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Study of Influence of Varies Stress Sources on Our Performances in Different Memory Tasks

Qingye Yuan[1,a,*]

[1]*Department of Math, University of California San Diego (UCSD), 92093, San Diego, United States*
a. memory_717@126.com
**corresponding author*

Abstract: We focused on the influence of stress on daily tasks like story detail remembering and word remembering based on two types of stress sources: 1. Under stressful music, 2. Experiencing a disappearance of the materials. We separate participants into three groups: 1. control group with no stress, 2. stress group-1 with stressful music, 3. stress group-2 with both stressor present. The results show there is no significant difference under different stress levels for story-remembering tasks, while in word-remembering tasks, our participants' performance dropped a lot when all stress sources were put on our participants.

Keywords: stress, story remembering, word remembering, semantic memory

1. Introduction

1.1. Why Is It Important?

Everyone experiences stress and memory interaction in everyday life, like preparing for exam, finishing task under limited resource, Recall name or face in social circumstance. Knowing the relationship between stress and learning result could help us make use of the stress if it is helpful and try to avoid it when it is harmful.

1.2. Background

The definition of the stress: the physiological or psychological response to internal or external stressors. Stress involves changes affecting nearly every system of the body, influencing how people feel and behave.

The definition of memory: the ability to retain information or a representation of past experience, based on the mental processes of learning or encoding, retention across some interval of time, and retrieval or reactivation of the memory.

When classifying long-term memories, we end up with two major groups. One is Declarative or Explicit Memory and the other is Non-Declarative or Implicit Memory.

Declarative memory is further subdivided into Semantic Memory and Episodic Memory [1]. In our article, we focus on semantic memory.

The effects of stress on memory include interference with a person's capacity to encode memory and the ability to retrieve information. The review article of Shields, Sazma, McCullough, & Yonelinas has explored the effects of stress on encoding, post-encoding, retrieval, or post-

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reactivation phases of episodic memory [2]. It indicated that when stress occurred prior to or during encoding it impaired memory, unless both the delay between the stressor and encoding was very short and the study materials were directly related to the stressor, in which case stress improved encoding. According to Schwabe and Wolf 's work we anticipate learning under stress reduces both recall and recognition performance [3]. Our research focused on making our participants get involved with stress in the encoding period, but we focused on semantic memory.

The Article of Shields et al. also mentioned effects were larger for emotionally valenced materials than neutral materials [2]. In our experiment, we used neutral materials.

Stress can be intrinsic or extrinsic. Intrinsic stress level is triggered by a cognitive challenge whereas extrinsic can be triggered by a condition not related to a cognitive task. In the article of Sandi and Pinelo-Nava, they conclude that no matter intrinsic or extrinsic, the stress is deleterious for spatial/explicit information processing [4]. Our stress sources are both extrinsic.

Stress can be acute or chronic. Some articles focused on acute stress' influence on learning. The meta-analysis of shields et al. indicated that acute stress can critically impact memory. It also raises basic questions on how acute stress impacts different phases of memory [2]. And Henckens et al. studied the effects of acute stress at memory formation [5]. In our research, we focused on the acute stress rather than chronic stress.

It is widely accepted that music could produce or relieve stress, there are many researches focus on how music could cope with stress: Labbé, Schmidt, Babin, and Pharr and Ferrer et al. [6, 7]. However, few researched have been done using stressful music as a stressor.

For how and why the stress influences our memory, there are many researches focused on it in Physiological level. Wolf's research indicates the neuronal correlate of the cortisol induced retrieval blockade and the reduced activity of the hippocampus, while regarding the effects on retrieval, cortisol enhances memory consolidation [8]. while in this article, Henckens et al. using an integrated experimental approach, studied the brain correlates between acute stress and memory formation at the system scale [5].

We have to admit the diversity of effects (including facilitating, impairing, and lack of effects) described for the impact of stress on memory function according to single classification criterion. However, they have proved insufficient to explain the whole complexity of effects [4].

1.3. Goal

1. To find out the influence of different stress sources in the learning stage of memory in different types of tasks.
2. To find out if the stress influence pattern is similar among different tasks.

1.4. Hypothesis

1. We hypothesis that with more stress sources added (higher press level), people's memory performance tends to decrease in all types of tasks.
2. We hypothesis for different task, the stress influence pattern will be different (how much performance changes are task related).

2. Method

2.1. Preparation

Design the method; since I like listening to music, I knew it could be a stress source, and I was enlightened in life that simulation of internet disconnection may work as a stress source. This leads to the creation of another stress source: disappearance of material for 10 seconds.

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Do a pre-experiment on participants to make sure the time duration of the task, the numbers and the difficulty of the questions are proper.

2.2. Recruit

The participants come from classmates, co-workers and street recruitment. We Recruit the first 26 people during the first recruitment period for the first two groups and 14 people in the next recruitment period for the third group. We asked them to do one survey and one questionnaire. The survey is about demographics like gender, degree, age, and self-memory ability evaluation... and the questionnaire helps us evaluate their current life pressure and depression level. All the participants were from China, between 17 and 36years old. All participants finished our experiment.

2.3. Grouping

Group 1(Control):13 participants do both memory tasks with peaceful background music

Group 2(Treatment 1):13 participants do both memory tasks with stressful background music.

Group 3(Treatment 2):14 participants do both memory tasks with stressful background music and experiencing a 10 seconds' material disappearance at the beginning (The material's disappearance, even 10 seconds, will give 13/14 participants additional pressure according to after the test survey.).

It is a single-blind experiment: participants in one group don't know the existence of other groups. It is a between subject design, each participant only does two tasks under one stress condition, The groups were stratified randomly sampled on gender, academic degree, and self-evaluated learning/remembering ability.

2.4. Task Description

task1. Participants will read a self-made 2 paragraphs story with many details. Given 2 minutes, they are asked to remember as many details as possible. After 2 minutes, everyone in each group will do a 30 seconds self-heart rate counting, not only to record their heart rate, but to stop the memory rehearsing.

After the heart rate counting, they will answer the test regarding the details like what is the color of the cat on the wall and how many guests in the house, etc. For all the questions, they must fill in the blanks with no choices. It tests recalling, not recognizing. Each detail is worth one point and the full score is 21.

task1 story material. The original material is written in Chinese, here is the translated version:

David came into a black house, the house had 4 rooms and there were 6 females dressed in blue and 8 males dressed in brown, they were in the living room. The hero used his Samsung phone to record the scenes, He saw 4 math books and 6 history books on the white triangle table, he saw a picture on the wall, with 5 yellow cats, 3 green dogs and 11 black goats. There are some hexagon photos of the president and guitarist on the wall.

Susan came to invite him into the party and let him pick a drink: he picked the coconut water. Susan played the third song in the playlist which has 12 songs in total.

Susan said there were still five guests to come. Susan wanted him to call two of the guest working in designing institute. She was determined to contact another two professors herself, one is an Ancient Greek literature professor and another is an Automotive engineering professor. One came from New Zealand and one came from India. The last guest is Jensen from Ukraine, he is a semiconductor engineer. He couldn't come due to the war. The party would formally start after 18 minutes.

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task2. Participants will read 20 words with no logical relation to each other like: mountain, soldier, chicken, hat. . ., they are given 40 seconds. When time is used up, they are told to do a 30 seconds self-heart rate counting, not only to record their heart rate, but to stop the memory rehearsing as well.

After the counting, they will answer the test to recall as many word as they could. Each word worth 1 point and the full score is 20.

task2 word material. Original material is written in Chinese. Here is the translated version:

yellow-river arithmetic bread hat movie farmer scissors conscience mountain tape tree sun mop bill train soldier park petroleum chicken gong-and-drum

2.5. Online Work Flow

- Count and record their heart beat for 30 seconds.
- Read the story and try to remember details for 2 minutes with different stress levels (peaceful music, stressful music, stressful music and disappearance of material for 10 seconds) in different groups.
- Count and record their heart beat for 30 seconds.
- Finishing the story detail recalling tests and give a stress evaluation score for this section. (No time limit and stress here)
- Read the 20 words they need to remember for 40 seconds with different stress levels (peaceful music, stressful music, stressful music and disappearance of material for 10 seconds) in different groups.
- Count heart beat for 30 seconds.
- Finishing the word recalling tests and give a stress evaluation score for this section. (No time limit and stress here)
- Report if disappearance of material gave them stress.

3. Results

Like showed in Figure 1, In the story detail remembering task, the Control group (participants do the memory task under peaceful music) has mean 13 and SD is 5.70. While the Stress group 1 (participants do the memory task under stressful music) has a higher mean value 15.1, and the SD is 2.43. The last group (participants do the memory task under stressful music and experiencing the disappearance of the material for 10 seconds) has the lowest mean value 11 and SD is 5.38.

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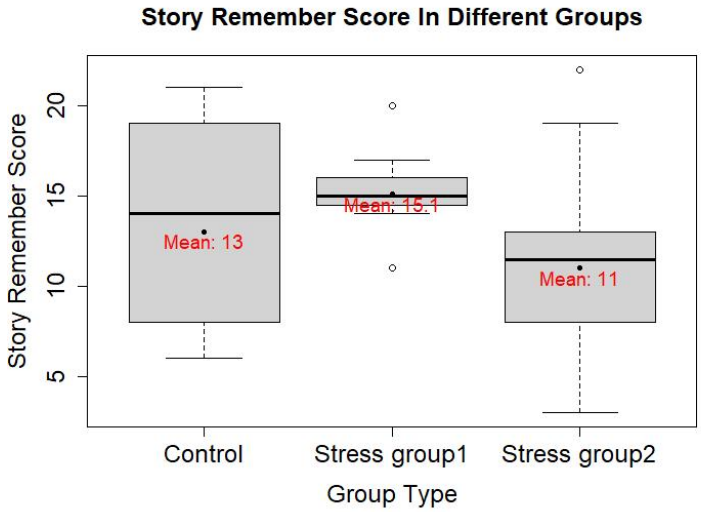

Figure 1: Story detail remember score under different pressure level.

The pattern of the word remembering task is similar, which is shown in Figure 2, the Control group (participants do the memory task under peaceful music) has mean value 10.9 and SD is 3.99. While the Stress group 1 (participants do the memory task under stressful music) has a higher mean value 11.3 and the SD is 5.10. The last group (participants do the memory task under stressful music and experiencing the disappearance of the material for 10 seconds) has the lowest mean value 6.7 and SD is 4.25.

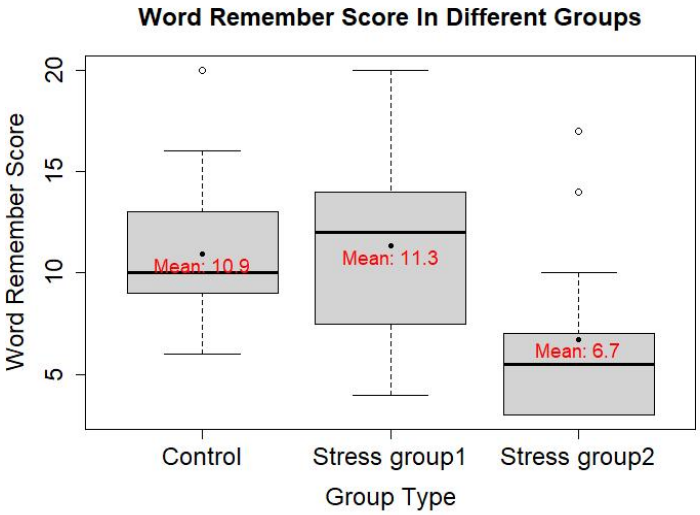

Figure 2: Word remember score under different pressure level.

Using Shapiro-Wilk Normality Test for the story detail remembering task, the p-value is .5042, and for the word remembering task, the p-value is .06. We can't reject normal distribution hypothesis for any tasks.

So we could use ANOVA to test whether stress level affected the participants' remembering performances in both tasks. The performances are represented by their answering scores.

In the story detail remembering task, stress has no significant effect, $F(2,36) = 2.336$, $p = .11$, as shown in Table 1. Compute Tukey Honest Significant Differences between each group pair for

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story detail remembering task, we see the Stress group1-Control pair's p-value is .53, Stress group2-Control pair's p value is .53, while for the Stress group2-Stress group1 pair, p-value is .09, as shown in Table 3. In words remembering task, the stress has significant effect, $F(2,36) = 4.428$, $p = .019$, as shown in Table 2. Compute Tukey Honest Significant Differences between each group pair for word remembering task, we see that for the Stress group1 - Control pair, p-value is .97, for Stress group2 - Control pair p-value is .049, while for the Stress group2 - Stress group1pair p-value is .032, as shown in Table 4.

13 out of 14 people in the third group reported that they felt additional stress as a result of the disappearance of the learning material.

Table 1: ANOVA test table of story detail remembering task.

	Df	sum of sq	mean of sq	F	Significance
groups	2	107.9	53.93	2.336	0.111
residuals	36	830.9	23.08		

Table 2: ANOVA test table of word remembering task.

	Df	sum of sq	mean of sq	F	Significance
groups	2	175.2	87.62	4.428	0.191
residuals	36	712.4	19.79		

Table 3: Using tukey method to test family-wise probability of coverage in story detail remembering task.

	diff	lwr	upr	p adj
Stress group1 - Control	2.083	-2.618	6.784	0.530
Stress group2 - Control	-2.000	-6.523	2.523	0.532
Stress group2 – Stress group1	-4.083	-8.703	0.536	0.092

Table 4: Using tukey method to test family-wise probability of coverage in word remembering task.

	diff	lwr	upr	p adj
Stress group1 - Control	0.410	-3.943	4.763	0.971
Stress group2 - Control	-4.209	-8.397	-0.206	0.048
Stress group2 – Stress group1	-4.619	-8.897	-0.341	0.032

This experiment has a confounding variable need to mention, all the groups have similar gender distribution, similar academic degree distribution, and similar self-memory evaluation, all participants were not smoking and drinking alcohol for a long time. But there is a difference in the age of the different groups. The means of the first two groups are 22 while the mean age of the last group is 30, as shown in Figure 3.

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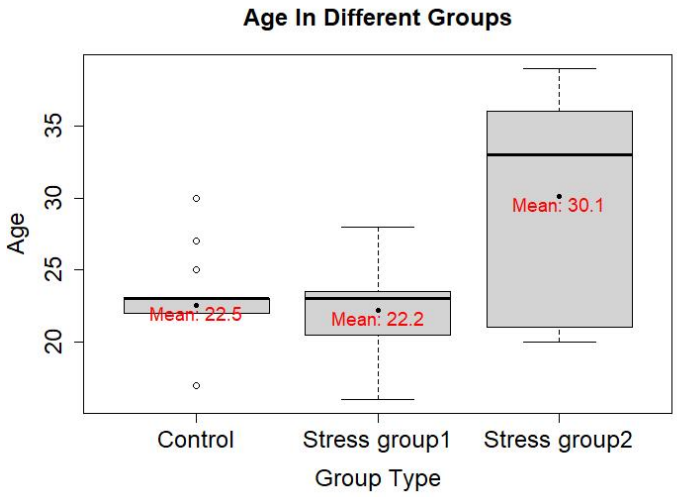

Figure 3: Age for different groups.

4. Conclusion

The answer to our first hypothesis is: it depends, in the story detail memory task, the stress seems not increase or decrease our participants' performance a lot. While in the word memory task, the stress did make a difference, especially in the last group.

The answer of our second hypothesis is: there is a difference between different tasks when exert same level of stress. This pattern difference may have some thought provoking reason: our memory may have different working structure and process in different tasks thus has different result under the same stress pattern.

There is also some other point worth mentioning: the stressful music as a pressure source seems improve the performance of participants in story detail memory tasks and word memory tasks slightly, however, not significantly.

The disappearance of the slides, similar to the internet disconnection in our daily life, combined with stressful background music, made participant's word memory performance drop significantly. But the story detail memory task, in which people could think in more logical manner and could form a vivid mind picture, did not dropped significantly under combined stress. Maybe new connections are harder to build for the logically unrelated words in the word memory task under stress.

The upside-down U-shaped pattern reminds us of Yerkes-Dodson Law: the performance is worst at extremely low or extremely high levels of arousal. So here comes the possible explanation: the performance increase may due to a proper arousal, and the decrease may due to attention distraction as a result of accumulated pressure.

This inverted-U-shape pattern is also fully discussed and reviewed by Salehi, Cordero, and Sandi [9]. The hypothesized mechanisms supporting the inverted-U-shape curve are comprehensively discussed in the review of Baldi and Bucherelli. They indicate emotional arousal level play roles in the modulation of memory process, reviews the relationship between stress, emotional arousal, peripheral epinephrine levels, cerebral norepinephrine levels and memory consolidation [10].

As for the physiological reasons, Sandi and Pinelo-Nava provide a brief review of the main neurobiological mechanisms proposed to make explanation for the different effects of stress in memory function [4]. Glucocorticoids were found as a common mediating mechanism for both the facilitating and impairing influences of stress in different memory processes and phases. Among the brain regions implicated, the hippocampus, amygdala, and prefrontal cortex were highlighted as

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critical for the mediation of stress effects. According to research of Schilling et al., there is a U-shaped dose-response relationship between salivary cortisol levels and recall performance [11]. Performance is the worst with either very high or very low cortisol levels. And as stated by Cools and D'Esposito, brain dopamine plays key role in cognitive function, and there exists of an optimum DA level for cognitive function as well [12].

Theoretical or methodological contribution: we used the disappearance of the material as a stress source, which is an innovative procedure in the stress-learning study; we also did two tasks to test semantic memory under stress so we can make comparison. These studies provide us with a broader perspective.

The article of Sandi and Pinelo-Nava mentioned five selected classifying factors (source of stress, stressor duration, stressor intensity, stressor timing with regard to memory phase, and learning type) [4]. In our experiment, we considered 4 out of 5 factors: the source of stress is stressful music or material disappearance, stressor duration is the same as learning time, it is timed to cover the whole encoding memory phase and the learning type is story detail learning and word remembering.

4.1. Limitations

1. Group three's mean age is older than group 1 and group 2(30 versus 23), and age could be a confound variable in this experiment.
2. The change of heart rate, which was supposed to be an indicator of stress, didn't change a lot during the whole test. Since test is online, we can't measure blood pressure or the respiratory rate. If we have devices and labs, we can monitor more physical signs in the whole process.
3. It is an online experiment; we can't make sure everyone not use notes to answer the tests and we can't check that everyone's music is playing at the same volume and that everyone tries their best in task.
4. Although everyone in the same group in the same stress source conditions, but as a result of difference of pressure resistance ability, they may not felt the same stress.
5. The participants are adults between 17 and 36, so whether these conclusions can be generalized to younger children or seniors is still uncertain.
6. We only make stressor show up in the learning stage, the effect of stress on other stages of memory like recalling stage is not tested.
7. There is no follow up testing, say, after 3 days we ask them to do another recalling test, how well they remembered the details or words in longer term is unknown.
8. The sample size is not big, not so representative of the population. Which can compromise the conclusions drawn from the studies.
9. All participants are from China and use Chinese as their learning language, may be not cultural representative.
10. Many other types of memory is not tested, e.g. learning new languages, memorizing unknown symbol or acquiring skills, etc.

4.2. Future Directions

1. We could add more older people in first two groups and/or add more younger people in the last group to eliminate the confound effect due to age.
2. There is sign that slight pressure may increase our memory performance, while not significant in this experiment, we could design a more delicate experiment to test it.
3. Could do the experiment on older adults and children, and see whether the conclusion could be generalized.

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4. The experiment is focused on story detail learning and non-logical related word learning, we can test the memory performance under stress for new language or meaningless symbol or other semantic memory tasks. We can also test with the peoples' episodic memory under stress, we can even do experiments on learning new skills to test procedure memory under stress.
5. We could do some further experiment regarding the relationship between stress and memory in the recalling phase.
6. We can ask our participants using some Mnemonic method under stress, see if using it could overcome the obstacle drew out by the pressure.
7. Check whether mindfulness can help with our memory under different stress condition.
8. The stress source could be some other sources like group competition, resource limitation and other forces push us to adapt to our environment or our future goal, so quite a lot circumstances to test.
9. Different vital signs can be monitored during the process and give us a more quantitative evaluation between stress effect and our learning performance.

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