Video Article

Using Practice Testing, Public Speaking, and Source Monitoring to Examine the Influences of Learning Strategies and Stress on Episodic Memory

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Abstract

Prior research demonstrated that learning information via retrieval practice, which entails studying and taking practice tests, resulted in less memory impairment under stress than learning information via repeated studying. The present experiment combined three experimental procedures to further examine the memory mechanisms underlying the efficacy of retrieval practice in the context of stress. A list-discrimination task was implemented, in which participants learned two distinct wordlists. This was combined with a retrieval-practice manipulation, as half of the participants engaged in practice testing and half engaged in conventional studying during learning. A week later, participants underwent stress induction, using the Trier Social Stress Test. Before and after stress induction, participants completed tests of item and source memory (i.e., list discrimination). The combination of these three procedures yielded informative results: retrieval practice, in the context of stress, improved item memory but not source memory relative to conventional studying. Limitations and future directions for the use of this methodology are discussed.

Video Link

The video component of this article can be found at https://www.jove.com/video/60026/

Introduction

Instances of acute psychological stress generally impair memory retrieval[1]. For instance, performing a high-pressure public-speaking task reduces the amount of information that individuals can subsequently remember[2,3,4,5,6]. This common finding is largely attributed to the neural influence of the human stress hormone cortisol. When cortisol levels are heightened after stress, cortisol binds to glucocorticoid receptors in the hippocampus[7,8], impairing recollection of previously-learned information[9].

In recent research, the detrimental effects of stress on memory retrieval were eliminated when participants studied stimuli using the highly-effective learning strategy retrieval practice[10]. Participants either learned a wordlist via repeated studying, or via studying followed by several attempts at freely recalling the words (i.e., retrieval practice). A day later, when memory was tested after stress induction, those who learned via repeated studying remembered fewer words than their non-stressed counterparts, whereas those who learned via repeated testing showed no memory impairment.

To better understand why retrieval practice so effectively buffered memory against the deleterious effects of acute stress, it is helpful to take a closer look at the memory processes being affected. The prior study simply examined item memory by having participants recall the words that they had learned[10]. In the present study, source memory was more carefully examined to determine whether retrieval practice was also supporting memory for the context in which each item was learned. This approach was informed by research showing that retrieval practice increases memory for contextual information associated with a given learning episode (e.g., when each item was learned, where each item was learned)[11].

To determine how retrieval practice interacts with acute stress to influence both item and source memory, it was necessary to combine three experimental procedures. First, a standard retrieval-practice manipulation was implemented in which participants either studied stimuli several times or engaged in studying followed by free recall. Second, a list-discrimination task was used to separately examine item and source memory. This involved having participants learn stimuli from two temporally-segregated and color-coded lists that could be differentiated on a later memory test. Third, a commonly-used method of psychological stress induction was used, in which participants must give a short speech and solve math problems while being judged[12].

Protocol

This research was conducted in accordance with current American Psychological Association (APA) professional ethical standards and was approved by the Tufts University Social, Behavioral & Educational Research Institutional Review Board.

NOTE: The experiment reported in the present manuscript was previously published elsewhere[13].

1. Participant Recruitment, Screening, and Scheduling

1. **Conduct a power analysis to determine the sample size needed to achieve the desired power and detect the expected effect size. The free software package G*Power[14] is useful for this step.**
    1. After opening G*Power, select **F tests** from the **Test Family** dropdown menu.
    2. Select **ANOVA: Repeated measures, within-between interaction** from the **Statistical test** dropdown menu.
    3. Select the **A priori** option from the **Type of power analysis** dropdown menu.
    4. Enter the predicted effect size in the **Effect size f** box.
    5. Enter the desired alpha value in the **α err prob** box.
    6. Enter the desired power value in the **Power (1-β err prob)** box.
    7. Enter 2 in the **Number of groups** box.
    8. Enter 2 in the **Number of measurements** box.
    9. Enter 0.7 in the **Corr among rep measures** box[13].
    10. Click **Calculate** on the bottom right of the window. The total sample size needed for the experiment will be displayed in the **Total sample size** box.
    11. Recruit 10-20 participants beyond the recommended sample size to account for participant error or dropout.

2. Recruit participants in the desired age range (e.g., 18-24 years old) who are native English speakers, are not color-blind, and have normal or corrected-to-normal vision. If interested in a representative sample, recruit both male and female participants.
NOTE: Women sometimes demonstrate a blunted cortisol response to psychological stress, particularly when in the follicular phase of their menstrual cycle or when taking oral contraceptives[15]. Consider measuring/controlling for female use of contraceptives and menstrual cycle phase (this was not done in the present study).
3. When scheduling, ensure that participants can attend both testing sessions, which are approximately 1 h each and occur one week apart.
4. Schedule participants in groups of two to facilitate peer evaluation during stress induction.
5. To ensure that cortisol samples are not biased by the use of stimulants, ask participants to refrain from stimulant use (e.g., caffeine, nicotine) for 6 h prior to each experimental session. To avoid contamination of saliva samples. Also ask participants to refrain from eating or drinking (besides water) for 1 h prior to each session.
6. Randomly assign participants to either learning group: study-practice or retrieval-practice.
7. Schedule all participants during roughly the same time of day (e.g., all morning testing or all evening testing) to control for diurnal variability in cortisol[16]. Schedule each participant's two experimental sessions for the same time (one week apart).

2. Construction of Stimuli and Memory Tests

1. **Encoding stimuli**
    1. In the interest of creating two dissociable learning events, create two distinct sets of materials for participants to encode.
    NOTE: This protocol involved two 60-item wordlists, one of which was labelled "The Red List" and was visually presented in red font, the other of which was labelled "The Blue List" and was visually presented in blue font. The wordlists used in the present protocol are available in **Supplementary File 1**.
    2. For the purposes of stimulus neutrality, ensure that each word meets the following criteria: (1) non-proper noun, (2) not a homograph, (3) four to eight letters long, and (4) concreteness rating of at least 4 on a scale from 1-7 (7 = most concrete). Compare the words to valence and arousal norms[17] to ensure that that they have valence ratings between 4.00 and 5.99 on a 1-9 scale (i.e., neutral valence) and arousal ratings lower than 4.00 on a 1-9 scale (i.e., not negatively arousing). Equate word frequencies across the lists by comparing them to an established word database[18].
    3. Use stimulus-presentation software to program each of the wordlists such that words are individually and randomly presented at a rate of 2 s per word.
    NOTE: This protocol used E-Prime version 2.1[19] for stimulus presentation, but common software can be used to this effect. The E-Prime scripts used for stimulus presentation in the present experiment are available in **Supplementary File 2**.

2. **Retrieval stimuli**
    1. To create plausible foil items for the recognition memory test, create a third 60-item wordlist. Adhere to the criteria outlined in step 2.1.2. The list of foil words used in the present protocol is available in **Supplementary File 1**.

3. **Memory tests**
    1. For the purposes of assessing memory performance both pre- and post-stress, create two functionally-identical memory tests. Construct two 90-item tests.
    NOTE: The present study used recognition tests, in which participants are presented with studied items and foil items and must indicate whether each item occurred on the lists they studied.
    2. Tests consist of 30 items from the red list, 30 items from the blue list, and 30 items from the foil list. Counterbalance or randomize which list items are presented on the two recognition tests. Also randomize the order in which the items are presented.

NOTE: Each item is accompanied by a list-discrimination question and an assessment of confidence. The list-discrimination question asks participants to indicate whether the item came from the red list, the blue list, or neither list. The confidence question asks participants whether they experienced high or low confidence in their list-discrimination judgment.

3. Stress-induction Protocol

1. Use the Trier Social Stress Test for Groups (TSST-G)[20] to induce mild, acute psychological stress.
   NOTE: The present protocol adapted the TSST-G to test participants in groups of two instead of four. Psychosocial stress induction of this nature, which involves giving a speech and solving math problems while being evaluated, is preferable to other methods of stress induction because of its ecological validity and ability to elicit a physiological stress response[21,22].
2. **To induce stress, do the following in this order:**
   1. Speech preparation
      1. Have participants sit at separate desks. Give both participants a sheet of blank paper and a pen or pencil. Read them the following instructions:
         "You will now have two minutes to prepare a speech in which you are applying for a job as a Teaching Assistant in any course of your choice. Please be prepared to discuss what skills and experiences you have that make you a qualified candidate for the job"*
         NOTE: *If working with non-student populations, change "Teaching Assistant" to a population-relevant position.
      2. Use a stopwatch or clock to time the 2 min period. Set up a video camera on a tripod while participants are preparing their speeches. Take participants' notes away when two minutes have passed.

   2. Speech delivery
      1. Read participants the following instructions:
         "*You have each been assigned a number on your desk. I will now call on you by number to stand and give your speech. When I call on you, please stand in the center of the room where you can be seen by the camera. You will be video recorded for the purpose of coding your non-verbal behavior at a later time."*
      2. Call on participants one at a time to stand up and deliver their speeches. Use a stopwatch or clock to ensure that each speech lasts for 2 min. If a participant finishes the speech early, tell them that they still have time left and they must continue.

   3. Oral subtraction
      1. Read participants the following instructions:
         "I will now call on you at random to solve simple math subtraction problems. When I call on you, please stand and solve the problem aloud. If you get the problem wrong, I will ask you to try again until you get it correct. As a reminder, you will be videotaped during this part of the experiment. Person X, please stand and subtract..."
         NOTE: Math problems involve subtracting a number in the teens (e.g., 13, 14, 15) from a 4-digit number (e.g., 4,563).
      2. Call on participants randomly and unpredictably (e.g., sometimes 2-3 times in a row) to solve math problems for 6 min. That is, participants solve math problems multiple times each for a period of 6 min. When participants give an incorrect answer, tell them they are incorrect and ask them to try again. Repeat the question if necessary.

4. Saliva Sample Collection and Supplies

NOTE: Saliva collection is only necessary during experimental session 2, in which stress is induced

1. Ensure that participants have adhered to the instructions outlined in step 1.5. If any of these criteria have been violated, make note of this and examine the participant's data as a potential outlier before conducting any statistical analyses.
2. When participants first arrive for this session, have them rinse their mouth with water to clear it of any sample contaminants.
3. **For the collection of saliva samples, use the passive drool method in which participants pass saliva through a straw into a collection tube. For sample collection, use smoothie-sized straws, cut into 2 inch pieces, and 2 mL cryovials. Ensure that all cryovials are labelled with necessary identifying information (e.g., participant number, sample number, date).**
   1. For each sample, have the participant place the 2 inch straw in the cryovial and drool into the straw until they have provided 2 mL of saliva. When they have finished providing a sample, have them discard the straw in a wastebasket and screw the cap on the cryovial. Offer participants gloves and sanitizing wipes before they provide each saliva sample.

4. Collect three saliva samples: (1) a baseline sample after participants arrive for session 2, (2) a sample immediately after stress induction is complete (~12 min after the onset of stress), and (3) a sample 25-30 min after the onset of stress induction, when cortisol reaches its peak post-stress levels in saliva[12].
5. Store the saliva samples in a freezer (0 °F) until analyzed.

5. Subjective Stress Measure

1. Choose a measurement of self-reported state anxiety/stress to administer at various times during the experiment.
   NOTE: The present protocol used the State-Trait Inventory for Cognitive and Somatic Anxiety (STICSA)[23]. The STICSA is a state measure of the cognitive and somatic sensations associated with anxiety. Statements are rated on a four-point Likert-type scale, and responses are added for a total score that ranges from 0-80 (higher scores are indicative of greater anxiety).
2. Before administering each iteration of the STICSA, inform participants that it is a measure of anxiety and they should respond based on how they are feeling in the moment.

6. Encoding Procedure (Experimental Session 1)

1. Instruct participants to read the informed consent form and, if they choose to participate, sign and return it to the experimenter.
2. Instruct participants that that they will be presented with a series of words that they must try to remember for a later test.
3. Present participants with either the Red List or the Blue List using the stimulus-presentation software and rate of presentation outlined in section 2.1.
4. **The next step depends on group assignment.**
    1. For participants in the study-practice group, present the same list two more times at the same rate of presentation. To clear working memory between each study event, have participants complete simple math problems for 30 s (e.g., 12 x 4). Either have participants complete this task with pencil and paper or embed the task into the computer program used for stimulus presentation.
    NOTE: The scripts included in **Supplementary File 2** have all encoding tasks embedded within them.
    2. For participants in the retrieval-practice group, give them two time-matched (i.e., 2 min) free-recall tests. Prior to the two tests, instruct participants that they should recall as many words as possible from the preceding list, in any order. During free recall, either have participants type their responses using the stimulus-presentation software program or have them write their responses on a sheet of paper. To clear working memory, have participants complete simple math problems between initial presentation of the wordlist and the first test, as well as between the two free-recall tests (see step 6.4.1).
5. Present participants with a 30 min clip from an emotionally-neutral movie or television show.
NOTE: The present protocol used the BBC television series *Planet Earth*. This 30 min delay helps establish a temporal distinction between learning the Red List and learning the Blue List.
6. Repeat steps 6.3 and 6.4 for the list that was not presented prior to the 30 min break.
NOTE: Steps 6.3 through 6.6 are depicted in **Figure 1**.
7. Have participants complete a first iteration of the STICSA to determine whether study practice and retrieval practice differentially influenced anxiety levels.

7. Retrieval Procedure (Experimental Session 2)

1. Follow steps 1.5 and 4.2 to ensure proper saliva sample collection.
2. Instruct participants to fill out a second STICSA as a pre-stress measure of subjective anxiety.
3. Instruct participants to provide the first saliva sample.
4. Administer one of the two tests constructed in section 2.3.
NOTE: The tests are depicted in **Figure 2**.
5. Complete the stress-induction procedure as specified in section 3.2.
6. Instruct participants to complete the third STICSA as a post-stress measure of subjective anxiety.
7. Instruct participants to provide the second saliva sample.
8. Give participants a 10 min break. In the present protocol, participants watched part of an episode of *The Office* during this break.
9. Instruct participants to provide the third saliva sample.
10. Administer the second test constructed in section 2.3 (depicted in **Figure 2**).
11. Debrief participants about the purpose of the experiment and excuse them.

8. Computing Dependent Measures

1. **After the conclusion of data collection, compute the dependent measures as follows:**
    1. Calculate hit proportions. For each participant, divide the number of studied items that participants correctly recognized by the total number of studied items that were presented on the recognition test.
    2. Calculate false-alarm proportions. For each participant, divide the number of non-presented foil words that participants falsely recognized by the total number of foils that were presented on the recognition test.
    3. Calculate source-memory scores. For each participant, divide the total number of hits that participants attributed to the correct source by their total number of hits.
    4. For average confidence, code the high- and low-confidence judgments as binary, with 1 representing high confidence and 0 representing low confidence. For each participant, calculate their proportion of high-confidence judgments.
    5. Calculate gamma correlations. For each participant, correlate their accuracy on each list-discrimination question with each accompanying confidence rating.
    6. Calculate delta cortisol. For each participant, subtract their baseline cortisol concentration from the cortisol concentration of the sample taken 25 min post-stress.

Representative Results

Efficacy of the retrieval-practice manipulation

Note that the following analyses were previously published by Smith et al.[13]. During encoding in experimental session 1, free recall of the words from each wordlist was relatively low for individuals in the retrieval-practice group. These individuals recalled, on average, 14 of 60 items and 13 of 60 items during their recall attempts for the first list. They recalled, on average, 16 of 60 items and 15 of 60 items during their recall attempts for the second list.

Of note is the fact that retrieval practice is only beneficial as a learning technique if the retrieval-practice attempts that one makes are successful. That is, an individual must successfully retrieve the studied information during their retrieval-practice attempts to experience any subsequent memory benefits. For example, an individual who recalls only 5 of 60 items during their retrieval-practice attempts would not show exceptional memory performance on a later test, while an individual who recalls 55 of the items likely would. Therefore, hit proportions on the final recognition tests for individuals in the retrieval-practice group were restricted to items that they accurately recalled at least once during session 1, in order to meaningfully examine the benefits of retrieval practice.

Using this restriction, the retrieval-practice group demonstrated higher hit proportions on the session 2 recognition tests than those in the study-practice group, as expected [$F(1, 60) = 80.34$, $p < 0.001$, $\eta_p^2 = 0.57$]. Individuals in the retrieval-practice group demonstrated average hit rates of 0.91 (standard error of the mean [*SEM*] = 0.02) and 0.91 (*SEM* = 0.01) on the pre- and post-stress tests (respectively), whereas those in the SP group had average hit proportions of 0.66 (*SEM* = 0.02) and 0.66 (*SEM* = 0.03).

Efficacy of the list-discrimination task

To determine whether performance on the list-discrimination task was due to participants' ability to discriminate between items learned on the two lists or was simply due to guessing, source memory scores were compared to chance levels of performance (i.e., 50% accuracy). Participants in the study-practice group exhibited above-chance levels of discrimination on both the pre- and post-stress recognition tests [pre-stress test: $t(29) = 3.14$, $p = 0.004$; post-stress test: $t(29) = 2.78$, $p = 0.009$][13]. However, those in the retrieval-practice group demonstrated chance levels of performance on both tests [pre-stress test: $t(31) = 0.76$, $p = 0.452$; post-stress test: $t(31) = 1.50$, $p = 0.144$][13]. Note that participants had accurately recalled these items at least once during their session-1 free-recall attempts, but still demonstrated chance levels of performance.

Efficacy of the stress-induction procedure

As shown in **Figure 3**, the modified version of the TSST-G used in the present protocol effectively induced both psychological stress and physiological stress. Participants demonstrated post-stress increases in STICSA scores [$F(1, 60) = 25.93$, $p < 0.001$, $\eta_p^2 = 0.30$] and cortisol levels [$F(2, 116) = 3.75$, $p = 0.026$, $\eta_p^2 = 0.06$]. Across the three measures of cortisol, participants demonstrated marked increases from baseline to 25 min post-stress [$t(59) = 1.97$, $p = 0.027$, Cohen's d = 0.25] and from 12 min post-stress to 25 min post-stress [$t(59) = 2.16$, $p = 0.018$, Cohen's d = 0.28]. Cortisol levels did not significantly increase from baseline to 12 min post-stress [$t(59) = 1.24$, $p = 0.110$].

Putting it all together: the influence of stress and retrieval practice on item and source memory

Across the measures of item memory, the combination of stress and retrieval practice generally produced the best performance on the session-2 recognition tests. The retrieval-practice group demonstrated a positive relationship between delta cortisol and hit proportions [$r(31) = 0.41$, $p = 0.023$], whereas the study-practice group did not [$r(27) = -0.17$, $p = 0.384$]. As depicted in Figure 4, the retrieval-practice group also demonstrated the lowest false-alarm proportions, but only on the post-stress test [$F(1, 60) = 4.10$, $p = 0.047$, $\eta_p^2 = 0.06$]. Last, whereas gamma correlations were generally at chance levels for list-discrimination, the post-stress gamma value for the retrieval-practice group was the only value to exceed chance-level performance [$t(31) = 3.03$, $p = 0.005$, $d = 0.54$]. This reflects participants' awareness of which items they correctly and incorrectly assigned to red and blue lists.

In contrast, source memory was unaffected by stress and, as noted above, individuals in the retrieval-practice group demonstrated chance-level performance (**Figure 4**). Despite correctly remembering 91% of the items that they correctly recalled during free-recall in session 1, individuals in the retrieval-practice group could not accurately remember whether these items came from the red or the blue list.

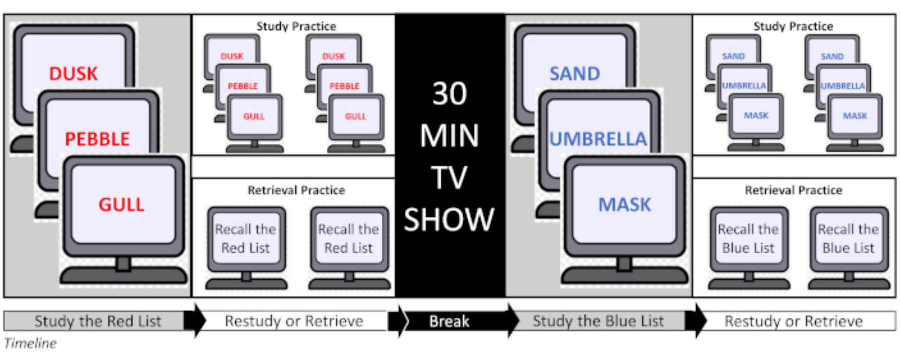

Figure 1: Graphic simulation of the encoding procedure during session 1. The stimuli depicted are representative of the two 60-item lists of stimuli. Please click here to view a larger version of this figure.

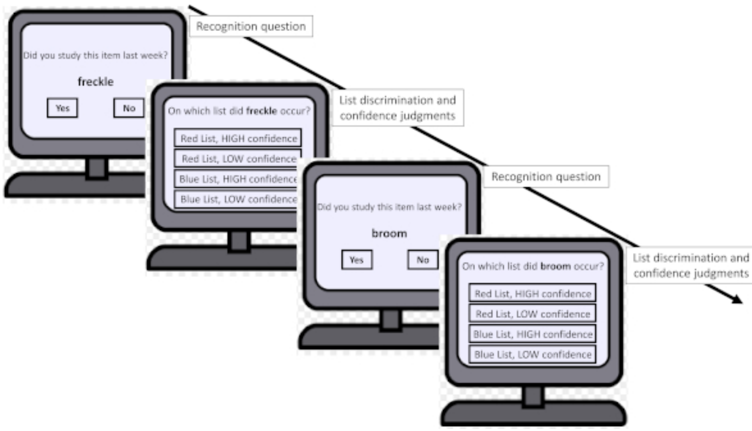

Figure 2: Graphic simulation of the recognition test and accompanying list-discrimination questions and confidence judgments. Each recognition question is presented individually, followed by a prompt to indicate which list the item came from and how confident the participant is in that judgment. Ninety items are presented in this manner on each recognition test (see section 2.3). Please click here to view a larger version of this figure.

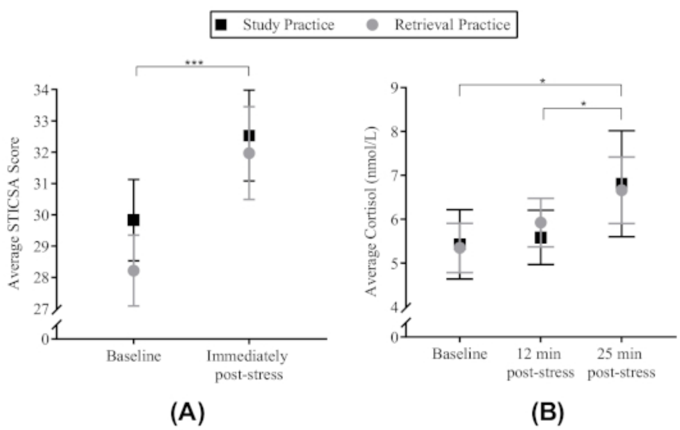

Figure 3: Evidence of the efficacy of the TSST stress-induction procedure. Stress increased subjective anxiety, as measured by the STICSA (**A**), and also increased salivary cortisol levels relative to baseline (**B**). Error bars represent *SEM*. $^{*}p < 0.05$, $^{***}p < 0.001$. This figure has been modified from Smith et al.[13]. Please click here to view a larger version of this figure.

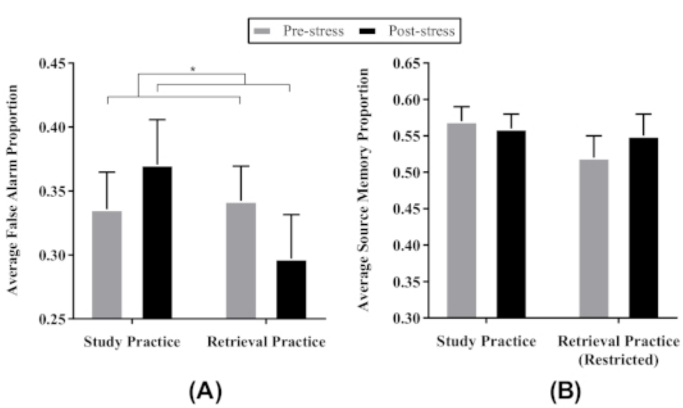

Figure 4: Evidence that the combination of stress and retrieval practice improved item memory (A) but not source memory (B). Error bars represent *SEM*. $^{*}p < 0.05$. This figure has been modified from Smith et al.[13]. Please click here to view a larger version of this figure.

Discussion

Episodic memories are associated with contextual information. To gain a deeper understanding of how psychological stress and different learning strategies influence episodic memory, it is important to consider how these variables influence the contextual elements of memory. The context associated with a memory (e.g., where the memory was acquired, when it was acquired) could be examined in infinitely-many ways. The present protocol took a step forward in examining memory for context with the use of a list-discrimination task, which assesses the source of a given memory. The novel combination of a list-discrimination task with stress induction and a retrieval-practice encoding manipulation allowed for a test of the memory mechanisms underlying the efficacy of retrieval practice for buffering memory against acute stress[10].

Future researchers may consider modifying the retrieval-practice manipulation employed in the present protocol. As stated in the Results, participants in the retrieval-practice group only recalled about 25% of wordlist items during their free-recall attempts in session 1. This low level of performance is not optimal either experimentally or practically, although the hit-proportion restriction used in the present protocol did allow for meaningful examination of the efficacy of retrieval practice. For consistency with previous literature[10], the present protocol required that the retrieval-practice group simply study each wordlist once and then make free-recall attempts without subsequent feedback or re-exposure to the stimuli. However, research suggests that retrieval practice results in more robust learning when participants are given feedback about their performance during the retrieval-practice attempts[24] and when participants are re-exposed to the stimuli between each retrieval-practice attempt[25]. Thus, a more effective retrieval-practice manipulation may involve multiple cycles of studying, free-recall testing, and feedback regarding correctness.

The list-discrimination procedure employed in the present experiment was only somewhat effective, given that some participants demonstrated chance-level performance. This task was borrowed from previous research, in which source memory was tested within minutes of the wordlist encoding procedure[26,27]. The one-week delay between encoding and memory testing that was implemented in the present protocol may have contributed to the observed chance-level list-discrimination performance. Thus, to improve list-discrimination performance so that any effects of stress and retrieval practice may become more apparent, future researchers may consider shortening the retention interval between encoding and testing. However, the one-week interval used in the present protocol may be desirable because it mimics more realistic circumstances (e.g., learning information today and recalling it a week from now). To maintain this delay but improve participants' ability to discriminate between items learned from the two wordlists, researchers may consider making the two encoding episodes (i.e., learning the two wordlists) more distinct. As examples, encoding of the two wordlists could be separated by a longer interval of time or the wordlists could be encoded in different physical locations.

In addition to the limitations of the retrieval-practice and list-discrimination protocols, the stress-induction procedure used in the present experiment demonstrated limited efficacy. Participants showed only a moderate increase in cortisol across the three measurements. Because this exact method of stress-induction has successfully induced stronger stress responses in previous experiments[28,29], the present results are likely due to sample differences rather than an ineffective paradigm. Women, particularly those taking oral contraceptives, often demonstrate a blunted cortisol response to acute stressors[15]. The present study recruited a largely-female sample (73% female), which may have contributed to lower post-stress cortisol at the group level. There are several options for controlling for this issue. Future researchers may choose to recruit a male-only sample[30], include sex as an independent variable in statistical analyses[4], or include contraceptive use and menstrual-cycle phase as variables in analyses on cortisol[1]. However, these options require additional considerations. The first limits the generalizability of findings, and the second and third require larger sample sizes to account for the addition of variables to the statistical model.

Some additional methodological changes should be considered. First, to better map the post-stress increase in cortisol and subsequent recovery period, researchers should collect more saliva samples. For example, some researchers opt to collect samples every 5-10 min after the onset of stress for up to one hour after stress induction[31]. Second, researchers may consider manipulating stress between-subjects. In the present repeated-measures design, issues such as participant fatigue could confound the effects of stress that were observed. A between-subjects design with a non-stressed control group would eradicate these potential issues. Additionally, the act of retrieving items on the pre-stress test may have imparted retrieval-practice benefits on the post-stress test, effectively reducing the benefits of the retrieval-practice encoding manipulation. A between-subjects manipulation of stress, featuring only one memory test (post-stress), would eliminate this potential issue. Third, researchers should consider the emotional impact of the distractor task implemented between stress induction and memory testing during session 2. Having participants watch a sitcom (i.e., *The Office*) may induce a positive mood. Including a post-sitcom measure of participants' mood states would provide a more precise understanding of how mood and physiological stress influence subsequent memory performance. As a final note, an additional baseline measure of state anxiety should be added to the beginning of session 1 in the present protocol. To examine if study practice and retrieval practice differentially impact anxiety levels during session-1 encoding, this initial measure is necessary for comparison to the measure that is taken at the end of session 1.

The present protocol employed a novel combination of three experimental procedures — a retrieval-practice manipulation, a list-discrimination task, and the TSST stress-induction technique — to examine one potential memory mechanism underlying the effectiveness of retrieval practice at creating stress-resistant memories. The results of this methodology showed that, in the context of stress, retrieval practice improved memory for the items that were learned but did not improve memory for the source of the items. These findings speak to the efficacy of combining these procedures to investigate questions related to retrieval practice, the contextual elements of episodic memory, and/or acute psychological stress. Future research examining questions related to one or more of these topics should consider using these techniques, but with attention given to the modifications outlined above.

Disclosures

The authors have nothing to disclose.

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