

Effects of Spaced Retrieval Training Combined with Errorless Learning on Working Memory in Hypoxic-Ischemic Encephalopathy; A Case Report

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Abstract

Background/Objectives The aim of this study was to investigate the effect of spaced retrieval training combined with errorless learning on working memory in hypoxic-ischemic encephalopathy with single case report.

Methods/Statistical analysis The subject was a 29-years-old man. The intervention was performed for 30 minutes per section and 12 times in total. The outcome measure was used the Rey-complex figure test for the cognitive function especially for memory function.

Findings: The subject showed a significant increase in the memory function after the intervention. As a result of this study, the recall success rate of subjects per session increased by more than 2% to baseline A 25.3%, intervention period B 28.0%, and baseline A' 27.3%. In addition, as a result of the Rey-complex figure test, it was significantly increased by 3.5 points in immediate recall and 3 points in delayed recall.

Improvements/Applications: This study demonstrated space retrieval training combined with errorless learning showed significant increase in the memory function for the hypoxic-ischemic encephalopathy.

Keywords: Cognitive function, Working memory, Hypoxia, Spaced retrieval training, Errorless learning

1. Introduction

Hypoxic-ischemic encephalopathy is a brain disease that causes severe neurological sequelae, such as impaired consciousness or cognitive impairment, and its prevalence is still unknown [1]. Brain tissue is damaged by various causes such as loss of blood supply, lack of oxygen supply, and toxic substances due to high metabolic requirements. Hypoxic ischemic encephalopathy is classified into ischemic, oligemic, anoxic, hypoxic, histotoxic, and anemic according to pathogenesis [2]. After the onset of hypoxic ischemic encephalopathy, consciousness disorders such as a vegetative state or a minimally conscious state begin. If there is a lot of neurological recovery after that, various clinical courses are shown up to the return to daily life, but it is very difficult to predict the prognosis [3]. The most common cause of hypoxic ischemic encephalopathy in adults is cardiac arrest, and other causes include carbon monoxide poisoning. It is known that the mortality rate is 60-85%, and the prognosis is so poor that 50% of the survivors remain with permanent neurological impairment, and only about 10% of patients recover the state before cardiac arrest [4].

In general, cognitive decline occurs in more than 50% of hypoxic ischemic encephalopathy patients. They often experience memory impairment, and attention executive functions also affected. Moreover, physical, cognitive, and behavioral problems occur for more than 6 months, and more than 50% of the survivors are accompanied by dysfunctions in activities of daily living [5,6]. All areas of cognition can be affected after hypoxic ischemic encephalopathy, but memory impairment is particularly common symptom, followed by deterioration of attention and executive function [6]. Previous studies suggest that the hippocampus is important brain structure for memory and it is very sensitive to decrease in cerebral blood flow [7].

Memory impairment that appears after brain injury plays a very important role in human activities of daily living. Memory can be broadly divided into explicit memory and implicit memory. Among them, memory loss

due to brain damage results in damage to explicit memory. Explicit memory refers to the ability to consciously recall or recognize recently processed information [8]. Explicit memory could be divided into two main categories, episodic memory and semantic memory. Episodic memory remembers events in a specific situation, such as what you ate for breakfast, or what happened at work. Semantic memory remembers general facts and events [9].

Spaced retrieval training was first proposed by Landauer and Bjork (1978). It is a memory training method that promotes storage in the learning process by repeatedly recalling the presented information while gradually increasing the recall interval [10]. According to the information used, spaced retrieval training includes object-name association, face-name association, object-topography association, and prospective training. It is applied as a method of performing a prospective memory task [11,12]. Errorless learning is the method of increasing memory efficiency by removing errors that may occur in the process of acquiring information. Errorless learning is mainly used in parallel with spaced retrieval training and gradual vanishing cues technique [13]. However, its effectiveness has not yet been reported in patients with memory impairment, such as patients with hypoxic ischemic encephalopathy.

In this study, we investigate the effect on memory recovery by applying spaced retrieval training combined with errorless learning in a patient with hypoxic ischemic encephalopathy.

2. Materials and Methods

2.1. Subject

The subject of this study was selected as those who were hospitalized in the department of rehabilitation medicine at B hospital located in Seongnam-si in Republic of Korea, and who had been diagnosed with hypoxic ischemic encephalopathy by a specialist in rehabilitation medicine. Patient with brain lesions other than diagnosis or with language problems that could affect functional tests were excluded from the study.

The subject was a 29-year-old male who had an underlying disease called Marfan Syndrome as a child. He was diagnosed with hypoxic ischemic brain injury due to sudden cardiac arrest in the intensive care unit one year ago after heart valve surgery. As a result of the Korean version of the mini-mental state examination(K-MMSE), it was 18 points indicating impairment in memory. When using both hands, he expresses clumsy, and there are no other physical problems. The range of joint motions (ROM) were normal and the general muscle strengths were good grade. As a result of the manual function test (MFT), it was 28/32 on the left and 29/32 on the right.

2.2. Study designs

This study was conducted using the ABA inversion design among the single-subject research design. A total of 12 trials were conducted, and no treatment was performed during baseline phase A and baseline phase A', and basic data are collected during each of the three sessions. The intervention phase B was the treatment period and was conducted for a total of 6 sessions. During the intervention period, treatment was applied once a day, 30 minutes per session.

2.3. Materials

After completing the 40-minute intervention and then 10 minutes resting, patient match the 5 cards with only the day of week were presented for recall the memory training activity, 5 times, a total of 25 times. And we calculated the recall success rate. In addition, the Rey-complex figure test was performed to evaluate the memory function. This test is one of the neuropsychological visual memory tests, and it is a tool to evaluate various cognitive functions such as spatial construction ability, visual perception, visual memory, and executive function including organizational strategy. [14].

We recorded the success rate during at the baseline, and analyzed the patient's data using a graph of the of the measured data for visual analysis method. The average value within the period of each variable is calculated, and the rate of change of each stage is compared and presented. The intervention effect is considered to be effective when a value exceeding the mean ± 2 standard deviation is measured twice in succession during the intervention period [15]. In the analysis of the treatment continuation effect, it is interpreted that there is a treatment lasting effect when it is higher than the average value at the baseline [16]. In addition, as an evaluation before and after intervention, the Rey-complex figure test was performed.

2.4. Methods

The spaced retrieval training applied by modifying the method implemented in the study of Lee (2014)[17]. The intervention performed in a relatively quiet cognitive therapy room and same environment each time.

The training method was that showed a card with matching the day of week-day. And then we said, for example “Remember to do banking on Monday”. For delayed recall, a spaced retrieval training grading to 30 seconds, 1 minute, 2 minutes, 4 minutes, and 8 minutes was used. To prevent errors in recall, if patient do not answer for more than 3 seconds and hesitate or if you do not know exactly and we said that “If you do not remember, please do not guess, and say you do not know. we will give you the answer.”

3. Results and Discussion

The success rate for each session of the subjects was 25.3% at baseline A, 28% in intervention phase B, and 27.3% at baseline A' [Figure 1].

As a result of this study, the subjects did not have any problems in composing ability and imitating drawing. Therefore, results of immediate recall and delayed recall were shown. Out of a total of 36 points, immediate recall improved from 26 to 29.5, and delayed recall improved from 20 to 23. [Table 1].

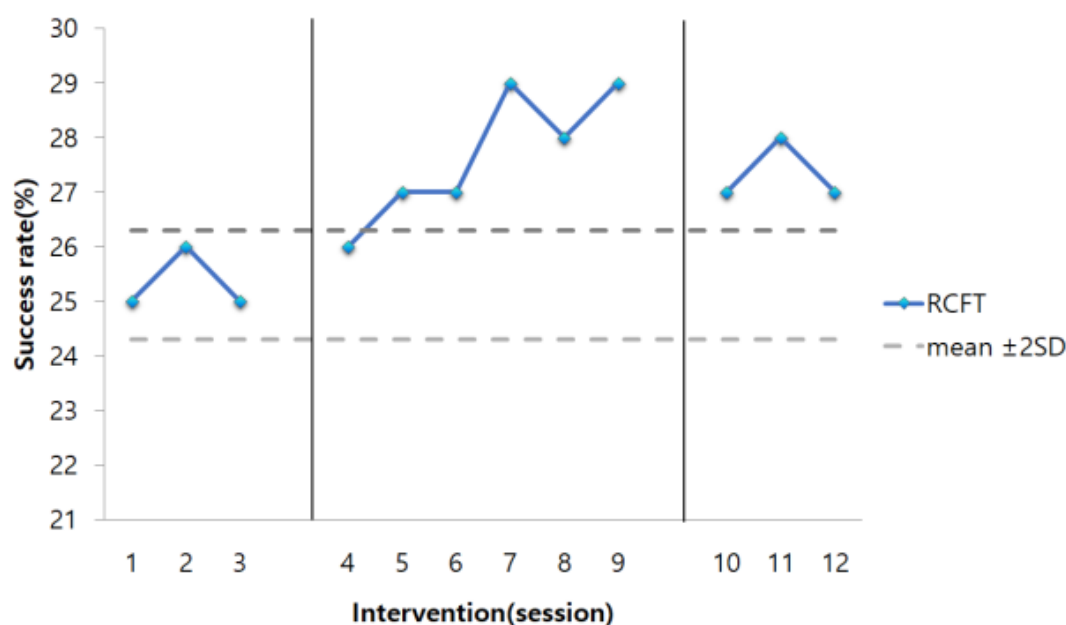


Figure 1. Success rate by daily intervention session

Table 1. Clinical parameters before and after treatment

Item	Pre-test	Post-test
IR	26	29.5
DR	20	23

IR: immediately recall; DR: delayed recall

Hypoxic ischemic encephalopathy frequently causes changes in cognitive and arousal states. These changes in cognitive arousal state appear in various forms, from coma, minimal consciousness state, and vegetative state to mild cognitive decline such as memory [18].

After hypoxic ischemic brain injury, various treatments can be tried for each area of decreased cognitive function. In the case of decreased attention span, self-alerting, brief mindfulness training, computerized cognitive therapy, and so on can be applied for sustained attention. It has been reported that time pressure training is effective when information processing speed is decreased. In addition, for selective attention or

divided attention, it is known that training in tasks related to daily life is more effective [19]. For memory loss, it is recommended to use external auxiliary tools such as smartphones, cameras, positioning devices, and notification services. Also, as a method of cognitive behavioral training that improves memory and enables new learning, spaced retrieval training, mnemonic devices, and errorless learning are representative. [20].

The aim of this study was to investigate the effect of spaced retrieval training combined with errorless learning for memory function in patient with hypoxic ischemic encephalopathy. As a result of this study, the recall success rate of patient per session increased by more than 2% to baseline A 25.3%, intervention period B 28%, and baseline A' 27.3%, and it was found that the average value above the baseline was maintained. Furthermore, as a result of the Rey-complex figure test, it was significantly improved by 3.5 points in immediate recall and 3 points in delayed recall. Regarding the errorless learning, it has reported errorless learning combined with spaced retrieval training is effective for memory function and activities of daily living [21]. Another previous study reported that errorless learning and spaced retrieval training are effective with mild dementia patients, especially in eating [22]. These results indicate that not only the improvement in memory of patients with mild cognitive impairment or dementia, but also other brain damage patients with memory impairment.

In this study, we reported improvement of memory function through spaced retrieval training in parallel with errorless learning in patient with hypoxic brain injury. Lee and his colleagues were reported that the effect of cognitive training was greater in subjects with high cognitive levels [23]. In the case of the subject of this study, the cognitive impairment was mild, and there was no impairment of concentration and orientation except for memory. Therefore, these results are consistent with this study using the same independent variable.

As this study is a single case study, it is difficult to generalize the study results, and it will need to be supplemented through comparative studies with more subjects and other brain injury patients in the future. In addition, it will be necessary to confirm the specificity of the subject and the connection between the improvement of memory and actual daily life activities. Finally, we suggest that spaced retrieval training combined with errorless learning improves the cognitive function in patient with hypoxic ischemic brain injury.

4. Conclusion

This study investigated the effect of spaced retrieval training combined with errorless learning on working memory in patient with hypoxic ischemic encephalopathy. As a result, spaced retrieval training combined errorless learning showed a positive effect on recall by intervention interval, and also reported a significant improvement in memory evaluation before and after intervention.

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6. References

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