The Relationship between Pain Sensitivity and Memory Accuracy

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ABSTRACT
Based on Body Specificity Hypothesis and Reuter et al.'s research on differences in pain sensitivity, the proposed study will address the correlation between pain sensitivity and memory accuracy. Participants will self-assess their pain sensitivity, BVMT-R will be used to test the memory accuracy and the results will be compared and analyzed using ANOVA. Since there has not been any empirical evidence about how pain can affect the functioning of brain, the experiment mentioned in this paper is to test whether the distinction in memory accuracy is related to differences in pain sensitivity.

***Keywords*：** *Bodily-relativity, Emotion, Pain sensitivity, Memory retrieval, ANOVA, BVMT-R*

1.INTRODUCTION

Emotion is extremely connected to our daily life but can also be critical in academic settings, as it can regulate many aspects of cognition. For example, a test or examination can be strongly associated with a sense of anxiety which can affect one's learning and memory. A lot of researchers devote most of their time exploring everything that could be influenced by emotion.

The result of a series of study implied that emotion can play an essential role at different stages of memorizing information, consolidating memories and the evoking of experiences later. Neuropsychologist Donald G MacKay and a group of researchers asked participants to involve in an emotional Stroop test. In the test, different words were presented in quick sequence and were printed in different colors. In one condition, several words were location consistent (i.e., always occupied the same screen location), whereas in another condition, several colors were location consistent. Then, in a surprise recognition memory test, participants were asked to recall the locations of location-consistent words or colors. The finding is that taboo words, intending to elicit emotional responses, were recalled more frequently than words which carried less emotional connotations [1]. Mackay's experiment suggests that emotional state can positively affect the encoding of information into the short or even long-term memory.

There are also a lot of other papers supporting the relationship between emotion and memory processing. When people experience a strong emotional event, they would have stronger memories of it as discussed by James McGaugh [2]. More specifically, researchers have investigated the effect of negative information and found that it can be better remembered than neutral information (McGaugh, J. L. 2003). Negative emotions can be caused by pain, such as waking up in debilitating aches that lead to frustration and resentment. However, different bodies cause different people to evoke different levels of emotions when they experience pain based on Body Specificity Hypothesis [3]. With the body-related differences, research has provided evidence that individual differences in pain sensitivity have a substantial influence on the cognitive processing of words [4]. Despite all those elaborate studies on emotion and body specificity, there is not much research devoted to the relationship between individual pain sensitivity and memory construction.

A study has shown that "pain sensitivity is known to vary greatly within culturally homogenous populations [5]." Based on what Reuter described this variation of pain sensitivity "not only allowed us to test participants with a similar linguistic, cultural, and educational background but also reduced the number of factors that may provide alternative explanations for our results." [4] Thus, our study will include people from the same country and same cultural background.

2.PROPOSED STUDY: HOW DO INDIVIDUAL'S DIFFERENCES IN PAIN SENSITIVITY CORRELATE WITH THEIR MEMORY ACCURACY?

Our proposed research will mainly focus on exploring whether pain sensitivity is related to people's memory processing. The hypothesis for this study is that people with more pain-sensitive bodies tend to have deeper and stronger memory, which supports the Bodily Relativity Hypothesis [6] as well.

To explore the correlation between pain sensitivity and memory accuracy, this study requests participants to fill up two forms: one to rate their pain sensitivity, the other to test their memory ability. The work will use the same method as Reuter at el. did to divide the participants into different groups according to their pain sensitivity. To address with the dependent variable, we will conduct a same test Benedict developed in 1997 called BVMT-R. Briefly, it contains some random geometric figures and requires participants to remember them and recall them in order to test their memory retrieval. At the same time, all participants will be given the same amount of pain stimuli and rate their memory performances under painful experience as a control.

With the ethical requirements of an experiment, potential participants' informed consent will be needed to obtain. Since this study may cause pain for participants, they are going to be provided with enough information about the experiment which enables them to decide whether to participate. In addition to that, the whole purpose of the research will be explained to the participants after the experiment, making sure that the experiment won't lead to any mental or physical harm to them.

3.METHOD

3.1 Participants

50 participants will be recruited for our experiment. At the same time, because different age groups have different accuracy of memory and females usually perform better than males in episodic memory function [7], those participants will all be 21-25 years old females from the US. Considering pain sensitivity as the only independent variable, participants cannot have had any head injury or any mental illness before, such as dementia, mental or cognitive disorder, and depression. Before the experiment, it is needed to ensure that participants have sufficient sleep last night and have no strong stress or depression, as these factors all affect memory performance.

3.2 Screening

In this study, participants should first finish an MMSE (Mini-mental State Examination) test. This is a set of 30-question task that doctors and healthcare professionals commonly use to check for cognitive impairment. This test contains questions about cognition and memory, and they are scored in a 30-point scale, with above 25 as normal and below as abnormal (have mental impairment). Those participants that score below 25 will be filtered out, which means they have some extent of neurodegenerative symptoms. The validity and reliability of this test has been proven by scientists [8].

3.3 Stimuli

In this experiment, electric shock will be used as a stimulus to cause painful feelings in participants and thus test the effect of pain sensitivity on retrieval of memory. The level of electric shock that will be used in the experiment is 3mA since it is within the maximum harmless current that people can accept. A higher electric current may cause damage to skin and muscle, and even to the brain if too intense, while the effect may be inconspicuous when using a lower electric current [9].

3.4 Pain Sensitivity Measurement

Just like what Reuter et el. did, participants are asked to self-assess their pain sensitivity by some questions in a questionnaire. Possible questions include "How frequently do you perceive pain?" and "Do you regard yourself as pain-sensitive?". The participants can give answers in a 5-point Likert scale which ranges from "very much" to "hardly ever". According to participants' self-assessed pain sensitivity, they will be allocated into three different groups (Low, Moderate, and High) for the independent variable of experiment.

3.5 Memory Accuracy Measurement

To test the accuracy of memory, BVMT-R will be used which is a commonly used assessment tool to measure visuospatial learning and memory abilities across research and clinical settings [10]. The measurement used to process the data in Tam's paper with Schmitter's regression analysis, since the question studied in this research is similar to that in his paper. Regression analysis will be used to process the data, and ANOVA (Analysis of variance) will be used too. ANOVA is a statistical approach that divides observed variance data into distinct components for further testing in a regression, and it can determine whether there are any statistically significant differences between the means of two or more independent groups (One-way

ANOVA in SPSS Statistics) [11,12]. Thus, ANOVA is the appropriate method for our study because this work tends to compare the accuracy of memory for different levels of pain sensitivity (low, moderate, and high). The equation of ANOVA is defined as:

$$F = \frac{MST}{MSE}$$

Where F is the ANOVA coefficient, MST is the sum of squares due to treatment and MSE is the mean sum of squares due to error. If there is no actual variation between the groups, the F-ratio of the ANOVA should be near 1. Since there is only one independent variable (pain sensitivity) in our study, one-way ANOVA is used.

4.PROCEDURE

For this study, at the first stage, a memory test will be conducted. After reviewing a recommendation list of cognitive assessments [13] made by scientists that aim to resolve Multiple Sclerosis, it is decided to apply one of the visuospatial tests that examine people's instant memory of visible objects and pictures named BVMT-R T1-3 [14]. The BVMT-R T1-3 test mainly contains a 2*3 stimulus array of abstract geometric figures that are randomly created. Figure 1 shows some examples of the shapes. Participants will be given three learning trials for 10s. Later, the pictures will be removed, and participants will be asked to recall the figures using pens and draw the geometric figures in identical positions with the same shape. The validity of BVMT-R T1-3 has already been proven by other researchers before [15-17].

During the second stage (memorizing stage), all participants will experience a level of constant electric current (3mA) for 10 seconds. After the 10 seconds of both reciting the stimulus (geometric figures) and experiencing the pain from the electric current, participants' responses will be checked and rated on a scale from 0 to 30 (2 potential points for each geometric shape*15 shape in total). Every time a participant doesn't draw either the position or the shape of the figure correctly, a mark will be taken off. The scores among each pain sensitivity group will be compared and analyzed using ANOVA and the results will be utilized to test our experimental hypothesis.

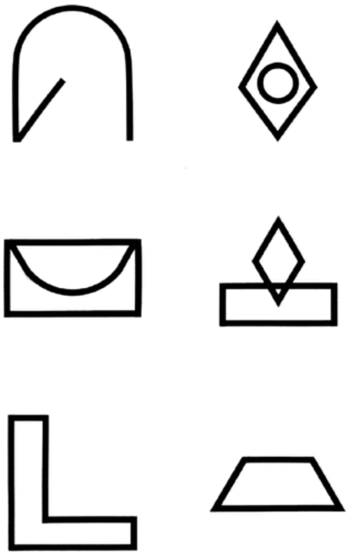

Figure 1. Example geometric figures of BVMT-R.

5. PREDICTIONS

According to the BVMT-R T1-3, our participants will be asked to remember as many random geometric figures as possible when as well experiencing the pain from electric current (3mA). Normally, the brain supports an interaction between pain and specific emotional states. However, according to Mark A. Lumley and Jay L. Cohen [18], when dysregulated (due to pain), the subcortical defensive circuit interacts with the cerebral cortex and yields the conscious experience of Fear and anxiety as well as evaluation and rumination about the consequences of pain and injury, including fear of pain [19]. In other words, pain can have influence on our emotional state by exaggerating it and making it negative. As a result, since more pain-sensitive participants perceive the same level of pain more intensely than people who are less pain-sensitive, they tend to evoke a stronger emotional state. Thus, based on the theory mentioned previously, participants from the High Group may perform better than participants from the Moderate Group on retrieving the geometric figures by revealing higher scores on BVMT-R T1-3 (figure 2). Likely, the performances of participants from the Moderate Group may be better than that of participants from the Low Group.

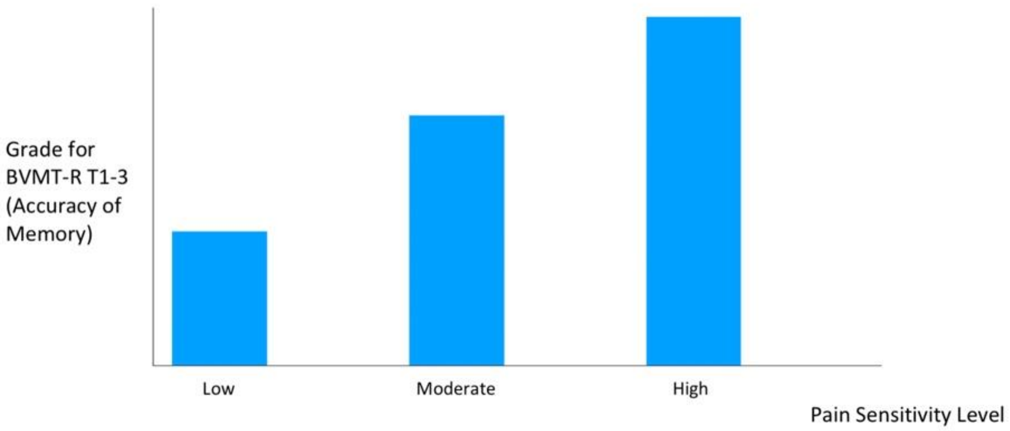

Figure 2. Predictions of the proposed study.

6. CONCLUSION

6.1.Implications and future directions

If the results of the proposed study support the experimental prediction, then it is reasonable to reach a conclusion with a positive correlation between pain sensitivity and memory accuracy, that the more pain sensitive a person is, the better performance he will produce in terms of memory accuracy.

Alternatively, if the results don't support our prediction, that the difference of the memory performances of the three different groups is not so distinct or contradicts with our prediction, the study has to result in a conclusion that there's no correlation between pain sensitivity and memory accuracy or a reverse relationship between the two variables, that people with higher pain sensitivity tends to have weaker memory.

Possibly, as the more pain sensitive participants experience the stimuli more severely, the distraction of pain from the retrieval of memory may be stronger. Since pain acts as a stimulus from participants' perspective in our experiment, it may also perform as a source of distraction during the procedure. So maybe this will be a reason for the better performance of people who are not that pain sensitive due to better concentration. This prediction also needs another new experiment that takes perceptual distraction (visual distraction/auditory distraction) as the independent variable to prove correlation.

In addition, other factors may contribute to this as well, such as the difference in language category. Maybe people who speak path languages like Spanish and manner languages like English can differ in memory accuracy. The differences in language category and structure may result in the distinction in memory retrieval or more specifically, the focus of memory. For example, English and Korean speakers present a clear difference in the focus of memory. English (a manner language) speakers shows a greater accuracy of answering manner questions while Korean (a path language) speakers shows a better memory of the path of the action. Since our study doesn't include investigating the differences in focus of memory, this correlation needs further exploration. In conclusion, pain and memory is a new area that awaits exploration.

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