FUNCTIONAL CONNECTIVITY WITHIN LANGUAGE REGIONS IN APHASIC PATIENTS DURING REAL-TIME fMRI-BASED NEUROFEEDBACK TRAINING

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BACKGROUND

A stroke occurs when the blood supply to the brain is interrupted. This disrupts the connectivity in the brain and forms lesions. It is one of the most common causes of disabilities, like aphasia in the adult population worldwide.

Aphasia is a language disorder that affects the ability to communicate. Approximately, 25% to 40% of stroke-affected subjects develop aphasia. In Broca's aphasia, the expression of speech is affected. It results from injury to the Broca's area in the left hemisphere inferior frontal gyrus, among other brain regions.

Means of language recovery in aphasic subjects include speech and language therapy (SLT). SLT facilitates learning which may bring about additional recovery by neuroplasticity which changes functional connectivity (FC) in the brain. Functional Magnetic Resonance Imaging measures brain activity and FC in it, in the form of BOLD signals.

OBJECTIVES

The study analysed the FC changes within the language regions and the adjoining regions in stroke-affected Broca's aphasic patients and normal subjects. The FCs in pairs of ROIs in various regions were determined. The study hypothesizes that repeated sessions of the training cause a rise in FC in these brain regions.

METHODOLOGY

The experiment was conducted on 4 test patients, 4 control patients, and 4 normal subjects.

The first session was a pre-training test session which included a picture-naming task after every baseline block and up-regulation block. The next four sessions were training sessions that did not have any test task and consisted of alternating baseline and up-regulation blocks. Only test and normal groups participated in the training sessions. This was followed by a post-training test session, which was similar to the pre-training test session.

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6
TEST	Pre Test Session	Training Session 1	Training Session 2	Training Session 3	Training Session 4	Post Test Session
	A B C	A B C	A B C	A B C	A B C	A B C
CONTROL	Pre Test Session	Post Test Session	A: Anatomical Scan (6 minutes) B: Functional Localizer (3 minutes) C: RT-fMRI Runs 1,2,3 & 4. (30 minutes)			
	A B C	A B C				
NORMAL	Pre Test Session	Training Session 1	Training Session 2	Training Session 3	Training Session 4	Post Test Session
	A B C	A B C	A B C	A B C	A B C	A B C

BOLD feedback was visually presented in the form of a thermometer during the upregulation block. An increase in the feedback was shown as red bars in the thermometer, and for any reduction below baseline, the blue levels were proportionately removed. During the baseline block, feedback was not provided, and the thermometer was displayed at a constant level of 10 blue coloured bars.

At the beginning of each fMRI session, the ROIs corresponding to the language areas, near the Broca's area (ROI₁) and Wernicke's area (ROI₂) were delineated based on a functional localizer fMRI run. These ROIs were used for neurofeedback subsequently in the RT-fMRI session.

The feedback value (BF) was computed with the mean of the latest three BOLD activity levels for the first ROI, and the correlation between the two ROIs using the latest ten values of both the ROIs' time series, as :

$$BF = \text{mean}(ROI_1) * [1 + \text{corr}(ROI_1, ROI_2)]$$

The ROIs in the study included the Broca's and Wernicke's areas, their right homologues, 11 ROIs surrounding the Broca's and Wernicke's areas, and 50 ROIs from the AAL space. The 65 ROIs were grouped into 12 modules, based on anatomical positions.

Pearson's correlation coefficient was used as the measure for functional connectivity between 2 ROIs, under various conditions. The results, along with their statistical significance (p-value<0.05(*), p-value<0.01(**), p-value<0.001(***), p-value<0.0001(****)), were expressed as colour-coded matrices with CONN toolbox and MATLAB.

RESULTS

The key observations of the study are that:

- in all groups, a rise in FC was observed primarily among the left hemispheric ROIs,
- while comparing the normal group over the test group, ROIs in the frontal polar region were noticed to have a significant rise in FC,
- while comparing the test group over the control group, ROIs in the supra parietal, and the right central opercular regions were found to have a significant rise in FC.

CONCLUSION

This study can contribute to the design of rehabilitative training systems that are tuned to activate the regions that have been observed to show an increased FC.

Scan here to download the connectivity matrices.