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Methodological school: Methods of data processing in EEG and MEG. Applied aspects of magneto- and electroencephalographic neuroimaging

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The Abstract book contains the abstracts of the posters presentations of the participants of the Methodological school: Methods of data processing in EEG and MEG, Moscow, 16-30th of April, 2013. The School was devoted to the theoretical and practical aspects of the contemporary methods of the dynamic mapping of brain activity by analysis of multichannel MEG and EEG.

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Reflection of human psychophysiological characteristics in phases correlations of EEG oscillations

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Introduction. This research was aimed to study the human spatiotemporal EEG structures during the resting state with respect to the individual psychophysiological characteristics. The construction of EEG spatiotemporal pattern was based on the evaluation of traveling waves (TW) [1]. Previous study showed that the individual EEG oscillators cannot substantially interact unless certain resonant relations exist between the characteristic frequencies of the autonomous oscillators, and traveling brain waves may be manifestations of this process at the very large scales, providing mechanism to effect a large-scale functional integration of neocortex [2].

Methods. The experiments were performed on healthy volunteers of both sexes, right-handed, aged 20-30 years, without history of TBI or psychological diseases. Twenty subjects were participated on this stage of research in 2 sessions of data recording (N=10 in each session).To detect the TW, we collected EEG data (28 channels between P5-P6 – FC5-FC6 points according international 10-10 placement system [3]) during resting state in eyes-open condition. EEG was recording in the pass band from 1 Hz to 70 Hz and quantized with frequency of 2000 Hz. Then we investigated how the phases of comparable waveforms oscillations were organized over the selected electrodes. Relative phases, as a function of time, were calculated for each of the electrodes. Then individual pattern was represented like a structure of phase's delays coefficients in result of accumulation and averaging about 3000 timeframes (100ms each) for every experiment.

For evaluation of volunteers psychological characteristics we used test of speech abilities – "pseudo-text reading speed" (placeholder text called "Loremipsum" was used), "block design test" (subtest of Wechsler adult intelligence scale) and "nervous systems lability" test [4]. Tests results were scaled. For each test, subjects were separating on two groups based on their scores.

Data was analyzed by the two-tailed T-tests ($p \leqslant 0.01$) and Spearman's rank correlations tests ($p \leqslant 0.05$). Then partial least squares (PLS) regression models and discriminant analyses (DA) were calculated [5].

Results. The individual relatively stable patterns of traveling waves were found. Their evaluation with respect to the psychophysiological data revealed significant correlations between the phase's delays coefficients in the right hemisphere (FC4, FC6, C6, CP6, CP2, P6 electrodes area) and speech abilities, that was

calculated based on the "pseudo-text reading speed" test scores (actual correlation coefficients with p-values and significance of groups separations in Figure 1). PLS-DA demonstrated separation of two groups of subjects (Figure 2). Based on leave one out cross-validation test (LOOCV), accuracy of PLS-DA model was 93.5%. PLS regression model is presented in Figure 3 (R2=0.8961).

	Spearman's rho	P-values	2-tailed T-test
P6	-0.79	4.94 * 10E-6	5.31 * 10E-6
CP6 / CP2	0.43 / 0.5	0.03 / 0.01	0.004 / 0.03
C6	0.49	0.02	0.003
FC6 / FC4	0.75 / 0.59	2.65 * 10E-5 / 0.003	6.3 * 10E-6 / 0.01

Fig.1. *Correlations between the "phase shift" coefficients and test scores ("pseudo-text reading speed")*

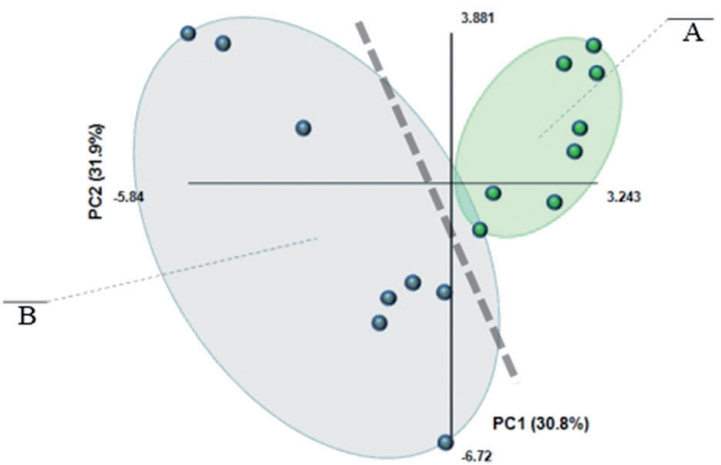

Fig.2. *PLS-DA model: high test scores (A) and low test scores (B) groups (with standard deviations of data sets)*

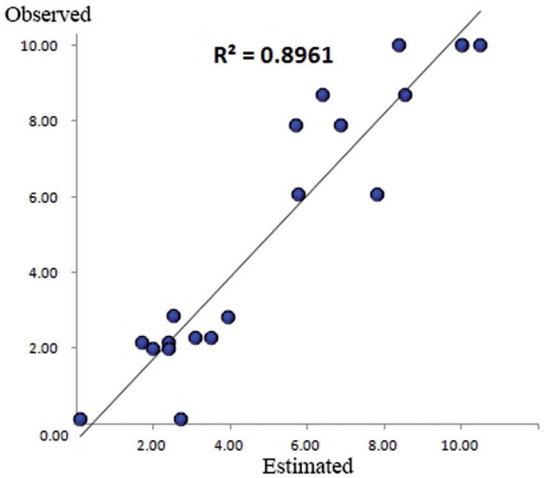

Fig.3. *PLS regression model: observed and estimated test scores*

Conclusion. Thus we have been studying correlations between the parameters of EEG traveling waves during resting state with open eyes and psychological characteristics of subjects. Our work demonstrates that the structure of the traveling waves in the resting state is an individual relatively stable pattern of the neocortex activation, and it can be classified with respect to the individual speech abilities. This means that the certain spatiotemporal phase relations of EEG oscillations can predicts the nature of the possible task-related neuronal activation and, consequently, predicts the expected results of psychological tests.

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Auditory evoked potentials during attentional lapses under decision making

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It is well known, that even in optimal conditions animals and humans make spontaneous errors which are the most prominent manifestations of attention system failures. Our goal was to investigate the causes of attention system failures in normal state of arousal and without distracting objects. We have designed a new task which allows to answer the following question: which stage of sensory processing is compromised during attention lapses?

Data was obtained from 30 participants (mean age – 20.9±1.3 years) with normal hearing. Participants were listening to four brief (40 ms) tones which were presented with equal probability. The stimuli could be discriminated by way of conjunction of two features: pitch and noisiness, so there were high pure, high noised, low pure and low noised sounds. Participants were asked to discriminate the stimuli and to respond by pushing one of two buttons. Interstimulus interval was 2500 ms ± 500 ms. Reinforcing picture appeared on the screen after correct responses.

Participants made errors in 9.6 ± 1.1% of trials and response omissions in 5.4 ± 0.7% of trials, the rest of the trials were performed successfully. Response times for errors were significantly larger than response times for correct responses. Amplitude of the P2 component was significantly greater for erroneous responses and omissions whereas amplitude of N1 did not vary upon the behavioral outcome.

Our behavioral data show that participants had well understood the task; therefore, errors and omissions were not caused by lack of understanding of the task by the participants. Also, N1 has demonstrated the constancy in all three behavioral states; hence, errors and omissions are not consequences of reduced arousal in participants. Thus, we hypothesize that attentional lapses were caused by some internal mechanisms. We assume that the state of mind-wandering, “disengaging of attention from constraints proposed by the task environment” (Smallwood et al., 2008), could be such a mechanism. We speculate that enhanced P2 is a reflection of some processes in auditory cortex which lead to premature termination of signal information processing and consequently to failures in the behavioral response. Thus, we consider that attentional lapses are manifestations of signal processing

suppression in sensory zones of neocortex, and they may be caused by activation of the default brain system (Raichle, 2001).

The study was implemented in the framework of The Basic Research Program of the National Research University Higher School of Economics in 2012-2013.

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Study of excitability in motor areas during motor imaginery: nTMS-fMRI research

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Introduction. Motor imagery (MI) is a mental performance of motor acts unaccompanied by any peripheral (muscle) activity. Physiological mechanisms underlying motor imagery are similar to the mechanisms of motor control (Stippich et al., 2002; Ehrsson et al. 2003; Neuper et al. 2005). It is generally accepted that there is overlapping of brain areas which are involved in motor execution and motor imagery. There are several publications reporting TMS-based studies that demonstrated an increase of corticospinal excitability during motor imagery, in particular, increased amplitudes of motor evoked potentials (Cicinelli et al., 2006; Stinear et al., 2006; Pichiorri et al., 2011). Transcranial magnetic stimulation (TMS) is a modern technique that can be used for evaluation of brain neuron excitability and for primary motor cortex mapping during motor imagery.

Purpose. to investigate the activity and excitability changes of cortical motor areas during MI in subjects, who trained with MI-based brain computer interface (BCI-trained), compared with not trained individuals using functional MRI and navigated transcranial magnetic stimulation (nTMS).

Subjects and methods. 11 volunteers without any neurological disorders (mean age, 36 yrs; age range, 24 to 68 yrs; 7 males and 4 females) were included into the study. The protocol was approved by local Ethical Committee of the Research Center of Neurology of RAMS, Moscow. Prior to the experiments, all subjects signed the informed consent form. Subjects of group 1 (n=5) had 10 to 15 sessions of BCI-supported training 20-30 min each. The training course was followed by fMRI and nTMS examinations. Subjects of group 2 (n=6) were tested without preliminary training session. All subjects were right-handed (Edinburgh Handedness Inventory). The BCI used in this study was based on the analysis of EEG patterns during grasping imagery. Functional MRI investigations were conducted using a Magnetom Avanto 1.5 T MRI system (Siemens, Germany). The neurophysiological investigation was performed using nTMS on the NBS eXimia Nexstim apparatus (Finland). The stimulation was made using eight-shaped mono-

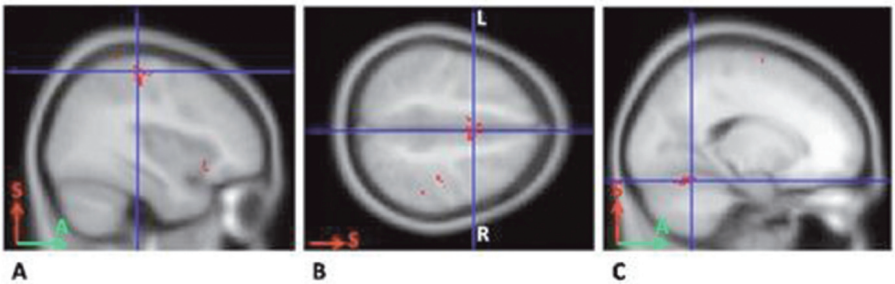

Fig.1. *Areas of brain activation during grasping imagery in BCI operators (group analysis of fMRI data, "Left hand imagery" > "Rest", p < 0.0005).*
A) Brodmann areas 3 and 4; B) Supplementary motor cortex; C) Cerebellum

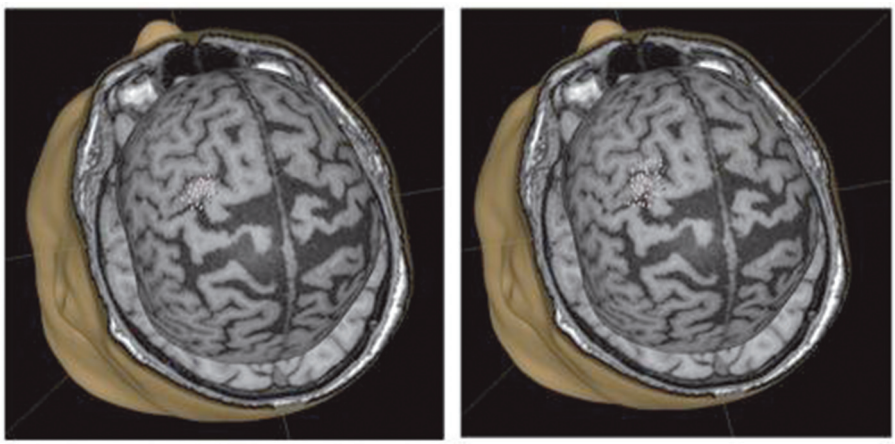

Fig.2. *Motor representation of target muscles in a BCI operator (group 1).*
A) Background mapping; B) Mapping during motor imagery

impulse coil Mono Pulse Nexstim. The magnetic impulse duration was 280 μs, the maximal magnetic field strength was 199 V/m. Evoked motor responses (EMR), amplitudes and latencies were registered for each muscle. Motor representation maps were obtained.

Results. FMRI mapping revealed the activation in 3 and 6 Brodmann areas, cerebellum and thalamus during MI in subjects of both groups. The primary motor cortex was activated in BCI-trained group only and the associative zones activation was large in non-trained group (Fig. 1). In all subjects of group 1 (BCI operators), the threshold of motor cortex was decreased by 6-18% (median change was 17%) during motor imagery compared to

the rest condition; in subjects of group 2, the threshold changes were not significant and nonuniform: in three subjects the threshold during motor imagery decreased by 1-8% compared to the rest condition; in two subjects, it became insignificant higher, and in one person it did not change during motor imagery (U-test, p=0.01). In BCI operators mean responses from APB and ECR during motor imagery were significantly higher than in control subjects. For APB the median change of motor response during motor imagery compared to rest condition was 63% in group 1 and 11% in group 2 (p=0.01); for ECR, it was 150% and 1%, respectively (p=0.03). Moreover, in BCI operators the cortex area whose stimulation induced EMRs was larger during motor imagery rather at rest condition. In subjects of group 2 we did not observe similar phenomenon (Fig.2).

Conclusion. BCI-supported motor imagery training increases the excitability of the motor cortex. These data can serve as a scientific background for BCI application in the rehabilitation of patients with cerebral palsy.

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The effect of movement observation on recuperation after physical work

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Introduction. In 1903 Sechenov I.M. suggested the central theory of fatigue [9]. In his investigation he discovered that recovery of his fatiguing right arm was better when diverting activity on left arm was performed. Sechenov assumed that this effect (later called Sechenov phenomenon) testifies on central mechanism of fatigue. Later investigations confirmed this theory. It was shown that mental activity, like solving math problems, also made positive effect on recuperation after fatigue [1, 5]. It was assumed that Sechenov effect is connected with the activity of reticular formation, which sends facilitatory signals to the fatigued muscles, as diverting activity performed during the rest pause [1, 2, 5].

So we can assume that diverting activity, which activates different parts of the brain, may enhance recovery after fatigue. It is known that in human brain there are systems of neurons, called mirror neurons, which can be activated by doing a movement and by observing a movement [4, 8]. In our investigation we decided to explore if cognitive activity which, as it assumed, activates these neurons has any influence on recuperation after fatigue.

Methods. Fourteen healthy right-handed subjects (aged 21–53 years old) participated in our experiment. The experimental part consisted of 11 bouts with static physical work and 10 bouts of rest. During fatiguing bout participants had to compress the dynamometer with force of 60% from their maximum voluntary contraction (MVC). Every rest bout followed a fatiguing bout (except 11 fatiguing bout). Rest could be passive or active. During the active rest a video with right hand compressing the expander was performed. During the passive rest participants observed animated picture with deforming circle. Active and passive rests alternated, so for one half of the subjects all even rests were active, and for other half of participants all odd rests were active.

To trace mirror neurons activity EEG recording and mu-rhythm analyzing was used. Mu-rhythm depresses during an action performance and during an action observation, so number of authors believe that it may be connected with mirror neurons activity [6, 7].

In our experiment EEG data were registered trough central cannels (C3, Cz, C4). Before the experimental part a control EEG recording in rest with open eyes was performed. For all subjects data from tree channels were averaged for control bout and for all rest bouts. Than for all participants there was calculated the logarithm of ratio of mu-rhythm value during each rest to the value of mu-rhythm with open eyes. Data was averaged for all passive rests and for all active rests, so for each subject there were two values.

To trace fatigue developing and recuperation after physical work EMG and handgrip data were recorded. Two EMG electrodes were placed on the inner area of the subject's forearm near the elbow to detect signals from anterior group of muscles. The ground electrode was placed on the 7th vertebrae of the subject's neck. Amplitude and spectral EMG analyzing was made. For amplitude analyzing the RMS parameter (root mean square) was used. RMS increases as fatigue develops. For spectral analyzing there was used the MPF parameter (mean power frequency). This parameter decreases as fatigue develops [3].

Handgrip data were registered trough the dynamometer KRG-4 and ForceFeedback program.

Statistical data evaluation was performed using methods of variance ANOVA.

Results. EMG analyzing showed that there were no significant differences not for RMS or for MPF between bouts after active rest and bouts after passive rest.

Handgrip analyzing either did not show significant differences between bouts after active rest and bouts after passive rest.

EEG analyzing showed there was depression of mu-rhythm during active rest: values of averaged logarithm of mu-rhythm amplitude during active rest are significantly lower than values of averaged logarithm of mu-rhythm amplitude during passive rest.

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Past and present: electrophisiological differences in processing time reference

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Recent studies have shown that reference to the past is more problematic in aphasic individuals than reference to the present (Anjarningsih et al. 2009; Bastiaanse, 2008). A fundamental issue concerns the extent to which past time reference difficulties are specific to aphasia. The present experiment was aimed at testing universal differences in processing present and past reference. We hypothesized that if past time reference problems are specific to aphasia, the same ERP effects should be observed while healthy individuals process verbs referring to the present and verbs referring to the past. However, if differences between present and past are more universal, non-similar ERP effects should be found.

Dutch sentences with mismatches between lexical adverbs and tensed verbs were tested. Two kinds of mismatches were used: sentences with a lexical adverb referring to the past, as in (1), and a verb in present form, and sentences with a lexical adverb referring to the present and a verb in past form (2):

(1) De kelner die **zonet** de peper **maalt** krijgt geen fooi.
the waiter who just before the pepper grinds gets no tip
*The waiter that is just before grinding the pepper doesn't get a tip.

(2) De kelner die **nu** de peper **maalde** krijgt geen fooi.
the waiter who now the pepper grounded gets no tip
*The waiter that now ground the pepper doesn't get a tip.

Sentences (1)-(2), together with two their correct counterparts (both adverb and verb referring either to the past or to the present) illustrate four experimental conditions of 80 items used in the experiment. To avoid repetition effects, experimental sentences were assigned to four lists. Together with 220 filler sentences (40 incorrect) each list contained 300 sentences. Thirty two Dutch native speakers participated in the study. They were instructed to read sentences presented word by word and to answer randomly presented questions by pressing buttons on the keyboard to check appropriate task performance. The brain activity was collected from 64 electrodes mounted in an elastic cap. The signal was processed according to a standard procedure in BrainVision Analyzer (Brain Products, Munich, Germany).

Comparing to their correct counterparts, present tensed verbs violating past time frame provided by an adverb elicited the P600 response, which was previously been argued to be an indicator of processing costs related to integration of syntactic and semantic analysis (Gunter et al., 1997). Interestingly, no extra brain activity time locked to the target verb was found when contrasting sentences with violations of time reference expressed through past tensed verbs to their correct counterparts. Post-hoc analysis, however, showed a delayed N400-like effect of time reference violation both in sentences with present and past tensed verbs. Such a sentence final negativity (Nref) has been previously described as reflecting a final reanalysis of the sentence (Baggio, 2004).

Processing present and past time reference expressed through verbs is different in healthy individuals. Violation of the previously set time frame with a present tensed verb elicits a clear P600 response time locked to the critical verb. It means that present time reference is started being decoded and integrated into the preceding time context as soon as such it is presented. In contrast, there is no response time locked to the target verb when time frame is violated with a past tensed verb. This could be due to the fact that the proper decoding of time frame from verbal morphology does not happen right after a past tensed verb is presented. Instead, processing past time reference is delayed. These findings are in line with aphasiological data and suggest that problems with past in aphasia are based on more universal differences between processing present and past time reference.

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Human brain reaction on images of faces presented in a negative emotional context

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This study investigates accuracy of eyewitness identification using event-related potentials (ERP). The goal is to determine certain brainwave patterns which may prove or reject eyewitness testimony. Identification rates are based on P300 patterns which reflect emotional reaction.

Twelve volunteers (10 female and 2 male) with mean age of 22,4 years participated in this experiment.

Participants first watched a video containing a scene of violent crime which lasted for 2 minutes. In this video a 'culprit' threatens to kill a 'victim'. A 'witness' which has no way to save or help the 'victim' is also present in the video. At the end of the video the participants of the experiment were exposed to the scene of crime.

A lineup of faces was presented after the video used and considered as a negative emotional context. This lineup contained six photographs: the culprit (C), the witness (W), the victim (V) and three other faces (referred to as "fillers", F1(male), F2(male), F3(female)). All the fillers had some overlapping attributes with the culprit (e.g. gender, nationality, age). Six photographs were presented 70 times in random order for the duration of 1000 ms each with a delay of 1000-1200 ms. The ERP-lineup took approximately 18 min to complete. Each stimulus was synchronized with an ERP recording.

In this experiment we registered event-related potentials during the lineup test, while participants were asked to identify the members of the previous video by pressing a button regardless to their role.

An electroencephalogram was recorded using Ag/AgCl electrodes, from scalp sites (Fp1, Fp2, F7, F3, Fz, F4, F8, T3, C3, Cz, C4, T4, T5, P3, Pz, P4, T6, O1, Oz and O2) in accordance with the 10-20% electrode system. Participants were grounded with a forehead electrode. The electrooculogram (EOG) was recorded from electrode below the right eye (vertical). EEG was recorded with a bandpass of 0,16-150 Hz and digitally sampled at 500 Hz.

Grand average waveforms were created for each of the stimulus (lineup member). The three scalp electrode sites demonstrated higher amplitude on P300 (400 ms – 550 ms latency) component (P3, Pz, P4) in the parietal lobe when the participants were exposed to images showing the faces of people who were present in the video compared to the fillers ($p<0.002$). Furthermore, two electrode sites on P200 (T5 and T6) in inferior temporal lobe were highly activated (195 ms – 210 ms latency) when the participants

were exposed to the picture of the face of the 'culprit' compared to both the faces of the people who were in the video and the fillers ($p<0.001$). Statistical significance of the comparisons observed was permitted by the use of ANOVA.

Taking into account the results of this experiment we can confirm the hypothesis that during the eyewitness identification certain difference in brainwave patterns can be observed when the eyewitness is exposed to the image of different people. After an experience of a situation considered in a negative context, the people who the observer saw during his or her experience cause a stronger variation of amplitude of the brainwave patterns compared to when the person saw fillers. This reaction is even more acute when seeing the 'culprit'. Thus, the difference of amplitude in the brainwave patterns on P300, among other responsible for strong emotional reactions, can potentially prove eyewitness testimonies.

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Visual Awareness in Inattentional Blindness Task*

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Introduction. Inattentional blindness (IB) is the inability of the subject to notice a fully visible salient item while subject's attention is engaged in some other task (Simons, Chabris, 1999). Behavioral studies of IB cannot clearly describe the level of processing of the unattended salient stimulus. We tried to investigate this question using ERP method. The goal of this pilot study was to find distinct physiological correlate of the IB condition. To do this we used the procedure developed in M. Koivisto experiments (Koivisto, Kainulainen, Revonsuo, 2009) where they varied visual awareness independently of space-based attention in the task of letter discrimination. Authors have found a "negative difference wave, visual awareness negativity (VAN) that typically occurs 150–250 ms from stimulus onset" (Revonsuo, Koivisto, 2010, p.226). Our aim was to verify whether the same visual awareness negativity occurs in the IB condition.

Method. 6 subjects participated in exchange for the payment, mean age – 21; all reported of normal or corrected to normal vision. The procedure of experiment was almost equivalent to the one used in M. Koivisto experiment (Koivisto, Kainulainen, Revonsuo, 2009). Two Latin letters were presented simultaneously for 17 ms, one letter – in the right and one – in the left visual field, equidistant from the fixation point. In the masked condition two masks were presented bilaterally at the SOA of 33 and 133 ms. In the unmasked condition one mask was presented unilaterally at the SOA of 33 ms, while in the other visual field two masks were presented at the SOAs mentioned above, interstimulus interval was 2000 ms. In our procedure the targets were presented in 75% of cases in the attended field and in 25% of cases in unattended field to manipulate space-based attention. In addition, after each trial subjects reported on target presence or absence. Thus, we created eight conditions: masked/unmasked, attended/unattended target, each of them could be reported correctly or missed. When the unmasked target presented in the unattended visual field was missed by the subject, we considered it to be the IB condition. EEG recording was performed with international 10/20 system on Mitzar EEG electroencephalograph with «WinEEG v.2.4» software for calculating EEG parameters.

Results. The analysis was provided with the same parameters as in the research of M. Koivisto. P1 (90–130 ms), N1 (130–200ms), N2 (200–300 ms) and P3 (350–700 ms) time windows were analyzed concerning VAN. This correlate was considered as enhanced negativity to unmasked stimuli than to masked ones. No significant differences between reactions to masked and unmasked stimuli were found in P1 and N1 time windows. VAN was

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first manifested in N2 time window (Levene's test, p=0,259; F=7,7; df=1, p=0,005) and was also detected in P3 (Levene'stest, p=0,94; F=10,1; df=1, p=0,001). As we received enhanced negativity to masked targets (VAN) in time windows considered in research of M. Koivisto and colleagues, then our data confirm the results of their research. The IB condition was considered as localization of unmasked target in unattended field (Kuvaldina, Adamian, 2011). VAN was observed when subjects reported to have noticed the target in P3 time window (Levene'stest, p=0,07; F=17,2; df=1, p=0,001) and was not observed in earlier time windows. In case when subjects reported to have missed the target VAN was observed in N2 time window (Levene'stest, p=1,45; F=5; df=1, p=0,025).

Conclusions. The goal of this research was to verify if visual awareness negativity occurs in the IB condition. The analysis of subjects' reports showed difference between masked and unmasked condition, thus revealing VAN in N2 and P3 time windows. Reaction in N2 time window in IB condition corresponds to experiments conducted earlier (Luck, Hillyard, 1994; Luck, Ford, 1998). Thus, this finding can imply processes essential for IB research.

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Characteristics of neocortex spike-wave activity in the rat model of epilepsy

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Epilepsy is the brain disorder characterized predominantly by recurrent and unpredictable interruptions of normal brain function, called epileptic seizures. Epilepsy is not a singular disease entity but a variety of disorders reflecting underlying brain dysfunction that may result from many different causes. Epilepsy is characterized by the propensity of the brain to generate bursts of excessive neuronal activity, seizures. It is well known that epileptic seizures are the result of the hyperexcitability of several excitatory neuronal circuits and sometimes a partial seizure can spread to the whole brain. In addition to the excitatory circuits, the inhibitory interneuron networks are also seems to be involved in the progression of epileptic seizure activity. There are a number of investigations related to different kinds of experimental models of epilepsy, which appeared to simulate the different types of human epilepsy. Also majority of them was implemented on brain slices or cell cultures, and have used adult animals. At the same time there are some types of the childhood epilepsy, in which spontaneous cessation of the illness is observed during maturation, and one suppose that fundamental mechanisms of childhood epilepsy can be explained by some peculiarities of developing brain.

The purpose of the present work was to investigate a development of neocortex spike-wave discharge (SWD) activity in developing rat induced by cortical microinjection epileptogenic drug. In order to characterize a age dynamics of seizure-like events in rat's postnatal ontogenesis we recorded electrocorticogram (ECoG).

The experiments were performed on 25 immature Wistar rats (from P17 to P42). Dams and litters were kept in standard conditions (12 h light–dark cycle, food and water ad libitum). Experiments were carried out on the basis of local ethical rules. Before surgical procedure rat pups were anesthetized with Zoletil (100 mg/kg), Rometar (1.3 mg/kg) and Novocain (0.5 ml 0.5%). Brain implants were designed as two modules with four electrodes in each hemispheres, which are spaced 1 mm apart. Modules were installed bilateral over the frontal cortex (AP- from +2 to -2 mm, L- +2,5 mm from bregma) for ECoG recordings. An indifferent electrode was implanted epidural above cerebellum. Also the two cannules for microinjection of 4-AP were implanted (AP- from +1 to +2mm, L- 0.5 mm). Experiment was conducted in freely moving rats after rehabilitation period of 2-3 days. ECoG recording was carried out during 1 hour without drugs and after that a microinjection of 4-AP (0.2-1.5 μL, 25 мМ into the cortex (h= 500-1000 μm) was made. Additional control experiments were performed in rats with microinjection of 0,9 % solution of NaCl.

According to our results the epileptiform SWD activity produced by 4-AP was demonstrated in all investigating pups. 4-AP induces an epileptiform synchronous activity such as "spike-

wave" complex. In spite of this, age differences were found in characteristics of SWD. The youngest animals (P19 – P25) had following characteristics of SWD: latent period after microinjection of 4-AP was 3-4 min., frequency of discharge was 5-6 Hz and total duration of seizures amounted 60% of total analyze epoch. In older rats (P35 – P42) we observed a SWD with latent period among 20-25 min., frequency 12-18 Hz and total duration less than 20% of total analyze epoch. Also the behavioral changes we observed in rats during the SWD spread. Some older animals were demonstrating generalized myoclonic seizures. In opposite to this, younger rats, demonstrated a shakes like a "wet dog", freezing and round moving. All these observations probably demonstrate insufficient development of cortical inhibitory mechanisms and immaturity of thalamo-cortical pathways in younger rats.

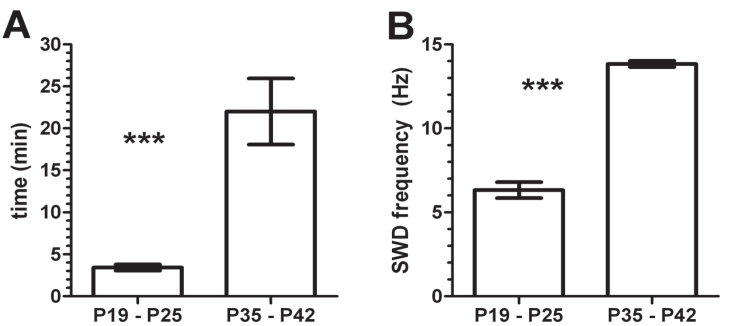

Fig.1. *Latent period (A) and frequency (B) of SWD after microinjection of 4 -AP*

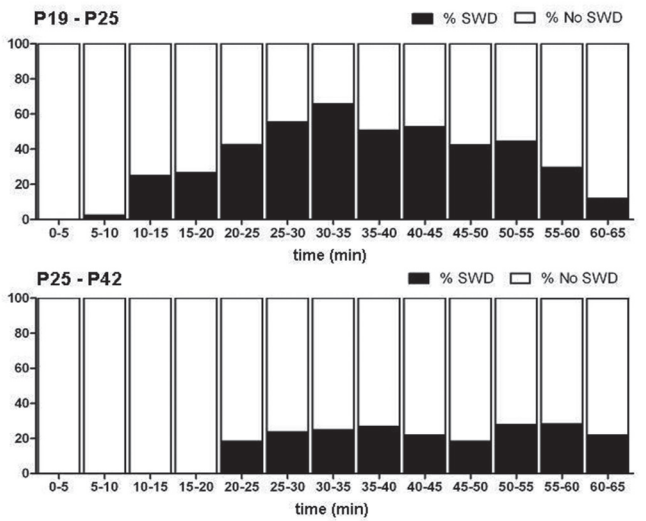

Fig.2. *Dynamic of total duration of SWD (in percent of analyzing epoch) after 4-AP microinjection*

The comparison of cognitive load different paradigms and fatigue

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Introduction. The processes of muscle fatigue and attention are closely bounded. During the development of central fatigue comes the inevitable oppression of cognitive functions. As a result of this process, voluntary and involuntary attention is particularly affected (Lorist et al., 2002; Zijdewind et al., 2006; Evstigneeva, 2009 a, b). Attention being an important activating system, due to the signals of the reticular formation influences the development of muscle fatigue which is still remains unexplored. Thus, the goal of our experiment was to study the effect of cognitive load that requires the activation of attention system on the development of muscle fatigue.

Method. Seventeen healthy adults (6 man, 11 women) ranging in age from 20 to 26 years took part in the experiment. The experiment consisted of three parts: the first – the «oddball paradigm», in which the activation of involuntary attention was observed; the second – the «Go/NoGo paradigm», where the system of involuntary attention was not activated, but the subject had to choose between two stimuli and the third, we called the «deviants only paradigm», that was also served as a control by the two previous paradigms. The «oddball paradigm» consisted of 83% of stimulus 1, with a frequency of 1000 Hz and 17% of stimulus 2, with a frequency of 1200 Hz. The «Go/NoGo paradigm» – 50% of stimulus 1 and 50% of stimulus 2. The «deviants only paradigm» consisted only of stimulus 2. While listening to acoustic stimuli the subject squeezed the working part of the wrist dynamometer to each stimulus 2 so that the line on the screen reached the target level. The target level was to be the value of the maximal voluntary contraction (MVC), which was measured before the experiment. In addition, the MVC was measured three times: after the first block of the experiment, after a 3-min break and after the second block.

Results. We analyzed three parameters: the amplitude of the dynamometer compression in response to stimulus 2, the value of MVC and the value of the subjective feelings of the muscle fatigue. The statistics was made by repeated measures ANOVA with Greenhouse–Geisser corrections. The analysis revealed significant differences in the dynamometer compression data for the «oddball paradigm» and the «deviants only paradigm», as well as the values for the «Go/NoGo paradigm» and the «deviants only paradigm». However, when comparing the «Go/NoGo paradigm» and the «oddball paradigm» no significant differences had been demonstrated. In addition, significant differences were found between the amplitudes of the MVC between the «Go/NoGo paradigm» and the «deviants only paradigm».

Conclusions. The results of the experiment showed greater subject's fatigue in the «deviants only paradigm» compared to the «oddball paradigm» and the «Go/NoGo paradigm». The observed effects may be due to the interaction of motor and cognitive processes, related in this case to the discrimination between stimuli. The necessity to discriminate between stimuli in the «oddball paradigm» and the «Go/NoGo paradigm» lead to the activation of attention systems in these paradigms and result in decrease of fatigue rate development.

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Phonological priming-effect on motor reaction time and movement-related cortical potentials

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This research is devoted to unconscious phonological priming in the auditory modalities using movement-related cortical potentials (MRCP) and the measurements of motor reaction time (RT). Two monosyllabic Russian words with different vowels ("garden" [sa:d] and "court" [su:d]) were selected for the experiment. The purpose was to compare repeated priming and alternative priming effects on MRCP components and RT. To ensure unconscious perception prime word was masked by sandwiching between 2 identical tones and modified in duration (cut out 30% of every sound). The amplitude of the tone was five-times higher than the amplitude of the prime word. The target word (375 ms) sounded 50 ms later after second tone, e.g. the target word [su:d] preceded by masked word [sa:d]. For the control used trials without prime word (2 tones with a silence between them before the target word). All trials were presented in pseudorandom order. Subjects didn't detect the prime word between tones. To implement the experimental task visual stimuli were created: written in large print white on a black background in the center of the screen. The subjects were instructed that a couple of words would be presented through the headphones. One should press the joystick button as quickly as possible, when the word heard in the headphones coincided with the word on the screen. The results demonstrated that the alternative priming significantly increased RT for primed word compared to non-primed one. As for repetition priming, we revealed two groups of subjects with different effect of prime word "sad" on RT to target-word "sad". Mean RT could either decrease (target word>repetition priming, p=0.007) or increase it (target word<repetition priming, p=0.00).

Different components of MRCP (readiness potential, pre-motion positivity, and motor potential) showed different amplitude changes for alternative and repetition priming. However, most statistical differences were obtained for motor potential. Its amplitude value for repetition priming was significantly smaller (p<0,05) than for alternative priming (different words) in parietal area.

Thus, phonological priming effect on behavior, which can be measured in movement reaction parameters, and on electrophysiological components of reaction such as MRCP. Significantly different effects of alternative and repetition priming on sensory-related ERP were already observed in our laboratory of physiology of sensorimotor system in previous research*.

* Neural correlates of the unconscious phonological priming: an ERP study. V. Khoroshikh, E. Kopeykina, Gennadiy Kulikov, V. Ivanova. 1st Conference of the European Society for Cognitive and Affective Neuroscience. May 9-12 2012, Marseille, France

Neural correlates of verb imageability

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Neuroimaging investigations in the concrete-abstract domain have repeatedly reported higher activity for abstract words in language-related regions of the left hemisphere (Grossman et al., 2002; Kiehl et al., 1999). A recent account (Rodríguez-Ferreiro et al., 2009) suggests that concrete and abstract words differ in their retrieval demands: the latter require more effortful integration due to being less imageable. Although imageability is claimed to be critical parameter affecting word retrieval, it is typically studied using a binary contrast of high- and low-imageable words. The aim of the present study was to find the support for linearly increasing engagement of language-related regions as a function of gradually decreasing imageability.

In a blocked fMRI experiment, three groups of German verbs were contrasted: tool verbs (denoting actions performed by hand with a tool, e.g. *to cut*), hand verbs (denoting actions performed solely by hand, e.g. to milk), and abstract verbs (e.g. *to hate*). A questionnaire completed by 50 German speakers confirmed the imageability hierarchy tool>hand>abstract, tool verbs being the most and abstract verbs the least imageable. Deep semantic processing was insured by the task. A verb (e.g. *to cut*) and two nouns (e.g. *bread* and *blood*) were presented in a triangular array; participants were required to choose the appropriate object for the verb. Stimuli were matched on frequency and length; the measures of association between a verb and the correct noun did not differ for tool and hand verbs, but were significantly higher than for abstract verbs. The baseline task aimed at the subtraction of visual processing and motor response from the experimental task was to identify which of two bottom strings of Wingdings characters was identical to the one on top. 17 healthy native German speakers (mean age 33) participated in the study.

Participants were significantly slower when choosing the appropriate object for abstract verbs than for hand verbs, and for hand verbs it took longer than for tool verbs. Concerning neuroimaging results, abstract verbs in contrast to hand verbs elicited stronger activation in the left inferior frontal gyrus (triangular part), middle temporal gyrus and temporal pole. Similarly, being contrasted to tool verbs, hand verbs elicited

stronger activation in the same gyri, but it was bilateral and extended to orbitofrontal, parietal and occipital regions. The left inferior frontal and middle temporal gyri were the only regions where all three groups of verbs showed stronger activation relative to the baseline. Region-of-interest analysis revealed that the amount of activation fits a linear model: abstract verbs elicited stronger activation than hand verbs, and hand verbs – stronger than tool verbs.

The converging behavioral and neuroimaging results indicate that imageability of a verb might influence both the time of its processing and the amount of cerebral activation it is related to. We argue that, in our experiment, it was imageability that modulated retrieval demands in a linear manner – specifically, through the engagement of inferior frontal and middle temporal regions.

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Topography of EEG power spectrum of left- and right-handed people during memory test

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Introduction. Comparison of brain activities of left- and right-handers can help us to understand some total principles of brain activity, because preference of one hand but not another reflects different organizations of neural process.

The aim of this work is to compare topography of EEG power spectrum of left- and right-handed people during memory tests.

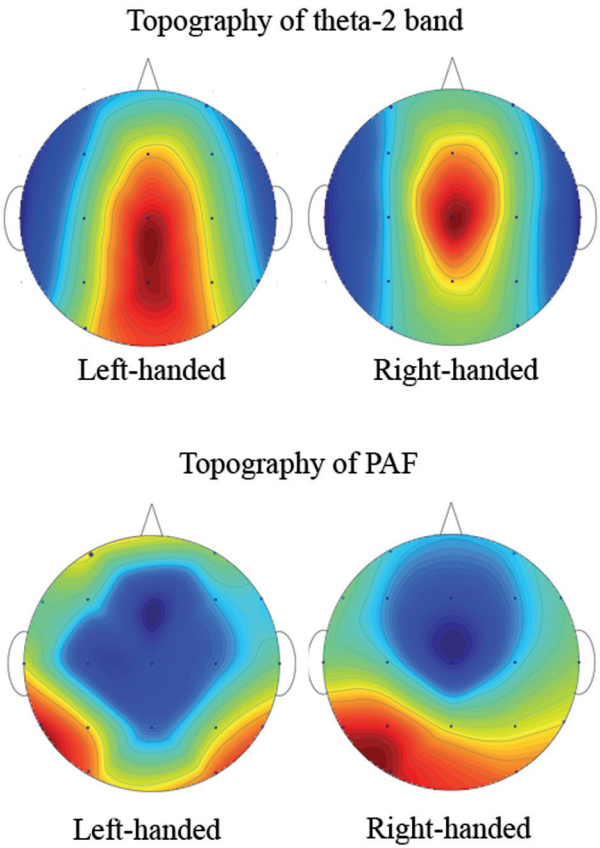
Methods. 14 volunteers (6 left- and 8 right-handed, all female), at age from 18 to 25 took part in the experiments. The Edinburgh questionnaire (Oldfield, 1971) was used to separate subjects into groups.

EEG was recorded monopolar, ipsilaterally. The electrodes was mounted by the 10-20 system in the following locations: Fp1, Fp2, F3, F4, Fz, C3, C4, Cz, P3, P4, Pz, O1, O2, F7, F8, T3, T4, T5, T6. General referent electrode was placed on the ear lobes. The ground electrode was placed of the forehead. EEG signal was digitally filtered at 0.5 – 30 Hz. Sampling rate was 500 Hz.

Memory test was match-to-sample task with slope of the line as the stimuli for memorizing presented during 5 sec. 18 sessions of memory test were recorded for each subject. Angle of the line for memorizing was 0, 45, 60, 90, 120, 135 degree. 3 sessions for each angle were recorded. Artifacts of EEG were removed using ICA (the program Neuron-Spectrum.NET_UM).

For calculation of power spectral density (PSD) *matplotlib.mlab.psd* function of *matplotlib* library (Hunter, 2007) for the Python programming language was used. The power spectral density was calculated by Welch's average periodogram method with the 500 data points windowed by the function *numpy.hamming* used in each block for the FFT and 50% overlap between blocks. The values obtained for the PSD of different frequencies were averaged for the following frequency bands: theta-1 (4-5 Hz), theta-2 (6-7 Hz), alpha-1 (8-9 Hz), alpha-2 (10-12 Hz), beta-1 (13-19 Hz), beta-2 (20-30 Hz). The peak alpha frequency (PAF) for each segment was determined using the center of gravity method (Klimesch, 1999). PAF is the weighted sum of spectral estimates, divided by alpha power: $(\Sigma(\alpha(f)\times f))/(\Sigma\alpha(f))$ Power spectral estimates at frequency f are denoted. The index of summation was in the range of 7 to 14 Hz.

For each subject PSD values were averaged for all sessions. Average values for each band was normalized by dividing value on each electrode by mean value of all electrodes for the aim to show topographical differences between groups. Significant changes of the PSD for intergroup comparisons were determinate by One-Way Permutation Test based on 99999 Monte-Carlo resamplings, sold in a package COIN for R programming language (Hothorn et al., 2006). Significance of differences was calculated separately for each electrode with no correction.



Results. The most interesting results were obtained by comparison of topography in the theta-2 band. Right-handed subjects show normal pattern of topography with diffuse distribution and focus around Cz. Left-handed subjects had topography of theta-2 band with shift to postcentral aria (Fig. 1). Statistical comparison of two groups shows significant differences in frontal (Fp1, Fp2), occipital (O1, O2) and parietal (P3, P4, Pz)

regions ($p<0.05$). Alfa-like topography of theta-2 band in left-handed may cause of slow alfa rhythm. Comparison of peak alpha frequency shows no significant differences between groups. Mean PAF of parietal (O1 and O2) electrodes for right-handed group was 10.29 Hz and 10.15 Hz for left-handed. Right-handers had asymmetric topography of PAF with faster PAF in occipital part of left hemisphere (Fig. 2), and left-handers had bilateral distribution of PAF. So, atypical topography of theta-2 band in left-handed group can't be explained by slower alfa rhythm.

Conclusions. In our investigation it was found that female left-handers had atypical topography of theta-2 band with shift to occipital distribution. This feature of topography can't be explained by slower alfa rhythm. It reflects alternative development of left-handers brain.

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High-frequency (60-90 Hz) gamma bursts characterize electrodecremental ictal onset pattern in patient with mesial temporal epilepsy: MEG study

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Background. One type of electroencephalographic (EEG) ictal onset pattern is a sudden «desynchronization» of electrical activity, when the signal looks almost flat – electrodecrement (ED). This EEG pattern provides poor lateralizing/localizing information on the ictal onset zone. However, intracranial electrocorticography (ECoG) studies reported that abrupt decrease of background cortical activity during ED may be accompanied by increasing extremely fast very low voltage oscillations. Moreover, according to the ECoG literature bandwidth between 60 and 99 Hz can provide clinically valuable information for defining ictal onset zones. Some studies showed that the resection extents of neocortices containing ictal high-frequency oscillations (60–99 Hz) recorded during chronic intracranial electroencephalography were correlated with postoperative seizure-free outcome. (Zijlmans et al. 2012; Park et al. 2012). The clusters generating HFOs are rather small, in the order of 1 cm^3 or less (N.Ellenrieder et al. 2012). Magnetoencephalograpy (MEG) being more sensitive to local neuronal population activity than EEG appears to be better for high-frequency oscillations detection. In this MEG study, we focused on frequency structure of brain oscillations during ED that preceded clinical seizure onset.

Methods. A 18-year-old man with drug resistant epilepsy due to right mesial temporal lobe lesion underwent MEG presurgical work-up. He had three similar complex partial seizures during whole-head MEG recording session. Each seizure was preceded by a clear diffuse electrodecremental pattern followed by highly synchronous beta oscillations about 10 sec before onset of clinical seizure and increase of EMG signal. MEG signals from 204 planar gradiometers (Elekta Neuromag, Finland) were analyzed during time period contained ED using Complex Morlet wavelets. We tried to use different bandwidth parameter of wavelet and finally set bandwidth = 4 and wavelet center frequency = 1. Spectral power within frequency range between 10 and 110 Hz was subjected to time and frequency normalization procedures. The period of analysis included 3 stages: “pre-ED”, “ED” and “ictal onset”, and its duration varied slightly (5-6 sec) between 3 seizures. As the next step we visualized spatial distribution of 60–90 Hz band spectral power during “ED” stage.

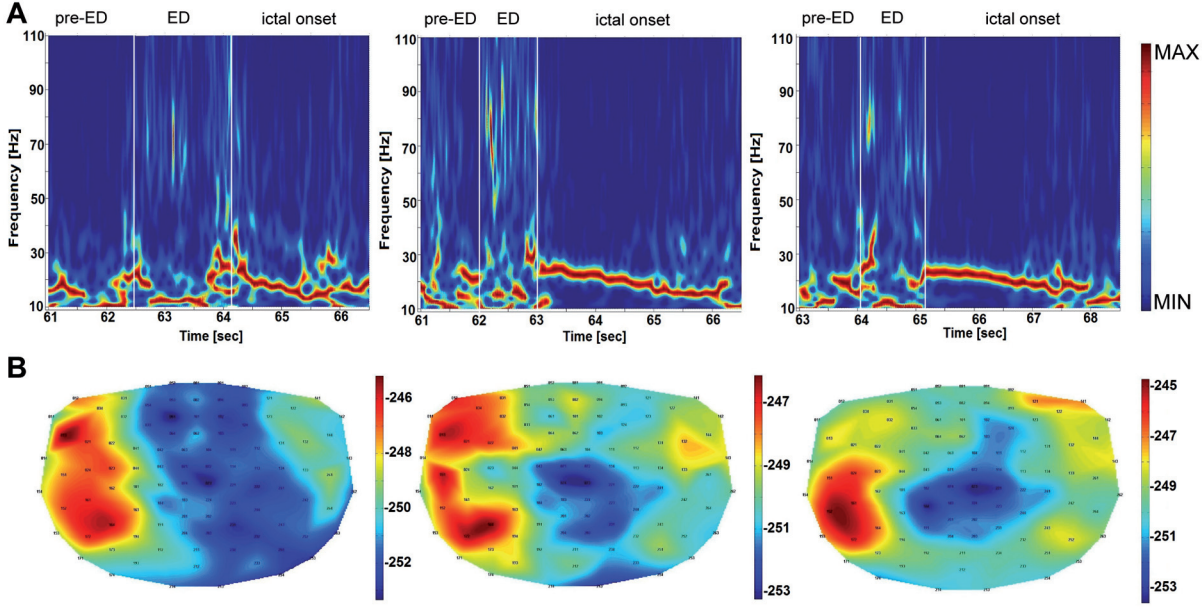

Fig.1. *Morlet spectrogram of MEG signal preceding onset of seizure's clinical signs in three seizures of the same patient. A) The changes in neural activity from ED to ical onset stage concentrate on transition from high gamma (60 – 90 Hz) burst to continuous gamma-beta oscillations with gradual frequency decline. Spectrograms were min-max normalized in frequency domain. B) Topographical distribution of 60- 90 Hz frequency range spectral density during electrodecrement.*

Results. ED was associated with high frequency (60-90 Hz) gamma bursts that followed by continuous low gamma-beta oscillations in all three seizures observed. Frequency of oscillations was slowing down from 30 Hz to 15 Hz alongside the Ictal Onset stage (Fig. 1A). Topographical distribution of high gamma bursts during ED stage (Fig. 1B) showed that so-called electrodecremental pattern contained oscillations that were clearly lateralized toward the left hemisphere and localized within the restricted range of MEG sensors. According to results of visual analysis routine the same sensors detected the major proportions of interictal and ictal MEG spikes.

Conclusion. Electrodecrement contains a rich set of oscillatory responses in localized region of cortex, including rapidly adapting high-frequency gamma onset followed by sustained gamma power (30Hz) increase with ongoing transition to lower beta frequency (15-20 Hz). The results are in excellent correspondence with previous invasive recordings of gamma oscillation in seizure onset zone (Park et al, 2012). Our findings support the idea that MEG fast gamma oscillations during ED are signature of epileptogenic brain region. This suggests that MEG-measured high frequency oscillations during ED may expand possibilities for non-invasive detection of seizure onset zone.

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Human brain evoked potentials to the animate and inanimate nature objects images

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We provided psychophysical and electrophysiological (evoked potentials) measurement to solve a problem of animate and inanimate natural images recognition after wavelet filtering in high and low spatial frequencies range. We presented to each subject 90 high and 90 low-frequency images of the same 45 animate and 45 inanimate objects. We show images each of categories twice. It was made 360 such presentations. As a result of the analysis it was succeeded to establish the characteristics of evoked potentials, reflecting the physical and semantic features of images. The study revealed significant differences in the evoked potentials components amplitude. Found that there are differences of evoked potentials components to stimuli in different spatial-frequency ranges of stimuli in the occipital regions, despite the fact that the instruction offered by the subject, did not include information on the need for separation of images based on their physical characteristics. Differences between the evoked potentials components in the frontal and central areas were also classified in accordance with the intended task for participants to discriminate the animate and inanimate objects.

We assume that a complete description of the physical properties of the stimuli occur in the occipital regions, and in the frontal cortex – their classification, in the accordance with the intended task for the participants.

The effects of separated alpha neurofeedback on emotional state and personality

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Introduce. Many reports have demonstrated that the left hemisphere is associated with more positive affect, and the right hemisphere in more involved in negative emotion(Baehr, Rosenfeld, & Baehr, 1997; Henriques & Davidson, 1991). Previous studies have shown that al-pha/theta and alpha asymmetry protocol can be used as an influence on the emotional state of the healthy subjects (Hammond, 2005; Raymond, Varney, Parkinson, & Gruzelier, 2005; Rosenfeld, 1997). At the same time, the previous findings suggest that neurofeedback can induce changes in personal characteristics (Bodenhamer-Davis & Callaway, 2004; Peniston & Kulkosky, 1990).

In this study we suppose the possibility of the external influence on the emotional state through the separate stimulation of alpha activity using EEG biofeedback.

Methods. Subjects (N=16; mean age 22,3±0,6) were randomly allocated to one of 2 training groups: the first group was trained to enhance relative alpha (8-12 Hz) activity in F4-O2 electrode position, the second group in F3-O1 position. Participants were matched for age and gender. Each participant was receiving 6 neurofeedback sessions over a period of 2 weeks.

Before the first and the last session EEG was recorded during 3 min eyes-closed rest from 19 locations placed according to the standard 10-20 system. EEG was recorded at 250 samples per second (0.5-70 Hz) referenced to digitally linked mastoids.

Pre- and post-training data of the full course of training were collected for the Cattell six-teen personality factor questionnaire, Strelyau test, Beck depression inventory, Spielberger's State-Trait Anxiety Inventory (STAI). Health, Activity and Mood questionnaire and Lusher test were performed before and after each training session.

To analyze the effect of the neurofeedback on the values obtained in the psychological testing and as well on the power of the alpha rhythm was performed ANOVA RM. Training ef-fects were assessed by 2 × 2analysis (GROUP: F4-O2 and F3-O1; TIME: pre and post).

Some people are not able to change their EEG in result of NFB(Hanslmayr, Sauseng, Doppelmayr, Schabus, & Klimesch, 2005). We analyzed responders and non-responders sepa-rately. Finally we used an ANOVA with RM by TIME and RESPOND factors.

Results. An analysis of the alpha rhythm power before and after the training revealed a significant effect for factor TIME in Fp2 (F=6,083; p=0,03) and F4 (F=4,969; p=0,046). No sig-nificant effects were obtained for factor GROUP and interaction TIME × GROUP.

Six participants were included to the responders NFB group(5 of them belong to the group «F4-O2»), others (N=10) were classified to the non-responders group. ANOVA revealed significant results for interaction TIME × RESPOND, indicating that alpha

power in O1 (F=7,893; p=0,016) andO2 (F=5,905; p=0,032) had significant increase in the responders group. To further analysis changes in alpha band for the responders group three-way ANOVA (TIME: pre and post; RESPOND: responder and non-responder; LOCATION: 19 electrode sites) were calculated. This ANOVA also revealed significant effect for interaction TIME and RESPOND (F=8,013, p=0,015).

We found the significant main effect of TIME (F=5,929, p=0,031) for the scale A Cattell's questionnaire. This finding was revealed for the first and second experimental groups. Moreover we obtained as significant interaction TIME×GROUP and TIME × RESPOND for the strength of excitation by questionnaire Strelyau and situational anxiety by STAI (p<0,05). In this case, the respondents and members of the group «F4-O1» showed scores decrease while the non-respondents and the group «F3-O1» showed scores increase.

Conclusions

1. Neurofeedback can be influence on the non-clinical subjects personality scores;
2. Separated alpha neurofeedback training causes no alternate changes in the emotional state;
3. Alpha protocol for the right hemisphere electrode positions has more positively effect for improvement in the training value;
4. For the responders stimulation of the alpha rhythm only one hemisphere causes an in-crease in power of the alpha rhythm on the whole surface of the cortex.

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The PPA activates when looking at geographic maps: an fMRI study*

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Introduction. In early 2000s researchers discovered that the human brain tends to specifically activate when the participant is looking at images of scenes (landscapes and cityscapes). The area which activates upon such stimuli was named the PPA – parahippocampal place area (Epstein & Kanwisher, 2001). Since then this part of parahippocampal gyrus has been studied considerably, but its functions are not yet fully understood.

Experimental data assumes that PPA not only activates in the process of looking at images of places, but is also involved in visual imaginary or in performing spatial tasks. For example, the participant looks at a geographic map and have to decide whether to turn left or right to reach a given destination point (Lobben et al, 2005).

We wondered if this activation is evoked by characteristics of such spatial tasks or by direct perception of geographic maps. We hypothesized that the presentation of geographic maps can activate PPA even during relatively passive viewing. To clarify the matter we used the functional ROI (regions of interest) approach. In each participant we distinguished the parts of parahippocampal gyrus that activated more statistically significant when he or she looked at the images of scenes than at the images of faces. Then we analyzed the activation within this region of interest.

Method and participants. 16 healthy right-handed subjects – aged 18-42 with an average age of 26, 12 women and 4 men – participated in the study. All participants had normal or corrected visual acuity.

Photographs of human faces and houses were used for a functional localizer. In the main part of the experiment participants viewed images of geographic maps without inscriptions and scrambled maps (control condition).

Functional imaging was conducted on a 1.5 T scanner Siemens Avanto scanner. T2*-functional images were acquired using EPI sequence with parameters TR/TE/FA – 2520 ms/50 ms/90°. 30 slices 3.8 mm thick contained 64×64 voxels of 3.6×3.6×3.8 mm each and were oriented in AC/PC plane. Anatomical T1-weighted images and field maps were also acquired for each participant.

The experiment consisted of 4 runs – 2 runs of functional localizer and 2 runs with geographic maps. In all 4 runs the stimuli (including baseline) were presented by

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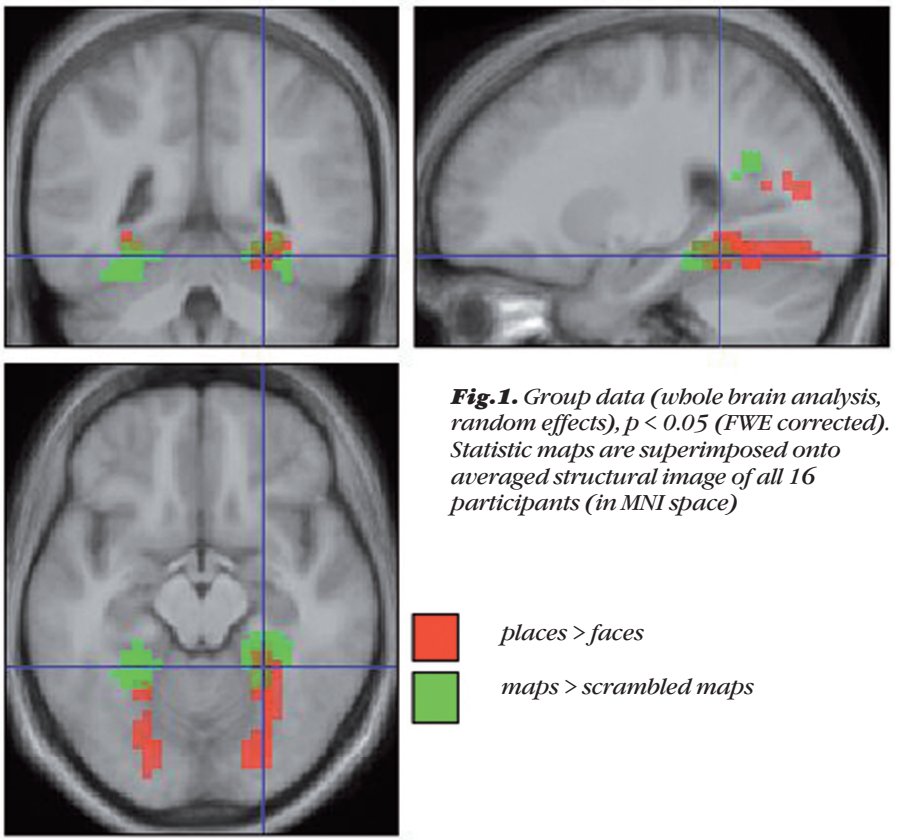

Fig.1. *Group data (whole brain analysis, random effects), p < 0.05 (FWE corrected). Statistic maps are superimposed onto averaged structural image of all 16 participants (in MNI space)*

20-second blocks (19 images per block). In total, all subjects were shown 15 blocks of photographs of faces and houses and 16 blocks of geographic maps and scrambled maps. All stimuli were presented on the screen with angular size of 12×10°.

The participants performed one-back task and raised their thumb when two images in a row were identical.

Results. The data were analyzed with SPM 8 and Marsbar. The PPA was defined for each subject as the intersection of the activation revealed by contrast 'places > faces' (p<0.05 without FWE) and the parahippocampal gyrus (according to the AAL atlas (Tzourio-Mazoyer et al). Statistically significant activation within PPA for 'geographic maps'>scrambled maps' contrast, p<0.05 was discovered in 11 participants. This result is significant (p<0.000001) at the level of the whole group of subjects. Group data (whole brain analysis, random effects), p<0.05 (FWE corrected) is also shown in Figure 1. Statistical maps are superimposed onto averaged structural image of all 16 participants (in MNI space).

Conclusions. The study has shown that the PPA activates when looking at the geographic maps even in the absence of specific spatial map-related task. This fact presumably provides evidence, that schematic abstract depiction of real landscapes and cityscapes are processed by the same brain region as their real prototypes.

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Development of a test procedure for the effectiveness of neurofeedback training

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Introduction. It is known that the neurofeedback training (NFT) allows an individual to transfer information about these or other characteristics of the electrical activity of the brain for the possibility of conscious control (Hassett, 1981; Buzsáki, 2006). However, most work which is published in this field, do not provide the quality control (i. e. the same conditions for control subjects) for the estimated result of neurotherapy (Zoefel et al., 2011; Nan et al., 2012). In this connection the actual task is development of a test procedure for the effectiveness of neurofeedback. As a parameter of neurofeedback you can use any rhythm or rhythms ratio, such as alpha-brain activity, theta/alpha ratio (Mullholand, 1995; Escolano et al., 2011).

Methods. A total of 18 students (10 females and 8 males, aged 20–29 years) took part in the experiment. During the experiment, the participants sat in an electrically shielded and sound attenuated room. EEG signals was recorded from 8 electrodes placed at F3, F4, C3, C4, P3, P4, O1, O2 (according to the international 10–20 system) with a sampling frequency of 500 Hz, the ground electrode was located at FCz and the reference was attached to the left and right mastoids. The signals were amplified by a 32-channels system Mitsar-202 and were recorded by Matlab software.

The participants were randomly allocated to NFT and control groups. Both groups consisted of 9 subjects (5 females and 4 males) and there was no significant difference in age between the two groups. For each participant the experiment consisted of two consecutive days with five sessions of 2 minutes each. In the beginning NFT, the both groups did resting baseline recording during 2 minutes with eyes open in the dark room. Using Fast Fourier Transform, the power in the alpha band (8–12 Hz) was calculated in real time mode for electrode P4. During the sessions, the feedback was given by means of a red square. The saturation of the feedback colour indicated the amplitude of alpha band in relation to the baseline resting. Red and black values symbolized an amplitude above and below the baseline, respectively. For all subjects were instructed to make the square as red as possible.

Results. All statistical analyses were carried out using Matlab Version 7.7. In order to evaluate trainability, the average amplitude of alpha band was calculated for the baseline and training sessions of each day and all subjects. The increase of the power of alpha band and the comparison of the amplitude of alpha rhythm before and after neurofeedback training was assessed by one-way ANOVAs, calculated separately for NFT group and control group. The between-group differences were analyzed by one-way analysis of variance (ANOVA).

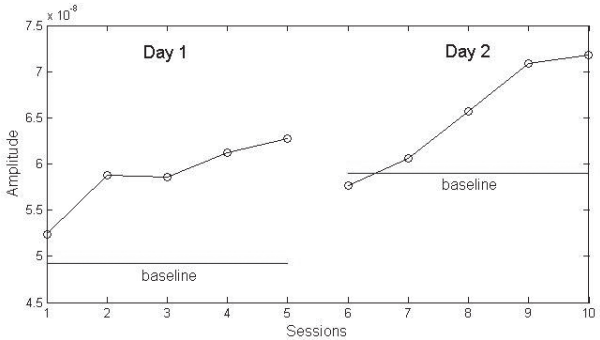

Fig.1. *Average amplitudes of alpha band across one responder according to the temporal course of the study relative to the baselines of the each days. Note, that the last sessions of the each day is significantly higher than the first sessions, both reflecting trainability*

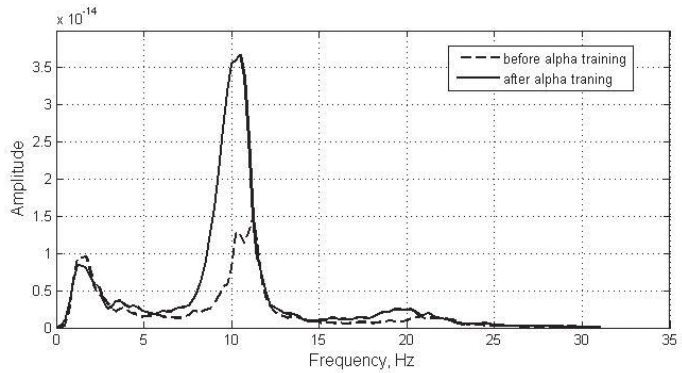

Fig.2. *The demonstration of the EEG frequency spectrum from P4 electrode. Frequency spectrum during the first session of the first day (dashed line) and the fifth session of last day (continuous line) for one responder. The influence of NFT on the spectrum is most pronounced and significant in the frequency range from 8 Hz to 12 Hz*

Conclusion. The analysis of the data showed the effectiveness of neurofeedback training for NFT group. By the end of the fifth session of last day, the amplitude of alpha activity was significantly higher than the first session of the first day (Fig. 1). The frequency spectrum before neurofeedback in regard to spectrum after neurofeedback for one subject is plotted in Fig. 2. The increase of average amplitude of alpha rhythm is visible as the difference

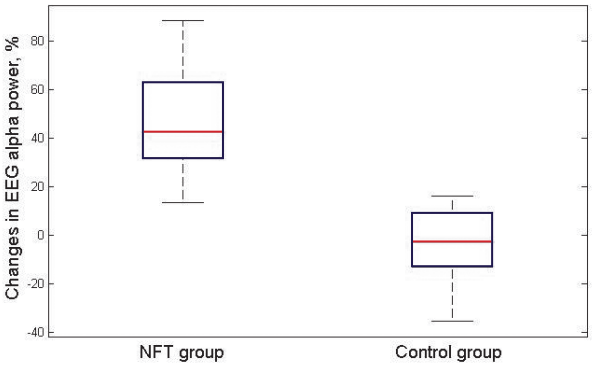

Fig.3. *Increase of the relational average power of alpha band for the NF training group and the control group for all participants ($F = 28.2, p < 0.001$). On each box, the central mark is the median, the edges of the box are the 25^{th} and 75^{th} percentiles*

between the spectrums. The influence of NFT on the spectrum is most pronounced and significant in the frequency range from 8 Hz to 12 Hz. There wasn't observed any increase of the amplitude of alpha activity in the control group. Difference between two groups from neurofeeback training is shown in Fig. 3. Change in EEG alpha power was given by means of a percentage. By the end of neurofeedback training, the alpha activity increased by 42.9% in the NFT group on average and decreased by 2.5% in the control group, respectively ($F=28.2$, $p<0.001$). This study shows the importance of quality control in experiments of neurofeedback. Further studies of this method and the search of optimal parameters of neurofeedback are necessary for the application in therapy.

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Executive functions, interhemispheric asymmetry and variability of EEG and fMRI changes during motor and speech tasks

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Individual differences in executive functions in subjects with different profiles of functional asymmetry were compared with formalized characteristics of fMRI and EEG response. 52 healthy volunteers (26 men and 26 women) age 21–30 years participated in the study. Functional asymmetry profile was measured and executive functions were assessed using D-KEFS Color-Word Interference Test, D-KEFS Verbal Fluency Test, D-KEFS Design Fluency Test (Delis-Kaplan Executive Function System). fMRI and EEG responses to motor and speech tests were analyzed in 24 subjects (12 men and 12 women) as well as EEG with closed and open eyes.

Subjects with primarily right asymmetry demonstrate good switching abilities and inhibition of reactions to irrelevant stimuli. Certain individual variability of hemodynamic and bioelectric responses in speech and motor tasks that correlates with gender and functional asymmetry profile was seen. Among functional EEG characteristics CNS activation in the condition of closed and open eyes plays an important role in reaction formation revealing functional connectivity of the left hemisphere with non-specific brain stem activation system. The higher the level of this activation the higher the speed and the number of errors in executive tests. Coherence of EEG spectra correlate significantly with switching and inhibition of interfering stimulate. As noise variants of EEG coherence spectra increase time to complete tests increases, but number of errors decreases.

EEG reactions during actual hand movement performance and motor imagery in healthy subjects*

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An important field of interest in the higher brain activity is the analysis of its functional specialization. The study of brain activity during the performance of motor tasks, such as fist clenching of the right and left hand, can be used as a model. The analysis of brain reactions during actual and imaginary movements becomes of particular significance in the development of the brain-computer interface, as well as the research for new methods of rehabilitation of patients with movement disorders.

15 healthy right-handed people (6 men and 9 women), aged 21 to 39, took part in this study. We analyzed EEG reactions during various functional movement associated probes (finger clenching into a fist with the right and then left hand) and the motor imagery of the same movements. Various EEG parameters were analyzed (average level of coherence, power, frequency and the effective bandwidth). These parameters were calculated for the entire frequency bandwidth (0.4–30 Hz), as well as the components within the ranges of the basic physiological rhythms: delta, theta1, theta2, alpha1, alpha2, alpha3, beta1 and beta2.

The EEG data showed that actual hand movements are characterized by an increase in coherence of high frequency alpha and beta rhythms in the contralateral hemisphere, an increase in the power and average frequency in the beta-rhythm was mainly in the left hemisphere. The EEG analysis during motor imagery demonstrated an increase of coherence in the alpha and beta rhythms in the right hemisphere. The dynamics of the frequency and power parameters of the EEG is similar to the ones in actual movement. The comparison of the reactive changes in the EEG pattern of the two experimental situations showed that motor imagery, in comparison with actual movements, was accompanied by increase in coherence in the low EEG frequency bandwidths (delta and theta) in the central areas with an accent to the left hemisphere.

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The EEG registration helped us obtain new useful information on the description of the specific changes of brain activity during actual movements and motor imagery, which is provided by different brain structures. EEG analysis of actual movements revealed systemic brain activity with the activation of both hemispheres in the formation of motor responses. Out of all the EEG parameters during actual movement, coherence in the high alpha and beta rhythm was the most reactive. During the imagination of right-handed movements the coherence increases in the high alpha and beta bands in the right hemisphere. During imaginary movement, in comparison with actual movements, the coherence increased in the slow rhythms in the central regions, with emphasis on the left. We propose that this approach can be useful in diagnostic studies in patients with motor dysfunction.

Correlation between EEG rhythms associated with movement and spatial reasoning*

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Introduction. It is known that EEG rhythms appearing during the movement suppressionare in μ frequency band and occur over the central areas of the scalp (Gastaut et al., 1965, Rogeul-Buser, 1997).But it was discovered earlier that the rhythms with the frequency about 11 Hz do also appear while solving tasks regarding to spatial-figurative type of thinking (Ivanitsky et al., 2008). The rhythmical patterns are highly individual and uniquely associated with the type of the mental operation being performed, but they are constant in time for every person.This observation leads us to a hypothesis that there is a simple correlation between rhythms of suppressed movement and spatial reasoning. This study aims to find the proposed correlation using Fast Fourier transform with Mann-Whitney U test to compare statistical difference of spectra.

Methods. 12 healthy voluntaries (7 males, mean age 22) participated in the study. The experiment procedure consisted of two parts. In the first part, a photo with the hand gesture showing from 1 to 5 fingers is presented on a screen (6 sec) following a red X or a green checkmark (2 sec): if it is the green checkmark – subject was instructed to repeat a gesture displayed on the screen by himself or say how many fingers are shown, but if it is the red X – do not repeat a gesture or do not say out loud the number of fingers. There are 3×60 reps of random gestures – 60 with the right hand, 60 with the left, and 60 gestures, when the subject said or equiprobably didn't say the number of fingers. It was necessary for comparison of suppressed movements with some other suppressed action as speech. In the second part, the person had to solve 2 kinds of 100 tasks presented randomly: verbal-logical (anagram) and spatial-figurative (choose the pieces to make a square).

The fast Fourier transform was used for calculation of average EEG spectra corresponding to each type of experimental conditions: move/do not move (red/blue line on Fig.1), say/do not say (red/blue – Fig.2), and verbal/spatial task (red/blue line on Fig.3). Mann–Whitney U test was performed to find a significance of spectral differences (blue and red lines under the graphs, $p<0.05$).

* The study was partly supported by RFBR grant #10-04-0154, Program of the Presidium of RAS «Basic sciences for medicine».

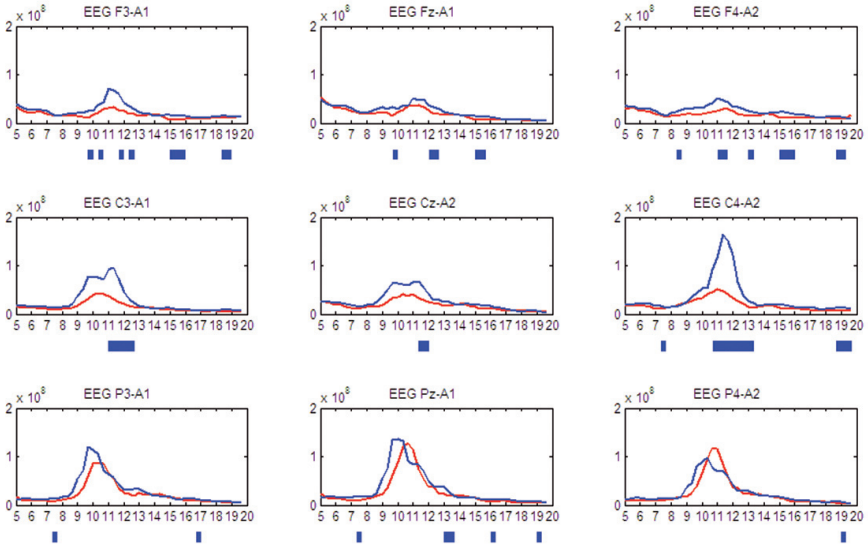

Fig.1. *Execution (red) and suppression (blue) of movement*

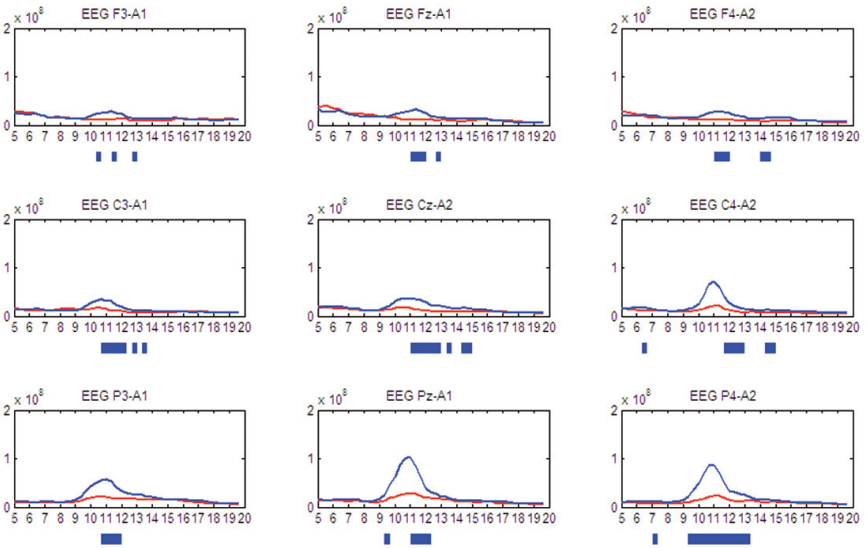

Fig.2. *Execution (red) and suppression (blue) of speech*

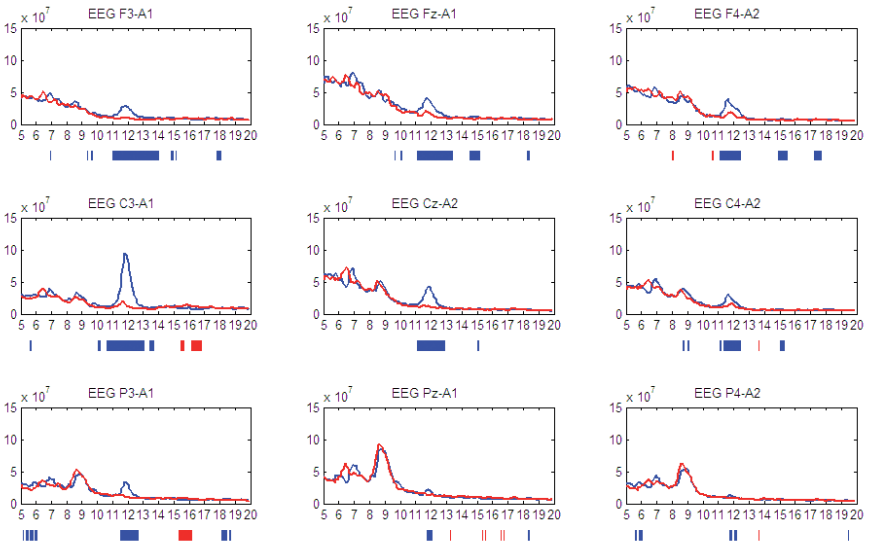

Fig.3. *Verbal (red) and spatial (blue) task solving*

Results. The peaks at μ frequency bandwere observed on the Fourier spectra while the subject suppressed the movement (Fig.1). These peaks were prominent in the central and parietal areas (C3-C4, P3-P4), but the significant difference in spectra between the suppressed movement and the executed movement were only in the central zones for more than a half of the tested people (7 of 12). 3 subjects had significant differences in the central areas, as well as in the parietal areas. The others had individual spectra characteristics.

Fig.2 illustrates the significant difference not only in central zone, but also in parietal (P3-P4) zones. When the subject spoke the rhythm in the parietal zones decreased in amplitude.Thus this rhythm might be responsible for the speech suppression for some individuals.

While solving the spatial/verbal problems(Fig.3) significant differences were observed in the central and the frontal areas, but a degree of the significance was greater in the central areas (C3, Cz, C4).

Thus, our primary hypothesis is confirmed for 7 from 12 subjects participated in the study: the suppressed movement rhythms are the same as the spatial reasoning rhythms. But the other 5 subjects have a different distribution of Fourier spectra, driving us to suggestion that the correlation between these rhythms is more complicated.

Conclusion. Our preliminary results suggest that there is some correlation between rhythms of the spatial reasoning and the suppressed movement, but this correlation

may differ from individual to individual. For better understanding of the nature of this correlation we are planning to use Independent Component Analysis (ICA) in order to find whether the dipole sources are the same for the suppressed movement and the spatial reasoning.

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B-Reactable: multimodal tabletop system for collaborative physiology monitoring and training

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Rapid development within the biomedical engineering field, especially Brain-Neural-Computer Interaction (BNCI) area, provides a solid technological base for new applications aimed at improving health and quality of life. In this project, aimed at combining research and training components, Dr. Valjamae will design, validate and optimize a novel multimodal system - B-Reactable - linking a tangible musical tabletop interface with BNCI technology for collaborative physiology monitoring and training in future health and professional applications.

This interdisciplinary research project is based on the joint pilot work with Prof. Jorda, University of Pompeu Fabra, Barcelona in 2010-11. The project is designed to be a vehicle for the training and consolidation of the research outcomes for further exploitation in the EU. In the envisioned B-Reactable applications, users will explicitly or implicitly learn to monitor and control their physiological signals using tangible objects, and hence, understand and influence their cognitive or emotional states. The project will reinforce the international dimension of applicant's scientific career by giving him the opportunity to be trained and acquire new knowledge in the Russian Federation, under direct guidance of Prof. Kropotov at the "Institute of Human Brain", Russian Academy of Science (IHB-RAS) and Dr. Ossadtchi at St. Petersburg's State University (SPSU). Prof. Kropotov is one of the leading neurofeedback scientists, with over 30 year research in computational models, normative databases, new paradigms and analysis methods, and extensive work on healthy adults, children and various patient groups. After training at IHB-RAS, Dr. Väljamäe will bring his new experience and tangible outcomes to the renowned Swedish Institute for Disability Research at Linköping University, where together with Prof. Vastfjall he will test and further refine B-Reactable, targeting cognitive aging for improving users quality of life and wellbeing.

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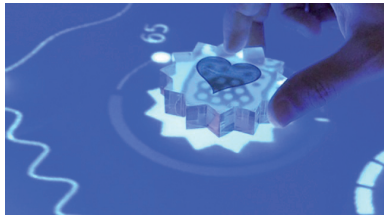

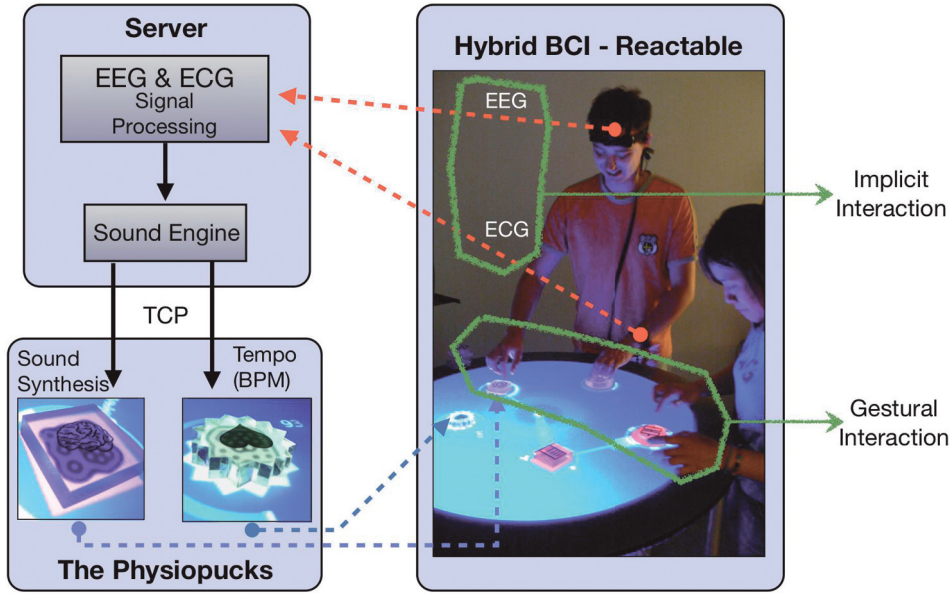

Left: *Tangible object – physiopuck - of B-Reactable that is linked to user's heart-rate signal.* ***Right:*** *B-Reactable system (figure from [1]).* ***Right:*** *B-Reactable system architecture*

Processing of semantic violations in Russian healthy speakers and aphasic patients

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The method of event-related potentials (ERPs) became an important instrument for investigating language processing mechanisms. Implementation of this method in aphasia studies allows to analyze types of linguistic information the patients are sensitive to and observe variations in the time course of different subprocesses underlying language comprehension. The goal of the present study was to examine processing of lexical-semantic information in Russian healthy individuals and aphasic patients grouped using aphasia diagnosis and lesion localization. For this purpose, ERPs effects accompanying processing semantically correct sentences and sentences with semantic violations were studied.

The experimental materials included 40 semantically correct Russian sentences and 40 their anomalous counterparts that were created by substituting the direct object with a semantically inappropriate noun (1).

1. Malysh		nabiraet	**pesok/*zvonok**	v	vedyorko.
child-SG.NOM	*fill-PRES.3SG*		*sand/*bell-SG.ACC*	*in*	*bucket-SG.ACC*

*The child fills the bucket with **sand/*a bell**.*

160 fillers (80 correct and 80 with syntactic or morphosyntactic violations) were also used. 8 healthy individuals and 16 aphasic patients with left hemisphere lesions (8 diagnosed as Broca's patients and 8 – as Wernicke's patients) participated in the study. The experimental sentences were presented auditorily. The participants were asked to listen attentively to the sentences and judge them as correct or anomalous.

The EEG was recorded using 128 electrodes mounted in an elastic net Geodesic Sensor Net (Electrical Geodesics Inc.). Data processing included: filtering (40 Hz low-pass filter), segmentation (200 ms before – 1000 ms after stimulus onset), artifact rejection, averaging by experimental conditions (within and between subjects), baseline correction (for 200 ms preceding stimulus onset) and calculation of difference waves. The statistic analysis was performed using repeated measures of ANOVA for three time windows: 300–500, 500–700 and 700–1000 ms.

The results show that, firstly, processing semantic violations in healthy speakers yields in a standard marker of semantic integration difficulties – the N400 effect (e.g., Kutas &

Hillyard (1980) – on English; Friederici et al. (1993) – on German), and, secondly, processing sentences with semantic violations in patients is dependent on both aphasia diagnosis and lesion site. Concerning aphasia diagnosis, in Broca's patients processing sentences with semantic violations elicited the N400 effect, as in healthy individuals. In contrast, no N400 effect was present in patients with Wernicke's aphasia. Instead, processing semantically anomalous sentences only elicited the P600 effect in them, which is usually considered to be a marker of sentence reanalysis and repair (Osterhout & Holcomb, 1992). Regarding lesion sites, processing semantically anomalous vs. correct sentences resulted in the N400 effect in patients with parietal lesions and intact frontal and temporal lobes. In contrast, no N400 effect was observed in patients with inferior frontal and temporal lobe lesions and intact parietal region, whereas the P600 effect was found instead.

According to the results, processing semantic violations in Russian healthy individuals yields in the expected N400 effect. This effect was also observed in patients with Broca's aphasia, which evidences for a relatively intact semantic processing in this aphasia type. However, in Wernicke's aphasics integration of semantic information might involve compensatory mechanisms reflected in the P600 effect. The analysis based on lesion localization indicates that parietal lobe is not critical to the generation of the N400 effect, whereas left frontal and temporal lobes seem to play a crucial role in semantic integration processes, which is in line with previous results of Kiehl et al. (2002).

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Исследование семантических ассоциаций брендов методом N400

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Цели и постановка задачи. Данная работа посвящена изучению нейробиологических маркеров ассоциаций брендов, основанной на концепции семантических ассоциаций (и/или семантического прайминга), заимствованной из области психолингвистики. Экспериментальная работа проводилась посредством регистрации компонента N400 вызванных потенциалов в парадигме зрительного предъявления пар стимулов существительно-прилагательное (например, «Мерседес-престижный»). Мы предполагаем, что семантическое несоответствие между брендом и его определением приведет к генерации негативной волны N400, происхождение которой связано с обработкой лингвистической информации на семантическом уровне и семантическим праймингом. Мы также предполагаем, что амплитуда негативной волны будет пропорциональна степени ассоциативной удаленности между словами или категориями.

Материалы и методы. В пилотном исследовании принимали участие здоровые девушки в возрасте от 17 до 26 лет (средний возраст составлял 19,9 лет, 6 человек). После получения информированного согласия, испытуемым предлагалось заполнить опросник на знание торговых марок, используемых в эксперименте.

Далее, в ходе ЭЭГ исследовния, испытуемым в течение 25 минут в случайном порядке предъявлялись 80 пар конгруэнтных (например, «Gucci роскошный») и 80 пар неконгруэнтых (например, «Gucci дешевый») словосочетаний. Слова предъявлялись по одному в центре экрана с межстимульным интервалом – 1000 мс и интервалом между пробами – 3000 мс между парами. В качестве контрольного условия в последовательности стимулов с вероятностью 20% появлялись абсурдные словосочетания (например «Gucci соленый»). После предъявления пары подлежащее-определение испытуемы должен был оценить конгруэнтность/неконгруэнтность пары нажатием на соответствующую кнопку клавиатуры. Стимулы предъявлялись при помощи программы NBS Presentation. Подача стимулов была синхронизирована с записью электроэнцефалограммы.

Регистрация электроэнцефалограммы (ЭЭГ) производилась с помощью 24-канального цифрового энцефалографа «Мицар-ЭЭГ-201» и системы позолоченных ча-

шечковых ЭЭГ электродов фирмы Nikolet, расположенных на поверхности головы в соответствии с международной системой 10-20 в 19 отведениях (Fp1, Fpz, Fp2, F7, F3, Fz, F4, F8, T3, C3, Cz, C4, T4, P3, Pz, P4, O1, Oz, O2). Референтные электроды размещались на мастоидах. Вызванный ответ регистрировался на предъявление второго стимула в паре слов.

Результаты. Предъявление некогруэнтной пары стимулов вызывало более высокоамплитудное отклонение вызванного потенциала через 400 мс после начала предъявления прилагательного, что видно на рис. 1А, иллюстрирующего RMS значение типичного испытуемого. Как видно на изопотенциальной карте распределения разностного потенциала (неконгрэнтный-минус-конгруэнтный) по поверхности скальпа (рис. 1Б), амплитуда данного разностного ВП имеет негативное отклонение в правых лобных и париетальных областях.

Выводы. Результаты пилотного исследования подтверждают нашу гипотезу о том, что при семантическом несоответствии между названием бренда и прилагательным возникает негативная волна N400, генерация которой связана с семантически неконгруэнтной структурой пары. В дальнейшем мы планируем показать, что чем больше несоответствие определения бренду, тем больше амплитуда N400. В целом, используя объективный коррелят семантических ассоциаций или ассоциации брендов, с помощью регистрации N400, можно успешно параметризовать и дифференцировать функционально-утилитарные свойства бренда и свойства, связанные с получением удовольствия (гедонические аракеристики).

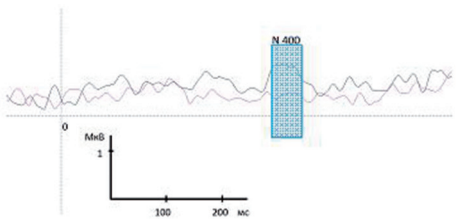

Рис. 1 А

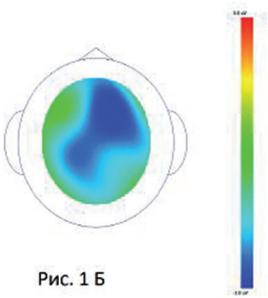

Рис. 1 Б

Рис. 1. А. RMS в ответ на предъявление конгруэнтного (красная линия) и конгруэнтного определения (черная линия). Б. Изопотенциальная карта разностной волны (неконгрэнтный-минус-конгруэнтный).

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