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Changes in Brain Network after Excitatory rTMS in Chronic Stroke Patients with Aphasia (Pilot Study)

Jihong Park[1*], Sungmin Cho[1], Won-Seok Kim[1], SuYeon Kwon[1], Nam-Jong Paik[1†]

Seoul National University Bundang Hospital, Department of Rehabilitation Medicine[1]

Introduction
In post-stroke aphasia rehabilitation, repetitive transcranial stimulation (rTMS) aimed to reinforce the activity of the brain regions in the left hemisphere. In the present study, we performed functional near-infrared spectroscopy (fNIRS) with excitatory rTMS treatment for selection of the most appropriate application of stimulation and detection of the changes in cortical brain network. The purpose of this study is to assess the changes in brain network after excitatory rTMS in post-stroke non-fluent aphasia patients.

Methods
Five right-handed patients with post-stroke non-fluent aphasia were included in this study. Excitatory rTMS (10Hz, 800 stimuli, 100% of resting motor threshold, tangential to the scalp) at the most activated area in Broca or Wernicke area with navigation system was done in combination with 30 minutes' speech therapy for 10 days. Western aphasia battery (WAB) and fNIRS evaluation before (T0), right after 10 sessions of treatment (T1) and 2 months after the last treatment session (T2) were done. 34 channels were set by arranging 12 sensors and detectors at intervals of 3cm covering Broca and Wernicke area according to the international 10-20 electroencephalography system (Figure 1). Wilcoxon signed-ranks tests were used to evaluate potential improvement in WAB. The most activated area of the left hemisphere in fNIRS analysis was selected for stimulation. The changes in brain network were analyzed by the graph theoretical approach.

Results
 The scores from subtests in WAB have increased after excitatory rTMS combined with speech therapy in all subjects (Figure 2). The thresholded correlation in the area of stimulation became higher in all patients. The changes of network parameters such as global efficiency and small-worldness in Broca and Wernicke area was significant after rTMS in all patients (Figure 3).

Conclusion
 Aphasia quotient and scores from all subtests in WAB have increased significantly after targeted excitatory rTMS combined with speech therapy in all subjects. The efficiency of brain language network has been changed after excitatory rTMS.
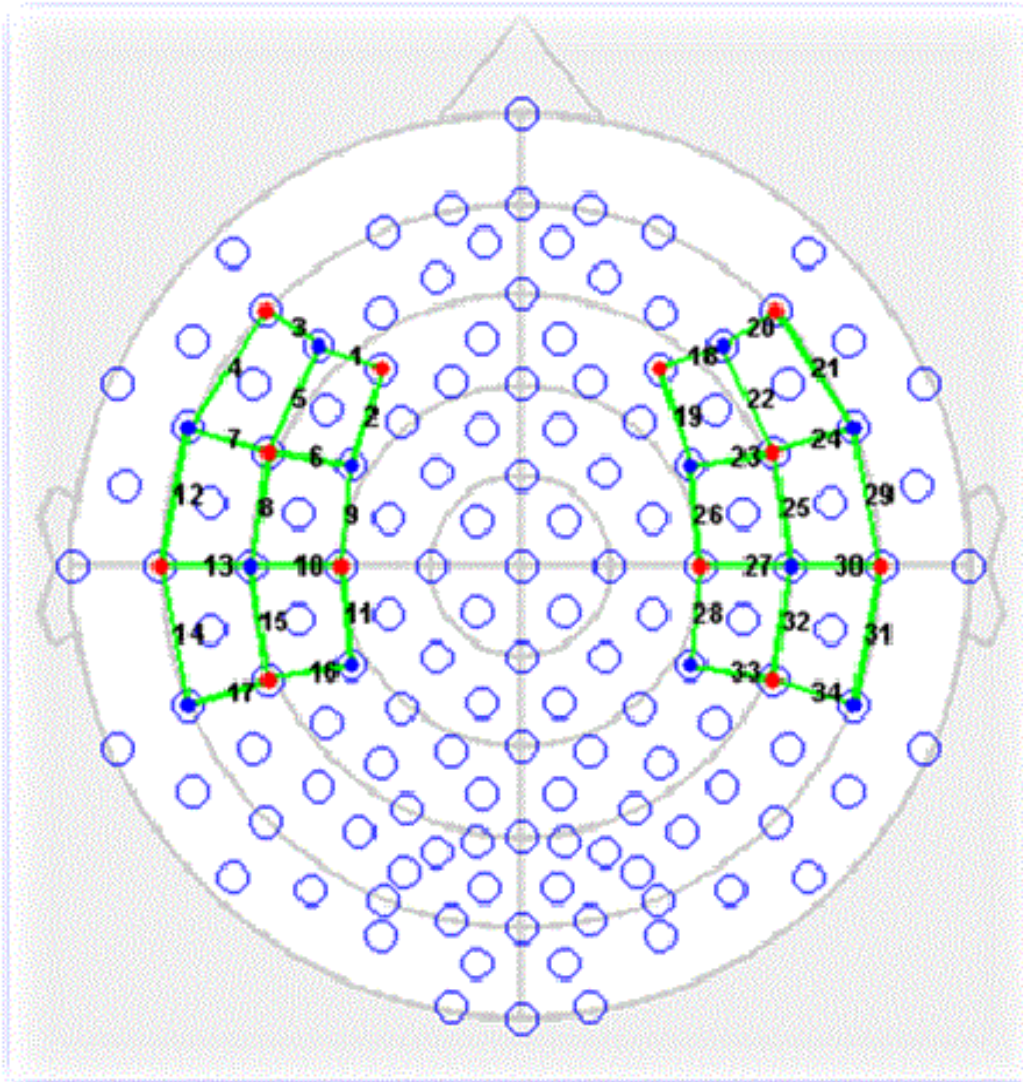
34 channels were set by arranging 12 sensors and 12 detectors at intervals of 3cm covering Broca and Wernicke area according to the international 10-20 electroencephalography system.

Subject 1 — 49/M, Left Middle Cerebral Artery Infarction (2015-2), Global Aphasia, Right handed

Activated channel: 4 (Broca Area)

	Speech	Repeat	Reading	Comprehension	Naming	Writing	AQ / LQ
T0	13	16	59	142	43	45	52.0 / 53.9
T1	14	12	66	140	62	49	56.8 / 58.4
T2	14	22	65	152	40	47	55.6 / 57.8

Subject 2 — 67/F, Left Middle Cerebral Artery Infarction (2010-5), Global Aphasia, Right handed

Activated channel: 8 (Broca Area)

	Speech	Repeat	Reading	Comprehension	Naming	Writing	AQ / LQ
T0	7	16	45	89	7	18	27.6 / 25.0
T1	9	20	41	91	16	16	34.4 / 33.1
T2	9.5	24	39	116	15	13	38.4 / 35.4

Subject 3 — 45/M, Left Basal Ganglia Infarction (2014-07), Anomic Aphasia, Right handed

Activated channel: 15 (Wernicke Area)

|	Speech	Repeat	Reading	Comprehension	Naming	Writing	AQ / LQ
T0	19.5	100	100	197	94	99	97.6 / 98.4
T1	19.5	100	100	200	100	100	99.0 / 99.5
T2	20	100	100	200	95	100	99.0 / 99.5

Subject 4 — 60/M, Left Middle Cerebral Artery Infarction (2014-11), Global Aphasia, Right handed

Activated channel: 13 (Wernicke Area)

	Speech	Repeat	Reading	Comprehension	Naming	Writing	AQ / LQ
T0	8	60	29	96	51	28	47.8 / 40.1
T1	9	80	54	130	47	31	56.4 / 51.7
T2	8	86	50	126	49	30	55.6 / 50.1

Subject 5 — 60/F, Left Basal Ganglia Hemorrhage (2010-10), Global Aphasia, Right handed

Activated channel: 13 (Wernicke Area)

	Speech	Repeat	Reading	Comprehension	Naming	Writing	AQ / LQ
T0	14.5	22	54	146	78	36	63.6 / 57.1
T1	14.5	28	60	159	82	41	67.0 / 61.6
T2	12.5	34	65	148	62	32	59.0 / 54.3

The scores from subtests in WAB have increased after excitatory rTMS combined with speech therapy in all subjects. The activated channel of the left hemisphere in each patient was selected as the stimulation site for excitatory rTMS.
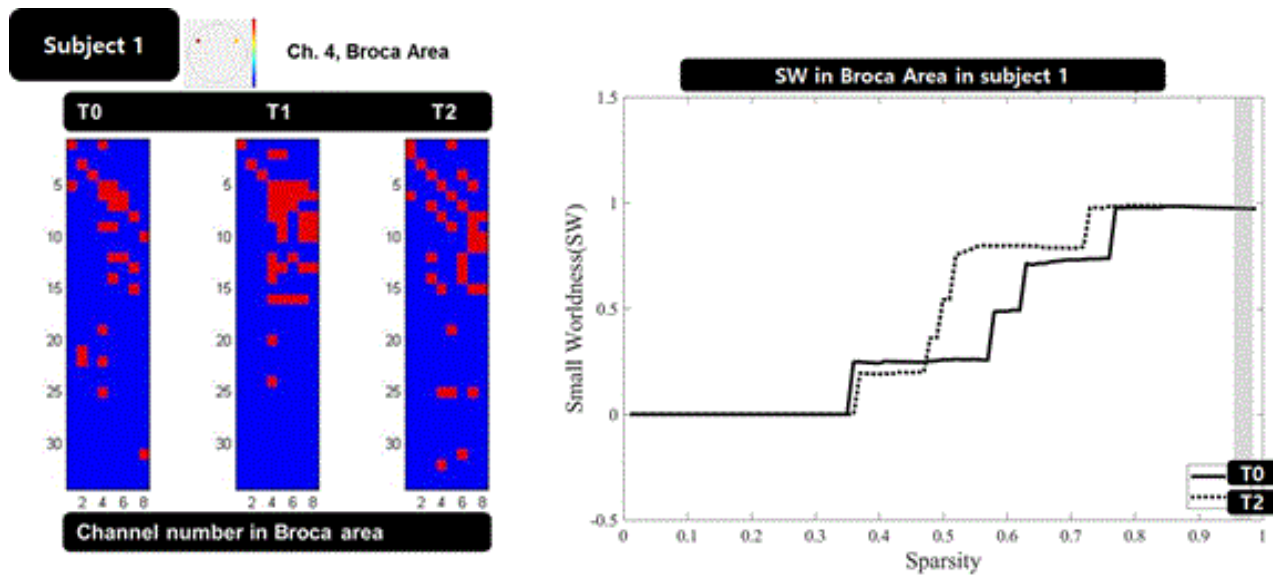
The number of thresholded correlation in Broca area including channel number 4 which was the excitatory rTMS target site increased along with the value of small worldness at certain sparsity.