covariance	0.02	0.01	**0.02**	-	-
Residual	0.81	0.02	**<.001**	-	-
Variability in severity (stressor days)					
Intercept	0.54	0.03	**<.001**	-	-
Residual	0.74	0.01	**<.001**	-	-

Note: bold significant at $\alpha = .05$; each stressor characteristic (i.e., frequency, severity, and variability of stressor severity on all days and on stressor-only days) was run separately in models with covariates; models fully adjusted for age, sex, race/ethnicity, education, self-rated health, employment status, and weekday vs. weekend. Variability of stressor severity was additionally controlled for personal mean of stressor severity.

Table 3-4: Moderation of stressor frequency, severity, and variability of stressor severity by age

	B	*SE*	*p-value*	*95% CI*	
Fixed interaction effects					
Within-person					
Stressor frequency	-0.002	0.00	**0.04**	-0.004	-0.000
Stressor severity	-0.001	0.00	0.12	-0.002	0.000
Stressor severity (stressor days)	-0.001	0.00	0.31	-0.003	0.001
Between-person					
Stressor frequency	-0.001	0.00	0.81	-0.01	0.01
Stressor severity	-0.001	0.00	0.27	-0.004	0.001
Stressor severity (stressor days)	-0.003	0.00	0.10	-0.01	0.001
Variability in severity	-0.002	0.00	0.47	-0.01	0.003
Variability in severity (stressor days)	-0.002	0.00	0.41	-0.01	0.003
Random effects					
Stressor frequency					
Intercept	0.45	0.02	**<.001**	-	-
Slope	0.09	0.01	**<.001**	-	-
Covariance	0.04	0.01	**<.001**	-	-
Residual	0.57	0.01	**<.001**	-	-
Stressor severity					
Intercept	0.45	0.02	**<.001**	-	-
Slope	0.02	0.00	**<.001**	-	-
Covariance	0.02	0.00	**<.001**	-	-
Residual	0.58	0.01	**<.001**	-	-
Variability in severity					
Intercept	0.45	0.02	**<.001**	-	-
Residual	0.62	0.01	**<.001**	-	-
Stressor severity (stressor days)					
Intercept	0.59	0.03	**<.001**	-	-
Slope	0.03	0.01	**<.001**	-	-
Covariance	0.02	0.01	**0.01**	-	-
Residual	0.81	0.02	**<.001**	-	-
Variability in severity (stressor days)					
Intercept	0.54	0.02	**<.001**	-	-
Residual	0.74	0.01	**<.001**	-	-

Note: bold significant at $\alpha = .05$; each stressor characteristic (i.e., frequency, severity, and variability of stressor severity on all days and on stressor-only days) was run separately in models with covariates; models fully adjusted for sex, race/ethnicity, education, self-rated health, employment status, and weekday vs. weekend. Variability of stressor severity was additionally controlled for person mean of stressor severity.

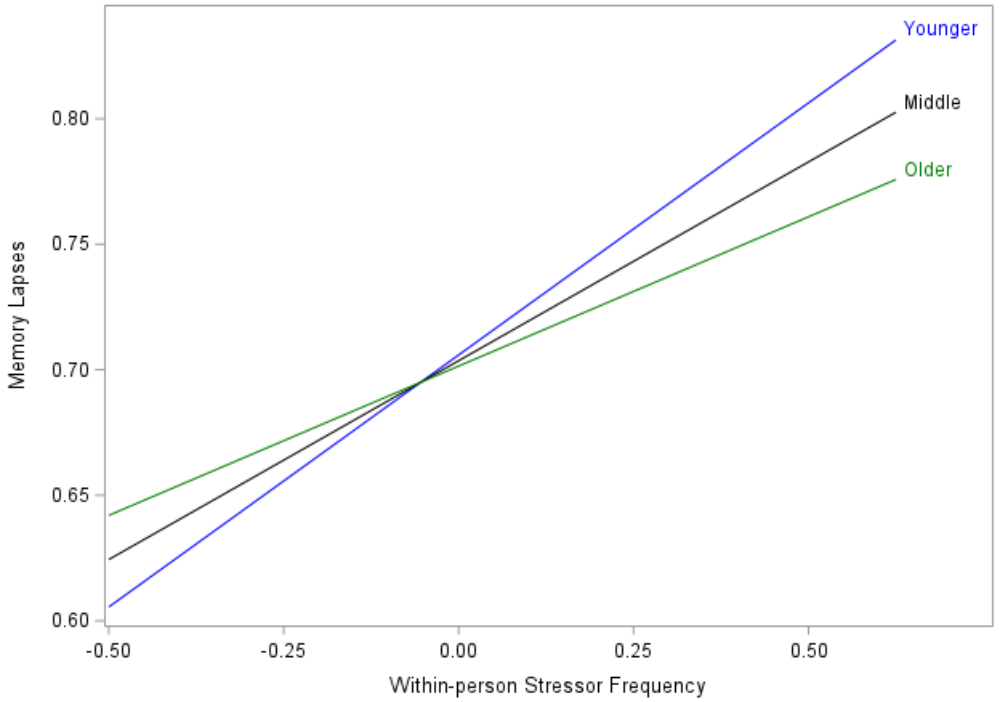


Figure 3-1: Simple slopes of interaction effect of age on stressor frequency and memory lapses. Younger = -1SD below sample mean (< 43.5yrs), Middle = at mean (57.1yrs), Older = +1SD above mean (> 70.1yrs)

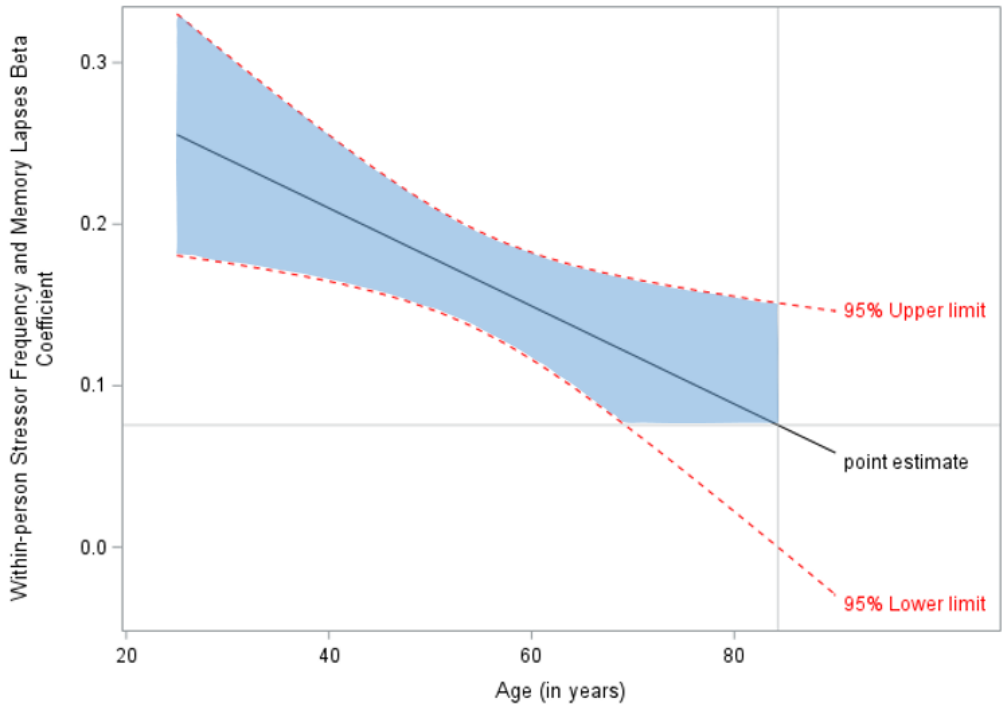


Figure 3-2: Johnson-Neyman plot of region of significance (shaded) indicates interaction between within-person stressor frequency and memory lapses is significant between ages 25 years to 84 years at $\alpha = .05$, such that on days when older individuals experienced more frequent stressors, they reported less memory lapses compared to their younger counterparts.

Chapter 4

Discussion

Discussion of Findings

This study aimed to investigate the relationship between experiences of daily stressors and memory lapses in a nationally representative sample of middle-aged and older adults. After controlling for sociodemographic covariates and self-rated health, results from this micro-longitudinal study found that on days when individuals experienced more stressors or a higher severity of stressors, they also experienced more memory lapses on that day. Similarly, participants who experienced more stressors or higher severity of stressors on average also experienced more memory lapses on average. Overall, the results of this study suggest that experiencing more frequent stressors, a higher severity of the stressors, and greater variability in stressor severity had an association with more memory lapses both in general and on a day-to-day basis.

When experiencing stressors, especially those with high severity, the body enters a state of heightened arousal in order to devote resources to dealing with the source of the stress whether that be escaping, attempting to resolve, or dealing with the consequences of the stressor. The Easterbrook Hypothesis (Easterbrook, 1959) suggests that this higher state of arousal also narrows our attention, thus ignoring or blocking out information that is not immediately relevant to the stressor. Our findings, particularly that on days when individuals experience more frequent or higher severity of stressors, may support this narrowing of attention; information such as where you put your keys when you enter your home or the timing of a later appointment may be set aside in order to prioritize information that is relevant to the source of the stress (Schwabe et al., 2022).

More broadly, frequent or high severity of stressors may lead to difficulties in regulating attention, particularly with the ability to willfully direct attention to or away from something (i.e., attentional control) (Helion et al., 2019) or the ability to suppress thoughts that are unrelated to the current situation (i.e., cognitive interference) (Sarason et al., 1996). Consequently, information not immediately related to the stressor that is not already blocked out may be overshadowed by thoughts of the stressful events and potentially not encoded properly (Diamond et al., 2007; Joëls et al., 2006). It is also possible that more cognitive resources are being delegated to the stressful situation, making previously encoded memories of irrelevant information more difficult to consciously activate when they are needed later (Klier & Buratto, 2020; Shipstead et al., 2015) through disruption in memory retrieval. Future research can further explore these possible mechanisms for daily stressors by examining the mediating role of attention and executive function in the relationship between daily stressors and memory lapses. Although these pathways have been explored in previous literature, these studies, as well as studies regarding the association between stress and memory in general, are typically in the context of chronic stress, high intensity of stress, and lab-induced stressors. Although informative, stress under these conditions may not necessarily reflect the mechanisms through which daily stressors affect memory.

Similarly, existing literature on the relationship between stress and memory largely focuses on chronic stress (Conrad, 2010; Hou & Tao, 2023; Öhman et al., 2007; Peavy et al., 2009), extreme stressors (e.g., traumatic events) (Diamond et al., 2007; Pitman et al., 2012), or neuropsychological test-based cognitive outcomes in a laboratory or clinical setting (McManus et al., 2022; Shields et al., 2017; Wolf, 2009). This study adds to the literature by examining everyday stressors (such as arguments or stressful experiences at work) and episodes of

forgetfulness on a daily level in real-life settings. This provides valuable insight into the relationship between stress and memory regarding tasks that are directly related to everyday functioning (e.g., remembering an appointment or where something was placed), which allows for high ecological validity. Additionally, the use of Daily Diary data collection techniques (Lischetzke & Könen, 2021) allows for the examination of micro-longitudinal changes in stress and subjective memory across multiple consecutive days, which can be lost when simply averaging these measures over the course of a week or more. This allows us to gain a further understanding of how this unavoidable part of life (i.e., everyday stressors) relates to memory on a daily basis with less interference from possible recall bias or loss of nuance from cross-sectional designs.

A highlight of this study includes the novel finding that those who experienced more variability in stressor severity across days when stressors were encountered also experienced more memory lapses on average. Though this may seem to contradict the notion that chronic stress has a negative impact on memory (Conrad, 2010; Öhman et al., 2007; Peavy et al., 2009), this may be further evidence for habituation or building up resilience to daily stressors (Grissom & Bhatnagar, 2009; Rankin et al., 2009). With consistent exposure to a stimulus such as stress, affective and physiological responses to that stimulus often lessen with each subsequent exposure, particularly if the stimuli are temporally close together (Grissom & Bhatnagar, 2009). Considering that these results were found using data collected across 8 consecutive days, it is possible that consistent exposure to similar levels of stress from day to day may attenuate negative responses to those stressors. However, considering that this sample had fairly low severity of stressors on average, these findings may be due to the consistency being at lower levels (i.e., consistently rating the severity as “slightly”), and the variability is a result of the

occasional experience of high severity. Additionally, these results regarding variability in stressor severity were not replicated when considering all Daily Diary days, which included a severity rating of 0 when the respondent did not report encountering a stressor. The large proportion of 0 severity responses in this model (63.1% of responses) compared to stressor-only days (6.2% of responses) may have artificially zero-inflated the data. These findings were replicated in both the core MIDUS sample and the slightly younger, more educated, and in better health Refresher sample. Future research can further investigate these findings by studying possible habituation and resilience in individuals who consistently experience high severity of stress versus those who consistently experience low severity of perceived stress.

In general, these findings emphasize that both frequent stressors and high severity of stressors can be disruptive to everyday life, which can have implications for the importance of stress management for short-term as well as chronic stressors. Our findings that individuals who experience more frequent stressors and higher severity of stressors on average also experience more memory lapses builds on existing literature demonstrating chronic stress's negative impact on memory (Conrad, 2010; Hou & Tao, 2023; Öhman et al., 2007; Peavy et al., 2009) by examining between-person differences on a shorter time scale. Chronic stress is categorized as stress that persists over months or years, whereas acute stressors are stressful events with extremely high severity such as traumatic events or major life changes. In our study, a similar negative association between stress and memory was found even with daily stressors that persisted over the span of just 8 days, which may suggest that stress may become a problem even before it reaches the month-long duration mark and even at the level of daily hassles.

It is important to note that the frequent and high-severity stressors reported during this period are only a short glimpse into participants' lives and may be a continuation of more long-

term stress. However, our findings also demonstrated on days when individuals experience more frequent or higher severity of stressors compared to their average also experience more memory lapses on that day compared to their average, and assessment of contextual effects found that these within-person differences had associations with memory lapses above and beyond that of the between-person differences. This suggests that frequent and high severity stressors can be disruptive even on a daily level and may indicate that rather than trying to modify exposure, it may be important to manage reactivity to stressors. Daily stressors are a normal and often unavoidable part of daily life, so managing reactivity may involve cognitive strategies or other techniques to help those exposed to daily stressors maintain their memory.

These findings may also have implications for clinical assessments of memory. Our findings in a large sample of a cognitively healthy adults suggest that forgetfulness of common things in daily life might not always necessarily be a sign of pathological cognitive issues. Frequent occurrences of forgetting things like a routine task that needs to be done or bits of important information often lead to concerns over declining cognitive abilities, especially in older adults (Jessen et al., 2020). However, being under stress at the time of the assessment is not always factored into these occurrences. When evaluating memory or getting a subjective rating of memory in clinical settings, it may be important to also inquire about the individual's current day-to-day levels of stress, their levels of stress on days when they notice more frequent memory lapses, and how often they encounter stressful events as these may contribute to subjective memory complaints. This additional information may be helpful differentiating a temporary and relatively manageable issue from more severe cognitive concerns.

Further exploration of age in relation to stressors and memory lapses demonstrated that on average, older individuals did report a slightly lower frequency of stressors, severity of

stressors, and variability in stressor severity compared to younger individuals, which is consistent with current literature (Stawski et al., 2008; Stefaniak et al., 2022). Our study extends this literature by investigating how age may interact with the relationship between experience of stressors and memory. Moderation analyses revealed that on days when older individuals experienced more frequent stressors, they concurrently experienced less memory lapses compared to those of younger ages. Memory performance, particularly episodic memory, tends to deteriorate with age (Naveh-Benjamin et al., 2003; Salthouse, 2009), so finding in this direction may indicate that older individuals develop resilience against additional stressful experiences from day-to-day and are thus less impacted on days when they experience more stressors than usual. In fact, studies have found that older adults demonstrate resilience in the face of many adversities that can be linked to stress such as low socioeconomic status and disability (MacLeod et al., 2016), possibly more so than younger adults (Gooding et al., 2012; Zapater-Fajarí et al., 2021). Further probing of the interaction demonstrated that age moderated the relationship between within-person stressor frequency and memory lapses from age 25 to 84 years, which may suggest that the relationship between stress and memory lapses functions similarly across adulthood. This may indicate that stress management, coping skills, and developing resilience is important at any age despite changes in frequency of encountering stressors or appraisals of those stressors (Almeida & Horn, 2004; Minton et al., 2023; Stefaniak et al., 2022).

Limitations

Though the MIDUS data is considered a nationally representative dataset, even with the inclusion of the Milwaukee project (an oversampling of Black participants) the sample is

predominantly non-Hispanic White individuals (82.2%) and in good health. It is also possible that there may be a selection bias with the Daily Diary project considering its high time involvement and other possible factors. Consequently, these may limit the generalizability of the results to other racial/ethnic groups other than non-Hispanic White individuals or selectively exclude those who have higher time and health constraints, all of whom are likely to experience higher frequency and severity of stressors. The lack of racial and ethnic diversity of the sample may particularly be a limitation considering one of the stressors evaluated in this analysis was experiencing discrimination, which is more prevalent in minoritized racial and ethnic groups as well as individuals with disabilities.

Furthermore, although the measures of stress and memory lapses capture common daily occurrences, there may be other sources of stress or lapses in memory in daily life that were not included in these measures. The DISE included an "other" category to account for stressors that do not fit into the existing categories; however, an answer of "yes" to this question would only count as one stressor even if there were multiple experiences that fell into this "other" category. Similarly, the frequency measure of stressors and memory lapses does not account for multiple occurrences of stressors or memory lapses of the same kind. For example, forgetting multiple appointments in the same day or forgetting just one appointment in the same day would both be scored as only one memory lapse. Though some of this may be accounted for with the measure of stressor severity (i.e., those who had multiple stressful events of the same kind may report higher severity for that stressor type compared to someone who only experienced one occurrence of that stressor), this may not always be the case considering that the sample reported fairly low stressor severity levels on average (M = 2.18).

As this study relies on self-reported stressor characteristics and memory lapses, there is a possibility of recall bias that is largely mitigated by the Daily Dairy design of the data collection. It is important to note that participants who are more prone to memory lapses may also have more difficulty in recalling both stressors they encountered and incidents of memory lapses that are the core of this study. Future studies can attenuate the possible influence of poorer overall memory by including data on objective tests of cognitive function and controlling for episodic memory scores, or getting additional information from an informant. Although the MIDUS sample participants are generally in good cognitive health, controlling for episodic memory instead of simply excluding those with poor performance will account for differences in cognitive abilities and be sensitive to those who may have low but subclinical episodic memory difficulties. Similarly, a strength of using the Daily Diary design is that frequent data collection intervals provides greater insight into temporal relationships, allowing observation of daily-level changes in stress and memory. However, reporting stressors and memory lapses at only one timepoint each day limits our ability to determine the temporal relationship between these variables and thus also limits the ability to accurately interpret any causal effects.

Conclusion

This study contributes to existing literature on stress and memory by revealing that more frequent and higher severity, and more irregularity in the experience of stressors are related to more memory lapses on average and day-to-day, and that the association between within-person stressor frequency and memory lapses was attenuated at older ages up to age 84. Variability in stressor severity was only associated with memory lapses when examining only days when at least one stressor was reported. Future research can build on these findings by including more

diverse populations, investigating possible mechanisms by which stress and memory may be related, including investigation of differences in consistently high or consistently low levels of stress, and expanding the types of daily stressors measured, using measures of stress and memory lapses that account for frequency of each type of stressor.

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Appendix

Supplemental Tables

Table A-1. Descriptive statistics of MIDUS core sample, Refresher sample, and combined sample.

	Mean (*SD*) or *n* (%)		
	Core (n=1124)	**Refresher (n=676)**	**Combined (n=1800)**
Demographic			
Male	479 (42.6%)	313 (46.3%)	792 (44.0%)
Non-Hispanic White	914 (81.3%)	566 (83.7%)	1480 (82.2%)
Age	62.4 (10.2)	48.3 (12.8)	57.1 (13.6)
Education	7.79 (2.4)	8.14 (2.4)	7.92 (2.4)
Self-rated health	3.53 (0.99)	3.64 (1.0)	3.76 (1.0)
Not working for pay	516 (45.9%)	423 (62.6%)	939 (52.2%)
Stressor			
Frequency	0.49 (0.43)	0.55 (0.43)	0.51 (0.43)
Severity (all days)	0.88 (0.87)	0.99 (0.91)	0.92 (0.89)
Severity (stressor days)	2.16 (1.0)	2.21 (1.1)	2.18 (1.0)
Variability (all days)	1.03 (0.71)	1.16 (0.70)	1.08 (0.71)
Variability (stressor days)	0.99 (0.74)	1.09 (0.75)	1.03 (0.74)
Memory			
Memory lapses	0.70 (0.81)	0.68 (0.79)	0.75 (0.84)

Note: self-rated health was on a scale of 1 – 5 where 1 = poor and 5 = excellent. Education on scale of 1 – 12, where a value of 7 is equivalent to 3 or more years of college with no degree, and a value of 8 is equivalent to graduating from 2-year college or vocational school. MIDUS = Midlife in the United States study

Table A-2. Demographic, stressor, and memory lapse comparisons between core sample (*n* = 1,124) and Refresher sample (*n* = 676).

	Test	Test statistic	p-value	W/df
Demographic				
Age	Satterthwaite T	-24.35	**<.001**	1183.1
Sex	Chi Squared	2.33	.13	1
Education	Wilcoxon W	2.99	**<.001**	640170.5
Employment status	Chi Squared	47.0	**<.001**	1
Self-rated health	Wilcoxon W	2.43	**.02**	633460.0
Stressor				
Frequency	Wilcoxon W	3.80	**<.001**	649150.0
Severity	Wilcoxon W	3.29	**.00**	643822.5
Severity (on stressor days)	Wilcoxon W	2.10	.29	511188.5
Variability	Wilcoxon W	4.01	**<.001**	651504.5
Variability (on stressor days)	Wilcoxon W	2.86	**.00**	358227.0
Memory				
Memory lapses	Wilcoxon W	2.10	**.04**	631106.5

Note: bold significant at $\alpha = .05$

Table A-3. Comparison of beta coefficients for fixed and random effects of associations between stressors and memory lapses by sample.

	Combined (n = 1800)		**Core (n = 1244)**		**Refresher (n = 676)**	
Fixed effects						
	Between	***Within***	***Between***	***Within***	***Between***	***Within***
Frequency	**0.79**	**0.14**	**0.70**	**0.12**	**0.93**	**0.18**
Severity	**0.37**	**0.07**	**0.32**	**0.06**	**0.44**	**0.08**
Severity (stressor days)	**0.21**	**0.06**	**0.16**	**0.06**	**0.27**	**0.05**
Variability	0.07	-	0.08	-	0.09	-
Variability (stressor days)	**0.17**	-	**0.14**	-	**0.23**	-
Random effects						
	B	***SE***	***B***	***SE***	***B***	***SE***
Frequency						
Intercept	**0.45**	0.02	**0.44**	0.02	**0.43**	0.03
Slope	**0.09**	0.01	**0.10**	0.01	**0.09**	0.02
Covariance	**0.04**	0.01	**0.04**	0.01	**0.03**	0.01
Residual	**0.57**	0.01	**0.53**	0.01	**0.65**	0.01
Severity						
Intercept	**0.45**	0.02	**0.45**	0.02	**0.43**	0.03
Slope	**0.02**	0.00	**0.02**	0.00	**0.02**	0.00
Covariance	**0.02**	0.00	**0.02**	0.01	**0.01**	0.01
Residual	**0.58**	0.01	**0.53**	0.01	**0.65**	0.01
Variability						
Intercept	**0.45**	0.02	**0.45**	0.02	**0.42**	0.03
Residual	**0.62**	0.01	**0.57**	0.01	**0.71**	0.02

Note: results significant at $\alpha = .05$ bolded; models fully adjusted for sex, race/ethnicity, education, self-rated health, employment status, and weekday vs. weekend. Variability of stressor severity was additionally controlled for person mean of stressor severity.