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ORIGINAL ARTICLE

Recent life stress exposure is associated with poorer long-term memory, working memory, and self-reported memory

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ABSTRACT

Although substantial research has examined the effects of stress on cognition, much of this research has focused on acute stress (e.g. manipulated in the laboratory) or chronic stress (e.g. persistent interpersonal or financial difficulties). In contrast, the effects of recent life stress on cognition have been relatively understudied. To address this issue, we examined how recent life stress is associated with long-term, working memory, and self-reported memory in a sample of 142 healthy young adults who were assessed at two time points over a two-week period. Recent life stress was measured using the newly-developed Stress and Adversity Inventory for Daily Stress (Daily STRAIN), which assesses the frequency of relatively common stressful life events and difficulties over the preceding two weeks. To assess memory performance, participants completed both long-term and working memory tasks. Participants also provided self-reports of memory problems. As hypothesized, greater recent life stress exposure was associated with worse performance on measures of long-term and working memory, as well as more self-reported memory problems. These associations were largely robust while controlling for possible confounds, including participants' age, sex, and negative affect. The findings indicate that recent life stress exposure is broadly associated with worse memory. Future studies should thus consider assessing recent life stress as a potential predictor, moderator, or covariate of memory performance.

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Recent life stress; long-term memory; working memory; self-reported memory; health; Stress and Adversity Inventory (STRAIN)

Introduction

A large body of research has shown that stress exerts substantial effects on human memory (Shields, Sazma, McCullough, & Yonelinas, 2017). The exact nature of this association, however, appears to depend on the specific type of stress experienced. For example, acute stress—which refers to the occurrence of a single, short-lived stressful event—can enhance or impair memory encoding, whereas it generally enhances retention and impairs retrieval (Cahill, Gorski, & Le, 2003; Gagnon & Wagner, 2016; Maheu, Collicutt, Kornik, Moszkowski, & Lupien, 2005; Wiemers, Sauvage, Schoofs, Hamacher-Dang, & Wolf, 2013). In contrast, chronic stress—which refers to an ongoing, persistent difficulty—generally impairs memory (Conrad, 2010; Peavy et al., 2009). Acute and chronic stress can occur over various periods of time, however, and although research has examined effects of stress over certain time periods—such as early life stress (Richards & Wadsworth, 2004)—to date no study has examined associations of recent life stress with long-term memory performance. Understanding these associations has important implications for multiple areas of research. For example, if recent life stress exerts effects on memory, then it may be important to ensure that individuals have not experienced much recent stress when testing for potential memory deficits in old age.

To our knowledge, only two prior studies have examined associations between recent life stress exposure (rather than perceived stress) and memory (Potter, Hartman, & Ward, 2009; Rickenbach, Almeida, Seeman, & Lachman, 2014). However, both of these studies examined self-reported memory problems rather than testing memory directly. Because these studies assessed self-reported memory rather than actual memory performance, it remains unknown if the associations observed were due to self-reporting biases or other confounds related to the use of self-report measures. Moreover, it is important to take into consideration the associations of stress with different forms of memory—such as working and long-term memory—in order to understand more nuanced associations between recent life stress and memory performance. Indeed, self-reported memory problems may be the result of poor working memory, poor learning, or poor memory retrieval, and additional research is needed to examine whether recent life stress exposure relates to each of these types of memory or just some of them.

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To address the need for research examining associations between recent life stress and memory, we examined how recent life stress is related to both working and long-term memory. To this end, we characterized recent life stress exposure in healthy young adults who completed measures of long-term, working, and self-reported memory, with a two-week delay between learning and retrieval for the long-term memory task. Because the measure of recent life stress used in this study was recently developed, we first validated it against two measures of health known to be associated with stress exposure. Then, we examined associations between recent life stress exposure and memory. Based on prior research showing that both chronic and early life stress impair memory, we hypothesized that greater recent life stress exposure would be associated with worse long-term, working, and self-reported memory.

Methods

Participants

Participants were 142 young adults (31 men, 111 women; *M* age =19.42, *SD* = 1.49) recruited from a university community who completed the study for course credit. Of these participants, 52.1% self-identified as Asian, 23.2% as White, 18.3% as Hispanic, 3.5% as Native Hawaiian or Pacific Islander, and 2.8% as Black or African American. The only exclusion criterion was an age of less than 18 years; this was intended to maximize the generalizability of the results obtained to the population we sampled.

Materials and procedure

All study procedures, including the life stress interview and memory tasks, were completed online. After signing up for the study, participants were sent to a website to complete the study. The first page of the website verified that participants were using a laptop or desktop computer in order to ensure that they were able to complete the online cognitive tasks. If participants failed this automatic check, they were instructed to return to the website once they were using a laptop or desktop computer and their session was terminated temporarily. If participants passed this check, they were forwarded to a website containing the consent form, which they digitally signed before beginning the study. All study procedures were pre-approved by the Institutional Review Board at the University of California, Davis.

Negative affect (PANAS-X)

Participants first completed the Positive and Negative Affect Schedule-Extended (PANAS-X; Watson & Clark, 1999) to assess current affect. Apart from the unextended version of this scale (i.e. the PANAS), the PANAS-X is the most widely used measure of current affect. Participants were instructed to report the extent to which they "currently feel (i.e. at this moment)" several positive and negative affective states using a scale from 1 (*very slightly or not at all*) to 5 (*extremely*). Because we were interested in controlling for negative affect in this analyses, we used these responses to create an overall PANAS-X negative affect score for each participant by averaging together the respective affective states. Higher scores thus indicated greater negative affect. Internal consistency of the negative affect items was very good, $\alpha = .89$.

Recent life stress

After completing the PANAS-X, participants reported their recent life stress using the Stress and Adversity Inventory for Daily Stress (Daily STRAIN; see Appendix).

The Daily STRAIN was derived for this study from the STRAIN system, which assesses lifetime stress exposure (e.g. Slavich & Toussaint, 2014; Toussaint, Shields, Dorn, & Slavich, 2016). Unlike the original STRAIN, however, the Daily STRAIN assesses the frequency of 14 stressors that are likely to occur over a two-week period (rather than over the entire lifespan). Three additional questions were included in the present study to assess college-related stressors (see Appendix) but these questions can be removed for noncollege samples. Example items include, "Over the past two weeks, how many times were you criticized, insulted, or made fun of by someone you care about?" and "Over the past two weeks, how many times did an important friendship or romantic relationship end with you and someone else?" Participants responded using a scale of 0–5 + the number of times. The frequency of each stressor (0–5) was then summed to create a total recent life stress score for each participant, with higher scores thus indicating more recent life stress.

Self-reported memory

Next, participants completed the Everyday Memory Questionnaire-Revised (EMQ-R; Royle & Lincoln, 2008), which was modified to assess memory over the preceding two weeks (rather than the preceding month). The EMQ-R reliably discriminates between healthy individuals and both individuals who have suffered stroke and individuals with multiple sclerosis (Royle & Lincoln, 2008). Participants were instructed to indicate how often different memory events occurred, such as "Forgetting when it was that something happened" and "Completely forgetting to do things you said you would do and things you planned to do." Participants responded using a scale from 1 (*Once or less in the last two weeks*) to 5 (*Once or more in a day*), with 3 (*About once a week*) as the midpoint. Higher scores thus indicate worse memory. Internal consistency of the EMQ-R was excellent, $\alpha = .91$.

Working memory task

We used a 3-back n-back task to assess working memory. This is a well-validated working memory task that has sufficient variability to permit analyses in college-aged samples (Henckens, van Wingen, Joëls, & Fernández, 2011; Qin, Hermans, van Marle, Luo, & Fernández, 2009; Schoofs, Preuβ, & Wolf, 2008). Participants were instructed to press the spacebar if the number on the screen was the same number they saw three trials ago. Additionally, they were told that if the number was not the same as the number presented three trials ago, they were instructed to avoid making a response.

Participants first completed 24 practice trials, after each of which participants received feedback indicating whether they made the correct response on that trial or not. Stimuli were presented in the center of the computer screen using 72px font. Each number was presented for up to 1500 ms, during which time participants were required to make their response. After a response was made or the trial timed out, there was a 1000 ms inter-trial interval before the next trial began. Participants completed a total of 50 trials. The number for each trial was selected randomly, with a constraint that the number selected had a 33% chance of being the same number as the number presented three trials ago—though this constraint was unknown to participants. To calculate a bias-corrected index of working memory accuracy, we subtracted false alarms (incorrect presses of the space bar; the current number was not the same number they saw three numbers ago) from hits (correct presses of the space bar; the current number was the same number they saw three numbers ago). Higher scores on this measure thus indicate greater working memory accuracy.

Memory encoding

Participants were presented with eight neutral and eight negative words. Neutral and negative words were matched for word frequency (Brysbaert & New, 2009) ($p = .744$) and character length ($p = .636$), but significantly differed in both valence (Warriner, Kuperman, & Brysbaert, 2013, $p < .001$) and arousal (Warriner et al., 2013, $p < .001$), with the negative words being more negative in valence and more arousing than the neutral words.

Participants were told to pay attention to the words and try to remember them because their memory would be tested later. After reading the instructions, participants pressed a button to begin the encoding paradigm. Words were presented in black, 30px font, one at a time, in the center of the screen against a white background. Each word faded in for 250 ms, then stayed on the screen for 3000 ms, and faded out for 250 ms, followed by an interstimulus interval blank screen of 1500 ms. This task was scripted using PHP and JavaScript. After all words were presented, the study automatically advanced.

Go/no-go task

Following the memory encoding task, participants completed a go/no-go task as a distractor between encoding and immediate recall. The go/no-go task was scripted in jsPsych (de Leeuw, 2015) and is a well-validated task that assesses response inhibition (Diamond, 2013; Shields, Sazma, & Yonelinas, 2016). However, because this task primarily served as a distractor for the memory task, participants only completed 44 trials. As such, this means that participants only completed 11 no-go trials, which produced little variability in errors of commission, and we did not analyze these data further.

Immediate recall

After the go/no-go task, participants were automatically directed to the instruction screen for the immediate recall task. Participants were given 2 min to type as many words as they remembered from the encoding paradigm into a text box; participants were not able to advance the study before the 2 min had elapsed. After 2 min had passed, participants answers were saved and the study automatically advanced. The number of words recalled was used for analyses of immediate recall, with higher scores indicating better recall.

Two-week delayed recall

After the immediate recall task, participants were told that they would receive an email with a link to a follow-up portion of the study two weeks after the day they completed this initial session and had to complete that follow-up portion to receive full credit. Participants were not told any details about what the follow-up session entailed. Two weeks after completing this initial session, participants received an email at 3 pm with a link to the task. Participants were given three full days to complete the follow-up session, although most participants completed the follow-up session the first day they could. After clicking the link, participants were told that they would complete a memory recall task. As in the immediate recall task, in the delayed recall task participants were given 2 min to type as many words as they remembered from the encoding paradigm into a text box, and participants were not able to advance the study before the 2 min had elapsed. After they finished the recall task, participants again completed the Daily STRAIN before being debriefed and given credit.

To examine forgetting rates by controlling for the number of words learned initially, the proportion of words recalled at the immediate test that were later recalled at the delayed recall test (i.e. words at delayed recall divided by words at immediate recall) was used for analyses of delayed recall performance. Higher scores indicate less forgetting between the immediate and delayed tests, with a score of 1.0 indicating identical recall performance at both tests.

Data analysis

All analyses were planned correlation or regression analyses of interest, conducted using R, version 3.4.0. In analyses incorporating covariates, participant sex, age and current negative affect were considered as covariates as prior research showed that each of these factors are related to self-reported stress (Brougham, Zail, Mendoza, & Miller, 2009; Stawski, Sliwinski, Almeida, & Smyth, 2008; Watson & Pennebaker, 1989). Because of the obtained sample characteristics, two additional variables are worth discussing here: race/ethnicity and the time of day. We did not expect ethnic differences or the time of day that the test was completed to impact memory performance or recent life stress exposure *a priori*, so we did not control for race/ethnicity or time of day in our *a priori* plan of analysis. Nonetheless, we conducted exploratory analyses and found that neither race/ethnicity nor time of day interacted with recent life stress to predict any of the outcomes, and controlling for race/ethnicity or time of day produced consistent results with our *a priori* plan of analysis.

Therefore, we retained our *a priori* plan of analysis and present it below.

Results

Preliminary analyses

Descriptive statistics for the demographic variables and all measures included in the study are presented in Table 1.

Daily STRAIN validation

Life stress exposure is known to be associated with poor health. As such, in a preliminary validation of the Daily STRAIN, we examined the associations between participants' responses on this measure and their self-reported recent physical and mental health problems using the Physical Health Questionnaire (Schat, Kelloway, & Desmarais, 2005) and Kessler 6-Item Psychological Distress Scale (Kessler et al., 2002), respectively. We employed these outcome measures because prior research has shown that they are strongly associated with other measures of life stress exposure (e.g. Toussaint et al., 2016). As hypothesized, greater recent life stress exposure was strongly associated with more self-reported recent physical health problems ($r = .58$, $p < .001$), as well as with more self-reported recent mental health problems ($r = .53$, $p < .001$). When these analyses were rerun while controlling for age, sex and current negative affect as covariates, the association between recent life stress and physical health problems remained significant ($\beta = .57$, $t\ (137) = 6.89$, $p < .001$), as did the association between recent life stress and mental health problems ($\beta = .47$, $t\ (137) = 5.51$, $p < .001$). Therefore, the Daily STRAIN appears to be a strong predictor of health outcomes typically associated with stress exposure.

Primary analyses

Given this evidence of the Daily STRAIN's predictive validity, we next turned to the primary analyses, which examined associations between recent life stress exposure and memory performance.

Performance based measures

Long-term memory

We first explored the association between recent life stress and immediate recall (i.e. after the one-minute distractor task). As hypothesized, greater recent life stress exposure was associated with poorer immediate recall ($r = -0.23$, $p = .006$), indicating that people with more recent life stress were less able to learn new information (see Figure 1). This association remained significant while controlling for age, sex and current negative affect ($\beta = -0.24$, $t\ (137) = -2.37$, $p = .02$, $\Delta R^2 = .039$). Moreover, the association between recent life stress exposure and immediate recall did not differ by word valence ($t\ (132) = 0.61$, $p = .55$). Namely, greater recent life stress exposure was associated with poorer immediate recall of neutral words ($r = -.22$, $p = .007$), as well as with poorer immediate recall of negative words ($r = -.18$, $p = .04$, Figure 1). Controlling for age, sex and current negative affect partially altered these results, as the association between recent life stress and immediate recall of neutral words remained significant with these statistical adjustments ($\beta = -.22$, $t\ (137) = -2.22$, $p = .03$, $\Delta R^2 = .034$), whereas the association between recent life stress and immediate recall of negative words was no longer significant ($\beta = -.19$, $t\ (137) = -1.91$, $p = .06$, $\Delta R^2 = .026$).

To examine whether recent life stress exposure was associated with a greater forgetting rate of items in addition to poorer initial learning (as reflected by worse immediate recall performance), we analyzed the delayed free recall data as a proportion of immediate recall. We found that greater recent life stress exposure was associated with worse proportion delayed of immediate recall ($r = -.17$, $p = .04$), indicating that participants with greater recent life stress exposure had indeed forgotten more words over the two week delay. We then decomposed the memory data by valence. Unlike with the immediate recall data, the association between recent life stress exposure and delayed recall was significantly greater for neutral words than for negative words ($t\ (132) = 2.02$, $p = .04$; see Figure 2). Specifically, participants with greater recent life stress exposure had worse delayed proportion of immediate recall for neutral words ($r = -.22$, $p = .01$), but not negative words ($r = -.03$, $p = .77$), indicating that participants with greater recent life stress exposure prior to learning forgot more neutral words over a two-week delay than participants with less recent life stress exposure; forgetting of learned negative words, however, was unaffected by recent life stress exposure. These results were largely the same while controlling for participants age, sex and negative affect during learning. Namely, associations between recent life stress and the delayed proportion of immediate recall for neutral words remained significant ($\beta = -.22$, $p = .04$, $\Delta R^2 = .032$), while the delayed proportion of immediate recall for negative words remained nonsignificant ($\beta = -.06$, $p = .57$, $\Delta R^2 = .003$); however, the delayed proportion of immediate recall for all

Table 1. Participant and descriptive statistics for all study variables.

Variable	*M*	(*SD*)	*n*
Race/Ethnicity			
Asian			74
Native Hawaiian/Pacific Islander			5
Black/African American			4
White			33
Hispanic			26
Sex			
Male			31
Female			111
Age	19.42	(1.49)	
Current negative affect (PANAS-X)	1.60	(0.66)	
Recent life stress (Daily STRAIN)	18.25	(12.2)	
Immediate recall	10.25	(3.17)	
Delayed recall	2.53	(2.83)	
Delayed recall of neutral items	1.39	(1.80)	
Delayed recall of negative items	1.14	(1.52)	
Working memory hits – false alarms	4.83	(6.16)	
Self-reported memory problems (EMQ-R)	2.05	(0.77)	
Physical health problems (PHQ)	2.29	(0.80)	
Mental health problems (K-6)	2.70	(0.93)	

PANAS-X: Positive and Negative Affect Schedule- Extended; Daily STRAIN: Stress and Adversity Inventory for Daily Stress; EMQ-R: Everyday Memory Questionnaire- Revised; PHQ: Physical Health Questionnaire; K-6: Kessler 6-Item Psychological Distress Inventory.

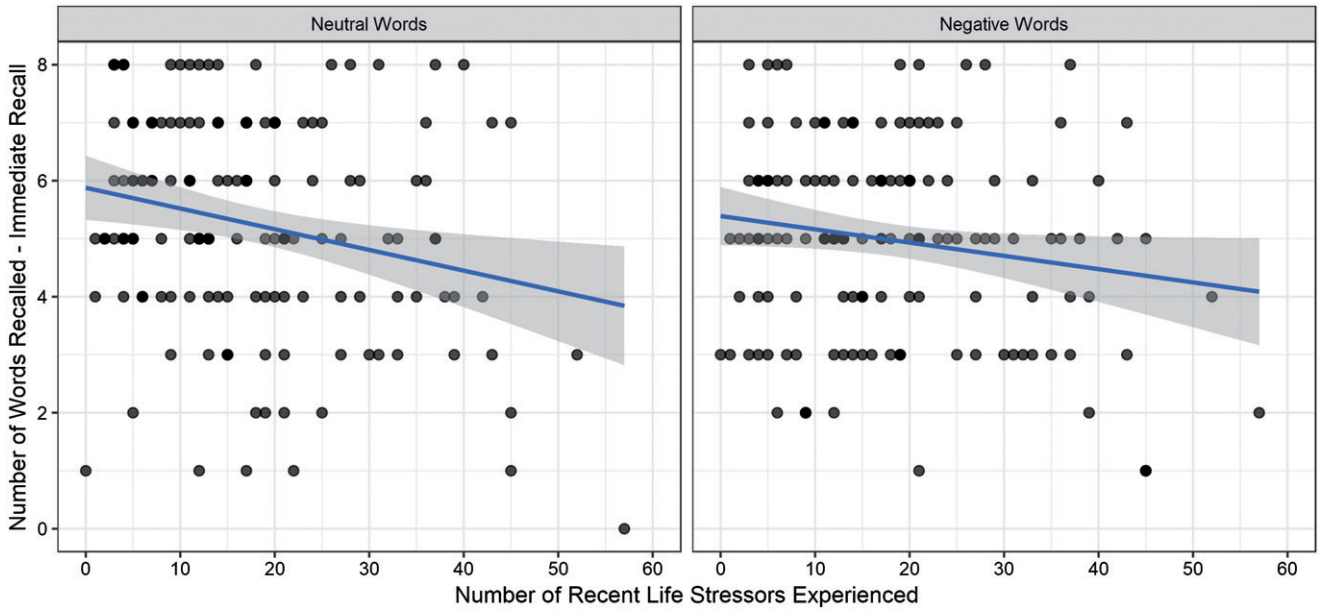

Figure 1. Association between recent life stress exposure and memory recall after a 1 min distractor task. Greater recent life stress was associated with poorer immediate recall of neutral words (left panel) and negative words (right panel). Moreover, these associations were robust while controlling for participants' age, sex, and negative affect assessed shortly before learning.

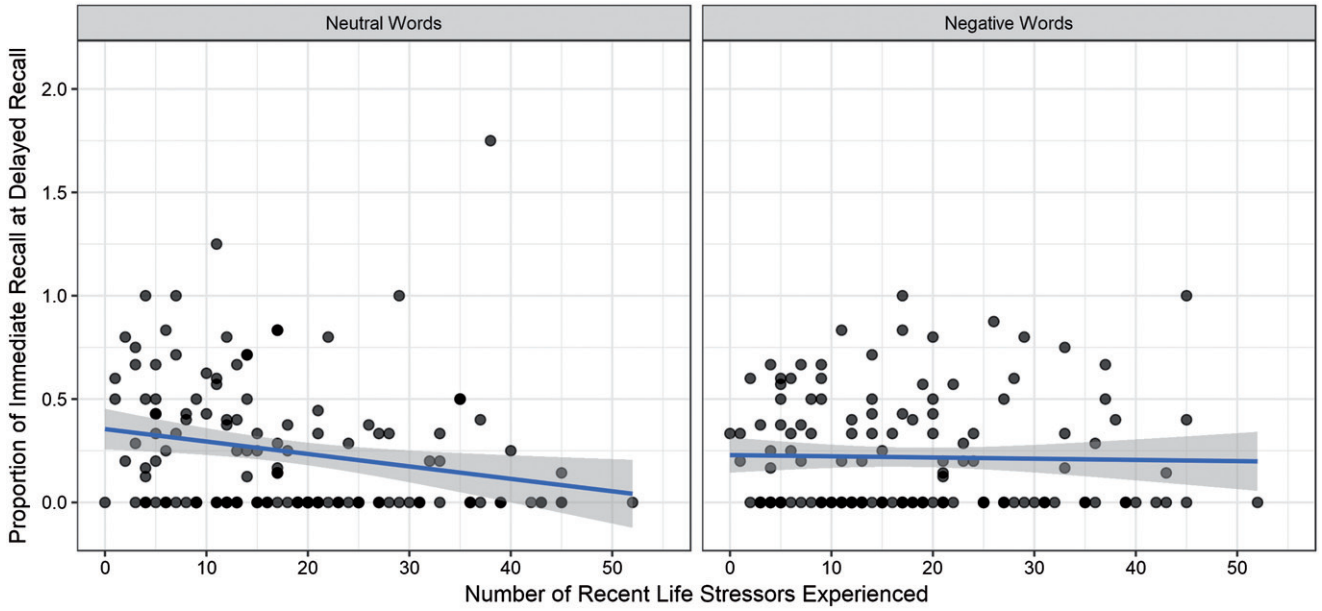

Figure 2. Association between recent life stress exposure and the proportion of words recalled during immediate recall at the delayed recall task. These scores indicate the forgetting of learned words, with higher scores indicating less forgetting (and a score of 1 indicating the same number of words recalled at the immediate and delayed tests). Greater recent life stress was associated with forgetting more neutral words (left panel), but not negative words (right panel). Moreover, these associations were robust while controlling for participants' age, sex, and negative affect assessed shortly before learning.

words was no longer significant ($\beta = -.19$, $p = .08$, $\Delta R^2 = .024$).

It is possible that these associations between recent life stress exposure and memory were observed due to the fact that people with greater recent life stress experience more stressors in general (i.e. as opposed to just over the past two weeks). To examine this possibility, we assessed recent life stress exposure two weeks later (after completing the delayed recall) using the same measure that was administered prior to learning (i.e. the Daily STRAIN). If the associations were driven by greater life stress in general, as opposed to greater recent life stress prior to learning, then life stress exposure measured two weeks after learning should also be associated with immediate recall, even though it was measured after immediate recall had finished. However, these analyses revealed that recent life stress measured two weeks after learning was unrelated to participants total immediate recall, immediate recall of negative words and immediate recall of neutral words ($|rs| < .10$, $ps > .29$). Similarly, recent life stress measured two weeks after learning was unrelated to participants proportion delayed recall of immediate recall for all words, neutral words only, and negative words only ($|rs| < .15$, $ps > .09$) and the magnitude of these associations became weaker while controlling for recent life stress prior to

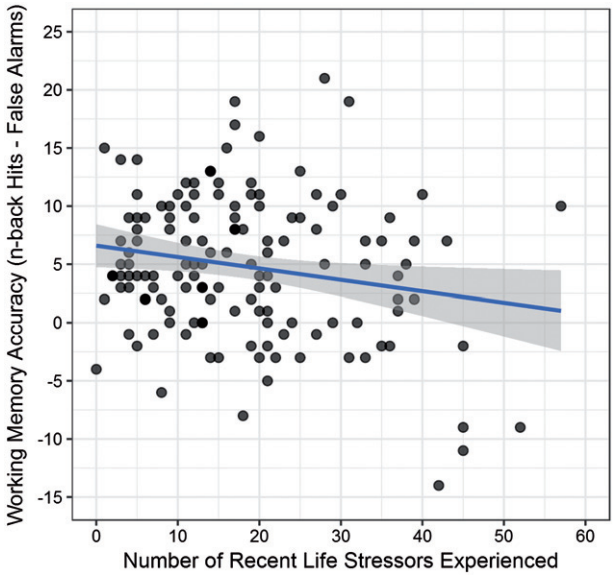

Figure 3. Association between recent life stress exposure and working memory accuracy (hits minus false alarms). Greater recent life stress exposure was associated with poorer working memory accuracy, and this association was robust while controlling for participants' age, sex, and negative affect assessed shortly before the working memory task.

learning ($ps > .49$). Therefore, it appears as though recent life stress measured prior to learning, rather than greater stress exposure in general, is most predictive of both poorer learning and greater forgetting in long-term memory.

Working memory

We also examined the association between recent life stress and working memory accuracy, calculated as hits minus false alarms in the n-back task. As shown in Figure 3, greater recent life stress exposure was associated with worse working memory accuracy ($r = -.19$, $p = .02$) and this association remained significant while controlling for age, sex and current negative affect ($\beta = -.28$, $t\,(133) = -2.77$, $p = .007$, $\Delta R^2 = .054$).

Consistent with the analytic strategy described above, we examined the association between recent life stress exposure measured two weeks after working memory assessment to ensure that the association observed was not simply due to individuals experiencing more life stress in general (i.e. as opposed to just over the past two weeks). However, recent life stress measured two weeks after working memory testing was not significantly related to working memory ($r = -.16$, $p = .07$) and the magnitude of this association became substantially weaker after controlling for recent life stress exposure measured prior to working memory testing ($p = .88$). Therefore, it appears as though the association between recent life stress exposure and working memory is not due to individuals experiencing more life stress in general.

Self-reported memory

We also examined the association between recent life stress and participants self-reported memory problems, as indexed by scores on the EMQ-R. As hypothesized, the association between recent life stress exposure and self-reported memory problems was significant ($r = .48$, $p < .001$), indicating that people with more recent life stress exposure had more self-reported memory problems. This association remained significant when controlling for age, sex and negative affect ($\beta = .51$, $t\,(137) = 5.69$, $p < .001$, $\Delta R^2 = .179$).

Again, consistent with the analytic strategy employed above, we examined the association between recent life stress exposure measured two weeks after the self-report assessment of memory to ensure that the association between recent life stress exposure and self-reported memory was not simply due to individuals experiencing more life stress in general. Although recent life stress measured two weeks after self-reports of memory was associated with self-reported memory ($r = .26$, $p = .002$), this associations was no longer significant when controlling for recent life stress exposure measured immediately prior to self-reports of memory ($p = .25$). Therefore, it appears that the association between recent life stress exposure and self-reported memory was largely due to participants experiencing more recent life stress and not to them experiencing a greater amount of life stress in general.

Secondary analyses

To ensure that the results observed were robust to outliers and correction to a normal distribution, we log transformed variables (adding 1.0 to variables containing scores that included zero) for which the D'Agostino test for skewness indicated significant skew (i.e. Daily STRAIN; immediate recall of neutral words; and proportion of immediate recall at delayed recall for all words, neutral words, and negative words). Then, we removed cases that were greater in absolute value than two standard deviations ± the mean on the Daily STRAIN. Five cases were identified as outliers and therefore removed.

After applying these changes, recent life stress (i.e. log-transformed Daily STRAIN scores) remained a significant predictor of immediate recall of all words ($p = .003$), log-transformed immediate recall of neutral words ($p = .001$), immediate recall of negative words ($p = .05$), log-transformed delayed proportion of immediate recall of all words ($p = .05$) and log-transformed delayed proportion of immediate recall of neutral words ($p = .004$), but not of working memory accuracy ($p = .08$) or log-transformed delayed proportion of immediate recall of negative words ($p = .83$). Including covariates (i.e. age, sex, and current negative affect) modified these results slightly. Namely, recent life stress became a significant predictor of working memory accuracy ($p = .04$), but it was no longer a significant predictor of immediate recall of negative words ($p = .10$). Broadly speaking, these analyses reveal that the obtained results were largely robust to outliers and non-normal data distribution.

Discussion

Although many studies have shown that acute and chronic stress impact memory (Conrad, 2010; Evans & Fuller-Rowell, 2013; Goldfarb, Shields, Daw, Slavich, & Phelps, 2017; McCullough & Yonelinas, 2013; Peavy et al., 2009; Richards & Wadsworth, 2004; Schönfeld, Ackermann, & Schwabe, 2014;

Schwabe & Wolf, 2010; Shields et al., 2017; Zalosnik, Pollano, Trujillo, Suárez, & Durando, 2014; Zoladz et al., 2015), relatively little is known about how recent life stress is related to memory (c.f. Potter et al., 2009; Rickenbach et al., 2014). To address this important issue, we assessed recent life stress exposure with a newly-developed measure, called the Daily STRAIN—which was found to be a strong predictor of recent physical and mental health problems—and subsequently examined associations between recent life stress and performance-based and self-report measures of memory. Consistent with hypotheses, we found that greater recent life stress exposure was associated with worse working memory and long-term memory performance over a two-week delay, in addition to more self-reported memory problems. These results are consistent with prior research showing that chronic stress impairs memory performance (Conrad, 2010; Peavy et al., 2009). In addition, the results indicate that recent life stress not only impairs the retrieval of learned information—as evidenced by an inverse association of recent life stress with the proportion of immediate recall remembered at delayed free recall—but that it also impairs actual learning of new information, as shown by an inverse association between recent life stress and immediate recall. In sum, therefore, these data are the first to demonstrate an association between recent life stress exposure and long-term memory performance, which may in turn provide researchers with a preliminary description of the specific phases of memory that are impacted by recent life stress.

To our knowledge, only two prior studies have examined associations between recent life stress and self-reported memory (Potter et al., 2009; Rickenbach et al., 2014), but these two studies reported differing results. Whereas Rickenbach and colleagues—who assessed daily stress—found an inverse association between stress and self-reported memory, Potter and colleagues—who assessed stressful life events over the preceding three years—found no association between stress and self-reported memory. In the present study, we found a significant association between recent life stress exposure and memory, with stress exposure being indexed as the total number of stressful life events and chronic difficulties that participants experienced over the preceding two weeks. These results may thus help clarify the mixed findings obtained by prior studies by suggesting that life stress may be more strongly associated with self-reported memory when the stressors occur in closer temporal proximity to the self-reported assessment of memory. The importance of the timing of recent life stress exposure relative to computer-based assessments of memory (as opposed to self-reported memory difficulties), however, remains unknown.

Although we measured self-reported exposure to recent life stress, the present results are in general agreement with prior studies that have examined associations between perceived stress and memory (Aggarwal et al., 2014; Ezzati et al., 2014; Potter et al., 2009). These studies have generally found that greater perceived stress is associated with worse self-reported (Potter et al., 2009) and long-term memory performance (Aggarwal et al., 2014; Ezzati et al., 2014). It should be noted, though, that despite a similar strength of association with self-reported memory (Potter et al., 2009), reported associations between recent perceived stress and long-term memory performance (Aggarwal et al., 2014; Ezzati et al., 2014) were weaker than the associations between recent life stress exposure and long-term memory performance that we observed in this study. Therefore, despite the general agreement in findings, recent life stress exposure may be a stronger predictor of memory than perceived stress.

Assessing recent life stress exposure, rather than perceived stress severity, raises a number of other important considerations. For example, measures of recent life stress exposure are relatively less biased by personality factors than measures of perceived stress, given that measures of general perceived stress severity are heavily influenced by personality factors such as neuroticism (Ebstrup, Eplov, Pisinger, & Jørgensen, 2011; Monroe, 2008). Although still subject to interpretational biases, self-report measures of recent life stress require individuals to focus on discrete life events and difficulties that are more objective in nature as compared to general reports of overall perceived stress burden (Monroe, 2008).

Nonetheless, self-reports of exposure present with their own drawbacks. For example, different people who have experienced the same stressor may interpret the meaning of the stressor question in different ways, leading them to in turn provide different answers about their experience with the stressor (Dohrenwend, 2006). Therefore, although the measure of recent life stress that we employed here has advantages over measures of perceived stress, care should be taken in interpreting the results. Alternative methods for assessing recent life stress exposure, such as experience sampling, are an attractive option for addressing this issue, but such methods also have drawbacks as they are much more resource-intensive and costly. Self-report measures of recent stress exposure thus provide a reliable and economically viable strategy for assessing recent stress exposure, especially when such instruments have been validated against several different outcomes (e.g. long-term, working, and self-reported memory, as well as poor physical and mental health) as is the case with the Daily STRAIN.

Limitations and future directions

The present results should be interpreted in light of several limitations. First, all data collection was conducted online and it is possible that some participants could have been distracted while completing the study. Because it is unlikely that these distractions were systematically related to participants recent life stress exposure, however, these effects could have contributed to measurement error and thus weakened the associations observed but they are unlikely to have substantially altered the basic nature and pattern of the results. Similarly, it is possible that some participants could have written the memory task words down during the encoding phase of the task, but this is unlikely given the memory scores observed. In fact, only five participants recalled all 16 words at the immediate recall test and no participants recalled all 16 words at the delayed recall test. In addition, even if participants had written down the words, we know of no reason to expect that the choice to write down the words would have been systematically related to recent life stress exposure.

Second, the design of this study was correlational and as such, it is not possible to determine whether recent life stress causes memory impairments or is merely associated with them. Alternatively, memory impairments could contribute to the generation of life stress. It is possible, for example, that worse memory leads to forgetting important social and work-related obligations, resulting in fights with upset friends and negative work-related outcomes. Of course, a third factor could be influencing both recent life stress and memory performance, producing the observed associations without any direct causal link between recent life stress and memory. Experimental studies that manipulate life stress and assess its effects on memory are important for adjudicating between these possibilities, and we believe that the present data provide important information that can help inform the design of such studies.

Third, although we conducted analyses to address the question of whether observed associations were due to people with more recent life stress simply experiencing more stress in general (i.e. as opposed to just over the past two weeks), we cannot completely rule out the possibility that stress occurring outside this two-week time period influenced memory. To address this issue, future studies will need to directly manipulate recent life stress or assess cumulative lifetime stress exposure.

Fourth, performance at the delayed recall test was low. Although over two-thirds of individuals recalled at least one word, floor effects may have altered the results. Nonetheless, recent life stress does seem to be associated with greater forgetting rates of neutral materials at least when a memory trace is weak, as was the case in the present data (see also Smith, Floerke, & Thomas, 2016).

Fifth, the effects observed in this study were relatively weak by conventional standards. This could have been due to several things, including the study design, the fact that the recent stress assessment window was limited to very recent stressors (i.e. two weeks opposed to slightly longer or much longer assessment windows), or the types of memory tasks used. It is also possible that associations of memory with recent life stress are simply weaker than associations of memory with other variables. Future research is needed to investigate these possibilities.

Sixth, the generalizability of these results to other tasks and populations is unclear. For example, we did not assess these associations in individuals suffering from depression, and these individuals may have shown a different strength of association than nondepressed individuals. Similarly, whether recent life stress might be related to tests of other cognitive processes—such as response inhibition or cognitive flexibility—is unknown, as is whether the observed associations between recent life stress and memory would generalize to different types of memory tasks, such as recall of images or recognition. Finally, the sex and race distribution in this sample was not representative of the broader US population. Although neither race nor sex interacted with recent life stress exposure to predict any of the outcomes studied (data not shown), future research is needed to replicate and extend the present findings in samples that are more representative of the US population, as well as populations in other countries (Henrich, Heine, & Norenzayan, 2010).

Despite these limitations, the present study has produced novel data linking recent life stress exposure and memory and thereby highlighted new avenues for future research. For example, the biological correlates of the associations documented remain unknown and examining such processes represents an important focus of future research. Similarly, as alluded to above, additional studies should aim to extend these results by examining the full range of cognitive processes that may be related to or affected by recent life stress exposure. We have shown here that recent life stress exposure is associated with several processes involved in memory, but it is likely that recent life stress exerts effects on cognition that extend beyond memory and additional studies employing different cognitive tasks are needed to investigate these issues.

Conclusions

In conclusion, although acute and chronic stress have received substantial attention in stress research (Juster, McEwen, & Lupien, 2010; Lennartsson, Kushnir, Bergquist, Billig, & Jonsdottir, 2012; Maninger, Capitanio, Mason, Ruys, & Mendoza, 2010; Miller, Cohen, & Ritchey, 2002; Shields, Kuchenbecker, Pressman, Sumida, & Slavich, 2016; Shields et al., 2017; Soares et al., 2012; Weymar, Schwabe, Löw, & Hamm, 2012), relatively little is known about how recent life stress influences memory. We found that greater recent life stress exposure was associated with poorer long-term, working, and self-reported memory, as well as worse self-reported health, in a diverse sample of young adults. Moreover, these associations were relatively robust while controlling for possible confounding factors and they were not accounted for by more general life stress exposure, which was assessed by re-administering the life stress measure two weeks following the baseline memory tasks. Future research is needed to replicate these findings in other populations and to extend the findings to other aspects of human cognition, health, and behavior.

Disclosure statement

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Appendix

Stress and Adversity Inventory for Daily Stress (Daily STRAIN)

Over the **past two weeks**, how many times …

… were you unable to do or buy things that you wanted?

… did you fail, or do poorly on, a test or major project in an important class (e.g., grade of C or less)? *

… did you feel overwhelmed or exhausted because you were studying for long periods of time? *

… did you not have enough time to study or complete assignments? *

… did you fight or argue with someone you care about (e.g., friend, family member or significant other)?

… did you do something you didn't want to do to make someone happy or accept you?

… were you ignored by someone you care about?

… were you criticized, insulted, or made fun of by someone you care about?

… did you stop talking to someone you care about because you were fighting?

… did your friends get together to do something fun without inviting you?

… did you want a best friend or romantic partner but did not have one?

… did an important friendship or romantic relationship end with you and someone else?

… did you feel uncomfortable or discriminated against because of your race, ethnicity, gender, sexual orientation, or religious beliefs?

… did you get sick or have a medical issue?

… did you have problems with your apartment, house, or those living with you (i.e., your roommates)?

… did you feel concerned for the health of someone you care about?

… did you have problems at work (e.g., didn't get the schedule that you requested, couldn't find someone to fill in for you, etc.)?

Response Scale

0 1 2 3 4 5+

*included to cover college-related stressors.