

Changes in neural activity in cognitive network after low frequency rTMS: A report of two cases

Youngsu Jung^{1*}, Jaehoon Sim¹, Jaewoo Choi¹, Jongmoon Kim^{1,2}, MinYoung Kim^{1,2†}

Bundang CHA, Department of Rehabilitation Medicine¹, Bundang CHA, Rehabilitation and Regeneration Research Center, CHA University²

Introduction

Dorsolateral Prefrontal Cortex (DLPFC) plays an important role in executive functions, such as working memory and attention. Repetitive Transcranial Magnetic Stimulation (rTMS) is a non-invasive brain stimulation tool that regulates cortical excitability and it is especially proven in motor recovery after brain injury but, there is little report about therapeutic effect on cognition. This study was conducted to observe changes in neural activity in concordance of clinical findings when rTMS was given with low frequency in contra-lesional DLPFC for cognitive function improvement.

Case reports

Protocol Patients received cognitive assessments such as Korean-Mini Mental Status Exam (K-MMSE) and Intellectual Quotient (IQ) before the examination. We performed fMRIs undergoing working memory before and after rTMS. rTMS was applied just before the fMRI with 1-Hz, 55s, 55 trains, 5s interstimulus interval and total 1,100 pulses to the contra-lesional dorsolateral prefrontal cortex (DLPFC). The forward and backward digit spans by the verbal serial numbers were performed as working memory tasks for 30 seconds, resting for 30 seconds, and 5 sets during fMRI scanning (3T GE/IDX scanner, in blood oxygen level dependent signal time-course, using a whole-body radiofrequency coil for signal excitation and an 8-channel phased-array head coil for signal reception using gradient-echo T2-weighted and spin-echo T2-weighted echo-planar sequences). Case 1 Patient A was a 17-year-old woman who complained of right hemiparesis after left basal ganglia hemorrhage. After 6 weeks of intensive rehabilitation, daily activities can be performed with minimal help. Her K-MMSE, IQ, digit span scores at the time of the fMRI are described in Figure 1-(A). Compared to the fMRI without rTMS, fMRI immediately after receiving inhibitory rTMS at contra-lesional DLPFC showed changes in neural activity during working memory task (Figure 2). Case 2 Patient B was a 40-year-old woman who complained of right hemiparesis after tumor removal with a central neurocytoma of the left corpus callosal body area. After 6 weeks of intensive rehabilitation, daily activities can be performed with minimal help. Her K-MMSE, IQ, digit span scores are described in Figure 1-(B). Compared to the fMRI without rTMS, fMRI immediately after receiving inhibitory rTMS at contra-lesional DLPFC showed changes in neural activity during working memory task (Figure 3).

Conclusion

When the inhibitory rTMS was performed on the contra-lesional DLPFC, immediate changes were observed in the superior temporal, inferior frontal lobe or

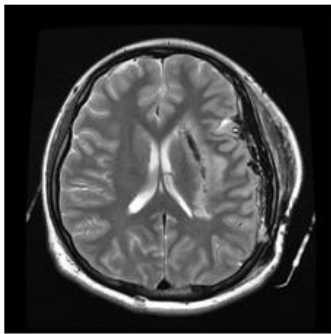
parahippocampal area those play and important role in attention and working memory in both patients. Further study with a larger number of patients and with a longer duration of rTMS treatment will be helpful (This research was respectfully funded by the Ministry of Trade, Industry & Energy (MOTIE) (No.10051152)).

Figure 1. Demographics of patients

(A)

Patients	Age	Brain lesion	Laterality	Onset after injury (days)	K-MMSE score	IQ	Forward digit span	Backward digit span
A	17	Basal ganglia	Left	82	30	84	9	5

K-MMSE, Korean version of mini mental status exam; IQ, full scale Wechsler's Intellectual Quotient

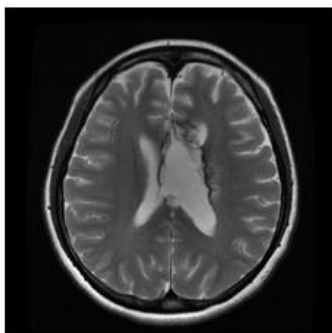


s/p craniectomy and hematoma removal with drainage tube insertion in left basal ganglia and deep white matter

(B)

Patients	Age	Brain lesion	Laterality	Onset after injury (days)	K-MMSE score	IQ	Forward digit span	Backward digit span
B	40	Corpus callosum	Left	80	25	98	9	6

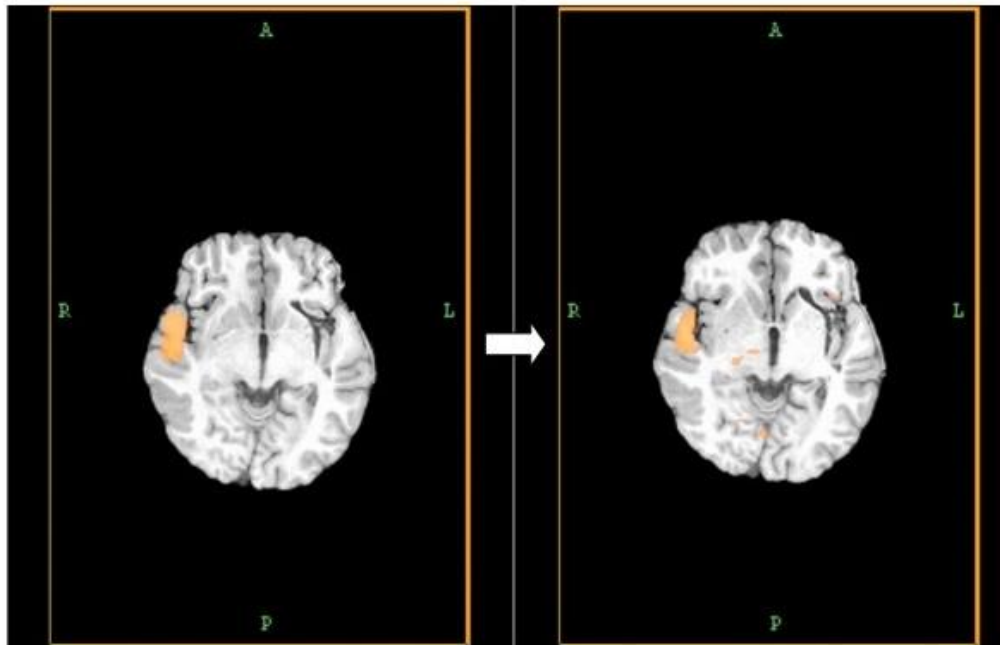
K-MMSE, Korean version of mini mental status exam; IQ, full scale Wechsler's Intellectual Quotient



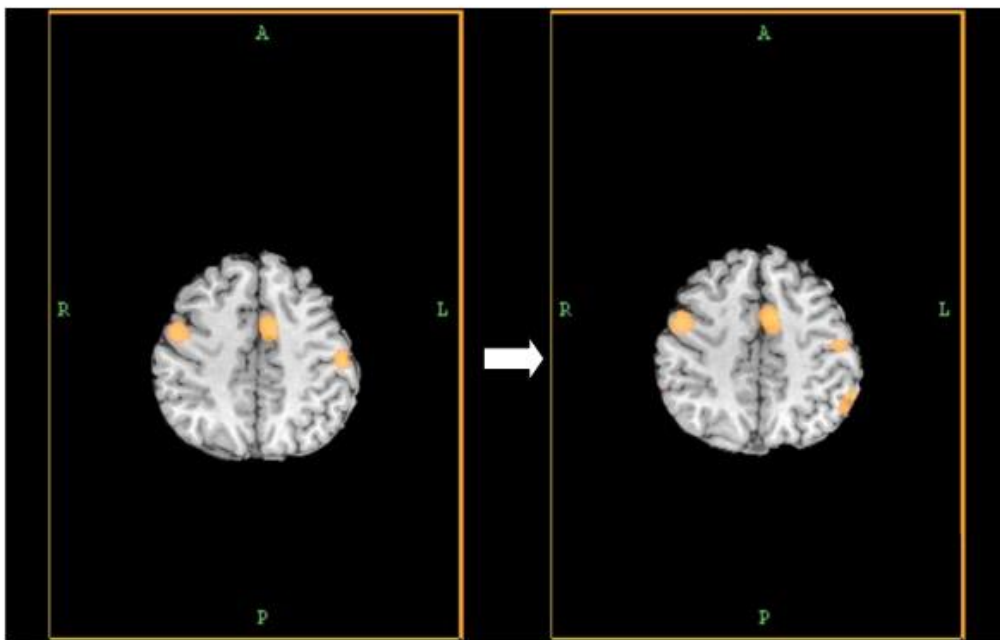
s/p left intraventricular tumor removal with thin contusional injuries in the left periventricular white matter, corpus callosum and anterior portion of the left basal ganglia

Figure 1. Changes in fMRI after inhibitory rTMS on contra-lesional DLPFC in patient A

(A)



(B)



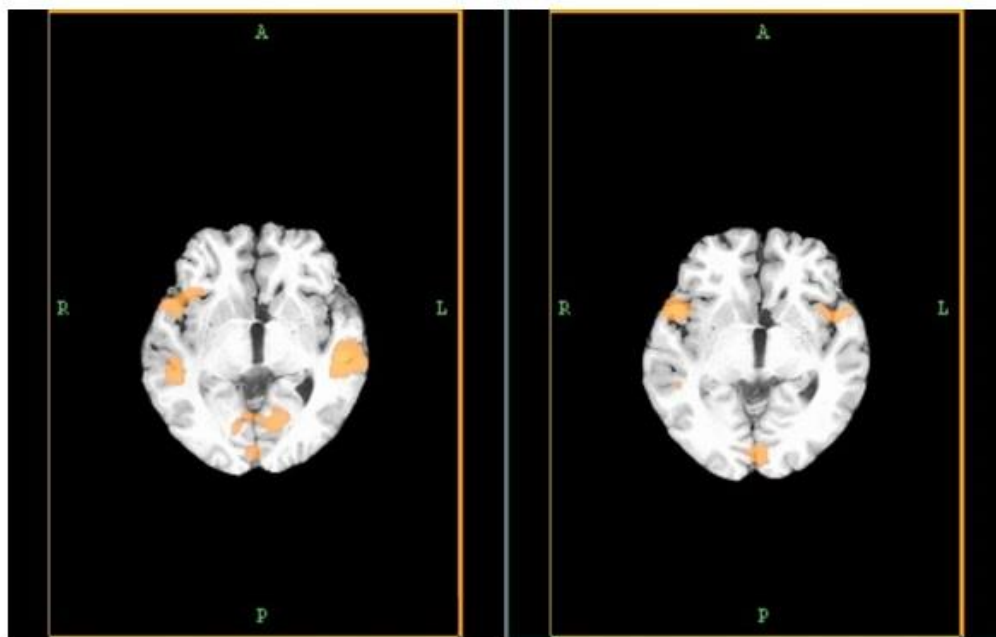
rTMS, repetitive Transcranial Magnetic Stimulation; DLPFC, Dorsolateral Prefrontal Cortex

(A) The activities of the left inferior frontal area and right thalamus were increased.

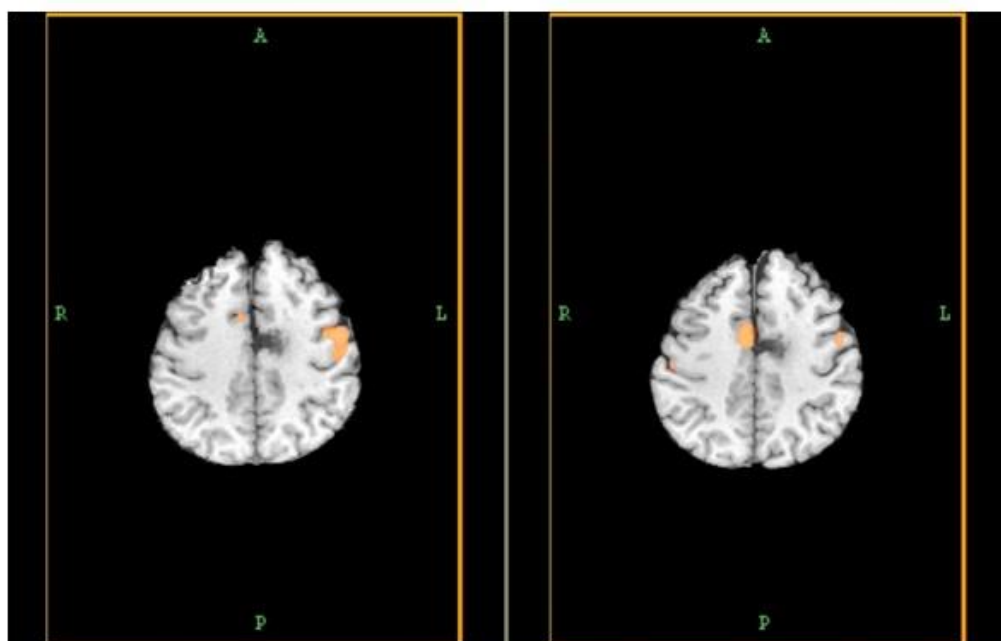
(B) The activity of the left superior temporal area was decreased.

Figure 2. Changes in fMRI after inhibitory rTMS on contra-lesional DLPFC in patient B

(A)



(B)



rTMS, repetitive Transcranial Magnetic Stimulation; DLPFC, Dorsolateral Prefrontal Cortex

(A) The activity of the left parahippocampal area was increased.

(B) The activity of the left superior temporal area was decreased.