Cognitive Fatigue in Memory Task Error of Middle School Students based on Brain Evoked Potential

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ABSTRACT

In order to study the cognitive fatigue behavior in false memory, this paper mainly studies related behavior data and brain evoked potential characteristics in cognitive fatigue. Based on the middle school students' fatigue degree in the recognition of false word memory and the characteristics of Brain evoked potential characteristics of recognition judgment, the study uses the research mode of "learning-recognition" to analyze and compare the behavioral features and Brain evoked potential characteristics of different cognitive fatigue in false word memory tasks. The study finds that in the false word memory tasks, the correct rate of correct memory is significantly higher than the correct rate of correct negation, and the P200 amplitude of correct negation is significantly lower than that of missing report while the LPC amplitude induced by the frontal area of the brain in the high cognitive fatigue group is more positive. The latency of N100 and P200 in the high cognitive fatigue group is significantly shorter than that of non-cognitive fatigue and the N100 amplitude in the high cognitive fatigue group is significantly higher than that of the non-cognitive fatigue group in most cases. The experiments show that the use of cognitive fatigue as a measure of individual cognitive ability is very effective.

Key Words: False Memory; Vocabulary, Cognitive Fatigue, Memory Tasks, ERP

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Introduction

From ancient times to the present, people's study of memory has never stopped. For humans, memory is both familiar and mysterious. With the development of science, people not only elucidate memory in various ways in theory, but also use various scientific and technological methods to conduct related research on memory (Fiene *et al.*, 2018). At the behavioral level, many researchers use the he associative false memory under DRM paradigm, namely, word-based false memory (Moore *et al.*, 2017); and some scholars use the event-based false memory under KK paradigm (Yang *et al.*, 2017). In terms of science and technology, methods such as Event-Related Potential (ERP), functional Magnetic Resonance Imaging (fMRI), Eye Movement Technique (EMT), and Positron-Emission Tomography (PET) have emerged examine the neurophysiological mechanisms of memory (Li *et al.*, 2016). ERP has a great advantage in studying the activity of cerebral cortex, and can further analyze the activities of nerve cells at the cerebral cortex during memory process, which provides more evidence for the recognition, analysis and correction of false memory (Biedermann *et al.*, 2016). In 1932, Bartlett began to study the false memory, which was more than 80 years ago. In the study of false memory, the study of influencing factors has great significance.

The influencing factors of false memory include: learning materials, test process and individual characteristics (Lamti *et al.*, 2016). Differences in presentation styles, presentation time, and processing levels of materials can lead to gaps in the aspect of cognition and analysis of

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the learners (Wang *et al.*, 2016); in test process, whether the comprehensive reception channel of tactus, olfaction, vision and audition or single reception channel should be adopted can have great impact on the accuracy of memory (Sundgren *et al.*, 2015). The scenarios, times, warnings, cues, etc. of tests will also produce similar results (Fallon *et al.*, 2015); the individual's own learning style, cognitive level, personality characteristics, anxiety level and mental status will also exert relevant impact on false memory (Park *et al.*, 2015). Thus, it can be seen that many factors can lead to false memory. Therefore, on the one hand, we need more exploration to have a deeper understanding of the relevant factors that cause false memories; on the other hand, in the process of relevant experiments, we also need to avoid the interference of results caused by unfavorable factors.

The application of ERP has some notable features in studying false memory tasks. Since false memory is a special case of correct memory, it seems to the outside world that false memory is whether the questions can be correctly answered, but there are different mechanisms in Brain evoked potential. Studies have suggested that false memory is actually the participation of implicit memory and that correct memory is the realization of explicit memory (Strauss *et al.*, 2015). When the evoked words are very close to the target words, the subjects often show more false judgment. In Brain evoked potential, different brain regions and different waveforms are induced. In the classical research mode of "learning-recognition", the new and old effects of word recognition will occur, which means that the old words produce a more positive ERP late positive component (LPC) than new words. In the same way, the new and old effects of re-judgment will be disturbed by three factors of false memory. Figure 1 shows the measurement mode of Brain evoked potential.

Cognitive fatigue refers to the sense of fatigue and tiredness experienced during the learning process. It can also be regarded as the reaction of psychological fatigue in individual cognitive aspect. When the degree of cognitive fatigue is too high, it will have a series of adverse effects on the students' learning, and they may present emotional expressions as disgust, irritability, resistance and desolateness, which is not conducive to further learning (Bridwell *et al.*, 2015). At present, there are relatively few researches on cognitive fatigue in student learning. This study hopes to provide further thinking for relevant researches through the analysis of middle school students' relevant characteristics of cognitive fatigue through word-based false memory and relevant features of EGG analysis.

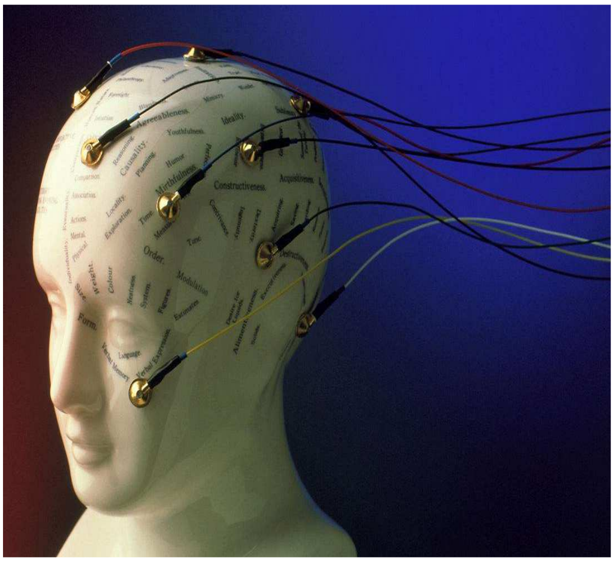

Figure 1. Measurement Mode of Brain evoked potential

Methods

Research Objects

This experiment selected the first-year junior high school and the second-year junior high school of 6 middle schools in S city. It adopted simple random sampling to select a class in each school and conducted a Raven's Standard Progressive Matrices (SPM) test for a total of 576 students. The subjects with IQ lower than 80 were excluded and the remaining 570 students were required to complete the Questionnaire on Cognitive Fatigue in Students' Learning Process and relevant evaluation was conducted afterwards. According to the above criteria, high cognitive fatigue group and non-cognitive fatigue group were selected from all the participants. There were 30 students in high cognitive fatigue group and 20 students in the non-cognitive fatigue group. The four dimensions of subjects in high cognitive fatigue group were higher than the critical value. There were 28 males and 22 females (as shown in table 1).

Table 1. Information Table of Subjects

Group	Count	Average age	Gender	
			Male	Female
Non-cognitive fatigue	20	13	8	12
High-cognitive fatigue	30	13	20	10

Research Methods

The 2 (degree of cognitive fatigue: high, non)×4 (recognition conditions: correct memory, false report, correct negation, missing report)×5(brain area: frontal area, temporal area, occipital area, central area, and top area), the mixing of three factors is adopted to conduct experimental design. The degree of cognitive fatigue is the intergroup variable; the recognition condition and the brain area are the intragroup variables; the degree of cognitive fatigue, conditions of recognition, and brain areas are the independent variables; he response time, the correct rate, and the peak value and latency of brain waves are the dependent variables.

This study adopts the learning-recognition paradigm task and there are three blocks in the experiment. The first block is used for practice, which contains the learning phase and recognition phase. There are 10 words in the learning phase and 20 in the recognition phase. Ten words were previously presented and 10 words are newly added in the recognition phase. in the latter two blocks for formal experiment, the learning period in each block contains 48 words and the purpose of the first and the last four words is to eliminate the proactive inhibition and retroactive inhibition of the memory. There are 80 words in the recognition phase, of which 40 are previously learned and 40 words are newly added. All the words selected are two-character words. Before the beginning of the experiment, the subjects carefully read the instruction and do exercises carefully until the beginning of the experiment.

Subjects are interviewed after completing the experiment and the interview is recorded with a voice recorder. The content of the interview mainly involves the features, time, difficulty of extraction, feelings, etc., of memory fatigue produced during the the experiment as well as some related problems. The laboratory's ERP recording and analysis system produced by Germany's Brain Product company is used and the EGG is recorded using the 32-lead electrode cap extended according to international 10-20 system. The four waveforms (correct memory, correction negation, missing report, false report) under the recognition conditions in the reaction process of subjects are extracted to conduct superposition averaging.

Research Results

(1) Behavioral Features of Middle School Students in Word-based False Memory Tasks

Table 2 shows the comparison results of accuracy of subjects in word-based false memory tasks and it can be seen from this table that the accuracy of correct memory is 76.00%, and the accuracy of correct negation is 58.00%. The accuracy of correct memory is significantly higher than that of correct negation.

Table 2. Average Accuracy in Word-based False Memory Tasks

Task Type	Count(N)	Accuracy(SE)
Correct memory	50	76.00%(0.021)
Correct negation	50	58.00%(0.028)

(2) LPC Characteristics of Middle School Students in Word-based False Memory Tasks

A two-factor repeated measure variance analysis is performed on the late positive component (LPC) of the 500ms-1000ms time window. The results show that the main effect of the judgment condition is not significant, and the interaction between the judgment and the brain regions is also not significant.

(3) N100 Characteristics of Middle School Students in Word-based False Memory Tasks

The two-factor repeated measure variance analysis of subjects is conducted on the N100 amplitude between 50ms-250ms. The results indicate that the main effect of the judgment conditions is not significant, and that the main effect of the judgment conditions and the interaction of brain regions is also not significant. The two-factor repeated measure variance analysis of subjects is conducted on the N100 latency between 50ms-250ms. The results indicate that the main effect of the judgment conditions is not significant, but that main effect of the interaction effect between judgment conditions and brain areas is significant. F (12,288) =2.285, $p< 0.05$. Further simple effect analysis is conducted on the interaction effect and the results are shown in Table 3. The four recognition conditions are significantly different in the central area but are not significantly different in other brain regions.

Table 3. Differences of N100 Latency in Each Brain Area in Word-based False Memory Tasks

P	Task Type	SS	DF	MS	F
0.015	Central area	6123.42	3	2044.14	3.74
0.810	Frontal area	482.13	3	160.71	0.28
0.600	Pillow area	529.11	3	176.37	0.64
0.553	Top area	309.56	3	103.19	0.70
0.223	Temporal area	2795.67	3	931.89	1.37

(4) P200 Characteristics of Middle School Students in Word-based False Memory Tasks

No only N100 is induced, but also P200 is induced when the subjects are completing the word-based false memory tasks. The repeated measure variance analysis is performed on the amplitude and latency of P200 to illustrate the characteristics of P200 induced by the subjects.

The two-factor repeated measure variance analysis of subjects is conducted on the P200 amplitude between 150ms and 250ms, F(3,72)=3.152, p<0. 05. The main effect of the interaction effect between judgment conditions and brain areas is significant, F(5,117)=2.792, p<0.05. Further simple effect analysis is conducted and the results are shown in Table 4, from which we can see the differences of P200 amplitude in various brain regions.

Table 4. Differences of N200 Latency in Each Brain Area in Word-based False Memory Tasks

Task Type	SS	DF	MS	F	P
Central area	45.23	3	15.08	1.54	0.205
Frontal area	40.35	3	13.45	1.53	0.207
Pillow area	52.74	3	17.58	1.82	0.164
Top area	51.35	3	17.12	2.13	0.098
Temporal area	201.34	3	67.11	8.23	0.000

The two-factor repeated measure variance analysis of subjects is conducted on the P200 latency between 150ms and 250ms. The main effect of the judgment conditions is not significant and the interaction effect between the judgment condition and brain areas is also not significant. This is consistent with the reports in the literature. There is no difference in the amplitude of subjects of middle school students under the four conditions.

(5) LPC Characteristics of Subjects in Word-based False Memory Tasks in Different Cognitive Fatigue Groups

It can be seen from Table 5 that amplitudes of F8, Fp1, and Fp2 are high under the correct negative conditions and there is no difference in different cognitive fatigue groups. The mean and standard deviation of three electrode points are shown in the table respectively. The LPC of subjects in high cognitive fatigue group is higher. Different amplitudes are induced by the same false memory tasks for subjects in different cognitive fatigue groups, indicating that there is a certain difference in the cranial nerve mechanism in high cognitive and no-cognitive fatigue groups.

Under correct negation conditions, there is difference in the LPC waveform of three electrodes F8, Fp1, Fp2. After the grand mean of LPC, the waveforms in high cognitive and no-cognitive fatigue groups are compared. There is significant difference in F8 and Fp2 in high cognitive and no-cognitive fatigue groups. Although the difference of Fp1 is not particularly noticeable, the data indicates that there is significant difference in Fp1 in high cognitive and no-cognitive fatigue groups. The LPC oscillogram correction of subjects in high cognitive fatigue groups can be clearly seen, indicating that there is a significant difference in the LPC waveforms between high cognitive and no-cognitive fatigue groups in the flase memory tasks. memory task group, and the waveform correction of subjects is induced in the high cognitive fatigue group.

Table 5. LPC Amplitude on Electrode F8, Fp1, and Fp2 in Different Cognitive Fatigue Groups (M±SD)

Group	Correct negation (F8)	Correct negation (Fp1)	Correct negation (Fp2)
High-cognitive fatigue	3.12±5.37	2.52±5.14	2.98±7.76
Non-cognitive fatigue	-1.63±4.78	-3.92±8.35	-4.82±9.97

(6) N100 Characteristics of Subjects in Word-based False Memory Tasks in Different Cognitive Fatigue Groups

As it can be seen in Table 6, the amplitude of each electrode is higher in high cognitive fatigue subjects, and it is recognized that there is a comparison of the mean value of different electrodes under recognition conditions. The N100 amplitudes of some electrodes of the subjects in the high cognitive fatigue group and non-cognitive fatigue are different in the cases of correct negation, missing report, and false report.

Table 6. N100 Amplitude on Different Electrode in Different Cognitive Fatigue Groups (M±SD)

		High-cognitive fatigue	Non-cognitive fatigue
Correct negation	C3	-5.12±4.03	-0.32±5.37
	Cz	-5.98±4.02	-1.35±4.72
Missing report	C3	-5.53±4.63	0.21±8.54
	C4	-3.02±4.56	0.72±3.92
	Cz	-7.86±5.03	-0.23±6.99
False report	C3	-6.03±4.32	0.34±2.02
	F3	-7.92±6.33	-1.34±5.03
	F7	-7.07±6.82	-0.53±5.43
	Fz	-7.46±6.02	-1.62±5.72

The N100 amplitude of subjects in two groups is detailed in the table. Thus, it can be seen that the N100 amplitude induced by false memory tasks in different cognitive fatigue groups is different, and the N100 amplitude of subjects with high cognitive fatigue level is relatively large.

The N100 amplitude of subjects in high cognitive fatigue group is relatively large and is farther away from the horizontal axis, while the N100 amplitude of subjects in non-cognitive fatigue group is closer to the horizontal axis and is relatively smaller.

The subjects in high cognitive fatigue group consume more attention and memory resources when completing the false memory tasks and the amplitude induced is also greater. The subjects in non-cognitive fatigue group consume less cognitive resources and the N100 amplitude induced is smaller.

The N100 latency between 50ms-250ms in high cognitive and non-cognitive fatigue groups is analyzed and one-way analysis of variance is used to analyze the latency characteristics of the two groups of subjects. After analysis, the degree of cognitive fatigue is significant in all brain regions in both high cognitive and non-cognitive groups and the latency of non-cognitive fatigue group is significantly greater than that of high cognitive fatigue group.

Table 7 selects Cz, Fz, Oz, Pz, and T8 as the representative for each judgment condition, and presents the average of the latency of N100. In the word-based false memory task, N100 waveform is successfully induced in these two groups of subjects and there is significant difference in all the five brain regions selected. Moreover, there is significant difference in all electrode points in each brain region. In the table, the average and standard deviation of the latency for each electrode point in the high cognitive and non-cognitive fatigue group under four recognition conditions are listed, and it can be seen that the latency of non-cognitive fatigue group is higher than that of high cognitive group, which indicates that there is a significant difference in the latency of the brainwave induced by the false memory tasks in the high cognitive and non-cognitive fatigue group.

The latency of N100 is higher in the high cognitive group; on the contrary, the latency in the non-cognitive group is relatively lower. The difference in these two groups is shown in the selected 5 brain regions and 20 electrode points. Thus, it can be seen that the subjects in the high cognitive and non-cognitive fatigue group not only differ in behavioral characteristics, but also differ in brainwaves at the physiological level.

Table 7. Latency of Different Electrodes on N100 in Different Cognitive Fatigue Groups (M±SD)

		High-cognitive fatigue	Non-cognitive fatigue
Correct memory	Cz	98.35±35.09	130.89±45.65
	Fz	102.45±32.45	192.34±46.89
	Oz	65.73±43.75	180.48±40.89
	Pz	80.78±39.64	197.59±33.56
	T8	85.72±23.67	185.01±66.73
Correct negation	Cz	99.75±35.66	201.36±47.78
	Fz	97.32±29.17	186.84±77.73
	Oz	70.21±18.01	195.75±30.04
	Pz	95.11±33.12	187.63±40.14
	T8	70.08±30.57	201.11±35.85
Missing report	Cz	120.67±20.19	231±53.72
	Fz	101.35±40.13	187.31±60.47
	Oz	79.93±60.17	192.76±24.42
	Pz	107.35±45.94	220.57±31.72
	T8	70.15±35.75	193.02±50.18
False report	Cz	97.15±37.24	173.19±60.57
	Fz	107.23±32.16	167.83±43.09
	Oz	69.05±43.53	175.79±45.73
	Pz	100.03±33.26	201.73±15.64
	T8	88.16±36.88	220.20±22.32

(7) P200 Characteristics of Subjects in Word-based False Memory Tasks in Different Cognitive Fatigue Groups

The one-way analysis of variance is used to analyze the P200 amplitude between 50ms-250ms in in the high cognitive and non-cognitive fatigue group and the difference between different fatigue groups in each brain region is not significant.

The P200 latency between 150ms-250ms in the high cognitive and non-cognitive fatigue group is analyzed and the one-way analysis of variance is used to analyze the latency characteristics of the subjects in two groups. After analysis, the degree of cognitive fatigue in the high cognitive and non-cognitive fatigue group is significant in all brain regions and the latent period of non-cognitive fatigue group is significantly greater than that of high cognitive fatigue group.

The electrodes Cz, Fz, Oz, Pz, and T8 under each recognition condition are selected as the representative, presenting the average and standard deviation of P200 latency. From table 8, it can be seen that the difference of latency in the high cognitive and non-cognitive fatigue group in each brain region is significant and the latency of the non-cognitive group is significantly greater than that of the high cognitive group. The difference of latency in the high cognitive and non-cognitive fatigue group at 20 selected electrodes is also significant and the latency in non-cognitive fatigue group is greater than that in the high cognitive group. Under recognition conditions, the difference of subjects in the high cognitive and non-cognitive fatigue group is significant and the P200 latency is different both in the correct and false memory, indicating that there is difference in terms of physiological indicators in different fatigue groups.

Table 8. Latency of Different Electrodes on P200 in Different Cognitive Fatigue Groups (M±SD)

		High-cognitive fatigue	Non-cognitive fatigue
Correct memory	z	189.43±24.51	229.73±15.14
	z	193.13±20.67	221.52±19.14
	z	156.73±10.56	251.49±8.27
	z	172.45±15.46	241.15±9.16
	8	173.24±31.76	245.09±40.15
Correct negation	z	182.15±31.57	230.91±13.21
	z	183.37±30.16	224.28±21.13
	z	160.03±6.78	230.15±26.58
	z	170.32±21.45	243.56±10.04
	8	166.87±25.14	243.34±6.01
Missing report	z	181.24±13.03	250.76±15.37
	z	190.34±14.61	220.19±34.52
	z	162.37±13.11	235.69±7.31
	z	173.24±23.72	252.31±8.94
	8	171.35±15.67	222.64±25.56
False report	z	189.03±31.04	232.47±15.18
	z	197.41±22.37	222.7±31.14
	z	157.16±9.06	245.78±10.19
	z	173.48±21.04	243.57±10.37
	8	183.68±25.48	263.73±27.78

Discussion and Analysis

The results of the study indicate that in false memory tasks: First, the accuracy of correct memory is significantly higher than that of correct negation; second, the P200 amplitude of correct negation is significantly lower than the that of missing report; third, the LPC amplitude induced by brain frontal area in the high cognitive fatigue group is more positive; meanwhile, the latency of N100 and P200 in the high cognitive fatigue group is significantly shorter than that of the non-cognitive fatigue group; finally, the N100 amplitude of the high cognitive fatigue group is significantly larger than that of the non-cognitive fatigue group in most cases.

Compared with expounding the principle of memory merely from the theoretical perspective, the application of various scientific and technological methods such as Event-Related Potential (ERP), functional Magnetic Resonance Imaging (fMRI), Eye Movement Technique (EMT), and Positron-Emission Tomography (PET) is undoubtedly a greater breakthrough. The Cognitive neuroscience can more intuitively record the various stimulus received by the brain, allowing us to quantify the entire stimulus process, which is more conducive to the deepening of scientific research. However, it also should be noted that the current development of these studies is only at the beginning stage and a lot of work needs to be done.

This study uses ERP to record the process of memory from both the behavioral data and the brainwave data, making it possible to analyze the generation of false memory. The experimental method also further promotes the cognitive neuroscience research of false memory. Through the analysis of the high degree of cognitive fatigue and non-cognitive fatigue, this experiment analyzes not only the difference between the two groups in terms of behavioral characteristics, but also the difference in brain electricity. This indicates that the use of cognitive fatigue as a measure of individual cognitive ability is very effective. This study only conducts relevant discussion in terms of cognitive fatigue to a limited extent and there is still a large amount of work that needs to be done for further exploration and research.

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