Brain activity functional analysis based on the fMRI data in healthy subjects between Stroop and emotion tests

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***Abstract*—In this work, we conducted the analysis of the functional magnetic resonance imaging data in healthy subjects that were obtained during experimental research when subjects are performing Stroop and emotion picture tests. The signals that have undergone preprocessing and filtration were used to test the method of functional connectivity analysis to find the connections between the brain regions that demonstrate significant changes between functional tests.**

***Index Terms*—fMRI; functional test; functional analysis; brain networks; connectivity**

I. Introduction

Functional magnetic resonance imaging (fMRI) is one of the most up-to-date non-invasive methods of neuroimaging together with fNIRS technique based on hemodynamic response registration [1]–[4]. The analysis of blood oxygenation changes in the activated areas of the brain allows us to study the peculiarities of their structural maintenance in norm and pathology [5], as well during different activities (in comparison to the resting state). In the literature the reactive increase of local (regional) blood filling of brain tissue (BOLD-effect) is considered to be as a marker of neuronal activity and fMRI tool is considered to be an optimal method for spatial neuronal activity and fMRI method is considered to be the optimal instrument for spatial mapping of activated neuronal ensembles [6], [7]. In recent years along with studying structural functional organization of different types of types of cerebral activity, the fMRI technique has been used to study the state of performing functional tasks. However, not enough attention is given to the full network functional analysis of the brain structures outside of the region of interest paradigm, despite functional network analysis proved to be useful [8]–[11]. The aim of this work was to analyze the differences in functional connectivity of brain between that occurs in healthy subjects during performing of Stroop and emotion tests.

This work was performed within the context of the ‘Priority 2030’ project of Immanuel Kant Baltic Federal University.

II. Experimental setup

The experimental data was obtained from 49 healthy volunteers. Subjects having previous history of or comorbid psychiatric conditions, autoimmune diseases, neurological diseases, history of head trauma or any metal implants incompatible with the MRI were excluded. All volunteers are selected in accordance with the following requirements: right-handed people, non-smokers, not professional athletes, who do not take medications, without neurophysiological diseases and diseases of the motor system. Within two days, prior to the experiment, subjects are tasked to keep a healthy lifestyle: no less than 8 hours of sleep, avoid ethanol-including liquids and psychoactive stimulants. Before the experiment, the extensive briefing is carried out, during which they are informed about the aims and methods of the experiment, and about the possible inconveniences related to its conduct.

The magnetic resonance scanning procedure was performed on a 3T magnetic resonance imaging system (GE Discovery 750w). The protocol included high resolution structural scan (Sag 3D T1) with slice thickness 1mm, matrix 256×256, TR (relaxation time) 7.2ms, TE (echo time) 2.3, and flip angle 12, and resting-state functional scan — 2D echo planar imaging (EPI), with slice thickness 3 mm, matrix 64×64, TR 2000 ms,

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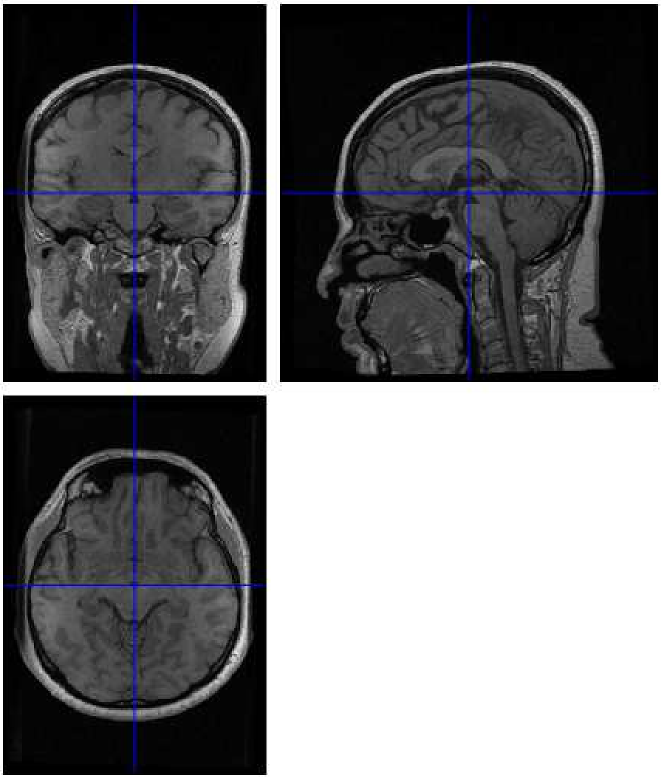

Fig. 1. T1 high-resolution anatomical image of one of the subjects

TE 30 ms, 36 slices, flip angle 90, a total of 192 volumes. Before the EPI sequence, subjects were instructed to remain calm and relaxed with eyes closed and not to think of anything in particular.

The two functional states included emotion test and Stroop test. The Stroop Color and Word test [12] is widely used in clinical and experimental practice. In this study, we decided to use this instrument in order to assess the ability to inhibit cognitive interference when two types of stimuli are coming at once (words that are the names of colors appearing in the same or different color). Thus we have congruent stimuli (the word "green" in green) and incongruent stimuli (the word "green" in blue). In addition, an n-back component was added, and in the first part of the task, subjects were instructed to press a button every time the word was the same as the one two screens back (word condition). In the second part, the subjects had to press a button every time the color of the word was the same as the one two screens back (color condition). There were four consecutive 60 second blocks of each active condition (word and color) alternating with an off block (fixation cross) with a duration of 20 s.

Emotion test was performed through the use of International Affective Picture System (IAPS) [13]. The IAPS includes an extensive set of standardized, emotionally evocative color images that are proven to reliably induce emotional responces. The stimulus set of affective images, which was used from the International Affective Picture System, as either positive or negative was used in a manner similar to the Stroop test. In addition to that, the subjects were asked to respond to every image in honest manner; for example, when a negative image is shown, subject should respond that the image was negative. Taking in account the neural correlates, we understood that the areas associated with emotion about positive and negative type emotions would differ from each other. According to the findings of the most of picture experiments on deception, we managed to find circuit of activations in the occipital and parietal regions [14].

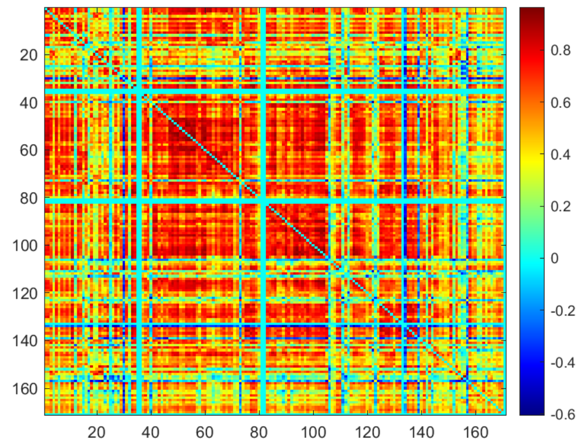

Fig. 2. Averaged correlation matrix for the parcellations

III. Methods and Results

The analysis of the MRI images was performed using the SPM 12 toolbox running on MATLAB R2019b for Windows. The preprocessing of the T1 weighted images included segmentation, and normalization. The images first underwent realignment for correction of head motion, co-registration with the high-resolution anatomical image (Fig. 1), normalization to the Montreal Neurological Institute space, and spatial smoothing with an 8 mm full width at half maximum Gaussian kernel. We matched MNI voxels to the AAL3 [15] anatomical parcellations of the spatially normalized single-subject high-resolution T1 of the cortex, the anterior cingulate, the thalamus, with the addition of some brain nuclei. Then, we calculated mean activity across the parcellations for each of the volumes/screenings. After that, we calculated Pearson cross-correlation maps for all of the mean parcellations activities. Averaged correlation matrix is presented in the Fig. 2

To assess the significant changes between the obtained correlation matrices for the groups, the false discovery rate [16], [17] with significance level of p=0.025 and 100000 permutations were used. Among the resulting significant connectivity top 30 of connections were taken and presented in the respective connectogramm is shown in Fig. 3.

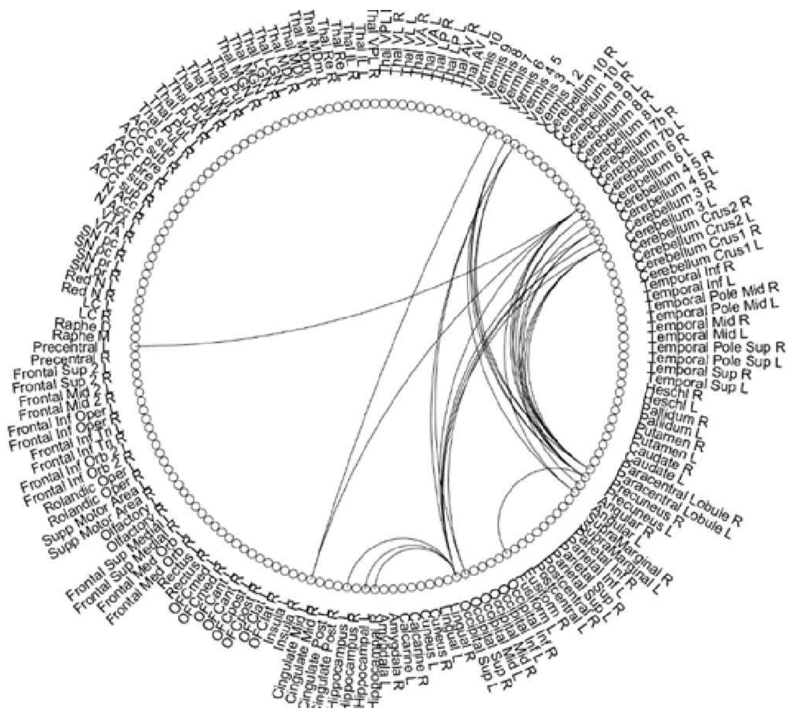

Fig. 3. Top 30 of the significant connections emotion vs Stroop test

IV. Conclusion

Thus, we performed functional analysis of thefunctional magnetic resonance data in healthy subjects that were obtained during experimental research when subjects are performing Stroop and emotion picture tests. We showed that the most significant changes in functional network connectivity include cerebellum – precuneus (8/30), vermis – precuneus (5/30), cerebellum – occipital superior cortex (4/30) connections.

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