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Feel Free to Write This Down: Writing About a Stressful Experience Does Not Impair Change Detection Task Performance

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Abstract

Acute stress impairs working memory (i.e., the ability to update and keep information in mind). Although that effect is well established, the boundaries around it are not. In particular, little is known about how recalling an unresolved stressor might influence working memory, nor is anything known about how stress—or recalling a stressful event—influences the processes underlying working memory task performance (e.g., sustained/controlled attention versus capacity). We addressed these issues in the present study (N=171) by randomly assigning participants to write about an unresolved, extremely stressful experience (stressful writing condition; n=85) or the events of the prior day (control condition; n=86) and subsequently both measured change detection task performance and used computational cognitive modeling to estimate the processes underlying it—namely, attention, capacity, and bias. We found that, relative to the control task, writing about a stressful experience did not impair performance on the change detection task, nor did it alter any of the processes underlying performance on that task. These results show that the effects of writing about an unresolved, stressful episode do not parallel effects of acute stress on working memory, indicating that experiencing a stressor may have very different cognitive effects than recalling it at a later time.

Keywords

acute stress; working memory; mild stress; expressive writing; visual working memory; capacity; attention; computational modeling

Acute stress impairs working memory—the ability to update, integrate, and keep goal-related information in mind (Schoofs, Preuß, & Wolf, 2008). Predominant theoretical explanations of this effect emphasize that impairing the ability to keep abstract information in mind forces one to deal with the stressful information or event, thereby increasing the chance of surviving the stressor (Arnsten, 2009; Shields, Sazma, & Yonelinas, 2016). Although the effect of acute stress on working memory is well documented, the boundaries of it are not. For example, does recalling an experienced stressor impair working memory in the same way as experiencing it? Similarly, does a stressor—or recalling a stressor—impair

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Data and scripts used in this study are available at https://osf.io/gk62n all components of working memory, or are some components (e.g., capacity) more affected by stress than others? The answers to these questions have the potential to reshape theories of stress and working memory, which currently assume all types of stress nonspecifically impair working memory by diverting cognitive resources to whatever is stress-relevant (Shields, Sazma, et al., 2016), as this theoretical account implies that stressors should impact attentional processes within working memory more than capacity or other processes. We answered these questions in the current study by examining whether writing about a stressful experience impaired visual working memory, which we decomposed using computational modeling into the component processes of attention, capacity, and guessing bias.

Prior work examining effects of acute stress on working memory has found that stress impairs working memory, especially for highly demanding tasks (Oei, Everaerd, Elzinga, van Well, & Bermond, 2006; Schoofs, Wolf, & Smeets, 2009; Shields, Sazma, et al., 2016; Shields & Yonelinas, 2018). Writing about a stressful experience, however, contains elements of both acute stress and negative affect inductions, and negative affect does not appear to alter working memory in the same way as stress (Blanchette & Richards, 2010; Mitchell & Phillips, 2007). The overall effects of negative affect on cognition are best summarized by the mood-as-information theory, which suggests that, rather than influencing working memory itself, negative affect shifts cognitive processing to a more analytic style in order to help systematically process and solve the problem contributing to negative mood (Mitchell & Phillips, 2007).

Writing about stressful and traumatic experiences has been studied within the fields of both emotion and coping with stress. For example, writing about an anxiety- or shame-inducing event provokes short-term physiological changes similar to stress, such as increasing heart rate and proinflammatory cytokine levels (Dickerson, Kemeny, Aziz, Kim, & Fahey, 2004; Moons & Shields, 2015). Moreover, writing about an anxiety-inducing event impairs performance an executive function task dependent upon cognitive flexibility (Shields, Moons, Tewell, & Yonelinas, 2016)—which approximates effects of acute stress on that task (Shields, Trainor, Lam, & Yonelinas, 2016). However, writing about stressful events can buffer against negative health effects of those stressful events (Smyth, 1998; Smyth, Stone, Hurewitz, & Kaell, 1999). As such, it is currently unknown whether writing about a stressful experience will impair working memory the same way that acute stress exposure does.

Current Research

We addressed the question of whether writing about a stressful experience would influence working memory by randomly assigning participants to write about either an unresolved stressful experience or a neutral experience and subsequently assessing participants' visual working memory using a change detection task. We further examined if writing about a stressful experience would alter component working memory processes by decomposing change detection performance into attention, capacity, and guessing bias using cognitive modeling. We hypothesized that participants in the stressful writing condition would evidence poor working memory, and this worse performance would be driven by poorer attention and—to a lesser extent—capacity.

Method

All manipulations were conducted and all measures were collected in the context of this study; no additional manipulations or measures were administered. Additional methodological information is presented within Supplemental Material.

Participants

175 young adults (M_{age}=20.71, SD=3.54, range=18–57; 88 female) attending a large public university participated in this study for extra credit. We aimed for 85 participants per condition because this sample size gave us 95% power to detect an effect size of d=−0.50 with a one-tailed test, which was slightly smaller than the effect of stress on working memory under precise conditions (Shields, Sazma, et al., 2016). We slightly oversampled, expecting some participants not to follow instructions (see Data Reduction and Analysis). We only invited participants who indicated that English was their primary language. Participants were randomly assigned to either the stressful writing induction (n=88, 43 female) or control (n=87, 45 female) condition. The sample was racially/ethnically diverse: 37.14% of participants identified as Asian, 29.71% as Hispanic, 28.57% as White, 2.29% as Black or African American, 1.71% as Native Hawaiian or Pacific Islander, and 0.57% as American Indian or Alaska Native. Age, sex, race, relationship status, and political affiliation did not differ between the stressful writing and control conditions, ps>.650.

Materials

Essay manipulation.—Participants in the stressful writing and control conditions were given 10 minutes to type an essay using a keyboard. Participants in the stressful writing condition were instructed to write about an unresolved stressful situation with a prompt only differing in a select few words from prompts given by Moons and Shields (2015). Participants in the control condition were instructed to write about all the events that occurred in their yesterday (Moons & Shields, 2015).

Negative affect.—To assess negative affect, we used the Positive and Negative Affect Schedule-Short Form (Watson, Clark, & Tellegen, 1988), 1988), which is the most widely used measure to assess affect in research settings. Although we were only interested in negative affect, we retained all positive affect questions to reduce demand characteristics. Participants were asked to report the extent to which they felt 10 negative and 10 positive emotions at that moment. Responses were provided on a 1(*Very slightly or not at all*) to 5(*Extremely*) scale. Responses to the 10 negative affect questions were averaged, with higher scores indicating greater negative affect. Internal consistency for negative affect was excellent both pre-manipulation, α=.90, and post-manipulation, α=.92.

Change detection task.—This study measured visual working memory using a change detection task adapted from Rouder et al. (2008), coded in PEBL (Mueller & Piper, 2014). The task consisted of 10 practice trials and 180 test trials (60 of each set size) divided equally into 3 blocks. Each trial began with a 500ms fixation cross, after which a non-overlapping randomly positioned colored array of 2, 5, or 8 squares was presented for 500ms. Colors were sampled from a pool of 10 possible colors, and no color was presented in two different squares simultaneously. The square array then disappeared and a blank screen appeared for 500ms. Next, a mask was presented in which all locations of the squares from study were shown but covered by grey squares for 500ms. Finally, the target square appeared, which remained on screen until participants indicated whether it was the same color it had been initially. The target square had a 50% chance of remaining the same color as initially presented; if it changed, the new color was randomly sampled from the remaining colors. After the participant provided his/her answer, s/he was given feedback for 350ms. With 120 trials using similar set sizes to those used here, test-retest reliability for the change detection over one month with no intervening practice was r=.81 (Xu, Adam, Fang, & Vogel, 2018).

Procedure

Figure 1 illustrates the study procedure. Participants came to the lab and were randomly assigned to their conditions. The number of participants per study timeslot varied from 1–13. Participants provided informed consent and then began the experiment. After an acclimation period (during which time they completed the Big Five Inventory as a filler measure; this measure was not scored), participants completed the pre-induction affect questionnaire. Next, participants were shown the essay prompt of their assigned condition. After 10min had elapsed, the program automatically continued to the post-manipulation affect questionnaire. Finally, participants completed the change detection, after which they were debriefed. All procedures were approved by the university's IRB.

Data Reduction and Analysis

Individual data files were examined for compliance with study instructions prior to any data reduction, and four participants (3 stress, 1 control) were excluded based upon this examination: one stress participant only typed only 16 words in his essay, and one control and two stress participants responded randomly to the change detection. All subsequent data reduction and analyses were conducted in **R**, version 3.5.0.

Bias-corrected change detection scores were calculated by subtracting false alarms from hits. Change detection performance was further decomposed by estimating parameters for attention, capacity, and guessing bias, using code adapted from Rouder et al. (2008).

ANOVAs were conducted using the afex package. Bayesian analyses—producing Bayes factors—were conducted in the BayesFactor package using noninformative Jeffreys priors for the population variance and a Cauchy prior for the standardized effect size. When testing evidence for the null hypothesis, we inverted the Bayes factors (i.e., 1/BF) such that higher values indicate greater evidence for the null. By convention, a Bayes factor BF_{01} greater than 3.16 indicates substantial evidence in favor of the null hypothesis (Jeffreys, 1961).

The data, code for the change detection, and code for analyses are available on OSF at https://osf.io/au2nd/

Results

Manipulation Check

As hypothesized, the ANOVA examining negative affect showed a significant Time×Condition interaction, $F(1,169)=37.55$, $p<.0001$, η_p^2. The stressful writing condition showed an increase in negative affect from pre- ($M=1.66$, $SE=0.08$) to post-manipulation ($M=2.07$, $SE=0.09$), $t(169)=7.01$, $p<.0001$, whereas the control condition showed a nonsignificant decrease in negative affect from pre- ($M=1.59$, $SE=0.08$) to post-manipulation ($M=1.49$, $SE=0.09$), $t(169)=1.64$, $p=.103$. Viewed differently, the stressful writing condition did not differ from the control condition pre-manipulation, $t(169)=0.66$, $p=.513$, 95%CI_{diff} [−0.14, 0.29], $d=0.10$, whereas the stressful writing condition reported significantly more negative affect post-manipulation, $t(169)=4.84$, $p<.0001$, 95%CI_{diff} [0.35, 0.82], $d=0.74$. Thus, participants in the stressful writing condition showed the expected effect: writing a stressful essay increased negative affect, indicating a successful manipulation.

Primary Analyses

We first examined whether overall performance on the change detection differed between conditions. We found that participants in the stressful writing condition ($M=52.66$, $SD=11.79$) did not differ from participants in the control condition ($M=51.48$, $SD=11.55$) in overall accuracy on the change detection (i.e., total hits-false alarms), $t(169)=0.66$, $p=.509$, 95%CI_{diff} [−2.34, 4.71], $d=0.10$. Moreover, there was substantial evidence in favor of the null hypothesis, $BF_{01}=4.93$ (Figure 2a). The lack of difference between conditions in behavioral performance (hits-false alarms) was present at low load (i.e., set size 2), $p=.670$, $BF_{01}=5.55$, medium load (set size 5), $p=.320$, $BF_{01}=3.81$, and high load (set size 8), $p=.813$, $BF_{01}=5.89$.

Decomposing raw performance on the change detection into component processes underpinning performance (see Figure 2b–d), we found no differences between conditions in attention ($M_{stress}=0.89$, $SD_{stress}=0.11$; $M_{control}=0.88$, $SD_{control}=0.10$), $t(169)=0.37$, $p=.710$, 95%CI_{diff} [−0.025, 0.036], $d=0.06$, capacity ($M_{stress}=3.07$, $SD_{stress}=0.82$; $M_{control}=2.98$, $SD_{control}=0.83$), $t(169)=0.74$, $p=.457$, 95%CI_{diff} [−0.16, 0.34], $d=0.11$,[1] or guessing bias ($M_{stress}=0.75$, $SD_{stress}=0.14$; $M_{control}=0.74$, $SD_{control}=0.12$), $t(169)=0.41$, $p=.684$, 95%CI_{diff} [−0.031, 0.047], $d=0.06$. Importantly, Bayes factors indicated substantial evidence in favor of the null for each of these tests: $BF_{01}=5.67$, $BF_{01}=4.67$, and $BF_{01}=5.60$, respectively. Thus, writing about a stressful experience does not impair overall behavioral performance on the change detection, nor does it impair any of the component processes that underpin performance on the task.

Additional results are presented within Supplemental Material.

[1]Removing the outlier (shown in Figure 2c) did not alter this result.

Discussion

Although acute stressors tend to impair working memory (Shields, Sazma, et al., 2016), little is known about how vividly recalling and writing about an unresolved stressful experience affects working memory. We addressed this gap by randomly assigning participants to either stressful or neutral writing tasks. Our results supported the null hypothesis: Bayesian analyses provided substantial evidence in favor of the idea that writing about a stressful experience did not impair change detection performance. Moreover, using cognitive modeling, we found that the writing about a stressful experience did not influence attention, working memory capacity, or guessing bias relative to writing about a neutral experience. Thus, writing about a stressful experience does not impair performance in the change detection task, nor does it impair the component processes that support performance on that task.

The results we obtained are what would be expected from the mood-as-information theory of negative affect and cognition, which suggest that negative affect does not impair cognitive function *per se*, but instead shifts processing to a more analytic style (Mitchell & Phillips, 2007). This is in contrast to theories of stress and cognition, which suggest that stress impairs working memory due to cognitive resources being diverted to dealing with a stressor (Shields, Sazma, et al., 2016). Therefore, writing about a stressful experience may be more similar to a negative affect induction than it is to an acute stressor.

One interesting divergence of our results from prior literature is that writing about a prior anxiety-producing event impairs a related executive function—namely, cognitive flexibility (Shields, Moons, et al., 2016). These studies differed in both the essay prompt—indeed, writing about an anger-inducing situation did not impair cognitive flexibility (Shields, Moons, et al., 2016)—and the cognitive process assessed. Future research should attempt to resolve this discrepancy by either assessing working memory after writing an essay describing an anxiety-inducing situation, or by assessing cognitive flexibility after writing an essay describing a stressful episode.

Interestingly, writing multiple essays on negative events over a longer period of time appears to have very different effects on working memory than writing about a single stressful event. In particular, two studies found that writing about negative events in multiple sessions over the course of at least two months enhances working memory capacity relative to writing about positive or neutral events (Klein & Boals, 2001; Yogo & Fujihara, 2008). How this effect emerges over time—in contrast to our null results—is a subject for future research.

Although this study has a number of strengths, including a large sample size, use of a well-validated working memory task and computational cognitive model, and an experimental manipulation drawn from prior studies, it has limitations. First, the working memory task used depends heavily on the hippocampus (Goodrich & Yonelinas, 2016). It is possible that effects on a working memory task more dependent on the prefrontal cortex would differ from what we observed here. Second, we did not assess mental health status or psychiatric medication use, both of which may alter stress effects on working memory. Finally, although our sample was somewhat racially/ethnically diverse, it was a college sample, which limits the generalizability of our results to a broader population (Henrich, Heine, & Norenzayan, 2010).

In sum, we examined the effect of writing about a stressful episode on change detection performance in a large sample of undergraduate participants. We further used computational cognitive modeling to decompose performance on the change detection into attention, capacity, and guessing bias. Contrary to expectations, our results show that writing about a stressful episode does not impair change detection performance overall, nor does it impact any of the component processes supporting change detection performance. Although experiencing a stressor impairs working memory, vividly recalling and writing that experience down does not.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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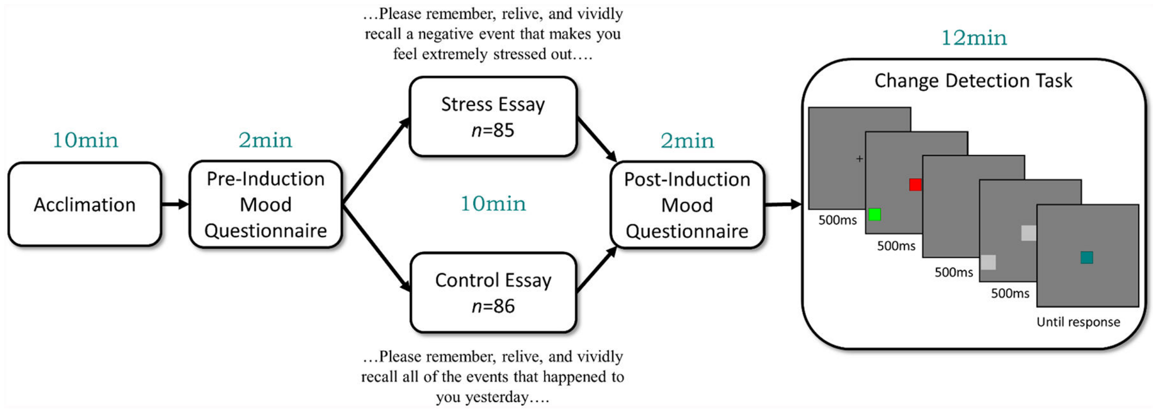

Figure 1.
Depiction of study procedure. After an initial acclimation period, participants completed the pre-manipulation emotion questionnaire. Participants then completed the stressful writing or control task, depending upon their randomly assigned conditions. Next, participants completed the post-induction mood questionnaire. Finally, participants completed the change detection task. Participants completed the study, on average, in approximately 35min. Note that numbers here reflect those used in analyses, after the four participants who failed to comply with study instructions were excluded (see Data Reduction and Analysis section).

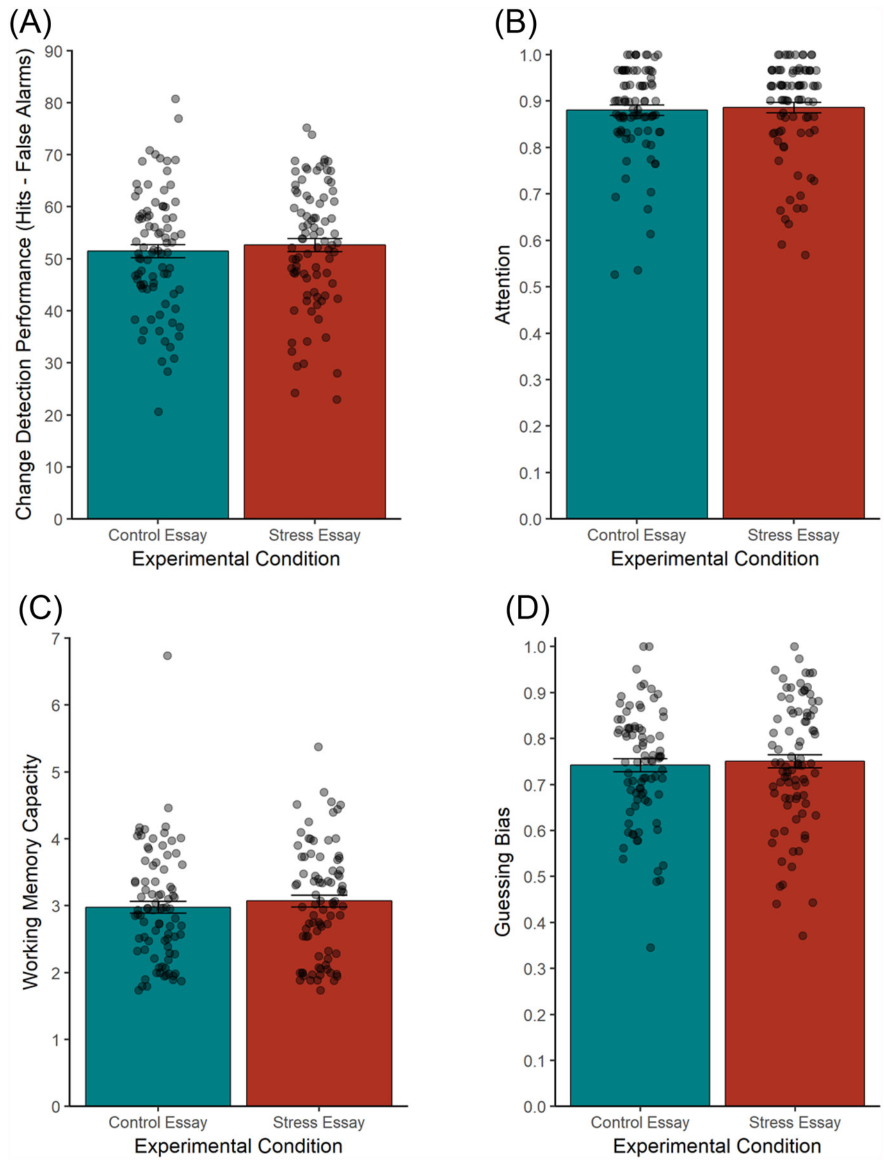

Figure 2.

Effects of the experimental manipulation on overall change detection performance (A) and estimated parameters underpinning performance (B-D). Participants in the stressful writing and control conditions did not differ on overall performance or in any estimated parameter. Removing the outlier in capacity did not affect the results.