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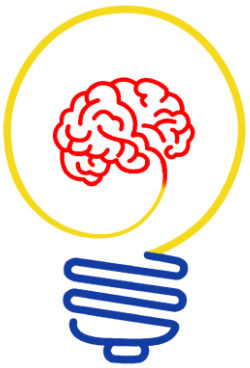

THE 4TH INTERNATIONAL CONFERENCE
BCI: SCIENCE AND PRACTICE. SAMARA 2018

Conference Proceedings

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Brain-computer interface: Science& Practice. Samara 2018

This book contains abstracts of plenary lectures and poster reports presented at the 4TH International Conference BCI: Science & Practice. Samara 2018. (BCI Samara. 2018). The BCI Samara.2018 was held October 12-13 of 2018 at the Samara State Medical University (Russia). This year the Conference continued the tradition of success made in 2015-2017. The two-days scientific part of BCI Samara.2018 included eight invited talks, the poster session, the panel discussion and two workshops. The satellite events were public lectures and Neurothlon competition.
We thank all the participants of BCI Samara.2018 and invite all the readers of this abstract book to join us in 2019.

Program Committee

Organizing Committee

Plenary session

Virtual Reality and the Brain: A Perfect Match

Doron Friedman

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The talk will cover some of the synergistic aspects of virtual reality (VR) and neuroscience. VR offers great advantages of studying the brain and mind; unlike most typical laboratory studies VR allows exploring the brain and mind in highly complex and naturalistic environments, with higher ecological (external) validity. Unlike field studies, VR allows for highly controlled experiments, maintaining internal validity.

In the first part of the talk I will provide some fundamental concepts and examples of VR-enabled brain research, with focus on behavioral realism. Next, I will present some examples of integrating virtual reality and the brain, highlighting the advantages that VR has for brain-computer interface research and applications

Experience of the motor function recovery in post- stroke patients using the hand exoskeleton controlled by the brain-computer interface based on motor imagery

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For the last three years we performed the extensive placebo-controlled, multicenter clinical trial to investigate whether stroke survivors with severe upper limb (UL) paralysis benefit from 10 BCI training sessions each lasting up to 40 min.

A total of 105 patients participated: median time since stroke is 8 months, 25 and 75% quartiles [3.0; 13.0]; median severity of UL paralysis is 4.5 points [0.0; 30.0] as measured by the Action Research Arm Test, ARAT, and 19.5 points [11.0; 40.0] as measured by the Fugl-Meyer Motor Assessment, FMMA. Patients in the BCI group (n = 55) performed motor imagery of opening their affected hand. Motor imagery-related brain electroencephalographic activity was translated into contingent hand exoskeleton-driven opening movements of the affected hand. In a control group (n = 19), hand exoskeleton-driven opening movements of the affected hand were independent of brain electroencephalographic activity.

Evaluation of the UL clinical assessments indicated that both groups improved, but only the BCI group showed an improvement in the ARAT's grasp score from 0 [0.0; 14.0] to 3.0 [0.0; 15.0] points ($p < 0.01$) and pinch scores from 0.0 [0.0; 7.0] to 1.0 [0.0; 12.0] points ($p < 0.01$). Upon training completion, 21.8% and 36.4% of the patients in the BCI group improved their ARAT and FMMA scores respectively. The corresponding numbers for the control group were 5.1% (ARAT) and 15.8% (FMMA).

These results suggests that adding BCI control to exoskeleton-assisted physical therapy can improve post-stroke rehabilitation outcomes. Both maximum and mean values of the percentage of successfully decoded imagery-related EEG activity, were higher than chance level. A

correlation between the classification accuracy and the improvement in the upper extremity function was found. An improvement of motor function was found for patients with different duration, severity and location of the stroke.

The study was supported by Russian Science Foundation, grant № 16-15-00219

BCI in psychiatry: pilot study

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P300-based brain-computer interface (P300 BCI) enables to detect the focus of human's attention to specific stimuli on the computer screen by analyzing the difference of EEG features between target and non-target stimuli reactions. Typically, in the P300 BCI paradigm the subjects' attention to the exact stimulus is caused by their practical interest to this stimulus, researcher's instructions or deviance of this stimulus (its clear distinction from other stimuli). At the same time, it can be built and applied the P300 BCI-based systems for detection of covert focuses of human interest, including emotional stimuli, in systems for monitoring human's normal and pathological state. In this work we investigate the properties of perception of stimuli with subjective emotional significance presented in oddball-paradigm. We also research the possibility of using P300 BCI for detection of covert focuses of attention. Hypothetically, this technology can be used for testing the person's ability of the emotional stimuli perception, which could be applied for the instrumental diagnostics of accentuated conditions or emotional perception disorders like autism or anorexia nervosa.

The objective was to investigate the properties of perception of stimuli with different subjective emotional significance and to evaluate the possibility of P300 BCI-based detection of covert emotional focuses of attention for healthy subjects and for patients with autism or anorexia nervosa.

14 healthy subjects and 12 anorexia nervosa patients participated in the EEG-study with consequent presenting of visual stimuli with emotional or neutral human faces photos. In the first block the participants' task was just to look at the screen with appearing stimuli (passive attention) while one of six stimuli in each trial was emotional. In the other two blocks the task was to silently count the number of the target stimulus presentations among non-target stimuli (active attention) with emotional or neutral target stimulus depending on the block. We analyzed the event-related potentials (ERP) for stimuli of different classes and the classification accuracy for target (or emotional) stimulus in P300 BCI-similar fashion.

In the first study on 14 healthy subjects showed that the accuracy of the passively presented emotional stimuli recognition (without the stimuli discrimination task) significantly exceeded the random level more than twice. We also found out the characteristic features of the ERP components evoked by the various images and under the conditions of low and high level of attention to the presented stimuli. The obtained results prove the hypothesis that P300 BCI paradigm can be used to detect covert attentional focuses to the external stimuli and complete the existing findings of the brain mechanisms responsible for the unconscious perception of the subjectively significant stimuli. In the second study on 12 anorexia nervosa patients showed that

presentation of images with body parts of thinness against other images resulted in higher EEG reactions compared to presentation of food images. Also the P300 BCI algorithm could classify the EEG reactions to both types of images with high accuracy, and the accuracy for body parts images was much higher than for food images (89% against 59%).
The obtained results create opportunities for developing the clinically applicable P300 BCI-based systems for detection of covert attentional focuses and prove the hypothesis that the BCI can be used to detect covert emotional focuses of attention and complete the existing knowledges of the anorexia nervosa development mechanisms.

Decoding, but what?

Mikhail Lebedev

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Brain-machine interfaces (BMI) are often described as devices that decode information from neural activity, for example arm coordinates represented by the discharges of motor cortical neurons. These decoded signals are sent to external equipment for the purposes of communication, restoration of functions, and rehabilitation. The existence of correlation between the neural activity and parameters of interest is taken as the evidence that the brain represents (encodes) particular types of information. Yet, neural signals typically represent multiple variables, often conceptually different, such as motor targets, orientation of spatial attention, gaze angle, temporal intervals, reward anticipation, etc. which makes makes it difficult to interpret the exact meaning of neural modulations, unless experiments are designed to manipulate different variables independently. Consequently, it is hard to tell what a BMI output represents. Additional problems to BMI decoding are introduced by overt behaviors: what appears to be a direct neural control of an external device may actually reflect small (ideomotor) movements of the limbs. Because of these issues, one should be cautious when explaining the results of BMI experiments (in particular, BMI-related plasticity) in terms of physiological functions encoded by neurons, and quantifying BMI decoding as information transfer rate. At the same time, multiple neural representations could be utilized in BMIs that multitask different functions. These points will be illustrated using data from different studies: from monkeys interacting with a robot to navigating rats.

Towards Zero-Latency neurofeedback

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Although the first neurofeedback experiments date back nearly six decades ago, the effectiveness of this paradigm is still a matter of debate. A detailed analysis of changes induced by P4-alpha EEG neurofeedback training showed that the mean alpha power rose due to an increase in the incidence rate of alpha episodes, whose amplitude and duration remained intact. These findings suggest that neurofeedback facilitates volitional control of alpha activity onset, but alpha episodes themselves appear to be maintained automatically with no volitional control – a property

overlooked by previous studies that employed continuous alpha-power neurofeedback. This result also brings about the question of feedback temporal specificity, the need to be on time to reward the very entrance into the desired transient brain state. We discuss theoretical basis motivating the need for latency reduction in order to fully unleash the power of neurofeedback. There is also shown a novel algorithm for predictive extraction of the envelope to significantly reduce the feedback presentation delay to ultimately reach zero-latency or even predictive feedback scenario.

Hijacking the brain with virtual reality: applications to upper limb stroke rehabilitation

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Virtual Reality (VR) has left the science fiction books, and is now almost a household term— like the terms television, toaster oven, and hair dryer. However, unlike these technologies—which serve a clearly defined purpose— we are only scratching the surface in understanding how to leverage the unique features of virtual reality beyond simple entertainment. Do we move similarly in an artificial virtual world as we do in our familiar physical world? Can visual illusions in VR be used in a therapeutic way to benefit motor recovery after disease? What happens in the brain when we move in the virtual world? I will discuss recent work in my lab that touches on the above questions in the context of rehabilitation of motor function after stroke, and potential relevance to BCI.

EEG-based Brain Computer Interface for post-stroke rehabilitation

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Keywords: Electroencephalogram, sensorimotor function, stroke hemiplegia, motor recovery, plasticity.

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Even scalp electroencephalogram (EEG) is a non-invasive, indirect measure of cortical activity, EEG based Brain-Machine Interface (BMI) can decode natural neural information from a targeted sensorimotor cortex in real-time, and translates it into machine control signals. It has achieved *telepathy-like* machine control (Hashimoto et al. BMC Neurosci 2010 [1]) or *cyborg-like* limb control, but also it achieves manipulation of the targeted neural activities via visual/somatosensory feedback (Ono et al. Front Neuroeng 2014 [2]; Ono et al. Clin Neurophysiol 2013). Neural decoding algorithm for EEG identifies the relevant feature covaried with cortical oxygenation signals of magnetic resonance image in the sensorimotor cortex (Tsuchimoto et al. Front Hum Neurosci 2017 [3]; Ono et al. Brain Topogr 2015 [4]), and manipulation of this feature through

contingent robotic movement support and neuromuscular electrical stimulation promotes cortical reorganization (Kasashima-Shindo et al. J Rehabil Med 2015; Ono et al. Brain Topogr 2015; Mukaino et al. J Rehabil Med 2014). Retention of improved brain activity and motor behavior through BMI manipulation is feasible as medical application (Kawakami et al. Restor Neurol Neurosci 2016 [5]; Shindo et al. J Rehabil Med 2011), as reorganizing damaged brain function and underlying neural circuits to promote functional motor recovery from pathoneurological conditions, such as post-stroke hemiplegia (Ushiba, Soekadar, *Prog Brain Res* 2016 [6]), incomplete spinal cord injury, and dystonic writer's cramp (Hashimoto et al. BMC Neurosci 2014). In this talk, neuroscientific relevance of BMI, clinical efficacy of BMI for post-stroke rehabilitation, and the undergoing regulatory process of our BMI collaborated with Panasonic will be overviewed.

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Artificial vision via a high-resolution, chronically implanted neuroprosthesis in the primate visual cortex

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Since the 1960s, experiments in both humans and monkeys have shown that electrical stimulation of the visual cortex produces percepts of light, known as 'phosphenes,' at specific locations in the visual field. This is hence a highly promising technique for the generation of useful visual percepts and restoration of low vision in profoundly blind people. To date, several pioneering clinical studies or clinical trials are either underway or being planned in blind human patients.
We have combined cutting-edge technological innovations with neuroscientific principles and clinical insight, to lay the foundations for a device that could lead to the restoration of a rudimentary form of vision in the profoundly blind. This included the development of customized cranial implants (Chen et al., 2017), new and improved surgical tools and techniques, a large-scale microstimulation and recording system, and sophisticated behavioural tests to assess the interpretability of phosphene percepts.

We created a chronically implantable, high-resolution neuroprosthesis system in primates, achieving unprecedentedly high channel counts of >1000 electrodes. This allowed us to stably record neuronal activity over large regions of visual cortex and to produce phosphene percepts in hundreds of locations across the visual field.
The artificial percepts generated by our system were successfully used to carry out sophisticated behavioural tasks for over 16 months and counting, fuelling an optimistic outlook for future clinical applications.

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Poster session

Decoding natural finger movements from micro-grid recorded surface EMG data

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Purpose:

Muscle-Computer interface (muCI) is a system that translates muscle activity (EMG) into control signals for an external device. Decoding movements from EMG can be used to empower assistive and prosthetic devices in people with limited capabilities as well as for detailed movement quantification for diagnostic and research purposes [1]. In this study, we have achieved high accuracy in decoding continuous, natural finger movements based on the surface EMG recorded with a compact high-density EMG electrode grid.

Main study design:

True finger coordinates and the EMG were recorded synchronously using a motion capture system and a high-density 64 electrode grid placed over the ventral side of the arm covering approximately 3 cm^2 of the skin surface. Recorded raw EMG data were band-pass filtered, rectified; extracted envelope was passed to Kalman data fusion algorithm [2] that learned the dependency between EMG data and finger movements as well as dynamical model of the movement. After this parameter identification step, the algorithm was used online to decode natural continuous finger movements.

Results:

Our results show the possibility of decoding wide range of natural movements from EMG signals recorded over a small skin surface. In the online runs, natural finger movements (flexion to variable degree, simultaneous flexion of multiple fingers) could be tracked with high fidelity solely based on the EMG data. We observed correlation coefficients in the 0.5-0.9 range between the true finger positions tracked with the motion capture system and those reconstructed from the EMG data.

Conclusion:

This represents a significant advance over previous research that mostly reports EMG based gesture recognition [3] or discreet detection of individual finger movements [4].

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Effects of focal vibration on spatial and temporal dynamics of EEG

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Keywords: focal vibration, sensorimotor rhythms, neurorehabilitation, electroencephalography (EEG)

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Purpose:

Focal vibration in the clinical setting is used for the treatment of neuromotor disorders (e.g. spasticity, co-contraction, Parkinson's disease) [1]. Despite the wide employment of the method significant ambiguity and inconsistency still surrounds the understanding of the neural mechanisms, underlying the observed positive therapeutic effects of focal vibration [2].

Main study design:

Here we study the online and offline effects of focal right-hand vibration stimulation (FV) during an isometric contraction of the groups of forearm muscles on the ongoing EEG activity in 11 healthy subjects. FV is delivered via a handgrip connected to a Power Plate personal platform (35 Hz, 31 m/s^2, 60s).

Results:

We discover significant event-related desynchronization of subjects individual alpha and beta sensorimotor rhythms (SMR) , prevalent in the contralateral hemisphere (ANOVA, p-value < .05) during focal vibration. Additionally, we observe significant bilateral synchronization of individual SMR in the alpha and beta bands after the offset of FV (ANOVA, p-value < .05). Also, vibration-free isometric contraction used as a control condition caused no significant changes to the SMR power.

Conclusion:

The findings of somatotopically specific increase in ERD during FV and an increase in ERS following FV may shed additional light onto the physiological mechanisms underlying vibration-based therapy. The observed synchronization\desynchronization indices may be used as gauges reflecting the quality of therapeutic intervention in neurological patients with motor deficits

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MRI from EEG is only Deep Learning away: the use of DL to unravel EEG-fMRI relationships

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Keywords: EEG, fMRI, deep learning, Convolutional Neural Network.

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Purpose:
Electroencephalography (EEG) and functional magnetic resonance imaging (fMRI) are unarguably the two most frequently used modalities to non-invasively map the workings of the brain. The two techniques are grounded into very different principles and have complementary spatial and temporal resolution properties. Despite the long history of these two methods the are still significant debates regarding the relationship between the measurements they yield.

Main study design:
In this work we for the first time demonstrate the use of a deep learning (DL) approach to map multichannel EEG into BOLD signal. To this end we employ convolutional neural network based architecture and train it to predict from a 16 second segment of time-frequency transformed resting state EEG data the BOLD signal registered within a slice whose acquisition time corresponds to the end of this 16 second long EEG data chunk.

Results:
We show that using sensitivity analysis of the network trained using 10 minutes of individual subjects EEG-fMRI data it is possible to establish physiologically plausible time-frequency intervals of EEG signal that contribute most to the fMRI measurements an thus to unravel the individual relationship between the two imaging modalities. We believe that this is the first attempt to utilize the DL architecture in min- ing the knowledge regarding the intricate relationships between EEG and fMRI data.

Conclusion:
We hope that the proposed approach after it is further developed and properly tested will allow to understand fundamental and individual mecha- nisms linking the neural activity data delivered by the two most ubiquitous brain imaging modalities.

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Flicker-free P300 BCI speller with facial stimuli

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Keywords: P300, brain-computer interface, speller, face, ERP

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User experience and performance of visual BCIs heavily depend on the characteristics of the stimuli. This is particularly true for P300 BCI, since it relies on processing of complex cognitive tasks. It has been shown in multiple studies, that using faces instead of flashing letters in row-column paradigm reduces error rate in speller applications [1,2]. However, facial stimuli differ in shape from flashing letters, and are usually larger and brighter, which may cause fatique. These parameters are often not controlled, and this study was designed to solve this problem.

25 healthy participants took part in the study. EEG was recorded with 18 electrodes. The user was presented with 6x7 matrix of flashing symbols of approximately 2.3° each. 4 stimulation modes were used: classic mode with flashing Latin letters [1], flashing neutral faces [2], flashing scrambled faces (3), and neutral faces, replacing their scrambled versions with each stimuli presentation (4). Faces were taken from Nimstim dataset [3]. Stimuli duration was 150 ms, with interstimulus interval of 50 ms. The subject was instructed to attend specific aim stimulus. Each stimulus was repeated 20 times before classification.

The only mode with median accuracy less than 1 was the one with standard flashing characters, yielding 0.88, this being significant difference with Wilcoxon test and Holm-Sidak correction for multiple comparison. This mode also had significantly less P300 amplitude, which is contributing to lower performance.

The non-conspicuous mode being not different from other modes with large stimuli is a good news for designing future speller interfaces, as it allows for less distraction by adjacent stimuli and less mental workload.

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Reconstruction of the vibrissa deflection direction from the neuronal activity in the rat barrel cortex

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Keywords: neural coding, spike rate, machine learning, electrophysiology, barrel cortex

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Purpose:
The information transfer and processing in the mammalian brain is mediated by the activity of individual neurons. Cracking the neural code is a crucial yet challenging problem in the BCI development. One of the important questions related to this problem is whether the information in the brain is represented by the exact spike timing or by the firing rate.

Main study design:
To address this question, we attempted to reconstruct the direction of a vibrissa deflection, using the evoked neuronal activity in the barrel cortex of anesthetized rats. To reduce the baseline bias the deflections were randomized using an in-house 2D piezo deflector. To record the neuronal activity, we first localized the principal cortical column using the optical intrinsic signal imaging (OISi) and then implanted a multi-site silicon probe into the column. We then performed the spike cluster analysis to extract the activity of individual cells and constructed spike features of cluster N-grams ranging from 1 to 3. We then trained a machine learning model based on the tree gradient boosting algorithm to reconstruct the vibrissa deflection angle from the N-grams scored by the Pearson correlation coefficient.

Results:
First, we showed that using just cluster monograms the model successfully reconstructed angles of vibrissa deflections with the score reaching 0.9. Second, we showed that accounting for the bi- and trigrams failed to improve the score significantly.

Conclusion:
We thus conclude that, in practice, the spike rate is a sufficient measure of the neuronal activity to study vibrissae state in the rat's somatosensory cortex.

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Safety issues of using virtual reality in patients with stroke in the sharpest period

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Keywords: Virtual reality, *P300, brain-computer interface, speller, face, ERP*

Purpose:
Virtual reality (VR) is used for the treatment of various diseases as a promising method of motor and psychological rehabilitation. The safety assessment was usually carried out in the form of an assessment of adverse events associated with the occurrence of dizziness or autonomic dysfunction. The use of VR as a method of rehabilitation in patients with stroke shows the

effectiveness of the early rehabilitation period. The question of the safety of the use of rehabilitation in VR at the stage of the most acute stroke period remains insufficiently studied.

Main study design:

Heart rate variability was analyzed in 10 patients at the age of 67 years in the sharpest period of ischemic stroke. On the NIHSS scale, the neurological deficit was 12. Patients underwent registration of HRV in the position lay before the procedure of verticalization. Then, in a random sequence and on different days, verticalization was performed in a sitting position or demonstration of the virtual environment of walking on a horizontal surface. In 30 minutes the registration of HRV was again conducted to assess the possible long-term effects of verticalization. As a statistical analysis It was used estimation method of dependent comparison groups without normal distribution (criterion Wilcoxon sign ranks for similar samples).

Results:

Verticalized patients had increased heart rate by 20% compared with the background state and subsequent registration; no significant change in heart rate was observed in patients with virtual verticalization. Also, virtual verticalization patients weren't noticed an increase in activation according to such parameters as AMO, indicating an increase in the number of similar cardiointervals. Growth of this parameter was observed during verticalization and remained unchanged with virtual verticalization of 18% and 8% respectively. During virtual verticalization, It's observed an increase in the power of ultralow frequencies up to 6000 [2000; 16000] ms2 ($p = 0.04$), which indicates psycho-emotional stress and functional activation of the cerebral cortex. This fact indicates the patient's sensory immersion into virtual reality.

Conclusion:

The obtained results suggest that for patients with the sharpest period of ischemic stroke, virtual reality classes for enhancing the motorized background synergies of walking are safe without causing sympathicotonia and without increasing risk of cardiovascular complications.

Anti-PSIICOS beamformer for solving EEG\MEG inverse problem or where has all that variance gone?!

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Keywords: MEG, EEG, correlated sources, inverse solutions, LCMV beamformer

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Purpose:

Non-invasive imaging techniques, such as EEG and MEG possess high temporal resolution, necessary to observe rapid cortical dynamics. The spatial resolution of these techniques critically depends on the method used for solving the ill-posed inverse problem. Approaches based on the linearly constrained minimum variance (LCMV) adaptive beamforming [1], achieve spatial super-resolution [2] by implicit analysis of the multichannel data covariance structure and designing spatial filters that suppress only those sources that are active within the analyzed time interval.

Synchronous activation of neural assemblies ubiquitously present in the brain in combination with LCMV's minimum variance design principle lead to significant reduction of the amplitude of such synchronous sources at the beamformer output.

We propose a novel beamformer approach immune to the underlying source synchrony. The major innovation here is a manipulation performed on the vectorized sensor-space covariance matrix implemented via a projection operation orthogonal to the PSIICOS projection introduced by us earlier [3] for imaging of coherent sources.

Results:

Results of the simulations and analysis of the real MEG data recorded during the auditory task show that (1) Source amplitudes reconstructed using Anti-PSIICOS beamformer exhibit significantly greater dynamic range as compared to those delivered by the conventional LCMV beamformer (2) Anti-PSIICOS yields very focal localization of synchronous sources of the auditory evoked response in the primary auditory cortex while the standard LCMVs nearly cancels these sources and (3) novel beamformer has significantly greater than the standard one tolerance to the forward model inaccuracies

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Neurodevice for prosthetics and exoskeletons control

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Keywords: electromyography, electroencephalography, exoskeleton, neurodevice

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The main aim of the project was to develop device capable of complex biosignal processing for applications in the areas of prosthetics and exoskeletons control systems. Proposed device is intended to register brain and muscle electrophysiological activity and predict user movement intention using machine-learning algorithms. Developed device consists of high precision low noise analog-to-digital converter (ADC), general purpose computer-on-module system with wireless interfaces and external sensor hub with data commutation controller

The investigation of P300 in personalized and non-personalized virtual reality

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Keywords: virtual reality, EEG, oddball paradigm, P300.

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Purpose:

The goal of the present study is to investigate the amplitude-spatial characteristics of cognitive potential P300 to auditory and visual stimuli in virtual reality (VR). Hypothesis: Different VR content is reflected differently in human brain activity.

Main study design:

The study involved 10 healthy right-handed young men aged 18-19 years: 5 subjects with the same skill (Group 1) and 5 subjects without that skill (Group 2). EEG was recorded monopolarly by 64 electrodes of 128-channel EEG recording system «BP-01030 BrainAmp Standart128» during presentation of visual and auditory stimuli using the oddball paradigm: 1) on the monitor screen and using the audio system (2D); 2) in personalized virtual reality (VR1), the content of which was made in accordance with the skill of testees from Group 1; 3) in indifferent virtual reality (VR2) [1,2]. We performed preprocessing of EEG data using BrainVision Analyzer 2.1, and then statistical analysis (t-test, ANOVA) of P300 characteristics in BESA Statistics 2.0.

Results:

Statistically significant differences in P300 amplitudes were found for the target auditory stimuli ($p \leq 0.001$) between 2D, VR1 and VR2 in both groups of subjects: in latency values of 356 and 386 ms for Group 1 and in latency of 414 ms for Group 2. In Group 1, the amplitude of auditory P300 significantly increased in VR1 compared to VR2 and 2D. Group 2 showed less pronounced differences in the amplitudes of auditory P300 between 2D, VR1 and VR2. We haven't detected statistically significant differences in P300 amplitudes for the target visual stimuli between 2D, VR1 and VR2 in both test groups.

Conclusion:

Thus, personalized VR content, associated with subjects' skills, causes a significant increase in amplitudes of the cognitive potential P300 to auditory stimuli with different localization depending on the latency. Different VR contents, non-associated with subjects' skills, initiate cognitive potentials P300 with equal latency and localization.

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The results of testing of inclusion of HSC “ReviMotion” in the process of complex rehabilitation of children with cerebral palsy

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Keywords: children, cerebral palsy, game rehabilitation, physical therapy, virtual reality, "ReviMOTION"

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Purpose:
Motor disorders in cerebral palsy are often accompanied by sensory defects, disorders of cognitive and communicative functions. A leading role in the rehabilitation of children with cerebral palsy is the physical therapy, the focus is on the most active movement initiated by the patient [1]. Parents of a child with cerebral palsy have to look for options of available activity and make efforts to keep motivation for movement. The application of virtual reality and games stimulate the patient to perform tasks and make the rehabilitation process more interesting and informative [2]. We have tested the system of game rehabilitation HSC "ReviMOTION" with Kinect sensor, game module and module of construction of rehabilitation programs. The sensor allows to interact with the game console, operate the character and produce the feedback, and the system includes scripts of games of different complexity with a set of specific exercises.
The goal of study: to evaluate the efficiency of a gaming system "ReviMOTION" in the rehabilitation of children with various forms of cerebral palsy.
Main study design:
The study included 22 children from 3 to 7 years old who received 2 courses of rehabilitation for 90 days in a semi – hospital in 2017-2018.: 6 patients with hemiplegia (group I), 12 – with diplegia (group II), 4 children-with ataxic cerebral palsy (group III). All children have the II level of functional abilities (GMFCS, MACS). Game rehabilitation was used during the second course and complemented the standard set of medical and psychological-pedagogical services; each child had an average of 45 lessons. The assessment of severity of disorders was held in accordance with the Gross Motor Function Measure 66/88 quantitative scale [3].
Results:
The best results were found in group I: the total coefficient increased by 11% compared to the indicator for the first course without inclusion in the rehabilitation process of training on "ReviMOTION". In group II, this indicator improved only by 9%, in group III – by 7.5%, which is associated with a much more severe lesion of motor functions of children of these groups. In General, all children (22-100%) showed improved balance and coordination, increased muscle strength, amplitude and synchronicity of movements, their tone was normalized and new motor skills appeared.
Conclusion:
The application of game rehabilitation gives positive results, goes well with other methods, motivates the child to the correct motor activity and the formation of a new motor stereotype.
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Implicit interaction with virtual reality to reduce the motor manifestations of Parkinson's disease

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Purpose:

PARKINSON'S disease (PD) impairs gait and motor function while also impacting cognition, most notably executive function (EF) and attention (1,2). As in the general elderly population, in PD, EF, attention, and DT abilities have been associated with fall risk. Pathways involving the basal ganglia in PD may be capable of plasticity, and their activity patterns may be partly corrected with appropriate intensive training (3). In addition, it is not clear if training in patients with PD can transfer beyond the task that was specifically trained or if long-term retention is possible (4). To address these questions, we employed virtual reality (VR), a relatively new intervention modality in the field of neurorehabilitation.

Main study design:

The analysis of 15 patients with Parkinson's disease at the age of 63 years. Patients received levodopa therapy in various dosages, as rehabilitation methods, patients were given virtual reality classes with an implicit demonstration of movement on a horizontal surface and sensory confirmation of the success of this action due to stimulation of proprioceptors of the foot. The number of classes was about 10 sessions, lasting 15-20 minutes. At the same time, the patient could see his "virtual legs". Walking speed varied in the range of 2-5 km / h. Assessment of motor function was carried out according to an unified Parkinson's disease rating scale of Movement Disorder Society (MDS UPDRS). Particular attention in this questionnaire was given to section 2 (motor aspects of everyday life) and the study of motor functions (section 3). As a statistical analysis, we used the method of estimating dependent comparison groups with no normal distribution (a criterion for Wilcoxon's sign ranks for related samples).

Results:

At the time of inclusion in the study, patients were characterized by the following indicators for the analyzed sections of the UPDRS scale. The evaluation score of the motor aspects of everyday life was 7, in the motor function evaluation section 28 points. It should be noted that the tolerability of the procedure of implicit observation of walking was satisfactorily tolerated by all patients and there was no discomfort in the form of dizziness or other undesirable effects noted when using VR. At the end of rehabilitation classes, the score on the scale of motor aspects of everyday life was 3, $p = 0.002$, and in the section on motor function evaluation 20 points, $p = 0.025$. There is a statistically significant improvement in motor functions in patients after ongoing rehabilitation in VR.

Conclusion:

The results suggest that for patients with extrapyramidal pathology exercises of VR may have a positive effect on the motor manifestations of the disease. To clarify the nature of this impact and

its mechanism, further study is needed in the form of an expansion of the group of studied patients and the use of more powerful statistical methods of analysis.

Activation changes of the postural-tetanic muscle motoneuron pulls in hypoxic hypoxia

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Keywords: motoneuron pool, activity, voluntary and passive movement, monosynaptic spinal H-reflex, hypoxic hypoxia.

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Purpose:
Despite a great experience of scientific cognition in the sphere of high-altitude and experimental hypoxia, many aspects of the problem of adaptive function changes in a human body, influenced by hypoxic exposures, are still scientifically relevant in applied neurophysiology and rehabilitation with exoskeletons.
Main study design.
The research was conducted on neurologically healthy men (19-26 y.o.), who were exposed to dosed impact (DI) of interval hypoxic trainings (IHT) (air breathing with oxygen (O_2) content of 9.9%, from 30 to 50 minutes for 19 days). Monitoring of the H-reflex and the M-response was performed using a neuromuscular analyzer (NMA-4-01 «Neuromian»).
Results.
The analysis of the influence of DI of IHT on the amplitude characteristics of the direct M-response revealed similar trends in amplitude rise by the 19^{th} day. However, the M-wave of the soleus muscle in the stimulation range from 24 to 34 mA was significantly lower ($p<0.01$). Significantly high amplitude values of the M-wave of the gastrocnemius muscle (32-40 mA) and the soleus muscle (38-46 mA) were observed; the first M_{max} peak of both muscles was determined at 20 mA, M-response reached its maximum at supramaximal stimulation (48-50 mA).
Conclusion.
Preliminary results of the study showed that IHT has to a certain extent the unidirectional effect on the motorneuron pool activation both of the soleus and gastrocnemius muscles at voluntary movement. Maximum activation of the H-reflex of the gastrocnemius muscle was the result of the tibial nerve stimulation with a current of medium intensity, which may indicate the increase in the excitability threshold of Ia sensory fibers after exposure to IHT. Amplitudes of the maximum H-responses increased during electric current induction in the range from 22 to 32-40 mA ($p<0.05$). Knowledge of such factors should be taken into account when using exoskeletons in persons with violation of supraspinal control.

Application of Neurochat™ Neuro-interface Set for Socialization of Patients with Speech Impairments: A Pilot Study

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Keywords: brain-computer interface (BCI), P300, aphasia.

Purpose:
Post-stroke aphasia affects about 20-40% of stroke patients [1, 2] and may lead to many challenges in daily communication with the environment. Brain-Computer Interface (BCI), including P300 based BCI, is one of the approaches that may be used for assisting such patients in socialization [3].

Main study design:
In this pilot study, we included 13 participants, aged 35-74, with post-stroke aphasia and studied their ability to use the BCI for spelling. Selection of the participants was based on the major inclusion criteria: ischemic stroke; aphasia, mostly of mild and medium severity; deficit in control functions. We used Neurochat neuro-interface set based on P300: an electrode wireless cap with 8 electrodes, and the 8 x 5 spelling matrix containing letters of the Russian alphabet from A to Ya, and other symbols.

Results:
Patients took part in 8.5 sessions in average. Each session was divided into two stages: the training and the spelling one. If results of the training stage were high enough, participants moved on to the spelling stage. For each session a different set of 5-letter words printed on a card in a large font from a list of randomized words was used. The word was placed near the monitor so that the patient could see and spell it focusing on a target letter in the matrix. The number of words per session varied from 2 to 6, depending on a patient's condition, the amount of time they had, and their results.

Most patients (12 out of 13) were able to use Neurochat, with 8 out of 13 patients having reached spelling accuracies up to 100% at least in one session. Accuracy varied from patient to patient, being rather high only for 4 patients — up to 95%. Other patients had lower accuracies, with 7 patients showing results within 60-80% interval and two — 40% and lower.

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Eye-brain-computer interfacing with smooth pursuit eye movements

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Purpose:
Gaze based interaction is increasingly used as an assistive technology for paralyzed people. However, spontaneous gaze behavior is similar to intentional gaze-based commands to computer. To avoid false triggering in response to spontaneous gaze fixations, a special brain-computer interface (BCI) was proposed [1, 2], allowing to send a command in response to a gaze fixation only if it is accompanied by an EEG marker related to user's expectation of system's response. Recently, we designed an effective algorithm for moving object selection with smooth pursuit eye movements [3] and, using its triggering as reference time events for EEG averaging, observed a similar EEG marker when pursuit was intentional [4]. Nevertheless, similar waveforms were also observed in conditions where pursuit was thought to be spontaneous, possibly because it could not be fully free from intention and/or expectation. The lack of "intention-free" reference conditions could hinder training of BCI classifiers.

Main study design:
In the current study, we attempted on designing and testing new, more "intention-free" reference conditions: (1) a participant is asked to find an object, among similar ones, that moves slightly faster (by 1.3˚/s); (2) a participant has to find five objects with a specified number of dots and to summarize the objects' numbers displayed on them.

Results:
Pilot experiments demonstrated a more clear difference between intentional pursuit-based selection and the reference conditions.

Conclusion:
In our poster, we will consider these preliminary results in the context of the development of hybrid eye-brain-computer interfaces (EBCIs) that could provide fluent interaction with a wide range of virtual and real-world systems.

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