Right cerebellum as a seed for rs-fMRI analysis of the functional brain reorganization in patients with aphasia

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Introduction. Resting state fMRI (rs-fMRI) has several advantages over task-related fMRI in case of patients with cognitive and motor deficits (Lee et al., 2013).

Aims. In order to analyze the functional brain reorganization in patients with aphasia we used the right cerebellum as a seed in rs-fMRI analysis because this brain region: 1) is usually preserved in patients with aphasia; 2) considerable contributes to language processing, as demonstrated in many neuroimaging and brain lesion studies (Ackermann et al., 2007). We expected to find a strong relationship between the activation of the right hemisphere of the cerebellum and the left inferior frontal gyrus (IFG) in healthy participants and changes in functional connections of the right cerebellum in a participant with aphasia due to a lesion in the left IFG.

Method. Ten healthy volunteers participated in the study (mean age 28.6, SD=9.8; 7 females). We also analyzed the data of 67-year-old woman with lesion in the left IFG and Broca's aphasia. T2*-weighted BOLD images (TR/TE/FA=3s/50ms/90°, voxel size 3.9x3.9x3mm, 35 axial slices, 180 measurements) and T1-weighted images (TR/TE/FA=1.9s/3.37ms/15°, voxel size 1x1x1mm) were acquired with a 1.5T Siemens Avanto scanner. fMRI data were preprocessed using SPM12. Seed-to-voxel connectivity analysis was performed using conn14.p. The ROI in the right hemisphere for seed based analysis was built in the marsbar toolbox as a sphere with radius 10 mm and center in {42 -56 -30}; coordinates for seeds were defined according to Stoodley and colleagues (2012) as a part of the cerebellum that were active during language task performance. We also used a ROI in the left cerebellum {-42; -56; -30} as a control seed. The data are reported with a statistical threshold of p=0.001, cluster FDR-corrected p=0.05.

Results. In the control group there were multiple brain areas positively correlated with the seed in the right cerebellum: the left cerebellum; bilaterally – fusiform gyrus, cingulate gyrus, and thalamus; in the right hemisphere – frontal operculum, insular cortex, pars opercularis of IFG; in the left hemisphere – middle frontal gyrus, middle temporal gyrus, inferior parietal lobule. We did not find any negative correlations between the seed in the right cerebellum and any other brain region in the healthy group. In contrast, for the participant with a lesion in the left IFG, negative correlations were revealed between the time courses of the BOLD-signal in the right cerebellum and clusters within superior frontal gyrus in the right hemisphere; in the left hemisphere - superior parietal lobule, superior and middle temporal lobe; bilaterally - precuneous and lateral occipital cortex. At the same time no positive correlations between the right cerebellum time course of activation and other brain areas were found. The time course of the BOLD-signal in the control seed (the left cerebellum) was positively correlated with a number of brain regions, similarly in healthy subjects and in the patient with aphasia.

Discussion. There is a wide range of cortical areas that positively correlated with time-course of BOLD-signal in seeds both hemispheres of the cerebellum during resting state in healthy participants. Contrary to our expectations, we did not find any significant correlations between time-courses of the seed in the right cerebellum and the left IFG. Nevertheless we revealed the changes from the positive to the negative correlations of BOLD-signal time course between the seed in the right cerebellum and the rest of the brain in the participant with the lesion in the left IFG. These results reflect the complex non-direct relationships between the left IFG and the right cerebellum and the presence of functional changes in the right cerebellum in case of Broca's aphasia despite of anatomical preservation of the cerebellum.