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Mirror neurons, time perception and gender difference[1]

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Studying the functions of mirror neurons in cognitive processes is an urgent problem of modern psychophysiology. According to the currently popular hypothesis (Skoyles, 2000), mirror neurons can serve as a neural basis for interpreting actions, imitating learning, and imitating the behavior of other people. The purpose of this study was to study the dependence of mirror neuron activity on gender differences in the observation and perception of time3. During the preliminary examination, the features of the lateral organization of the brain were studied with the determination of the leading hand (using the questionnaire method) and the speech hemisphere (dichotic test). As models of cognitive activity, the subjects were offered activities related to the observation and measurement of short time intervals (200 and 800 MS), with the observation and reproduction of a five-second rhythm. As markers of mirror neuron activity, we used depression of the mu-rhythm of the EEG in the alpha and beta frequency ranges, cortical interactions at the frequency of this rhythm, and results of fMRI scans of the brain. The electroencephalographic study involved volunteers, practically healthy men (31 people) and women (34 people) aged 18 to 23 years, and University students. Before and during cognitive activity, EEGS were recorded in the frontal, Central, temporal, parietal, and occipital leads according to the "10-20%" system. When processing the obtained data, the

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maximum values of cross-correlation functions and spectral power estimates were calculated on short (1.5 s), artifact-free segments of EEG recording for 3 s and 1.5 s before performing a speech or non-speech action and immediately after the specified event. For statistical data processing, we used the "MatLab v 6.5" package, nonparametric variance analysis, and the Wilcoxon criterion for related and independent samples. In part of the experiments, the activity of the brain was studied by fMRI in the observation and perception of time, in the observation and utterance of words. These studies involved 20 men and 20 women aged 19 to 27 years, University students. The results of functional MRI were obtained in the complex of NBICS technologies of the Kurchatov Institute using a SIEMENS Magnetom Verio 3 Tesla tomograph. All fMRI data was pre-processed using the SPM8 package. Within each of the paradigms, pairwise comparisons were made based on student statistics and individual and group maps with a significance level of $p<0.001$ were obtained. All the obtained statistical maps were applied to the reference T-1 image and anatomically linked "active" voxels to the CONN Atlas. Studies have shown that cognitive activity associated with the observation and perception of time is accompanied by depression of the mu-rhythm at certain frequencies and, most often, increased levels of cortical connections at the frequency of this rhythm between the Central and other cortical zones. The nature of these changes significantly depends on the gender, lateral organization of the brain, the frequency of mu-rhythm, the method of scaling time intervals, the type and stage of the activity performed.

The results of fMRI brain scans showed that monitoring the performance of cognitive activity related to the perception of time is accompanied by activation not only regions of the cortex, where the "motor" mirror neurons (Rizzolatti and Sinigalia, 2012), but other sensory, motor and association areas of the cortex and the basal ganglia and cerebellum, which are considered a place of storage of motor programs. It turned out that the performance of the proposed cognitive activity is partially accompanied by activation of the same brain regions as when observing its performance. In particular, in men, when measuring time intervals, activation of the middle frontal gyrus, right, precentral gyrus, right and left, temporal pad, right and left, lateral occipital cortex, right and left, basal nuclei and some areas of the cerebellum was detected, which are also activated when observing the performance of this activity. Along with this, activation of the frontal pole, right, postcentral gyrus, right and left, precuneus, lingual gyrus, right and left, middle temporal gyrus, right and left, wedge-shaped and other cortical zones was detected. In addition, research has revealed clear gender differences in the activation of "interested" brain structures when observing and performing the proposed cognitive activity. So, if in men, when measuring time intervals, the number of activated voxels in the precentral gyrus, on the right and on the left is 1426 and 1532 voxels, respectively,in women

– 917 and 394 voxels. If the number of activated voxels in the area of the middle temporal gyrus, on the right and left, is 102 and 106 voxels in women when observing the reproduction of the rhythm, then 71 and 15 voxels in men, respectively. Probably, these differences are related to the peculiarities of the lateral organization of the brain in men and women. The results obtained and some literature data (Kosonogov, 2012) indicate that mirror neurons themselves do not provide interpretation of actions, although they participate in these processes. The increase in cortical connections at the mu-rhythm frequency between the Central and other cortical zones, as well as activation of the basal ganglia and cerebellum found during observation and perception of time, suggest that these neurons provide interaction between the prefrontal, sensory and motor cortical zones, as well as places where motor programs are stored in the brain. The result of the interaction of these structures, apparently, is an understanding of the actions and intentions of other people. According to the researchers (Schippers et al., 2010), this is achieved by copying the observer's brain of another person's actions by extracting the corresponding motor programs. This "intermediary" function of mirror neurons explains why they are activated not only when observing, but also when performing and mentally reproducing the same action.

The results show that the activity of mirror neurons significantly depends on the gender and lateral organization of the brain.

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