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# Writing about a stressful experience improves semantic clustering of memory in men, not women

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#### Abstract

Writing about negative experiences can produce multiple benefits, including improvements in mental and emotional health. However, writing about negative experiences potentially be detrimental, as reliving and reexperiencing a negative memory can be painful. Although the emotional effects of writing about negative experiences are well established, the cognitive effects are less heavily explored, and no work to date has examined how writing about a stressful experience might influence episodic memory. We addressed this issue in the present study (N = 520) by having participants encode a list of 16 words that were organised around four semantic clusters, randomly assigning participants to write about an unresolved stressful experience (n = 263) or the events of the previous day (n = 257), and assessing their memory in a free recall task. Writing about a stressful experience did not influence overall memory performance; however, the stressful writing manipulation increased semantic clustering of information within memory for men, whereas the stressful writing manipulation did not influence semantic clustering of information within memory in women. Additionally, writing with more positive sentiment improved semantic clustering and reduced serial recall. These results provide evidence for unique sex differences in writing about stressful experiences and the role of sentiment in the effects of expressive writing.

#### KEYWORDS

acute stress, episodic memory, expressive writing, semantic clustering, sentiment

# 1 | INTRODUCTION

Writing about, and in doing so reliving and recalling, stressful experiences is a surprisingly influential procedure. On the one hand, the process can be beneficial for resolving unresolved emotional issues and coping with experiences that have been particularly traumatic (Horneffer & Jamison, 2002; Schoutrop et al., 2002; Stone et al., 2000). On the other, reliving a stressful experience can itself be distressing, potentially resulting in negative affective and physiological changes (Dickerson et al., 2004; Moons & Shields, 2015). Although the emotional and psychological benefits of writing about stress are well known, the potentially detrimental effects, including potential detrimental effects on cognitive processes such as memory, are less known. The current study addresses that gap by determining how a single instance of writing about a stressful experience affects episodic memory.

Writing about stressful events has been extensively studied as an intervention for stress and anxiety related to unresolved past trauma (Horneffer & Jamison, 2002; Schoutrop et al., 2002; Stone et al., 2000; Ullrich & Lutgendorf, 2002; Vrielynck et al., 2010). This work has found that writing about past stressful experiences confers a number of psychological and emotional benefits. In particular,

repeated instances of journaling interventions result in greater improvements in mental and emotional health (Horneffer & Jamison, 2002; Schoutrop et al., 2002; Stone et al., 2000). These benefits are generally attributed to interplay between emotional and cognitive processing of the prior experience. Although cognitive mechanisms have been found to play a role in the emotional benefits of writing about stressful events, potential cognitive benefits have not been well explored.

Additionally, the effects of writing about prior negative experiences may not be completely beneficial. For example, writing about anxiety-inducing, shame-inducing, or guilt-inducing events induces a physiological response similar in some ways to an actual stress response, including changes in heart rate and salivary proinflammatory cytokine activity (Dickerson et al., 2004; Moons & Shields, 2015). Additionally, writing about an anxiety-inducing event impairs some cognitive processes (Shields, Moons, et al., 2016) in ways similar to the effects of stress (Crosswell et al., 2021; Shields, Sazma, et al., 2016). However, shame, guilt, and anxiety are all specific emotions. Although these emotions are induced by stress in certain situations, they may also have specific patterns of proinflammatory cytokine activity that differ from those induced by acute stress (Moons & Shields, 2015). To date, only one cognitive process has been examined within the context of writing about a single stressful experience (Shields, Spahr, et al., 2020). Therefore, it is not yet known if writing about a stressful experience acutely mimics the effects of stress on cognitive processes.

One cognitive process studied in extensive detail with respect to stress is episodic memory (Shields, Sazma, et al., 2017). Stress exerts complex effects on memory, though it generally impairs memory encoding and retrieval (Kuhlmann et al., 2005; Roozendaal, 2002; Smeets, 2011; Wolf, 2017; Wolf et al., 2016). Although there is substantial evidence to say that repeated instances of writing about and recalling stressful experiences have emotional benefits, the opposing effects of stress on memory consolidation and retrieval further complicates the question of how writing about stress impacts memory recall. As an additional complication, initial writing sessions within the long-term writing paradigms have been found to be accompanied by negative emotions (Pennebaker & Beall, 1986), with emotional benefits not being seen until subsequent sessions have been completed. Should a single instance of writing about a stressful experience induce a similar response in individuals as an acute stressor, similar impairments in memory encoding and memory retrieval would be expected to be observed.

Learnt information can be encoded and stored in multiple ways. One such way is via semantic clustering, in which individuals tend to store and group information and memories based upon their semantic meaning (Bousfield, 1953; Manning & Kahana, 2012; Manning et al., 2012). For example, someone presented with the words 'apple, table, lamp, banana, truck, cherry' may remember the words 'apple, banana, and cherry' together because they are all fruits. In contrast, episodic memories involve reliving autobiographical experiences in their original context and are organised by their spatiotemporal

specificity. In the previous example, someone relying more on episodic memory processes may remember the words 'apple, table, and lamp' together because they were presented close together in time (i.e., serial recall). As a result, retrieval of an episodic memory involves an individual reliving the experience in its original context, with all the sensory experiences and emotional components attached (Renoult et al., 2012; Tulving, 2002). Furthermore, semantic clustering and episodic recollection differ in the brain regions primarily involved in the activation of each system: The prefrontal cortex plays a key role in semantically clustering encoded information (Long et al., 2010; Manning et al., 2012), whereas episodic memory is supported primarily by the medial temporal lobe, and most specifically the hippocampus (Behrendt, 2013; Burgess et al., 2002). Therefore it is possible that writing about a stressful experience may differentially affect these memory processes, as differential effects of stress on separable memory processes have been observed in prior work (e.g., Sazma et al., 2019; Shields et al., 2019).

Another potentially important factor in determining the effects of writing about a stressful episode on memory processes is sex. Generally, women tend to perform better on episodic memory tasks (Herlitz et al., 1997; Maitland et al., 2004; Pauls et al., 2013; Yonker et al., 2003); however, when task type is considered, men perform significantly better on visuospatial episodic memory tasks, with women performing better on auditory or verbal tasks (Herlitz et al., 1997; Maitland et al., 2004). In contrast, sex differences in semantic clustering at retrieval are more clear-cut. Women tend to consistently display greater immediate and delayed recall on verbal learning tasks, and this finding has been attributed to women being more likely to use semantic clustering strategies (Berenbaum et al., 1997; Kramer et al., 1988, 1997; Sunderaraman et al., 2013). There are also relatively clear-cut sex differences in psychological benefits of writing about stressful experiences; although it is beneficial to both sexes, the emotional benefits of writing about stressful experiences tend to be stronger in men than women (Horneffer & Jamison, 2002; Stone et al., 2000). In short, given sex differences in the long-term benefits of writing about stressful experiences (Olivares & Manier, 2005; Procaccia et al., 2021; Range & Jenkins, 2010) as well as the effects of acute stress on memory (e.g., Shields, Sazma, et al., 2017), it is likely that sex differences exist in the acute effects of writing about a specific stressful experience on memory. To date, however, no research has examined this possibility.

#### 1.1 **Current research**

We addressed the question of whether writing about stressful experiences would influence long-term memory, semantic clustering, and episodic memory, and whether that influence would differ by sex, by randomly assigning participants to write about either an unresolved stressful experience or the neutral events of the previous day. Following the writing task, we assessed memory via a word recall task. We hypothesised that participants in the stressful writing condition would have poorer memory recall, semantic clustering, and

episodic memory, and that women would be less affected by writing about stressful experiences than men.

# 2 | METHOD

#### 2.1 | Participants

Our sample size was determined by an a priori power analysis. In particular, an unpublished secondary analysis of data from a very similar study (Shields, Spahr, et al., 2020) from our group found a sex by writing condition interaction in predicting working memory task performance at set size five, with an effect size of f = 0.16(data available for that study on OSF). Because this effect was found in a post hoc secondary analysis, we targeted 95% power to detect a stressful writing induction by sex interaction effect of the same magnitude in this study. Recruiting 510 participants provides 95% power to detect f = 0.16. We slightly overrecruited to account for potential failures to follow instructions, and we thus recruited 524 participants for this study, with four participants being excluded during analyses ( $M_{age} = 19.26$ , SD = 1.89; 314 women). Participants received extra credit for participating. Participants were randomly assigned to either the stressful writing condition (n = 263; 61.2% women) or control condition (n = 257; 59.5%)women). Of this sample, 81.73% of identified as White, 7.50% as Black or African American, 6.35% as Hispanic, 2.50% as Asian, 1.15% as American Indian or Alaska Native, and 0.58% as Native Hawaiian or Pacific Islander. Age, sex, and race/ethnicity did not significantly differ between the stressful writing and control conditions, ps > 0.238.

#### 2.2 | Materials

# 2.2.1 | Essay manipulation

Participants were given 6 min to type an essay. Participants in the stressful writing condition were given the following prompt:

Please write an essay in the space provided below. Please remember, relive, and vividly recall a negative event that makes you feel extremely stressed out. Choose an event that has not been resolved and is still a source of stress for you. Please give as much detail as necessary to vividly describe the situation and why it stresses you out. You will have six minutes to complete this task. You must write for the full six minutes. The study will automatically continue when the six minutes is over as long as you have written something, but you will not be able to complete the study if you do not write anything. Participants in the control (i.e., neutral writing) condition were given the following prompt:

Please write an essay in the space provided below. Please remember, relive, and vividly recall all of the events that happened to you yesterday. Please describe any and all events regardless of whether they were routine or unusual. Please give as much detail as necessary to vividly describe the situation. You will have six minutes to complete this task. You must write for the full six minutes. The study will automatically continue when the six minutes is over as long as you have written something, but you will not be able to complete the study if you do not write anything.

#### 2.2.2 | Manipulation check

Participants were asked to rate the writing task they completed using two visual analogue scales: 'how stressful was the writing task you just completed?' and 'how unpleasant was the writing task you just completed?'. Scores ranged from 0 ('Not at all stressful') to 100 ('Extremely stressful'). The scale was marked with numbers in increments of 10.

#### 2.2.3 | Writing sentiment

As an additional manipulation check, participants' responses to the writing task were analysed for sentiment using the sentimentr package in R, version 2.9.0. Sentiment scores were calculated for each sentence within each participant's essay based on word usage such that positive values indicated more positive sentiment and negative values indicated negative sentiment. Scores for each sentence were then summed across sentences for each participant to produce an overall sentiment score for their essay.

### 2.2.4 | Memory recall

Memory recall was assessed in this study via a delayed recall task with stimuli from Shields, Doty, et al. (2017). Participants were shown a list of 16 words one at a time, with each word presented for five seconds. The words were grouped into four semantic clusters (two negative, two neutral), with each cluster designed to suggest a non-presented lure word. Neutral and negative words were matched for word frequency (Brysbaert & New, 2009), p = 0.744, and character length, p = 0.636, but significantly differed in both valence (Warriner et al., 2013), p < 0.001, and arousal (Warriner et al., 2013), p < 0.001, with the negative words being more negative in valence and more arousing.

### 2.3 | Procedures

Study procedures were completed online. Participants completed an informed consent form followed by a demographic questionnaire before being shown the word list for the memory recall task. Participants then completed filler self-report questionnaires during the delay period. Next, participants completed either the stressful writing task or the control writing task, depending upon their assigned condition. The writing task was administered long after encoding in order to ensure that any potential effects of it on memory could not be attributable to effects on perceptual, attentional, or encoding processes while viewing the word list. Following the manipulation, participants were presented with the visual analogue scale as a manipulation check. Finally, participants then completed the recall portion of the memory recall task (see Figure 1).

# 2.4 | Data analysis

Individual participant responses were examined for complying with study instructions prior to any data analysis. Four participants were excluded from analyses because of this, with one participant writing nonsense words and three participants not writing anything.

Scores for semantic clustering, serial recall, and unserialised semantic clustering were calculated along with overall recall scores. Semantic clustering scores were created by determining the proportion of words recalled adjacent (before or after) to other words within the same one of each of the four total semantic categories (i.e., bread, death, music, rape). The final semantic clustering score was the proportion of words recalled that met those criteria averaged across all categories recalled. For example, if a participant recalled roll, butter, grave, and sound, in that order, their proportion of semantic clustering would have been 0.5, because the words recalled fell into the categories of, 'bread', 'death', and 'music' Similarly, if a participant recalled dread, loaf, grave, stereo, record, guitar, food, butter, in that order, their semantic clustering score would have been 0.556 ('bread' clustering: 2/3, or 0.667; 'sound' clustering: 4/4, or 1; 'death' clustering: 0/2, or 0; total: (1 + 0.667 + 0)/3 = 0.556). Serial recall scores were created by calculating the proportion of words recalled by a participant that were recalled in the order they were presented in. Finally, unserialised semantic clustering was calculated as the difference between semantic categorisation and serial recall.

Type III sums of squares ANOVAs were run using the car package in R. Four ANOVAs were used to examine the effect of Condition (stressful writing; neutral writing) and Sex(men, women)<sup>1</sup> on overall recall, semantic clustering, serial recall, and unserialised semantic clustering (semantic clustering-serial recall), as well as the interaction between Condition and Sex. Additionally, three ANOVAs considered Condition, Sex, and Overall Recall Score as predictors of each outcome in order to assess whether the relations between Condition, Sex, and memory processes (e.g., semantic clustering, serial recall) differed as a function of overall memory. Overall recall was mean centred for these analyses. Finally, two ANOVAs were used to examine the effect of Condition and Sex on recall of negative words and recall of neutral words. Reported values for all analyses are estimated marginal means and standard errors. All data analyses were conducted using R. version 4.1.3. Syntax and data are available upon request.

### 3 | RESULTS

#### 3.1 | Manipulation check

As expected, participants in the stressful writing condition  $(M_{\text{Stress}} = 40.23, SE_{\text{Stress}} = 1.87)$  reported that the writing task was significantly more stressful than participants in the neutral writing condition ( $M_{Control} = 18.2, SE_{Control} = 1.50$ ), t(512) = -9.27, p < 0.001, d = -0.82, 95% CI [-26.92, -17.51]. Similarly, participants in the stressful writing condition ( $M_{\text{Stress}} = 50.22$ ,  $SE_{\text{Stress}} = 2.07$ ) that the writing task was significantly more unpleasant than participants in the neutral writing condition ( $M_{Control} = 26.21$ ,  $SE_{Control} = 1.91$ ), t (513) = -8.53, p < 0.001, d = -0.75, 95% CI [-29.61, -18.52].Additionally, we observed a sex difference in reported stressfulness of the writing task across both conditions: Women ( $M_{Women} = 32.0$ ,  $SE_{Women} = 1.65$ ) reported significantly greater stressfulness than men  $(M_{Men} = 24.6, SE_{Men} = 2.03), t(512) = -2.92, p = 0.004, d = -0.27,$ 95% CI [-26.93, -17.50]. There was no significant sex difference for reported unpleasantness of the writing task, t(513) = -0.97, p = 0.33. Sex did not interact with condition to predict self-reported stressfulness or self-reported unpleasantness of the writing task, ps > 0.132 (see Figure 2).

Additionally, responses in the stressful writing condition (M = -0.10, SE = 0.04) displayed significantly more negative sentiment than participants in the neutral writing condition (M = 0.90, SE = 0.04),



FIGURE 1 General procedures and timing for the study.



**FIGURE 2** Mean unpleasantness (a) and stressfulness (b) of the writing task grouped by experimental condition and participant sex. Unpleasantness of the writing condition was significantly higher when writing about a stressful experience. Stressfulness of the writing condition was significantly higher when writing about a stressful experience and was significantly higher for women. \*\*\*p < 0.001, \*\*p < 0.01, \*p < 0.05.

t(514) = 16.99, p < 0.001, d = 1.5, 95% CI [0.88, 1.11]. There was no significant sex difference for sentiment of participants' written responses, t(514) = 0.72, p = 0.470.

### 3.2 | Primary analyses

For our primary analyses, we first examined whether overall memory recall score differed by both sex and writing condition. In a 2 × 2 ANOVA predicting overall recall score from Condition (stressful writing, neutral writing) and Sex (men, women) a main effect of Sex emerged, F(1, 512) = 10.40, p = 0.001,  $\eta_p^2 = 0.020$ , whereas the main effect of Condition and the Condition × Sex interaction were not significant, ps > 0.342. Examining the main effect of Sex in greater detail, we found that men ( $M_{\text{Men}} = 7.42$ ,  $SE_{\text{Men}} = 0.24$ ) had significantly lower recall scores than women ( $M_{\text{Women}} = 8.41$ ,  $SE_{\text{Women}} = 0.19$ ), t (512) = 3.23, p = 0.001, 95% Cl<sub>difference</sub> [-1.59, -0.36].

We next examined whether semantic clustering differed as a function of Condition or Sex. In this, although main effects of Condition and Sex were nonsignificant,  $p_S > 0.527$ , we observed a significant Condition × Sex interaction, F(1, 485) = 7.66, p = 0.006,  $\eta_p^2 = 0.020$ . Probing this interaction, we found that men randomized to the stressful writing condition (M = 0.841, SE = 0.027) showed greater semantic clustering than men randomized to the neutral writing condition (M = 0.762, SE = 0.025), t(485) = 2.16, p = 0.031, 95% CI [-0.15, -0.01], whereas women did not differ by condition(stressful writing women: M = 0.837, SE = 0.021; neutral writing women: M = 0.787, SE = 0.020), t(485) = 1.73, p = 0.084, 95% CI [-0.06, 0.12].

When examining serial recall and unserialised semantic clustering (i.e., penalising recall that occurred in the same order as encoding, even if that ordering was semantically clustered), no significant effects of Condition, Sex, or their interaction emerged, ps > 0.104 (see Figure 3).

Recall based on word valence (negative, neutral) was then assessed to investigate how word valence interacts with both sex and writing about a stressful experience. In a 2 × 2 × 2 MANOVA predicting recall from Condition, Sex, and Word Valence, a main effect of Sex merged, F(1, 512) = 10.59, p = 0.001,  $\eta_p^2 = 0.019$ , along with a main effect of Word Valence, F(1, 512) = 54.99, p < 0.001,  $\eta_p^2 = 0.087$ . No significant main effect of Condition, no significant Condition × Sex interaction, no significant Condition × Word Valence interaction, no significant Sex × Word Valence interaction, and no significant three-way Condition × Sex × Word Valence interaction emerged, ps > 0.248. Examining the main effect of Word Valence in greater detail, we found that participants recalled significantly more neutral words (M = 4.26, SE = 0.089) than negative words (M = 3.66, SE = 0.086).

Finally, (centred) sentiment of responses was then analysed as a predictor of our four cognitive outcomes, along with Condition and Sex. There was no significant association between sentiment and overall recall, nor any interaction between sentiment and anoy other variable in predicting overall recall, ps > 0.131 In an ANOVA predicting semantic clustering from Sentiment of written essays, Condition, and Sex, a significant main effect of Condition emerged, F(1, 481) = 4.10, p = 0.043,  $\eta_p^2 = 0.010$ , a significant main effect of Sentiment emerged, F(1, 481) = 6.08, p = 0.014,  $\eta_p^2 = 0.010$ , and a



FIGURE 3 Overall recall (a), semantic clustering (b), serial recall (c), and pure semantic clustering (d) as functions of experimental condition and participant sex. Overall recall significantly differed by sex. Semantic clustering had a significant interaction between condition and sex. Serial recall and pure semantic clustering did not significantly differ by condition or sex. \*\*\*p < 0.001, \*p < 0.01, \*p < 0.05.

significant Condition  $\times$  Sex interaction emerged, F(1, 481) = 6.10,  $p = 0.014, \eta_p^2 = 0.010$ . Examining the main effect of Sentiment in greater detail, we found that for every one standard deviation increase in essay sentiment, semantic clustering was predicted to increase by 3.81%,  $\beta = 0.15$ , t(481) = 2.46, p = 0.014. We also observed the same Condition  $\times$  Sex interaction as in models without sentiment described above. Essay sentiment was also a marginally significant predictor of serial recall, F(1, 481) = 3.41, p = 0.065,  $\eta_p^2 = 0.006$ , and did not interact with sex or condition: for every one standard deviation increase in essay sentiment, serial recall decreased by 3.58%,  $\beta = -0.11$ , t(481) = -1.84, p = 0.065. Finally, essay sentiment was also a significant predictor of unserialised semantic recall, and essay sentiment did not interact with sex or condition: for every one standard deviation increase in sentiment, unserialised semantic clustering increased by 7.4%,  $\beta = 0.24$ , t(481) = 3.95, p < 0.001(Figure 4). In this model, we also observed a main effect of Condition; Examining the main effect of Condition in greater detail, we found that participants in the stress condition (M = 0.483, SE = 0.025) had significantly greater unserialised semantic clustering than participants in the neutral condition (M = 0.404, SE = 0.025). Thus, writing about stressful experiences, especially with a positive word sentiment, was associated with stronger semantic clustering of encoded information.

Additional analyses examining semantic clustering, serial recall, and unserialised semantic clustering using mean-centred overall recall as a predictor, along with analyses examining recall of false lures and number of intrusions, can be found in Supporting Information S1.



**FIGURE 4** Unserialized semantic clustering as a function of the sentiment of participants' essays. Sentiment was a significant predictor of unserialised semantic clustering,  $\beta = 0.242$ , p < 0.001.

# 4 | DISCUSSION

Although a number of positive and negative effects of writing about prior negative experiences have been explored (Dickerson et al., 2004; Horneffer & Jamison, 2002; Moons & Shields, 2015; Schoutrop et al., 2002; Shields, Spahr, et al., 2020; Stone et al., 2000), less is known about how writing about negative experiences affects cognition, particularly episodic memory. We addressed this gap by randomly assigning participants to either a stressful or neutral writing task, and subsequently assessing their memory recall. Our results showed that although writing about a stressful experience did not directly affect overall recall, there was an interaction between the writing condition participants were assigned to and participant sex, such that writing about a stressful experience increased semantic clustering in men but did not affect semantic clustering in women. Additionally, we found that, across conditions, essays with more positive sentiment were predictive of greater semantic clustering, reduced serial recall, and greater unserialised semantic clustering.

Our finding that writing about a single stressful experience enhanced semantic clustering in men but not women was unexpected. However, there are at least a few possible explanations for this finding. First, stress differentially affects many processes by sex, including memory performance, working memory, and emotion regulation (Gupta & Chattarji, 2021; Kinner et al., 2014; Schoofs et al., 2013). Furthermore, although this finding is somewhat inconsistent (e.g., Shields, Sazma, et al., 2016), some work has found that stress enhances working memory performance in men but impairs it in women due to its differential effects on hippocampal neuronal function (Schoofs et al., 2013). Importantly, individuals with high working memory capacity are more likely to utilise semantic clustering strategies (Rosen & Engle, 1997) and more effective semantic clustering strategies have been associated with greater working memory (McNamara & Scott, 2001). It is possible, therefore, that the mild stressfulness of the writing task enhanced men's working memory, which in turn led to greater semantic clustering. However, follow-up research specifically examining dynamics between writing about stress, working memory, and semantic clustering strategies would need to be conducted to test this hypothesis.

Another potential explanation for the interaction between writing condition and sex in relation to semantic clustering is that writing about a stressful experience seems to be a more therapeutic experience for men than for women: Research investigating the benefits of writing about stressful experiences has found that men benefit from this writing to a greater degree than women, showing greater overall improvements in psychological wellbeing (Horneffer & Jamison, 2002). Interventions that increase psychological wellbeing, such as yoga and meditation, have been found to lead to improvements in executive function (Cohen et al., 2018; Helber et al., 2012; Luu & Hall, 2017; Shields, Skwara, et al., 2020). Men rated writing about a stressful experience to be more stressful than the neutral condition, though less than women rated it, possibly providing a 'sweet spot' for therapeutic benefits. If writing about a single stressful experience improves psychological wellbeing in men this set of findings could provide a possible mechanism by which writing about stressful experiences improves semantic clustering for men but not women. These findings may translate to clinical significance, as small effects (especially those related to stress) are often clinically significant among large populations. Additionally, people

memorise a lot of information every day in academic, professional, and personal settings. A one unit increase in memory recall out of 16 items total (or 6.25%) could therefore translate into a clinically meaningful difference in cognition.

Finally, the results obtained concerning sentiment were seemingly opposite in direction of the main effects of stress. Writing about stressful experiences (i.e., more negative sentiment) led to improved semantic clustering while responses that contained more positive sentiment were also associated with improved semantic clustering. These findings suggest there is something unique about writing about unresolved stressful events compared to writing about negative events in general. Prior work inducing negative affect via similar expressive writing paradigms has found that specific negative emotions differentially affect cognitive functions and biological processes (Moons & Shields, 2015; Shields, Moons, et al., 2016; Tiedens & Linton, 2001). This, along with our observed findings related to writing about stress, suggests that cognition is differentially affected by distinct induced affective states. Additionally, the role of negative events in memory processes may play a role. Negative events have been found to cause individuals to focus more on item-specific information (Kensinger, 2009), reducing the role of semantic clustering in recall. However, this is generally only found with integral emotional effects, in which the negative events are the items to be memorised, rather than incidental emotions, which the present study used. This suggests that not only can negative emotions differentially affect cognition, but that differences exist in the effects of integral and incidental emotional effects on memory. Furthermore, sentiment-related findings may provide further evidence of therapeutic benefits of writing about stressful experiences. Writing about stressful events using positive language may be indicative of reappraisal of adverse experiences in a more positive light, even implicitly at a linguistic level. This may explain the cognitive benefits of writing about stressful experiences specifically when done so using positive sentiment. Future research should examine the effects of writing about stressful experiences compared to anxiety and anger inducing writing tasks in order to investigate what makes the effects of writing about stressful experiences unique.

The null result we obtained regarding overall recall is consistent with previous work in the literature regarding the effects of writing about a single stressful experience on cognitive outcomes. For example, Shields, Spahr, et al. (2020) found no effect of writing about a single stressful experience on a working memory task that depends heavily on the hippocampus (Goodrich & Yonelinas, 2016). This is in line with our null findings related to both overall free recall and serial recall, as these episodic memory metrics depend upon the hippocampus as well (Alkire et al., 1998; Behrendt, 2013; Burgess et al., 2002; Strange et al., 2002).

Although this study has a number of strengths, including a large sample size, use of a well-validated memory retrieval task, and a manipulation pulled from prior research, it also has limitations that should be noted. First, the study was conducted online during the COVID-19 pandemic. Research conducted online during

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this period may have an increased number of inattentive subjects (Peyton et al., 2021); although this issue has not been found to affect study generalisability (Peyton et al., 2021), it is worth noting that participants completed the study in a context of their choice (e.g., at home) rather than a controlled environment (i.e., in the lab). Additionally, the COVID-19 pandemic has been found to impact stress resilience, mental health, and immune responses in a variety of ways (Manchia et al., 2022; Mattos dos Santos, 2020; Pfeifer et al., 2021). These results therefore may not generalise to participants whose baseline stress differed from those in our study. Second, it was a sample of college students recruited from university psychology courses. As a result, the sample was Western, educated, industrialised, rich, and democratic, impacting the generalisability of our results to other cultures (Henrich et al., 2010). Additionally, the diversity of our sample was restricted to that of the university recruitment pool, which prohibits conclusions to the broader population given differences between our sample and the broader US population in terms of age, race/ethnicity, socioeconomic status, and years of education. Third, stress can be classified by both valence and arousal. Although valence of the essay was evaluated based on word usage, and participant valence was assessed via self-report questionnaires, participant arousal was not assessed. Future research should examine potential specific links between arousal following writing about a stressful experience and cognitive processes. Finally, writing about stressful experiences may differentially affect visual memory and verbal memory. Given that sex differences in visual and verbal memory exist, the inability of this study to assess both should be noted as a limitation.

#### 4.1 | Conclusion

In summary, we investigated the effects of a single instances of writing about a stressful experience on memory recall in a large sample of undergraduate participants. Our results showed that writing about a stressful experience, relative to writing about a neutral one, resulted in an increase in semantic clustering of encoded information in men. Additionally, writing about a stressful experience exerted effects opposite in direction of sentiment in general, suggesting a possible unexplored benefit when writing about adverse experiences and using positive language. The next time you feel stressed about something, take some time to write about it; doing so might just help you better organise your thoughts.

#### CONFLICT OF INTEREST STATEMENT

The authors report there are no competing conflicts of interest to declare.

#### DATA AVAILABILITY STATEMENT

Syntax and date used in this study are available upon request from the authors.

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#### ENDNOTE

<sup>1</sup> Participants were asked 'What sex were you assigned at birth?', so analyses presented examining self-reported sex rather than gender.

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