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Retrieval from Long-Term Memory: Dipole Sources Localization Study

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Brain mechanisms of successful and unsuccessful retrieval of the names of familiar people from the long-term memory were researched. The participants (N = 17, aged 18-20) were shown with photos of movie stars, whose names they needed to remember. Each photo was presented for 800 ms followed by 2000 ms pause. Event related potentials (ERP) were registered in three cases: 1. The participant successfully remembered the name; 2. The participant did not know the name; 3. The participant knew the name but was not able to remember it quick enough. EEG was registered using the 10-20% system (21 channels). Dipole sources of brain activity were calculated for each ERP (using BrainLoc 6.0 software). In case '3' high activation of right parahippocampal, left orbital gyrus and left anterior cortex was present. In cases '1' and '2', when the participant had successfully accessed long-term memory, high activation of left precuneus was present. Besides, in case '1' the activation in precuneus was higher than in case '2'. In case '3' no activation in precuneus was registered. In other studies, activation in precuneus was also registered during recognition of familiar words, objects, and places (Maddock et al., 2001; Sugiura et al., 2005; Heun et al., 2006; Kozlovskiy et al., 2012). Activation in parahippocampal area was higher in case '3' than in cases '1' and '2'. In case '1' activation in the Broca's area was present around 400-500 ms from the stimulus. The obtained data allows for a suggestion that activation of precuneus is necessary for successful retrieval from long-term memory. Unsuccessful retrieval of a familiar name causes constant activation of hippocampal area, which means that such information exists in long-term memory but cannot be retrieved because precuneus is inhibited by the orbital gyrus and anterior cortex. Activation in the Broca's area during the last stage of successful name retrieval may have been induced by the fact that participants were pronouncing the names of movie stars silently to themselves. The research was supported by the Russian Science Foundation (project № 16-18-00066).

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Mental activity in different semantic contexts has EEG correlates in 10-13 Hz frequency band

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The aim of this study was to determine the correlates of mental activity in different semantic contexts in EEG alpha sub-bands. A person can use two strategies of thinking (divergent and convergent) for mental task solving. Event-related changes in upper alpha sub-band power are associated with sensory-semantic processing. Divergent thinking is accompanied by the increase in upper alpha power, whereas convergent thinking is characterized by the decrease alpha power. In situations when divergent thinking is predominantly used, alpha power in the right hemisphere is higher than alpha power in the left hemisphere. We have studied the dynamics of EEG power during solving of interesting and uninteresting tasks (10-20 system electrode positions O1, O2, P3, P4, C3, C4, F3, and F4). Our participants were high school students specializing in Biology or Physics. They were asked to solve several school tasks of four types: Biology test, Physics test, creative Biology task and creative Physics task. We also recorded EEG during nonsemantic tasks solving as a control. We analyzed the averaged power spectra in 6-8 Hz, 8-10 Hz and 10-13 Hz frequency bands. We used MANOVA and Student's t-test (with Bonferroni correction) for statistical data analysis. Mental activity in different semantic contexts has psychophysiological correlates in upper alpha sub-band (10-13 Hz). In both groups of students solving of creative tasks from familiar semantic contexts was accompanied by bigger alpha power compared to solving of creative tasks from other semantic contexts. This phenomenon was observed in frontal, central, occipital areas on both sides of the brain and also in the right parietal area (P4). Students specializing in Biology had higher upper alpha power during Biology tasks solving compared to controls. However, no significant differences were observed between nonsemantic tasks and semantic tasks solving performance of students specializing in Physics. We suppose that this effect is due to the different task structures. So we suggest that Biology tasks solving and Physics tasks solving employ divergent and convergent thinking in different proportions. During dedicated task solving, upper alpha sub-band power asymmetry is observed in larger areas of cortical surface in students specializing in Biology (central, parietal and occipital lobes) compared to students specializing in Physics (parietal lobe only). Presumably, this phenomenon is also related with the task structure. Thus, the dynamics of EEG upper alpha sub-band power represents a psychophysiological correlate of the mental activity in different semantic contexts.

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Saccadic preparation at the experimental scheme with distractors during stimulation of leading and unleading eye

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For successful goal-directed behaviour, it's crucial to attend relevant stimuli in the visual field while ignoring distractor elements. The oculomotor system is a good model for the study of this competition between different elements. The goal of this research was to analyse spatial-temporal parameters of saccades and presaccadic EEG-potentials at the simultaneous presentation of the target and distracting stimuli to the leading and unleading eye. The complex of the positive and negative potentials was revealed in the saccade latent period. Latency of all components was shorter upon presentation of stimuli to the left, unleading eye, that may indicate the earlier saccade preparation. At the same time LP saccades were longer in this conditions ($p < 0.05$). The results show that early potentials N1 and P1 were higher in amplitude and dominated in the contralateral parietal-occipital areas. It can be reflection of visual

sensory processing. The amplitude of the later negative potential N2 at the stimulation of the right eye increased in the case when target stimulus was at the same location than at the previous realisation. It's possible that N2 component is connected with processes of preliminary extracting of motor program from memory together with attention processes. N2 amplitude was higher when the distance between target and distracting stimuli was 15 degrees in comparison with the minimal distance 5 degrees. It's corresponded with LP data. The findings show an active role of attention and decision-making processes in saccade programing. The study has been funded by the Russian Academic Excellence Project '5-100' and partially supported by RFBR (the projects № 12-04-00719).

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EEG fractal dimension as a marker of cognitive success: Evidence from conceptual thinking tasks

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The aim of the present study was to specify the results recently obtained by our group (Shcherbakova et al., 2014) and extend them by including the baseline IQ measurement. In the first stage, participants (N = 154, aged 18 – 34) solved the tasks of J. Raven's "Standard Progressive Matrices" test (SPMT). After ranking the participants with accordance to their obtained scores, we chose two groups out of the initial pool. "Group 1" consisted of 10 % of the participants (N = 20) with the highest IQ scores (124 to 130), "group 2" consisted of 10% of the participants (N = 19) with the lowest IQ scores (98 to104). In the second stage, the participants of both groups solved 3 verbal cognitive tasks, requiring conceptual operations: "Generalization of Three Words" (Kholodnaya, 2012), "Answering The Metagrams" (Shcherbakova, 2009), "Giving Reasons For Opposite Statements" (Vudzhek, 1996). The tasks were presented on a computer screen and scalp EEG (19 locations, using the 10/20 electrode system) was captured during the solving process. Answers to the tasks were scored 0, 1 or 2. The EEG data were only analyzed for the initial (first 10 s) and the final (last 10 s) stages of the solving process. For all the tasks, the EEG fractal dimension (D0) was calculated with the use of Higuchi algorithm (Higuchi, 1988). The results showed that in cases of correct answers for cognitive tasks, there was a decrease of the EEG fractal dimension at the final stage of the process, which corresponded to what we have observed in our previous studies (Shcherbakova et al., 2014). Another finding was the contradirectional effect of (D0) on the answer correctness in "group 1" and "group 2" ($F(1,280) = 12{,}327$; $p = 0{,}00052$). In "group 1", D0 was lower when the task was solved correctly and higher in case of incorrect solution. In "group 2", the opposite regularity was found: lower (D0) corresponded to the correct answers and the higher one – to the incorrect answers. We consider psychometric IQ to be a mediator in the (D0) – answer correctness relationship. Participants with higher IQ might have better metacognitive skills, which allowed them to assess the correctness of the conceptual operations they performed and the correctness of their answers. The result of such self-assessment might influence (D0) as an aggregate indicator of cognitive activity. The research was supported by the President of Russia grant №МК-7507.2016.6 and RFH grant №16-36-01071.

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Electrophysiological manifestations of inhibitory processes in auditory attention depend on the level of perceptual load

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As many researchers have noted, attention has two aspects: first, it leads to the better evaluation of the object of interest; second, attention is responsible for the discontinuation (inhibition) of the processing of the irrelevant objects. These aspects of attentional processing are independent one from another to some degree. The purpose of this work was to study manifestations of facilitatory and inhibitory aspects of attentional processing under different levels of perceptual load in event-related potentials. Levels of perceptual load were set by inter-stimulus intervals (ISI) in different blocks of modified odd-ball auditory task (mean ISIs were 600 and 900 ms). The pitch of the stimuli defined attended and unattended channels. Participants (n=12) task was to detect deviants (they were defined by the length of the stimuli) in the attended channel while ignoring all the information in the unattended channel. To be able to disentagle inhibitory and facilitatory components of attention, neutral condition was introduced. In neutral condition participants task was to detect very easily distinguishable auditory stimulus (defined by the pitch, length and the presence of admixed noise). Since this stimulus was very salient and easy distinguishable from the rest of them, there was (supposedly) no need to neither enhance nor inhibit incoming information. Performance of the task was best at longest ISI's and worst at shortest ISIs. Facilitatory and inhibitory components of event-related potentials (ERPs) were present at all levels of ISI length. Amplitude of the inhibitory component (also called rejection positivity) was significantly smaller for longer ISIs. In addition, amplitude of P3b component (usually seen as a correlate of attentive target detection) for deviant stimuli in the unattended channels was significantly greater for longer ISIs. The results obtained indicate that in auditory modality greater perceptual load leads to the greater inhhibition of the distracting information, while lesser perceptual load leads to greater intrusion of distractors in the attentive task. The article was prepared within the framework of the Academic Fund Program at the National Research University Higher School of Economics (HSE) in 2015-2016 (grant № 15-01-0159) and supported within the framework of a subsidy granted to the HSE by the Government of the Russian Federation for the implementation of the Global Competitiveness Program.

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Effect of aging on ERP latent components in cued GO/NOGO task

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As people age, their performance on tasks requiring cognitive control often declines. In the present study, two hypotheses of aging are tested. In the context of first hypothesis, processing speed generally declines with age. Other, compensatory theory is built on the finding that age-related increase in the frontal lobe activity is in general accompanied by decreased activity in posterior brain regions. This posterior-anterior shift in aging is considered as a compensatory mechanism reflecting to offset posterior-related neuroanatomical and neurophysiological declines