The Influence of Stress Time and Prototype Location on College Students' Scientific Problem Solving

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Abstract

In this paper, we use the two-stage experimental paradigm of "learning multiple prototypes - testing multiple problems" with scientific inventions as experimental materials, and discuss the correct rate and response time of scientific problem solving. The results show that: (1) The correct effect of the scientific problem solving is better than that of the pre-stress archetypal science. This shows that the knowledge of the prototype after stress can be transformed into a stress memory or Emotional memory, so the extraction is easier. (2) The main effect of the stress time is significant, and the response to the scientific problem immediately after stress is significantly longer than the reaction time after 25 minutes of stress response. (3) The interaction between the prototype position and the stress time course has an impact on the correct rate of scientific problem solving. Under the condition of the initial prototype learning condition, the correctness of the scientific problem solving problem immediately after stress is significantly higher than that of the stress To solve the problem of scientific problems to solve the correct rate. (4) The interaction between the prototype position and the stress time has an effect on the reaction of the scientific problem. Under the initial prototype learning condition, the scientific problem of the problem test immediately after the stress is significantly longer than 25 minutes after the stress Problem of the scientific problem solving reaction time. Under the post-prototype learning conditions, the question of scientific problems immediately after stress response to the problem-solving reaction time with the stress after 25 minutes of the problem-solving scientific problem-solving reaction time difference was not significant.

Keywords: stress time course; prototype position; prototyping; scientific problem

1 Introduction

The scientific case concerning the resolution of scientific problems under stress is very common. From the legend of "using the two big hats to parachute out of the granary fire sea" by China, "Fett plugged with an air bag into an inflatable pillow Toxic chlorine leak "classic story, all shows the psychological state of mind under the creative thinking.

The impact of psychological stress on creativity has drawn the attention of researchers. However, due to the complexity of stress and the difference of creative measurement methods, the conclusions so far about the relationship between the two have not been consistent. Studies have shown that there is a positive correlation between psychological stress and creativity. The time pressure experienced by scientists and engineers can positively predict a series of behaviors including creativity (Andrews, Farris, 1972). Some studies further found that time The greater the stress, the more creative the individual, but only in the high-expected conditions (Wang, Qia, & Yu, 2017). However, there is also evidence of a negative relationship between the two, with internal and external stressors significantly reducing individual creativity (Shanteau, Dino, 1993; Alexander, Smith, Tivarus, & Beversdorf, 2007). The reason for this is that some researchers think that the difference between psychological stress and creativity is due to the different use of cognitive resources. When the utilization of cognitive resources is better, the negative impact is reduced, and there is a positive correlation between psychological stress and creativity. When the utilization of cognitive resources is poor, negative effects are added, and psychological stress and creativity are negatively correlated. The theory of "prototype inspiration" (2004, 2005) proposed by Zhang Qinglin and his team suggests that creative thinking in real life is mainly realized through archetypal inspiration.

As an important cognitive resource, whether the prototype can be successfully extracted from memory is the key to solve the scientific problems. Therefore, the reason for the difference between psychological stress and creativity may be related to the successful extraction of the prototype.

The reality of prototype knowledge may come from the previous study of the knowledge system or experience schema, may also come from the experiment to provide new knowledge and information learning. This is also related to the learning sequence (location) of the prototype knowledge. In other words, the prototype knowledge may be acquired prior to stress, may also be acquired immediately after stress learning. On the prototype position, Zhu Haixue et al. (2012) took the scientific invention and creation as the experimental material and the "one-to-one" experimental paradigm to explore the influence of the prototype position on the activation of prototype events and the solution of scientific problems. The results showed that post-prototype performance was significantly better than the first prototype, showing a higher accuracy, shorter response time. The difference lies in the prototype "before" and "after" in the prototype will have different forms of representation, one is with the problem of characterization (post-prototype), one is without problem characterization (pre-prototype) (Zhu Haixue, Luo Junlong, Yang Chunjuan , Qiu Jiang, Zhang Qinglin, 2012). Similarly, does pre-stress learning and post-stress learning have learning differences? So as to affect the prototype activation in solving scientific problems and thus affect the accuracy and reaction time of solving scientific problems?

In addition, previous studies have shown that the impact of learning after stress on memory has the opposite result. Some studies have suggested that stress can impair memory (Elzinga, Bakker, & Bremner, 2005; Kirschbaum, Wolf, May, Wippich, & Hellhammer, 1996; Payne et al., 2007) and other studies suggest enhanced memory (Schwabe, Bohringer , Chatterjee, & Schachinger, 2008; Smeets, Giesbrecht, Jelicic, & Merckelbach, 2007). If subjects were stressed shortly before learning, stress-induced elevation of cortisol was positively correlated with memory, but stress-induced cortisol was elevated if participants were stressed for a longer period prior to learning Negatively correlated with memory (Quadflieg, Schwabe, Meyer, & Smeets, 2013). And in different stress duration this damage to the memory is different. Specifically, there was no impairment of memory recall when memory tests were performed immediately after stress, before cortisol levels were elevated. At 25 minutes after stress, the extraction score was impaired when the cortisol level peaked and the cortisol level 90 minutes after stress returned to baseline with impaired extraction performance. Extraction injury 90 minutes after stress was greater than after 25 minutes (Schwabe & Wolf, 2014). However, after learning first, stress is consistently manifested as enhanced memory (Cahill, Gorski, & Le, 2003; Smeets, Otgaar, Candel, & Wolf, 2008). At the same time, there are also studies using the Trier social stress test (TSST) to induce stress responses in subjects and to examine the impact of psychological stress on individual creative activity. It was found that psychological stress and creativity exist Inverted U-shaped relationship, the highest level of creativity of individuals under moderate stress (Che Xianwei, Qi Mingming, Guan Lili, Zhang Qinglin, Yang Juan, 2014). This may also explain the different levels of creativity in different stress schedules.

Taken together, the prototype position and stress schedule may have an impact on scientific problem solving. This study proposes to make the following assumptions:

H1: The correct rate of solving scientific problems under the condition of post-prototype learning is higher than the correct rate of solving scientific problems under the condition of prior prototype learning.

H2: The resolution of scientific problems under post-prototype learning is faster than that of scientific problems under pre-prototype learning.

H3: The correct rate of scientific problem solving immediately after stress is higher than the correct rate of solving scientific problems after 25 minutes of stress.

H4: Scientific problem solving immediately after stress The correct rate of scientific problem solving after reaction is shorter than 25 minutes after stress.

2 Methods

2.1 Participants

A total of 120 undergraduates from an ordinary university in China were randomly selected, with an average age of 21.4 years. 67 boys and 53 girls, arts and science students balance. Visual acuity or corrected visual acuity, and have preliminary computer skills, all subjects were right hand, no recent drug intake, and no mental or mental history, volunteered to participate in this trial, and did not contact Prototype inspired test.

The experiment includes four experimental levels, namely, stress 0 minutes - pre-stress prototyping; stress 0 minutes - prototyping after stress; 25 minutes after stress - pre-stress prototyping and 25 minutes after stress - Prototype learning after stress. All subjects were randomly assigned to four experimental levels of experiments, each group of 30 people. After completing the experiment, the participants got the appropriate amount of compensation.

2.2 Material

Estimate the task of stress material: reference stress test materials such as Qi Ming-ming (2012, 2014), write 240 arithmetic questions, each question is less than two 10 and the number with two decimal multiply. Select 200 undergraduates at random and ask them to judge whether the arithmetic result of the arithmetic problem is less than 10 within the limited time, press "1" instead of "2".

According to the research results of Qi Mingming et al. (2012,2014), the final formal test material was composed of 120 items with a correct rate between 0.45-0.55 at 1880ms-1916ms for a single single selective reaction, and the reaction time was 1890 . 3 ± 176. 5, the correct rate of 0. 52 ± 0. 19.

Scientific Questions Materials: The scientific questions are selected from "Scientific Invent Inventing Problem Materials Library" by Zhang Qinglin and Luo Junlong (2001), and eight questions are selected as the test materials for this experiment. Here are 2 examples of 8 test questions:

Scientific Question 1: Basketball players slip easily on smooth plastic factories and may be injured. How to make the rubber sole of sports shoes with non-slip function?

Prototype: Octopus has a lot of concave sucker, the wife can firmly in the object surface, to prevent the fall off.

Reference answer: Soles can increase the friction, or have a certain adsorption capacity. You can make nails shoes, or rough the basketball court ground.

Science Problem 2: Science Problem: When building slabs made of concrete, the concrete is very hard and solid after it is solidified, which increases the load-bearing requirements of the house's frame structure and therefore increases the cost of building it. How to make both hard and light concrete floor?

Prototype: In the production of plastic, adding a foaming agent, can produce a large number of small bubbles of plastic, not only save raw materials, and very light, the same hardness.

Reference to the answer: In the production of concrete floor, adding a blowing agent, can produce a large number of small bubbles of bubble concrete, light and hard.

2.3 Experimental design

Experiment using 2 × 2 between-proup design. The independent variable 1 is the stress schedule, ie, different time points after stress, including 0 minutes immediately after stress, and 25 minutes after stress. Argument 2 is the prototype location, which is the location of the prototype learning, including pre-stress prototyping and post-stress prototyping. Dependent variables for college students to solve the problem of correct rate and response time.

2.4 Procedure

Participants first entered separate rooms, each equipped with a Pentium 2 IV computer, monitor, and chair. Using E-prime2.0 software programming to complete the random presentation of experimental materials and automatically record the reaction time of the subjects. The stimulus presentation process is shown in Figure 1. The whole process includes stress, learning and testing of three stages. According to different locations and time courses, the experiment includes four levels of experimental treatment, that is, prototype learning - stress 0 minutes - problem testing; prototype learning - 25 minutes after stress - problem testing; stress 0 minutes - prototype learning - problem testing 25 minutes after stress - prototype learning - problem measurement. E-prime 2.0 program using programming to complete the random presentation of experimental materials and automatically record the reaction time of the subjects. Experiment to take individual test method. Subjects were randomly assigned to four experimental conditions.

Stress-Induced Phase: The subject is informed first of all: the test will compare his estimated response time and correct rate at this stage with those of other participants participating in the experiment at the same time, evaluate their mathematical abilities and give results based on the comparison The corresponding experimental reward. In the computer screen randomly presented (3000ms) prepared 120 difficult arithmetic questions, subjects are asked within a limited time to make the subject of the result is less than 10 judgments, the key reaction to submit the judgment result is "1", not Press "2". Subject disappears, according to the subjects to submit the judgment is correct or not to give the appropriate feedback, including the correct, wrong or time to three kinds of feedback.

Prototype learning phase: The "8-to-8" "learning-one-test" paradigm is adopted, in which the subjects test eight scientific questions after learning eight prototype knowledge materials. The screen appears experimental instructions on the subject, the participants understand the guide after the press spacebar; the screen presents a prototype of the text material, the subjects quickly press the space bar after understanding the prototype presentation time limit of 60s, 60s have not yet understood automatically enter the next A prototype of text material. All subjects need to practice experiments before the formal experiment to ensure that they can correctly understand the experimental tasks and familiar with the experimental process.

Quiz stage: first in the center of the screen showing the fixation point "+" as a reminder, black and white, the time is 1s, then presented a scientific material (time limit 90s). During this period, the subjects were tasked with reading and understanding the problem quickly and trying hard to think about the solution to the problem. Asked them to think of a solution, immediately press the space bar, the button will appear on the screen after several options for the subjects to choose. Subjects were asked to press the corresponding number keys to select the words that were consistent with the key information contained in the solution they thought of. After the respondent made the corresponding selection button, he then tested the next scientific question. If the problem material is presented 90s, the subject still can not think of the solution, did not make any key reaction, the program will automatically enter the next question test. Until all eight science materials have been tested.

In the prototype learning - stress 0 minutes - problem test under the experimental treatment, the first prototype study, then the task of stress-induced assessment of stress-induced challenge 0 minutes immediately after the test. Under the prototype learning - 25 minutes after stress - the experimental treatment of the problem test, the first prototype study, after the stress task of estimating tasks, stress-induced 25 minutes after the problem test. In the stress 0 minutes - prototype learning - problem test under the experimental treatment, the first task-induced stress induction, induced stress immediately after the prototype learning and problem testing. Since prototyping does not take up to 10 minutes and does not produce stress hormone cortisol (Joëls & Baram, 2009), we tested this condition as stress for 0 minutes for problem testing.

Under the experimental condition of 25 minutes after stress - Prototype Learning - Problem Test, the task of stress estimation was performed first, and prototyping and problem testing were conducted 25 minutes after the stress induction (including prototype learning time).

3. Results and analysis

The result of each scientific solution to the standard answer against the standard score of 5 points, and the average of 8 scientific questions divided by 5 for the correct rate of scientific problems. The average response time of the eight scientific problems recorded in the E-prime 2.0 program is the response time of the scientific problem solving. Statistical analysis of the data was performed using SPSS 21.0.

3.1 Stress induced results

Single factor analysis of variance on the response time and the correct rate of the four task under the experimental treatment, the results show that the response time of the four groups of estimated tasks are between 1880ms-1916ms, the correct rates are at 0. 45 -0. 55 Between the correct rate and response to the main effect of the group were not significant. Indicating that the stress of the four experimental treatments is effective and there is no significant difference in stress state.

3.2 Impact of Stress Duration and Prototype on Correctness of Scientific Problems

The 2 × 2 non-repeated measures ANOVA of the correct rate of scientific problem solving showed that the main effect of the prototype position was significant. The accuracy rate of post-prototype learning was significantly higher than that of the prior prototype learning Rate: $F(1,116) = 7.80$, $p < 0.01$, $\eta^2 = 0.06$. In addition, the interaction between the results prototype positions and stress duration was significant: $F(1,116) = 16.64$, $p < 0.001$, $\eta^2 = 0.125$ (Table 1). Simple effect analysis showed that the accuracy of scientific problem solving ($M = 0.56$, $SD = 0.14$) was significantly higher than that of the 25-minute stress-solving scientific problem under the condition of prior archetypal learning Rate ($M = 0.44$, $SD = 0.10$). The correct rate of scientific problem solving ($M = 0.53$, $SD = 0.15$) was significantly lower than that of the 25-minute post-stress scientific problem solving problem ($M = 0.61$, $SD = 0.13$, $p < 0.001$) (see Figure 1).

Table 1 under different levels of treatment of scientific problems to solve the average accuracy and standard deviation

Processing level	M	SD	N
Stress 0 minutes - Pre-stress Prototype Learning	0.56	0.14	30
Stress 0 minutes - Prototype learning after stress	0.53	0.15	30
25 minutes after stress - pre-stress prototypical learning	0.44	0.10	30
25 minutes after stress - Prototype learning after stress	0.61	0.13	30

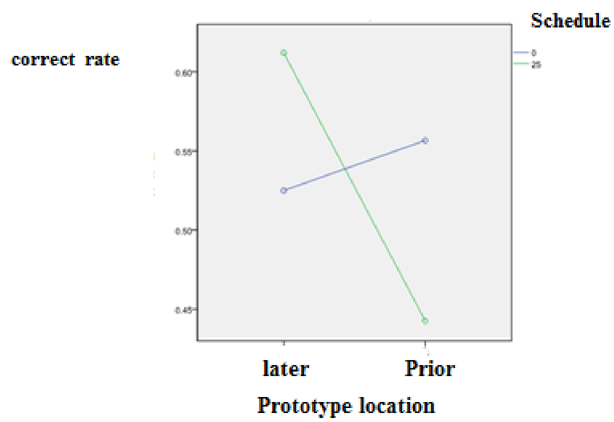

Figure 1 Prototype location and stress duration interaction

3.3 The Impact of Stress Duration and Prototype on the Resolution of Scientific Problems

A 2 × 2 non-repeated measures ANOVA was performed on the resolution of scientific problems. The results showed that the main effect of stress duration was significant. The reaction time of immediate scientific problem solving after stress was significantly longer than that of 25 minutes after stress When: $F(1,116) = 7.22$, $p < 0.01$, $\eta^2 = 0.059$. In addition, the interaction between the resulting prototype position and the stress time-history edge is significant: $F(1,116) = 3.39$, $p = 0.06$, $\eta^2 = 0.028$ (see Table 2). The simple effect analysis showed that under the condition of prior archetype learning, the scientific problem solving reaction immediately after the stress test (M = 35780.89, SD = 9482.32) was significantly longer than that of the scientific problem solving test after stress 25 minutes (M = 25941.37, SD = 14893.63). In the post-prototype learning condition, the scientific problem-solving reaction immediately after stress (M = 34567.28, SD = 10420.95) and the 25-minute stress-solving scientific problem solving reaction (M = 32727.58, SD = 12096.24, $p < 0.001$) was not significantly different (see Figure 2).

Table 2 under different levels of treatment of scientific problems to solve the average response time and standard deviation

Processing level	M	SD	N
Stress 0 minutes - Pre-stress Prototype Learning	35780.89	9482.32	30
Stress 0 minutes - Prototype learning after stress	34567.28	10420.95	30
25 minutes after stress - pre-stress prototypical learning	25941.37	14893.63	30
25 minutes after stress - Prototype learning after stress	32727.58	12096.24	30

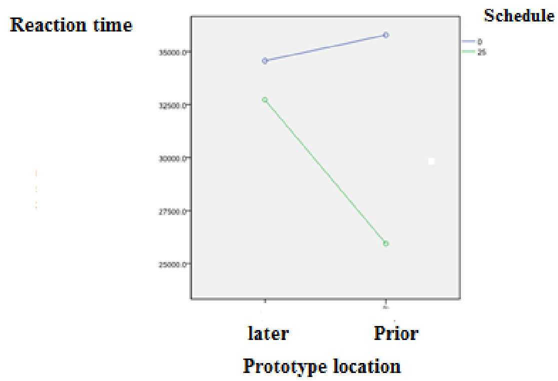

Figure 2 Prototype location and stress duration interaction

4 Discuss

In this study, we selected eight scientific inventions to create experimental problems as experimental materials, manipulated the location of the prototype (before or after stress induction), stress duration (immediately after or 25 minutes after stress induction) Prototype Position Effect and Stress Duration Effect in Scientific Problem Solving.

Prototype position effect, the prototype "before" and "after" will produce different learning effects, that is, prototype memory. The results show that after the stress, the correctness of solving the scientific problems of the prototypical subjects was significantly higher than that of the prototypical science subjects before stress. That is to say, if prototyping is conducted after stress, the prototype can be activated and extracted correctly in later scientific questions.

In the stress time-history effect, this study found that under the condition of prior prototype learning, the correct rate of solving scientific problems immediately after the stress test was significantly higher than that of the scientific problem solving after 25 minutes of stress testing. However, in response time, regardless of whether the prototyping was before or after the stress response, the response to a scientific problem immediately after stress was significantly longer than the reaction time to a 25 minute stress response to a scientific problem.

And under the condition of post-prototype learning, the correct rate of solving scientific problems immediately after the stress test is significantly lower than the correct rate of solving scientific problems after 25 minutes of stress testing. In addition, under the condition of prior archetypal learning, the response to a scientific problem immediately after the stress test was significantly longer than the response time to a scientific problem-solving test within 25 minutes after stress. In post-archetype learning, the scientific problem solving immediately after stress was not significantly different in response to the scientific problem solving response at 25 minutes after stress.

Previous studies (Zhu Haixue, Luo Junlong, Yang Chunjuan, Qiu Jiang, Zhang Qinglin, 2012) also explored the positional relationship between prototypes and scientific problems and found that prototypes produce prototypical representations of different nature before and after scientific questions Species are characterized by questions (post-prototype) and non-problematic (pre-prototypes). Under the condition that a prototype is presented after a scientific problem occurs (the latter prototype group), this prototype representation is essentially a composite representation associated with the problem, making it easier to directionally and objectively highlight the scientific principles related to the problem. When the subjects to solve scientific problems can quickly find a solution to the problem, so the correct rate is higher, the response time is shorter.

Similarly, in the study of the relationship between prototype and stress, prototypical stress may be a prototypical representation of stress with stress, while pre-stress prototyping may be a prototype without stress . Stress is believed to increase attention and alertness, thereby enhancing the coding of stressful experience and enhancing memory consolidation in response to stress. Therefore, when stress is part of the learning environment, stress is thought to improve memory as it occurs during learning. And memory is impaired when stress occurs outside the learning environment (Diamond et al., 2007; Joëls et al., 2006).

The post-prototype learning conditions in this study may be stress as part of the learning environment, making the prototype easier to be activated and extracted in later problems. This is also supported by some studies (Schwabe, Bohringer, Chatterjee, & Schachinger, 2008; Smeets, Giesbrecht, Jelicic, & Merckelbach, 2007). However, the previous study did not investigate the reaction time, this study makes up for this point. For stress conditions after first learning, stress is shown to impair memory after learning but before preservation (Buchanan, Tranel, & Adolphs, 2006; De Quervain, Roozendaal, & McGaugh, 1998; Kuhlmann, Piel , & Wolf, 2005; Schwabe & Wolf, 2009; Smeets et al., 2008; Hupbach & Fieman, 2012; Schilling et al., 2013; Schwabe et al., 2009). This study did not examine the conditions under different durations before stress. Future research should further improve the time-history effect before stress.

In addition, previous studies have found that immediately after stress, learning to learn, stress-induced elevation of cortisol and memory were positively correlated, but if the subjects longer after stress study again, the stress-induced cortisol Negatively correlated with memory (Quadflieg, Schwabe, Meyer, & Smeets, 2013). In particular, memory stress was recorded immediately prior to cortisol level up to the peak without any impairment in memory testing. At 25 minutes after stress, extraction results are impaired when cortisol levels peak (Schwabe & Wolf, 2014). The conclusion of this study is the opposite. But also received indirect support from some other studies. For example, studies using the Trier Social Stress Test (TSST) to induce subjects' stress response and investigate the impact of psychological stress on individual creative activity have found that there is a gap between psychological stress and creativity U-shaped relationship, the highest level of creativity of individuals under moderate stress (Che Xianwei, Qi Mingming, Guan Lili, Zhang Qinglin, Yang Juan, 2014). This may also indicate a higher level of inventive step in prototyping at 25 minutes after stress and a higher correct resolution of the problem. In this regard, these results have yet to be further verified. At the same time, there are some shortcomings in this study. For example, in stress-induced failure to use cortisol indicators to monitor the state of stress. In addition, there is a certain gap between simulated intellectual state of emergency and reality. In reality, acute mental state is usually the state of stress that contains scientific problems. In this study, stress and scientific problems are separated.

5. Conclusion

In this study, the subject of scientific problems was used as experimental materials to explore the prototype position effect and stress time-history effect in solving scientific problems, and the following results were obtained:

(1) The main effect of the prototype position is significant, and the correct rate of solving scientific problems in prototypical learning after stress is significantly better than that of scientific problems in pre-stress prototyping, indicating that the prototypical knowledge of post-stress learning may be transformed into a Stress memory or emotional memory, so extract more easily.

(2) The main effect of stress duration was significant, and the reaction time of solving the scientific problem immediately after stress was significantly longer than that of solving the scientific problem after 25 minutes of stress.

(3) The interaction between prototype position and stress duration has an impact on the correct rate of scientific problem solving. Under the condition of prior prototype learning, the correct rate of solving scientific problems immediately after stress testing is significantly higher than 25 minutes after stress The scientific problem solving test to solve the correct rate.

(4) The interaction between the prototype position and the stress time-history has an impact on the solution of the scientific problem. Under the condition of the prior prototype learning, the response to the scientific problem immediately after the stress test is significantly longer than the response time of 25 minutes after the stress Problem testing is a scientific problem solving reaction time. In post-archetype learning, the scientific problem solving immediately after stress was not significantly different in response to the scientific problem solving response at 25 minutes after stress.

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