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CAN A TIRED MIND UNDERTAKE ASSOCIATIVE? THE EFFECT OF EGO DEPLETION ON THE ASSOCIATIVE ABILITY OF COLLEGE PROFESSORS

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Abstract. *Associative ability is an important way of thinking. It is also an important part of the constructive imagination of college professors. In order to explore the ego depletion effect of college professors on their associative ability, this paper uses two experiments to explore two aspects of the associative ability. In Experiment 1, college professors were asked to test their divergent association ability immediately after ego depletion. It finds that teachers with low ego depletion had stronger divergent association ability. On the other hand, the convergent association ability was tested in Experiment 2, showing that people who have higher ego depletion are capable of lowering convergent association ability of college professors. The following conclusions can be drawn from the two experiments: ego depletion has an effect on the associative ability of college professors. The main effect of ego depletion is significant. The main effect of age is significant. Because the p value of the gender is not above 0.5, we think the main effect of gender is not significant. However, the interaction between age and ego depletion is significant.*
Keywords: Ego depletion, Divergent association, Convergent association, College professors

1. **Introduction.** In the era of industry 4.0, innovation is the main driving force of development. [1] found that universities and their knowledge production institutions are becoming the core driving force of innovation. According to [2], the innovation ability of colleges is mainly measured by the innovation performance of college professors. Through the reflection of scientists who make great inventions, [3] found that creative association plays an important role in invention and technological innovation. Therefore, we can know that the innovation of college teachers is closely related to their own associative ability. However, in the existing literature, scholars mainly study how to cultivate students' associative ability, but there are relatively few researches on the associative ability of college teachers. In order to create more innovative results for colleges and universities and make them play a better role in the construction of national innovation system, we study the associative ability of college teachers, the main undertaker of college innovation. Association process is a kind of intelligent thinking, which needs to be realized by reasoning, extrapolation and other processes. The implementation of association process needs the participation of self-control resources. However, one's self-control resources are limited, and after self-control resources are consumed, the performance of the next execution process will be poor (e.g., [4,5]). The process of self-control in which resources are consumed is called ego depletion, the decline of individual executive function after ego depletion becomes ego depletion effect [6,7]. Ego depletion can engage the possibility of leaks [8] and reduce escalation of commitment [4]. Some scholars [9,10] think that the ego depletion

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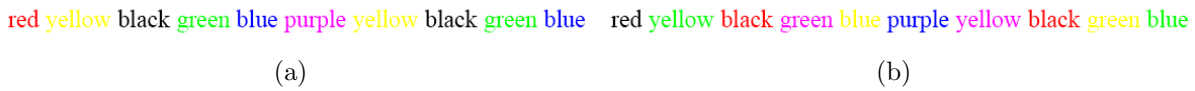
effect is not strong and reliable. They suggest ensuring the validity of experimental data of ego depletion through pre-experiments. Therefore, we ensure the effectiveness of the ego depletion experimental stimulus by pre-experiment. The innovation of this work is to explore the ego depletion effect on the associative ability of university teachers through relatively objective eye movement experiments. We hope college administrators pay more attention to the ego depletion of college professors. They can adopt more policies to reduce the ego depletion of college professors. In addition, policies make college professors contribute more to the development and improvement of the national innovation system.

The specific organization of this paper is as follows. Firstly, we recommend the background and some related reference to people. Secondly, we design a pre-experiment to ensure the validity of the stimulus. Third, the process and participants of the formal experiment are introduced. Next, we discuss the results, the major contributions and the significance of this work. We think the major contribution of this work is helping the college professors improve the association. In the end, we pointed out some further work and concluded the results of this work: the ego depletion of college professors can affect their association abilities. And the effect increases with the age.

2. **Pre-Experiment.** According to the view of [9], we designed the pre-experiment to the effectiveness of the ego depleting experimental material. Firstly, we design the stimulus you can see in Figure 1, Figure 1(a) is low ego depleting experimental material, Figure 1(b) is high ego depleting experimental material. The following is the same as here. Secondly, we show 20 experimental materials, each of which is presented at 10 seconds. Finally, we collect data and analyze it.



(a) (b)

FIGURE 1. (color online) Ego depletion experimental stimulus

Based on [11], the average blink time and the average fixation duration can more reliably reflect a person's mental fatigue, we analyze the eye movement index of participants to ensure the validity of the ego depletion stimulus. We deleted the data in which eye tracking failed. The data of 20 college professors (including 10 low ego depletion data, and 10 high ego depletion data) were valid and retained. According to blink time and average fixation duration, we sum all the trials of each participant. Then we calculate the mean value of each participant. We use SPSS software to carry out the independent sample T test on the mean value.

The results show that the average blink time of teachers with high ego depletion was significantly higher than that of low ego depletion teachers, $M_{low} = 85.77$, $M_{high} = 162.17$, $t(18) = -2.846$, $p = 0.011 < 0.05$. At the same time, the average fixation duration of teachers with high ego depletion was significantly greater than that of teachers with low ego depletion, and $M_{low} = 372.93$, $M_{high} = 552.45$, $t(18) = -2.153$, $p = 0.045 < 0.05$. Combining with the test results of the above two eye movement indexes, it can be concluded that the experimental material is presented at a frequency of 10 seconds for 20 trails.

After verifying the effectiveness of the ego depletion experimental material, we started the formal experiment.

3. **Experiment 1.** The experiment is to test the divergent association ability of college professors.

3.1. **Participants and settings.** The participants were composed of teachers with academic graduate qualifications and above, and the experimental effective data is 51, of whom 25 were men, 26 were women, 20-30 years old were tested 11, 31-40 years old were 10, 41-50 years old were tested 10, 51-60 years old were tested 10, over age 60 were tested 10. All the experimenters had not participated in similar experiments before. The vision or correction vision was normal, colorless blind and color weakness, volunteered to participate in the experiment, after the experiment they can get a gift.

3.2. **Stimulus and apparatus.** According to Jill ford's unconventional use test in the divergent thinking experiment, we produced the divergent association experimental stimulus. From the questionnaire, the most frequent uses are selected as routine use (area 1, 2), and 2 novel and common uses (area 3, 6), 1 novel and uncommon use (area 9) and 4 irrelevant uses were selected as experimental stimuli (see Figure 2). The number in the picture will be hidden during the formal experiment.

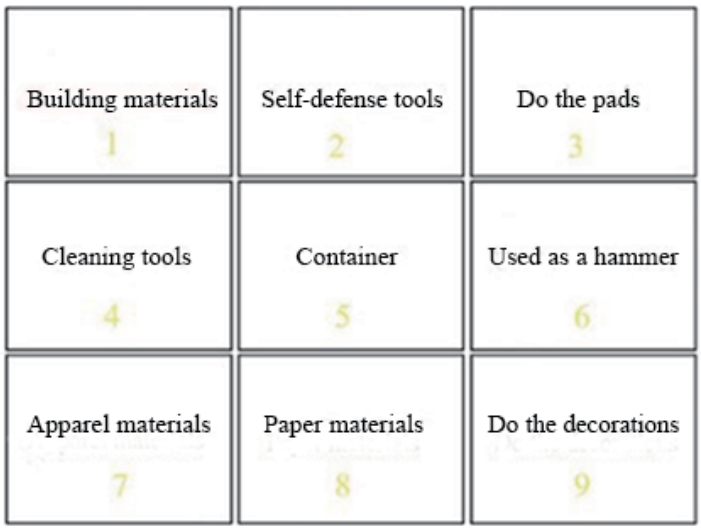


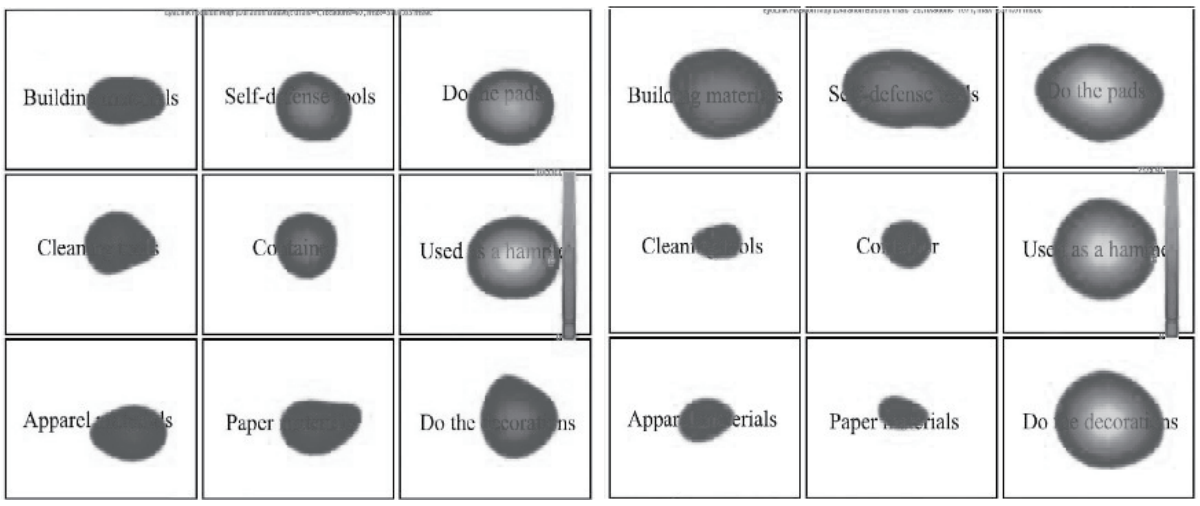
FIGURE 2. Free association experimental stimulus

The eye tracker used in the experiment was Eyelink1000+. The sampling frequency was 1000 Hz. Participants' left eye data were collected. We use SPSS24.0 to analyze the data which are collected from the eye tracker.

3.3. **Procedure.** The experiment adopts the sequential task paradigm. The experiment contains ego depletion experimental task and divergent association experiment task. Firstly, we carry out the calibration phase. When participants enter the laboratory, we use the 9 point grid-pattern to gain an accurate calibration. Participants whose calibration value is not greater than 0.8 are allowed to start the experiment. Secondly, we start the ego depletion experiment. When the calibration meets the requirements, the participants enter the ego depletion experiment. At this time, ego depletion experiment instructions which showed on the screen are as follows: Please say the color of the Chinese characters in the following pictures according to the swatches. Next, the swatches will be presented. After participants are familiar with the swatches, they can press the SPACEBAR to enter the formal experiment. Then the corresponding ego depletion stimulus will be presented according to the group. Every group is showed the trial 20 times. Each trial's rendering time is 10 s. Lastly, we test the divergent association. After the participants complete the ego depletion experiment, the screen will present the guide to the divergent association experiment: Please find the use of "a brick" in the figure below within 30 s. Then, the screen will present the stimulus of divergent association to the participants. In this 30 s, the eye movement indicators of participants will be collected and used for analysis.

4. **Discussion.** According to the conclusion of the eye movement index in reading research [12,13], the following three eye movement indexes are proposed to be used for analysis. 1) Regression count. In reading, the regression is conductive to the deeper processing of the article. The understanding of the content of difficulties, errors and omissions of important content is one of the reasons for the regression. 2) Total fixation duration. The total fixation duration is the sum reading time of the interest area. Depending on the total fixation duration of each area of interest, we can know the time at which the participants process the interest area. 3) Heat map. The heat map can visually show the area of the participants' attention concentration and the changes of the attention area.

4.1. **Heat maps.** The follows figure is the heat map of college professors under different ego depletion extent. The white color in the figure indicates the participants give more focus to this area compared to the black. We can see that 1) compared with high ego depletion teachers, low ego depletion teachers are more able to focus their attention on the area related to the topic, the hot spots in the unrelated uses area 4, 5, 7, 8 are less; 2) after ego depletion, the hot spots in the common uses area 6 and the uncommon uses 9 with the low ego depletion teacher difference are more significant.



(a) (b)

FIGURE 3. Free association heat maps

4.2. **Statistical analysis.** At first, we delete the invalid data according to the criteria as follows: 1) The data with eye tracking failure; 2) The data with fixation duration of less than 80 ms or greater than 1200 ms; 3) The data with average plus or minus three standard deviation data. Then, we use the SPSS software to carry out the independent sample T test on the experimental data. The test results showed that there was a significant difference in the regression count of the participants with different ego depletion, $t = 2.06$, $p < 0.05$, $M_{low} = 3.00$, $M_{high} = 3.40$, the high ego depletion has more regression count; The total fixation duration of the participants with different ego depletion was significant, $t = 5.03$, $p < 0.05$, $M_{low} = 1293.75$, $M_{high} = 1374.58$, the low ego depletion was easier to process the information, and the total fixation duration was shorter.

Scholars in [5] find the significant age and gender differences in children's sharing behavior after ego depletion. In order to explore whether this gender and age difference also has an impact on college professors' divergent associative ability, we do the ANOVA analysis of the total fixation duration and regression count by using SPSS24.0. The results are shown in Table 1.

Table 1. ANOVA analysis summary table

	Regression count		Total fixation duration	
	F	p	F	p
Depletion	8.036	.005	56.892	.000
Age	10.661	.000	3.650	.006
IA	31.185	.000	15.985	.000
Depletion * Age	2.730	.030	2.435	.048
Depletion * IA	20.599	.000	38.161	.000
Age * IA	3.732	.000	3.916	.000

Note: $p < 0.05$, the same below.

From Table 1, we can know the following. The main effect of ego depletion is remarkable. The main effect of age is remarkable. The main effect of the interest area is remarkable. The interaction between ego depletion and age is remarkable. The interaction between the ego depletion and the interest area is remarkable. The interaction between age and the interest area is remarkable.

In [14], the association ability is composed by the divergent association ability and the convergent association ability. Experiment 1 has studied the divergent association ability. In order to carry on comprehensive research on the associative ability, we designed Experiment 2 to study the convergent association ability.

5. **Experiment 2.**

The experiment is to test the convergent association ability of college professors.

5.1. **Participants and settings.**

The participants were composed of teachers with academic graduate qualifications and above, and the experimental effective data is 50, of whom 25 were men, 25 were women, 20-30 years old were tested 10, 31-40 years old were tested 10, 41-50 years old were tested 10, 51-60 years old were tested 10, over age 60 were tested 10. All the experimenters had not participated in similar experiments before. The vision or correction vision was normal, colorless blind and color weakness, volunteered to participate in the experiment, after the experiment they can get a gift.

5.2. **Stimulus and apparatus.**

The experimental apparatus is the same as Experiment 1.

The ego depletion experimental stimulus is the same as the divergent association experiment. According to the Jill Ford's divergent thinking test, we make the convergent associative experimental stimulus. Synonyms of "elation" are selected from the synonym dictionary. According to the interpretation of these words showed in the dictionary, we make the stimulus as follows (see Figure 4). Except area 2, 3, 5, 6, the rest is the synonym for elation. The number of the interest areas is larger, the less relevant to the word. The number in the stimulus is the area of interest number, during the formal experiment, the numbers will be hidden.

5.3. **Procedure.**

The experimental procedure is the same as Experiment 1.

6. **Discussion.**

6.1. **Heat maps.**

Figure 5 shows a heat map of the association process of college professors under different loss levels. Figure 5(a) represents the heat distribution of college professors under low ego depletion; in the low ego depletion, the hot spots of college professors are more concentrated in the area of interest 8, 9. Figure 5(b) represents the heat distribution of college professors under high ego depletion. With high ego depletion, the concentrations of college professors are the interest area 1 and 4. Through the observation

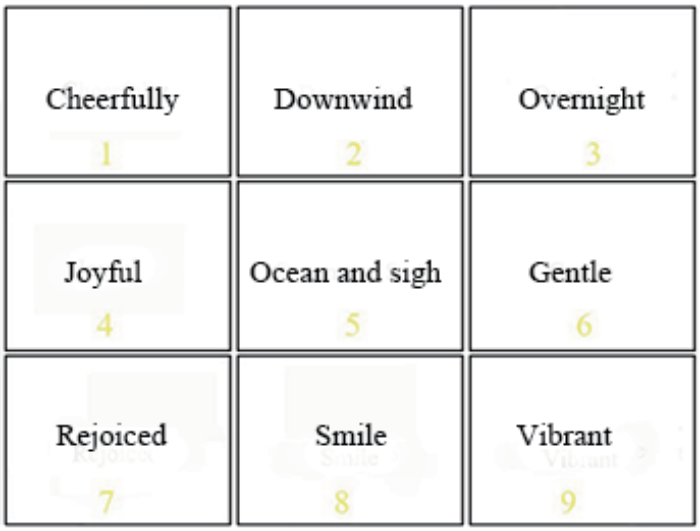
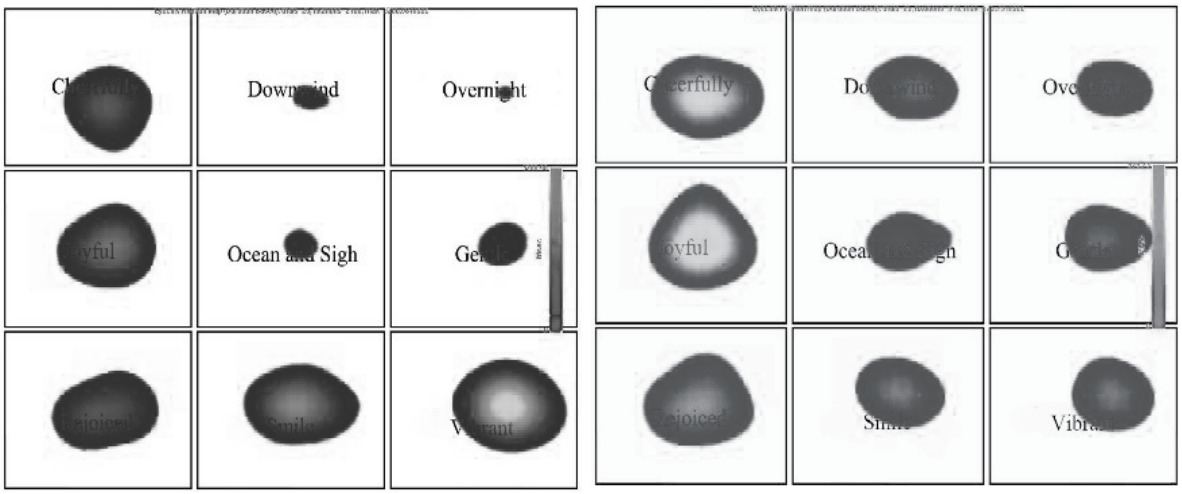


FIGURE 4. Controlling associative experimental stimulus



(a) (b)

FIGURE 5. Control association heat maps

of these two pictures, we can see that: 1) compared with the high ego depletion of teachers, low ego depletion teachers have a stronger association ability; they can better deal with the information given by the test questions; the unrelated words area 2, 3 have less heats; 2) After experiencing high ego depletion, the association ability of college professors decreases.

6.2. **Statistical analysis.** Through SPSS software, independent sample T test was carried out on the experimental data. The invalid data have been deleted. The results showed that there is a significant difference in the regression count of the participants with different ego depletion, $t = 3.54$, $p < 0.05$, $M_{low} = 2.41$, $M_{high} = 2.98$. The more regression count from the participants with high ego depletion, the more difficult information processing. The total fixation duration of the participants with different ego depletion is significant, $t = 2.52$, $p < 0.05$, $M_{low} = 1638.95$, $M_{high} = 1881.28$. Low ego depletion is easier to process the information, and the total fixation duration is shorter. The ANOVA analysis results are shown in Table 2.

From Table 2, we can know the following. The main effect of ego depletion is remarkable. The main effect of age is remarkable. The main effect of the interest area is remarkable.

Table 2. ANOVA analysis summary table

	Regression count		Total fixation duration	
	F	p	F	p
Depletion	34.833	.000	8.998	.003
Age	10.700	.000	2.779	.027
IA	11.898	.000	12.695	.000
Depletion * Age	.673	.611	2.457	.046
Depletion * IA	12.239	.000	7.600	.000
Age * IA	2.396	.000	3.084	.000

The interaction between ego depletion and age is remarkable. The interaction between the ego depletion and the interest area is remarkable. The interaction between age and interest area is remarkable.

7. **General Discussion.** In this paper, two experimental tasks of divergent association and convergent association were used to investigate the influence of ego depletion on the associative ability of college professors. It was found that the performance of high ego depletion group in these two experimental tasks was significantly lower than that of low ego depletion group. The regression count and total fixation duration were shorter in the area requiring higher associative ability. Associative ability as a kind of psychological ability, a way of thinking, [15] not only depends on their own congenital ability basis, but is also related to the life experience of participants. Experienced people are more informed, able to process information faster and generate more creative ideas. The older participants generally have more life experience than younger participants, but in the same ego depletion group, the consumption of self-control resources is more than the younger participants, and influenced their experimental performance of associative. Therefore, we should pay high attention to the ego depletion of college professors. There is no significant difference in the performance of gender in associative experiment. The main reason may be that women are better at open creative thinking. They had stronger processing ability of information that can make up for the ego depletion.

From [16], we can reduce the influence of ego depletion on college professors' associative ability by motivating them to mobilize more self-control resources and compensating for ego depletion. The implementation of specific measures can be done in the following method, through proper rest, (such as the midday rest) to make the former ego depletion compensation, through some reward, (such as more bonuses, a longer vacation time) for college professors incentive, make it can mobilize more residual energy at work to complete the task.

8. **Conclusion.** The main conclusions are as follows: 1) ego depletion will affect the association ability of college professors; 2) the association ability of college professors with the same ego depletion is significantly different in age, and the difference in gender is not significant; 3) the influence of ego depletion on the associative ability of college professors increases with age.

In the study, the degree of ego depletion is only two conditions. We can set multiple degrees to have a more comprehensive understanding on the ego depletion effect of the college professors in the future. In addition, the foundation of psychological ability that makes up the academic imagination of college teachers also includes academic evaluation ability, etc. Future research can take these psychological abilities as research objects to have a more comprehensive understanding of the psychological ability of academic innovation of college teachers. In addition, other factors affecting academic innovation of college teachers can also be explored in the future, and appropriate measures can be

proposed to improve academic innovation of college teachers, provide more innovative results for schools, and provide support for the development of the country in the era of innovation.

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