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Proceedings of the Conference

Extracting Digital Intelligence with BCI, BDB and Neuro-Networking

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A system approach of the state-of-the-art neurotechnology is shown with 3 branches of R&D directions:

1. Brain Computer Interface (BCI) – implanted and wearables
2. Brain Data Bank (BDB) - analytics and visualization
3. Digital Intelligence Processing – neuronet modeling and Artificial Intelligence (AI.)

Focus of the BCI mechanism has migrated into wearables in recent years for de-stressing, selective mind control and performance aid under pressure, away from early endeavors of implanting electrodes and wiring under the scalp. The most promising wearable form is cited as a wireless sensor patch adhered to the forehead with no dangling of external head gears. Numerous big brain signal datasets collected through intrusive and non-intrusive BCIs have emerged from many institutional projects, cited since 1999 - 7 examples are mentioned with the source, size, type of signals and year of availability. Specific examples of EEG signals (> 350 GB uncompressed) is shown for the UCSF NeuroRacer, comparing the young and the old people in performance evaluation of playing a multi-tasking video game.

Datasets are embraced with utility associated with a brain data bank concept to capture the use of neuro network modeling - deep learning processing which manifested up to 80% success rate for prediction of emotions, (although an exceptional case with auto classification of EEG signal features has claimed 98% accuracy preliminarily.) All these efforts eventually can drive toward a standardized brain data bank format per an earlier version of CTA-2060 specification on Interoperability.

The future of brain data bank research and anticipated time line was further compared and contrasted with the development history of DNA. The complexity of the brain based on EEG signals alone without addressing holistic effects of other physiological signals is left for anyone's judgement as whether the current trend in brain research could be parallel to DNA's proven success. It is noted that no discovery has been cited of a standard fundamental separation of neuro cells and networks, analogous to Adenine, Cytosine and the helix structure found within DNA.

Optogenetics and prospects of restoration of vision

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The problem of the possible restoration of acceptable visual functions to blind people with the help of prosthetics of nerve cells preserved in their "blind" retina is extremely relevant and close to solution.

It is possible to formulate the main provisions that are fundamentally important for the optogenetics prosthetics of the degenerative retina:

- The restoration of vision is the first, the most real and near-term application of optogenetics methods in clinical practice.
- Ganglion cells of the degenerative retina are most reliable for optogenetics prosthetics.
- Cationic and anionic channel rhodopsins of chlorophytic and cryptophytic unicellular algae are the most real "tools" for optogenetics prosthetics of ganglion cells.

Important tasks:

- optimization of cation and anion channel rhodopsins parameters (photosensitivity, conductivity, lifetime, absorption spectra);

- an increase in the level of gene expression of the channel rhodopsins in the cell;

- search for specific promoters for subpopulations (ON, OFF, ON-OFF) of ganglion cells.

- The adeno-associated virus is the only vector available today to deliver the gene to retinal nerve cells. It must be conjugated to a specific promoter for a given neuron.
- Following the restoration of monochromatic vision, using the spectrally different channel rhodopsins, it is possible to restore color vision as well.
- The authors of clinical trials (the company RetroSense Therapeutics) believe that patients, if optogenetics prosthetics of ganglion cells are successful, will be able to see objects (table and chairs).

Experiments on animals do not allow us to evaluate the quality of the restored vision. However, the successes in electronic prosthetics (Argus II system) testify to the truly limitless plasticity of the brain and allow one to hope for the success of optogenetics prosthetics of the degenerative retina.

A Three-phase Motor Relearning: error-potentials, motor correction and neurofeedback for memory-consolidation

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Three components are embedded in relearning of motor skills: error detection, training to reduce errors, and memory consolidation of the improved motor execution. We integrate here three components that we have previously studied separately, into a triple-stage paradigm that includes EEG markers for error detection, BCI-based motor correction and memory consolidation of the corrected motor motion through neurofeedback processes. In our earlier work we show that error potentials are uniquely associated with error characteristics, suggesting a potential BCI system for error-tailored correction, rather than generic BCI. The third component relates to neurofeedback. Our earlier studies of neurofeedback theta after motor learning showed applied significant effect of enhanced motor memory consolidation in the experimental group compared to the control groups. This paper describes a preliminary three stage protocol of motor rehabilitation: error detection, BCI for motor correction and then a neurofeedback for consolidation of the corrected motion.

Keywords: EEG, error potentials, memory consolidation, neurofeedback, motor enhancement

I Introduction

Motor impairments after stroke or accidents have been a major importance to the scientific-engineering community, and the question of the optimal way to support efficient learning of motor execution and relearning, lead to thousands of studies and reports. Roughly, the literature can be separated into two categories – avoidance of errors such as in driving a wheel chair, and relearning of motor acts. The first is often based on identification of event-related potentials correlated with errors, e.g. [1-5]). The second is based on theories of motor performance and often engages robotic arms to train the impaired motion [6-7]. Here we integrate three components of our previous work to synergistically enhance each other. The first concerns early identification of motor errors through error potentials. The second relates to a brain computer interface system that activates a robotic arm to train and correct the executed motion. The third is activated once the motor execution reaches a level that is advanced compared to the initial. At this point we suggest to activate a neurofeedback system to enhance motor memory consolidation by that generate a steady long lasting neural pattern of motor performance.

II EEG DETECTION AND MOTOR ERRORS

Yazmir and Reiner [4] have previously shown that motor failures differ from motor successes and are correlated with unique ERP characteristics [4]. More specifically they tested natural, user initiated errors in an immersive haptics enabled virtual tennis game. Event related potentials of success and failure were extracted from the EEG. Their results showed a distinct, detectible and

distinguishable ERP evoked by: "success/hit" and "failure/miss" events. Results also show that the ERP associated with success, occurred much earlier compared to the ERP associated with failure, peaking at time-zero, i.e. exactly when the ball hits the gate, while the failure ERP occurs after it happened, suggesting a faster processing of success compared to failure, in the context of this spatial setup. The differences were detected in waveform patterns, latencies, amplitudes of the peaks, scalp distribution and source estimation results. An interesting result reported in the above study, and which is relevant to this paper is the increase in the mu power band (9.75-12.5 Hz) at Pz and decrease at C4 electrodes, accompanied by increase in the theta power band (4.75-6.75 Hz) at Fz and Pz electrodes, for success. Interestingly, hippocampal-striatal theta are also correlated with consolidation of motor memory [11] and parietal theta is correlated with increased fatigue/mental load of motor acts [12] suggesting a possible link between memory formation, fatigue and failure/success related brain activations. These results hinted at the potential role and application of theta neurofeedback for motor memory consolidation.

In a later paper, Yazmir and Reiner [5] identified error and success related ERP's that are initiated internally by the user, rather than induced by the system, in the process of an ongoing ecologically valid, 3D - multisensory realistic task, with no external artificial felicitators of errors. They show that errors that were correlated with distinctly different signal characteristics, when all are in the context of the same game, same spatial configuration and identical environment conditions. This suggested a methodology to detect the type of error, via EEG signatures and respond accordingly with a system of brain-computer-interface that detects the type of error, as argued in [4].

Rehabilitation of motor skills often integrates external robotic system that train the body to relearn a motor act, by applying forces and leading the body part in the correct, or close to correct motion, assuming that a repetition of the motor act enhances the neural underpinning network that is correlated with the motor skill, e.g. in [7-8]. This protocol for rehabilitation is largely used for retraining patients with lost motor skills. (e.g. see [9]). Motor training leads to a plateau of the learning curve. The question we raise here is whether an established and validated neurofeedback process of memory consolidation of a motor sequence will enhance the execution beyond the learning curve plateau achieved by motor training alone.

III MOTOR MEMORY CONSOLIDATION

Consistent repeating empirical results showed that sleep enhanced motor memory consolidation. and that this process does not happen during awake hours [10, 11]. In a recent study we explored processes of consolidation of memory during awake hours. Assuming a system-level approach to consolidation of memory of a two phase consolidation process, we showed that memory consolidation can be enhanced by using theta neurofeedback. we assumed two levels memory formation. The first is hippocampal dependent, involves registration, and is correlated with hippocampal theta. The second is considered largelya s hippocampus independent, and involves exchange of information between the initial hippocampal encoding and remote regions through theta synchronized oscillations. Since theta plays a central role in exchange of information in the process of memory consolidation, we hypothesized that elevated theta during awake hours will enhance memory consolidation and used a neurofeedback protocol, i.e. a conditioning method for the control of self-brain activity, to enhance the relative power of theta or beta oscillations. Results show a significant improvement in performance in the experimental group, relative to the control groups, immediately after neurofeedback, which was further improved after night sleep in all groups, with a significant advantage favoring the experimental group. The theta oscillation

power during training was correlated with the level of improvement, showing a significant relationship between memory consolidation, and neurofeedback.

IV SUMA– ERROR POTENTIALS, BRAIN-BASED CORRECTION AND NEUROFEEDBACK FRO MEMORY CONSOLIDATION

To summarize, we have developed a neural-based, protocol which relies on integration of multiple neural processes of: identification of errors, correction, and a oscilatory –based process of memory consolidation.. Resuts from healthy patients show a significant effect of neurofeedback on motor memory consolidation. Preliminary results with patients show a similar effect. The effects are of special advantages in cases where the the learners start from a lower motor level – we found that the lower performers achieved most from neurofeedback, if indeed controlling the oscillations was achieved. A major risky point is related to the users' ability to control their own braiwaves for improved amplitude of the target oscilatory band during neurofeedback. Hence a central question to test is the neurofeedback control skills of motor patients. Some, with specific locations of stroke, might not be able to control the particular oscillations, while for others the combination of EEG error detection, targetted BCI robotic – based training, and consolidation of the learned pattern via neurofeedback provide a synergetic new paradigm for rehabilitation.

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Saccadometry – the global approach

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Summary of Presentation at Pavlov Institute of Physiology and IEEE Brain Initiative Conference SPCN 2018.

Saccadometry - objective evaluation of Brain Functional Integrity, lateralized measure of cerebral impairment.

Allows the insight into the underlying neural mechanisms of decision-making

Remarks about bioengineering research strategy - Applicable Research - Translational research

Exploiting physiological Knowledge for Problem solving - *Knowledge become the Product*

Multilevel control of saccadic refixation response.

Design requirements of stimuli-response experiment for simultaneous evaluation of low level execution of saccades and high level, cortical decision process regarding saccade usefulness.

Brain cognitive dilemma - should respond to the stimuli …or consider it a potential distraction, which should be avoided?

Analytical Saccadometry requires Normalized Stimuli, Low noise saccadic signal, Theoretical Framework, Analytical Software.

Correctness of saccades - one aspect of brain integrity, Saccadic velocity directly reflects the muscle contractions, requires exceptionally high bandwidth (900 Hz) of neuronal generation and transmission system. Evidence the disturbances in motor control system as the whole.

Saccadic generator - stereotypic behavior - Saccadic Peak Velocity (saccade duration) is a basic human physiological constant.

Cortical processes suspend the execution of saccade until the checklist of cognitive demands has been approved.

Saccadic response time (RT) – may serve as an objective and robust indicator of brain promptness as information processing system.

Time structure of saccadic refixation response - High Physiological Variability of saccadic latency, how to handle it?

Two populations of saccadic responses: Quick but Risky versus Delayed but Appropriate,
they cannot be separated by calculating the saccadic latency average.

Professor Roger Carpenter, Cambridge University, contribution to saccadometry, the Elementary decision making – LATER model, Linear Approach to decision Threshold with Ergodic Rate. Important observation, not the latency of response, but its promptness should be in focus (saccade promptness is the reciprocal of its latency).

Human ‘interface’ to Decision (RT) experimental data, Distribution shape become replaced
by the accumulated promptness probability plot (Reciprobit Plot)

The LATER bridges the experimental data with high level cognitive processes taking place when human makes a decision either to respond or not.

Saccadometry instrumentation, minimally intrusive eye movement sensor measuring the arithmetic average of left and right eye movements.

Mile stones of saccadometry evolution: departing from complex manual adjustments to automatically operated measuring system, moving the eye movements research from laboratory

to the field, understanding that each research question requires task optimized instrumentation, advancing automatic eye movement instrumentation to automatically conducted diagnostic experiments and signal analysis.
Saccadometer – palm size, mobile eye movement laboratory for evaluation of saccadic metricity in temporal and spatial dimensions.
Only three numbers completely describe the elementary decision processes involved in saccadic refixation response. It deserves consideration of being used as a basic brain metrics. It may serve as individual reference for comparison of actual brain status, after being exposed to harmful environmental influences.

Neurophysiology investigation of Insight in humans

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The neurotechnological revolution in recent years, involve the new attention to neurophysiological studies of insight. Particular interest to create artificial intelligence systems induce the modeling the activity of neural networks are concentrated not to the analytical and conscious step by step way of problem solving but by unconscious way including the insight. For the other hand this investigations of unconscious of problem solving are very important for investigation and rehabilitation of mental and gnostic disorders. It turned out that clinical and engineering solutions are consonant with the traditional ideas of Gestalt psychology. It was within the framework of Gestalt psychology that David Field and Robert Hess proposed the new methods research of insight [1, 2]. The David's Field elegant modeling simulating the work of neural net of the the primary visual cortex neurons in BA17 - Brodmann area 17.

We prolonged this Gestalt like approach, and proposed to measure the threshold of incomplete figures couture we cane identified the incomplete object. These moment of recognition at the threshold we described as the onset of the insight. So we compare insight appearance with the threshold of image recognition under conditions of uncertainty. It should be noted that not every psychophysical threshold is an analog of insight. The effect of uncertainty, the stage of pre-accumulation and emotional support of the recognition threshold is important attributes of insight. These factors are absent in the definition of many psychophysical thresholds, for example, in determining the thresholds of contrast sensitivity or resolution thresholds.

As a tool for studying insight, we selected a method for determining the threshold for recognizing incomplete fragmented images, the computerized method of the Gollin test in the version developed in the Vision laboratory of the Pavlov Institute of Physiology of the Russian Academy of Sciences. The existing methods for visualizing the activity of the human brain and the digital synthesis methods developed by us test signals (incomplete images corresponding to the Gollin test) made it possible to determine the ways of solving the problem posed [3]. This stimulus for recognition requires the involvement of subsequent, less studied parts of the brain. Thus, the achievement of the goal at this stage is reduced to solving the problem of determining the threshold, corresponding to the moment of transition of the results of unconscious,

subconscious processes to a conscious level of decision-making. This transition can be identified with the moment of occurrence of insight, a well-known phenomenon of a sudden understanding of the process being solved, in this case the information of disparate fragments into as a gestalt by "sudden illumination".

We have shown for the first time the dynamics of the BOLD signal in fMRI study change from small at the sub threshold, to the grate at the threshold and again small at above-threshold levels [4, 5, 6]. Measurement of recognition thresholds by methods of digital processing of brain responses will lead to a targeted modeling of insight in artificial neural networks that perform a non-analytic way of solving problems. The recognition threshold is accompanied by a maximum of the entire brain activity, exceeding the "rest" level in the absence of stimuli, as well as the sub threshold and above-threshold level when the object was clearly visible and clearly visible. Reorganization of the activity of the neural network is caused by the redistribution of the activity of the cortical areas of the brain and subcortical nuclei, which was established on the basis of the BOLD signal change. The change in the BOLD signal over time correlates with a change in the EEG spectrum decrease in alpha and an increase in gamma-rhythm. This result confirms the results of other researchers. The maximum of neural activity at the time of threshold recognition of the shape of the figure is accompanied by a pronounced emotional response, which we recorded on the basis of verbal responses of the subjects and the results of objective measurements of the pupil diameter, eye microsurgery and tension of the facial muscles accompanying any emotional reaction. The zone BA37 is located in the rear part of the lower-temporal region and in the fusiform gyrus. It has significant connections with the left lower-temporal region (BA20, BA21), the left prefrontal cortex (BA9, BA46, BA45 and BA47), the left insula (BA13), the left and right preclinical (the catching areas BA7, BA19), and in the occipital region BA18). Probably, the left zone BA37 is the area of the nodal intersection of two neural networks: one that performs visual recognition, and the other, which provides a description of the semantic properties of speech. The results of image processing of blood flow activity maps in the brain according to the BOLD signal made it possible to establish that the activity of insula (BA13), prefrontal cortex takes an important part in providing the solution of problems of this type outside the occipital (zone BA17, BA18, BA19) and the temporal cortex (zone BA37) (BA9, BA46, BA47, BA10) and the waist cortex (BA24, BA30). This data are in a good correlation with EEG results [7].

The multi-level process of decision-making on conflicting assessments, shown experimentally in this paper, as we see, is realized in the opponent's human brain structures. The importance of making a decision on the conflicting (in our terminology) estimates was predicted [8]. The maximum of activity of certain zones is established at the moment of reaching the threshold level of presentation of the contour corresponding to the moment of the insight occurrence. This increase in activity causes a decrease in activity in other, adversarial zones. Ensuring a balance of criteria in making a decision is carried out by redistributing activity between brain regions. Brain structures that provide the most important cognitive functions and the emotional processes that accompany them, interact synchronously, but there are opposing interactions between them. As a result, it becomes possible to implement a decision on multiple criteria and on conflicting assessments of the event. It is this principle of the interaction of elements in the decision-making process. These very general ideas about decision-making can now be applied to optimize an artificial neural network, both local and large-scale, that provides targeted, motivated behavior. These ideas resonate with a number of existing works on local and global neural networks. Simulation of the activity of neural networks suggests that the mysterious insight mechanism can be organized on a simpler neural network inherent in higher vertebrate predators and primates.

The mystery of this mechanism lies in the fact that its preliminary part occurs outside our consciousness, and the result of preliminary image processing comes to consciousness. The analytical way of solving problems is probably much more complicated, as it requires the involvement of elements of inner speech and logical conscious thinking, closely related to the speech of a person. Training of neural networks is based precisely on the opponent interactions. These interactions are multilevel. The first level is the opposition within the receptive field, the next is the opposition between the receptive fields and the highest level is the opponent interaction between the large-scale neural networks. In this paper, we examined some features of large-scale neural networks. And this type of opposition is different mediators, for example, serotonin and dopamine. Training of neural networks can occur through punishment or rewards, or in real life - with timely or delayed recognition the friend from foe.

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Description of the total EEG states of neural networks of the brain of two interlocutors during the dialogue

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The relevance of the research is in determination of the neural mechanisms of social interaction which is important for understanding the social nature of human behavior. To describe the state of neural networks of the brain of interlocutors in the process of verbal and nonverbal communication - a new method of EEG hyperscanning (synchronous EEG recording of the state of neural networks of two brains simultaneously while interaction) was applied.

To distinguish the verbal and non-verbal component during the dialogue an experiment design was developed. It assumed different modes of location of the interlocutors in the same room (face to face, back to back), different modes of communication (silence, monologue and

listening, dialogue), different roles of interlocutors (speaking and listening), modes of visual perception (with eyes open, eyes closed). [1] Each pair of interlocutors went through 10 stages of interaction under different regimes.

Registration and processing of bioelectric activity of the EEG brain was carried out with the help of two 31-channel analyzers with 8 polygraphic channels in each "Mizar-EEG-202". (sample rate - 2000 Hz) and WinEEG programs. The conversation was recorded with the help of microphones. The electrodes were arranged in accordance with the international system 10-20.

18 volunteers participated in the experiment - 9 men and 9 women. The age range of both men and women was 22 to 29 years (mean age group 25.4 □ 1.7).

WinEEG was used to process the data. Correction of blink artifacts was carried out by zeroing the independent components of the EEG corresponding to eye blinking.

When analyzing the data, two approaches were used: one - based on the total EEG (power) indicators and the other - based on the spectral-frequency analysis.

Calculation of the Wilcoxon test for total EEG (power) confirmed the statistical significance of the difference in the location of the two interlocutors during the interaction (z = -11, 67, p = 0.000). The largest total EEG power was defined for the "face to face" situation.

The calculation of the nonparametric Friedman criteria for repeated measurements when comparing the total EEG (power) showed the statistical significance of the difference in the different modes of communication (chi-square = 3555.85, p = 0.000). The greatest total power defined the ‘monologue regime’.

On the basis of the EEG spatial-frequency spectrum, it was shown that there was statistically significant differences between all regimes and interaction conditions in all frequency ranges with the exception of the alpha-rhythm in the situation when the recipients were in back to back position (this effect corresponds to the effect of increasing alpha rhythm in closed eye, opened yet by G. Berger). Most differences in interaction modes were shown in the beta and gamma frequency bands and were best seen in the temporal leads of the brain. In a silent mode and eyes closed mode the greatest alpha rhythm was shown (exceeds the rhythms of all other spectra), when communication appeared there was no such effect. During all types of communication (monologue, listening, dialogue, silent with open eyes) there was an increase in power on beta-2 and gamma spectrum. [2]

On the basis of the conducted research it was possible to show that the design structure allowed to establish certain patterns of neural network reorganization of the brain of interlocutors in the process of dialogue according to EEG data. It was shown that the total EEG of interlocutors depends on the combination of interaction of verbal and nonverbal components. The largest total EEG capacity differs the interlocutors' location "face to face" compared to "back to back", in which non-verbal information about the interlocutor was available. All this can be interpreted as an increase in brain activity in case when both types of communication are present: verbal and nonverbal.

When comparing the conversation modes in relation to each other the largest total EEG power appeared in the monologue mode (when the partner is just listening) compared to silent mode, listening and dialogue mode and what is utmost interesting - in comparison with the dialogue mode.

This can be interpreted as an increase in the brain activity of the interlocutor in case he does not receive verbal feedback from the partner but uses only non-verbal information to receive feedback from the interlocutor. The monologue mode was the most energy-consuming mode of communication.

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Abstracts of the Conference

Development and testing of usability interface

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The aim of this project was to develop a designed prototype for the application framed as a tool for preparation for exams of subjects at university. The aim was to create easy-to-use and effective interface with a structured program and tasks which would help to pass the exam and get a good grade. The prototype has been created by using the service «Justinmind». After implementing of the prototype the numbers of tasks were thought out for the user. The client segment of the application was the students studying different subjects at the university. The number of students were asked to make the test tasks by using the prototype. After collecting the results the interface was slightly changed. There were additional buttons added and the locations of some buttons changed.

On forecasting of gender and age structure of the population

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The object of the project is to realize a methodology for predicting the gender and the age structure of the city. Throughout the research there has a neural network model been implemented. The method of forecasting was realized in Matlab tool. For making qualitative forecast the best suitable number of neurons and layers was chosen. As input, the data about the birth rate, mortality migration gain, population were taken. As output the numbers of gender and age structure were taken. The quality of the network was checked by correlation coefficient. After getting the best neural network model the prediction for 10 years was developed and compared to existing official data. The indicator of deviation from the results is 3%.

Moving Signal localization in presence of stationary Masker in free field

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It is known that the ability to localize a stationary signal in the presence of masker is dependent on the spatial location of the stimuli. For stationary signals, the greater the distance between signal and masker, the more precise signal localization. Sound localization was studied for moving signal in presence of stationary masker in the free field conditions. The masker was always stationary (15° at right). The moving signals traveled to or from the masker along two paths situated 86° ÷52° and 52° ÷ 18° at left. The signal was emitted with different delays respect to the onset of the masker. Strong effect of delay was shown for all listeners. At short delays, regardless of the instructions, all subjects pointed the trajectory near the masker, suggesting that they perceived one stationary signal.

Differences and similarity of changes in crossed and uncrossed retinal pathways during development of different types of amblyopia

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Abnormal binocular experience during early childhood may lead to amblyopia, which subsequently reduces visual acuity and changes visual-motor behaviour. Our aim was to investigate the development of impairments in crossed and uncrossed pathways originating from either retina in feline experimental models of deprivation and disbinocular amblyopia. Using histochemical staining for cytochrome oxidase the functional activity in eye-specific layers of lateral geniculate nucleus (LGN) of both hemispheres was estimated in unilaterally convergent strabismic kittens (SK) and monocularly deprived kittens (DK) at ages of 1 to 5 months. We found alterations of LGN layers activity in the projection of the entire visual field in DK, but only in the projection of central 10-15 degrees in SK. In both experimental groups a relative decrease of activity in layer innervated by uncrossed pathways from impaired eye was observed earlier than in layer innervated by crossed pathways from this eye. Moreover, these changes were found in DK at the age of two months while in SK they were found at the age of three months. The observed differences in development of deprivation and disbinocular amblyopia strongly suggest the different mechanisms implicated in them.

Use of spatial modulations of brightness gradients in the categorization of visual images

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The process of categorization requires the information that is extracted pre-attentively. So, this information describes single brightness gradients of an image and their spatial modulations. There may be 3 dimension of the modulations, and they are contrast, orientation and spatial frequency modulations. Our research was aimed to find whether the information about the brightness gradients modulations is useful in categorizing faces and objects. The initial images were preliminarily processed with our model in order to extract the areas with modulations of single dimension in various spatial frequency bands. The test stimuli only consisted of areas containing modulations of one certain dimension. The observers had to categorize the presented stimuli as accurately as possible. We found that the contrast or orientation modulations in the low-frequency part of spectrum provide enough information to categorize a face (by race, gender and emotional expression) with 95% accuracy, and an object (basic-level categorization) with 85% accuracy. The modulations of spatial frequency were comparatively useless. Thus, the obtained results suggest that the information about the brightness gradients modulations is useful for the categorization process. Supported by MESRF project 3336.

Estimation of signal-to-noise ratio and mean square error based on sequential filtering approach for cardiac cycle tones

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To date, identification of cardiac cycle tones based on sequential filtering is a very actually task in the field of modern methods data processing. To improve the quality of identification of cardiac cycle tones, noise compensation, are used a variety of adaptive approaches based on sequential low-frequency, high-frequency, rejection and band-pass filtering. The use of consequentially connected band-pass filters it is relatively easy to adapt their parameters to the parameters of identifiable tones of the cardiac cycle tones.

The purpose of this work is to confirm the possibility of using adaptive sequential band-pass filtering for sequential identification of cardiac cycle tones in the presence of acoustic and electrical noise. For identification cardiac cycle tones the signal was recorded by a microphone, built into the head of the stethoscope, at certain points of auscultation of the heart of the biological object. This type of registration has improved identifiability of cardiac cycle tones on the surface of the thorax of the biological object. Identification of the cardiac cycle was carried out by filtration using two sequences of band-pass filters, each of which contains stable Butterworth filters of the second order. During the identification of cardiac cycle tones, the proposed approach demonstrated increased resistance to interference (signal to noise ratio, SNR) and reduces errors identification of tones (mean square error, MSE). The obtained quantitative results of SNR, MSE allow noting that this approach more accurately identifies cardiac cycle tones a biological object.

Temporal resolution under perception of the sound source movement with the model signals simulating a sensorineural hearing loss

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The symmetrical sensorineural hearing loss caused by age-related pathology of the cochlea and other structures of the auditory system is of interest as a model of the gradual switching off the high-frequency binaural mechanism. The high-frequency hearing loss not only worsens speech recognition, but also affects distance estimation, since the difference in loudness is one of the main cues of remoteness of the sound source (Ahveninen et al., 2014; Carlile, Leung, 2016). In case of sensorineural hearing loss both the binaural and monaural mechanisms used by the auditory system to estimate the distance from the listener to the source sound change in comparison with normal hearing. The purpose of our study was to obtain new data on the perception of approaching and withdrawing under the simulating of hearing loss in accordance with typical audiograms at mild and moderate degrees of sensorineural hearing loss. In the task of estimating movement direction 10 subjects with normal hearing showed impairment of motion perception for simulated moderate degree: temporal threshold and total percentage of mistakes increased.
This work was supported by state budget for the state assignment for 2013-2020 (№ S. R. AAAA-A18-118013090245-6; GP-14, section 63.2) and by the RFBR grant (No. 18-015-00296).

Alternative communication and practice of its application

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The possibility of communication is one of the foundations of human life and society. Its manifestation can be different and have verbal and non-verbal in nature. Methods of communication, which replace or Supplement speech interaction between people, include alternative and augmentative forms of communication (AAC). In this case, augmentative communication can be used throughout a person's life or perform a temporary function. Depending on the capabilities of the patients, various means can be used for AAC: gesture signs (words are explained by gestures); graphic symbols (bliss symbols, pictorial symbols-Picture Communication Symbols and Pictographic Ideographic Communication); subject symbols (for example, word Premak cubes). Also, possible options for the use of electronic devices for the AAC. In recent years, successfully developed the technology of eye tracking, which allows using eye

movements to control a computer to access the Internet, to communicate and to generate speech. These developments have become an indispensable tool in a crisis condition, characterized by immobility of the person. One of them is assisting the eye tracker Sterh, which is domestic development with Russian interface, fully ready for practical application.

Manifestations of central auditory disorders and the effectiveness of hearing aids

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A study of patients with chronic hearing loss showed that the main negative factor of the effectiveness of hearing aids is the severity of the central auditory disorders. As additional factor the technical characteristics of hearing aids are treated. To increase rehabilitation benefit, a set of measures are recommended: for prevention and correcting central auditory disorders, for rational fitting of hearing aid (according to individual features of auditory system), for well-formed adaption to the hearing aids (assistive technology of auditory training). The experience of using different methods of assessing central auditory disorders is also discussed.

Comparison of visual illusions with known mechanisms of perception

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We studied properties of the Wundt-Hering illusion and the Oppel-Kundt illusion. Several experiments were carried out. In the Wundt-Hering illusion we compared the curvature of the lines crossing the divergent lines and the curvature of the mentally drawn lines through points located on the fan. It was shown that the curvature of the lines evaluated identically for continuous lines and for interpolated lines. In the Oppel-Kundt illusion we founded the invariant dependence of the illusion on number of internal addition lines relative to the spatial interval sizes. We compared experimental psychophysical data with modeling results taking into account the signal processing mechanisms in the visual system. Appearing illusorily curvature in the Wundt-Hering illusion was obtained in model as a result of selective attention mechanism which calculated centroids between fan center and points of interpolation. The distortions of size estimation in the Oppel-Kundt illusion were determined by processes with receptive fields of the visual system. The effect of size invariant perception in the Oppel-Kundt illusion was predicted by model of modules, consisting of 4-5 harmonics. These modules are formed from simple and complex receptive fields of neurons of striate cortex. The size of module which gave maximal response on spatial interval with additional lines was taken as a size of the illusion.

Time dynamics of the priming effect in the heterosensory interaction in children of preschool age

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The temporal dynamics of the priming effect during heterosensory interaction in preschool children was studied. To identify the ways to develop the anticipatory abilities of preschool children, age characteristics of the processes of involuntary and voluntary attention as the leading mechanisms for the formation of anticipatory activities that provide for tuning of the organism to the perception and

movements were carried out. The priming paradigm was used as a research model, which allows determining the distribution of attention between perceived stimuli, as well as the temporal dynamics of the process of identification of a heterosensory object. In the course of the study, the dependence of the priming effect on the congruence / incongruity of consecutively presented heterosensory stimuli and the interval between them in children of 4, 5, and 6 years was determined. The obtained results allow to reveal the features of the formation of heterosensory anticipation processes in a given age period. The reported study was funded RFBR according to the research project № 16-06-00345, № 17-06-00644-OGN

Mathematical model of primary visual cortex: orientation and direction selectivity, effects of appearing motion and stimulus retention

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The responses of the primary visual cortex to visual stimuli reveal a number of effects that reflect the nature of information processing. A consistent description of the mechanisms of these effects observed in vivo and in slices is a challenging task. The proposed model provides a biophysically-detailed description of the mechanisms of primary visual cortex functioning in terms of the activity of neuronal populations. It is based on the conductance-based refractory density (CBRD) approach designed for a single population. The composed model considers the cortex as a layered heterogeneous continuum and takes into account the structure of the orientation hypercolumns. The model reproduces a number of known experimental intracellular and optical recordings in the primary visual cortex of cats and monkeys, in particular: the effects of orientation and direction tuning; the effect of retention of cortical activity caused by a brief stimulus; the effect of apparent stimulus movement; and the influence of saccadic movement of the stimulus on the spiking activity. According to the model, the most important factor in the manifestation of the effects is the strength of exciting intra-cortical connections and the structure of on-off receptive field projections.

The neural basis of sensory comparison – Gnostic units, cell ensembles or a cerebral bus?

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Are objects, words, concepts represented by the activities of single neurons? These (still-hypothetical) cells were called ‘gnostic units’ by Konorsky and ‘grandmother cells’ by Lettvin. A traditional alternative is ‘ensemble coding’, where a given entity is represented by the pattern of activity in many cells.

Our psychophysical experiments suggest that a quite different form of coding might exist in the brain. We measure the human ability to compare one stimulus with a second that is presented at some distant, arbitrary point in the visual field. Thresholds for comparing spatial attributes, colours or motion are independent of the spatial separation, even if the two stimuli are separated by 10 degrees of visual angle and fall in opposite hemifields. This ability is so natural and effortless that neuroscientists seldom ask how it is achieved.

Are such comparisons performed by dedicated ‘comparator units’, one for each pair of positions and each attribute? We judge this unlikely, owing to the combinatorial explosion of possible pairs, the necessary volume of white matter, and the energetic cost of radiating of ‘junk’ messages. Instead we propose a ‘cerebral bus’, analogous to the man-made Internet, where the same physical substrate carries different messages from moment to moment.

Letter identification strategies in Russian: an experimental study

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In the alphabetic scripts words are recognized via their constituent letters. However, letter identification is still the least studied subject in the field of visual perception. The aim of this research is to detect mechanisms of letter identification on early stages of visual recognition by Russian native speakers. The experiment was developed using the eye-tracker and the invisible boundary technique. The participants were asked to identify an either isolated (a) or masked (*a*) letter presented in the parafovea in Georgia font. Confusion matrices of the Russian alphabet were created, and the identification of isolated letters turned out to be more accurate, than masked ones. When comparing this experiment to the previous study on Courier New, it appeared that masking drastically complicates the task when letter is presented in Courier New, rather than Georgia. However, no such difference in fonts was found on isolated letters. As masked letters imitate reading, it can be concluded that font influences letter recognition within a word (Georgia is more readable, than Courier New). Cluster analysis revealed that these fonts prioritize different letter features, which shows that letter identification in reading is led by their distinctive features, not by their abstract representation. Funded by RSF#14-18-02135.

Complex sound processing by multipeaked neurons in brain auditory centers

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In multiple neurophysiologic studies of the brainstem auditory centers and auditory cortex neurons, called complex or multipeaked were described (Sutter, Schreiner, 1991; Egorova et al., 2001; 2012; Egorova, 2005; Anderson, Linden, 2011). These neurons had a complex shape of their excitatory frequency receptive fields and at least two excitatory characteristic frequencies. The multipeaked neurons were found in the auditory midbrain (central and dorsomedial nuclei of the inferior colliculus) (Egorova et al., 2001; 2012), diencephalon (medial geniculate body) (Anderson, Linden, 2011) and primary auditory cortex (Sutter, Schreiner, 1991; Egorova, 2005). The properties of the receptive fields and the impulse activity characteristics of the multipeaked neurons are poorly studied. Thus, in present study we compared the basic spectro-temporal characteristics of the multipeaked neurons from different house mouse brain auditory centers, which in spite of the wide use of this animal in neurophysiological studies of the hearing mechanisms did not study yet. The functional specialization in sound processing as well as the nature of the multipeaked neurons are discussed. Supported by state budget for 2018 – 2020 (reg. № AAAA-A18-118013090245-6).

Electrical activity of the monkeys' brain in performing visual spatial tests

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The closest animals to humans according to the anatomical and physiological characteristics are monkeys. Therefore, information about electrical processes in the monkeys' brain during cognitive activity can be extrapolated to some extent to humans for understanding the principles of human brain functioning.
An electrocorticogram (ECoG) was recorded in two monkeys Macaca Mulatta from the brain surface with the help of epidural electrodes placed on frontal, central, parietal and occipital areas of the brain. Monkeys were trained to perform visual spatial tests of different complexity, presented on the

touchscreen of computer. In case of correct answer (touching screen in the required area) food reinforcement was automatically given. To attract monkeys' attention to the screen, a warning sound was given one second before the images appeared.
Analysis of evoked potentials showed that the first reaction, as a negative potential deflection, was observed in occipital regions on average 50 ms after visual stimulus presentation, followed by a series of positive and negative waves, including late components with a latency of 300 ms. Wavelet analysis of ECoG showed that approximately 500 ms after a warning sound (500 ms before the visual test), the power of oscillation in occipital regions at frequency of 40 Hz begins to increase, reaching maximum at the moment of visual test presentation, after which it decreases sharply. Presumably, the rhythmic activity at 40 Hz reflects an increase in attention during preparation for action, which may shed light on the origin of contingent negative variation discovered by G. Walter in 1964.

Investigation of monkeys' reaction time in performing tasks of varying difficulty

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Reaction time is one of the key indicators in psychophysiological experiments, as it reflects the final stage of information processing, the decision-making. It is well known that the reaction time increases with the task difficulty. However, this sometimes does not occur in animals. The conditions necessary for obtaining a correct reaction time in monkeys are investigated in the work.
Visual tests of varying levels of difficulty were presented to monkeys Macaca mulatta on the touchscreen of the computer. The task was to recognize the dominant orientation in textures of varying degrees of orderliness. The more ordered the image, the easier task. On a group of 5 monkeys, two types of experiments were conducted, differing in the time of stimulus presentation and in the time of response expectation. In the first experiment, the stimuli were presented for three minutes, and during this time monkeys could receive a reward for the correct answer. In the second experiment, the stimuli were presented for only 800 ms and a response was expected within 1800 ms.
The time constraints did not change the percentage of correct answers, but led to significant decrease in reaction time, on average by 800 ms. Moreover, in experiments with a long expectancy time, the reaction time did not depend on the task difficulty, and in experiments with a short expectancy time, the reaction time significantly increased with the task difficulty. Thus, when investigating the reaction time, the necessary condition is to respond as quickly as possible. In human experiments it is enough to give such an instruction, however in animal experiments it is necessary to introduce time constraints on the expectation of a response.

Comparative dynamics of human experience emotions neurophysiological markers at the time of conscious and unconscious perceptions sensory information

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Emotion is a multicomponent reaction of organism to relevant stimuli and situations. The Influence of consciously perceived affective sensory stimuli on a human physiology and behavior is well studied today, but little is known about the effect of unconsciously perceived emotional stimuli. Also there is unsolved question about the fundamental differences in physiological and behavioral reactions to emotional stimuli perceived either consciously or unconsciously.
The purpose of current research was to carry out the comparative study of objective physiological changes in response to emotions of different valence provoked by consciously and unconsciously

perceived emotional stimuli. Precisely we analyzed dynamics of physiological measures (EEG, ECG, SGR, pneumogram and the latency of sensorimotor reaction) to acoustic stimuli with different emotional contents.
It was received that both consciously and unconsciously perceived affective stimuli provoke definite changes in frontal asymmetry (FAS) ratio of EEG, which correspond to the valence of the experienced emotion. However in most cases these changes to unconsciously perceived stimuli started earlier, but were less stable than in response to consciously perceived stimuli. Activation of sympathetic nervous system and arousal occurs in both cases of sensory perception of emotional acoustic stimuli. In case of unconscious perception the complex of vegetative reactions (according to an ECG, SGR, respiration rate) were more pronounced , but didn't depend on the valence of the provoked emotional state as compare to conscious perception. Consciously perceived negative emotional sounds led to an increase in the time of sensorimotor reaction and number of the missed reactions. The revealed differences in dynamics of physiological indexes to unconsciously and consciously perceived emotional acoustic stimuli improved understanding of the common principles of physiological mechanisms of emotional processes.

Automated analysis of Drosophila pulse song

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The song produced by Drosophila melanogaster males when they court a female is widely used in neurogenetic studies to investigate the functioning of neural circuits. It consists of the pulse and sine components. Pulses are organized in trains separated by noise or sine fragments. Pulse song reflects the functioning of the singing central pattern generator itself as well as descending and feedback influences on it. Here we present the program Drosophila Courtship Song Analysis (DCSA) which allows automatic pulse song recognition and analyzes such parameters as frequency of trains initiation, their duration, number of pulses within a train, interpulse intervals, number of cycles within a pulse, pulse carrying frequency and others. Automatic pulse recognition in sound records (wav files, mono, 44100 Hz, 16 bit) is based on sound signal features, empirically selected when analyzing natural pulse song, and applied at successive stages of analysis. Despite the program algorithm recognizes almost all song pulses, a manual correction in the editor mode is required, mainly to delete some unrelated signals. Examples of the program practical use in researches of our laboratory are reported.

Information system for the development of speech hearing and memory in adult hearing aid users

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Objective of the work is to devise the information system of auditory training for improving of speech hearing and memory in adult hearing aid users. The main cause of the need of auditory training practice is central auditory processing disorder (CAPD), which inevitably develops in patients with chronic sensorineural hearing loss as a consequence of auditory deprivation. Patients with CAPD have difficulties with understanding complex signals, especially, speech in background noise.
The optimal algorithm of auditory training and trial version of information system were worked out and tested in group of adult hearing aid users with poor speech-in-noise recognition (from 60 to 74 years old). Auditory training lasted for 8 weeks, with lessons 2 times a week during 60 minutes. The following exercises were used: 1) discrimination of signals varied in duration, frequency and intensity; 2) dichotic

audition (speech, digital signals); 3) discrimination of speech stimuli, including speech in background noise; 4) perception and reproducing of meaningless sentences with various lengths (from 3 to 7 words). The level of tasks was gradually complicated during the learning sessions. Tonal threshold audiometry, evaluation of central auditory system functioning, and speech audiometry in free field were examined before and after training. The data obtained shows significant improvement of speech perception and speech intelligibility under noise conditions in all patients passed the course of auditory training.

TuSion: five approaches for neurogaming. Mechanics that lie between art and BCI.

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TuSion is a mobile application which allow to work with brain states while playing games using neurointerfaces. The main brain-computer interface idea of TuSion is that the advanced, stable and fine BCI have to use fine neurofeedback protocol which is pretty manipulated in vary range of all controlled parameters. Five different approaches on neurogaming engineering were developed during the research.

Possible errors using different methods of visual acuity testing

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Background: Commonly clinicians use wall charts or chart projectors to measure visual acuity.
Aim: The aim of this study was to investigate the consistency of visual acuity estimates from wall mounted visual acuity charts and automatic chart projectors.
Materials and Methods: This study involved thirty patients aged between 17 and 78 years old (17 males, 13 females), with spherical refractive error ranging between +3.5 and −7.75D with different ocular pathology. Visual acuity was measured with wall mounted Golovin-Sivtcev letter chart (WM) and automatic chart projector (CP).
Results: Visual acuity estimates showed no statistically significant difference at the same distances. However we find a lot of individual differences if the distance of testing was not equal. Statistical analysis showed that visual acuity estimates were significantly different between the WM and CP ($P = 0.04$) at distances less than 2 meters.
Conclusions: Different methods of testing may lead to individual errors in visual acuity estimating, especially using PC with reduced distances.

Emotional component of alternative communication in adolescents

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The present study aims to study of the emotive component (Emoji) unique features of alternative adolescent communication.
The study examines differences special aspects of basic emotions (by P. Ekman) using the photographs and Emoji (by K. Isard) the eye tracker (VT3 mini, the frequency sample - 60 Hz , software MangoldVision). In this study there are 5 author tests (in jpeg ; size: 1366 x 768; font: Arial Narrow, 26 pt, # 000000).
28 students of the seventh grade participated in the research study who are in 13-14 age bracket, including 11 girls and 17 boys. All participants of the research had normal vision or corrected-to-normal vision.

It was found that the process of understanding the semantic Emoji is faster than the photo on average ($p < 0.05$) when they complete text tasks. Also Emoji have fewer fixations and observations. Analyzing of teenager emotions It was found that they are looking at the eye area($p < 0.01$) when they examine the Emoji and the photo . Also It was revealed more fixations, observations and observation length in the eyes and mouth area on a picture than on a Emoji ($p < 0.05$; $p < 0.01$). In addition, the results showed that in general fixations, observations and observation length are more on a picture than on a Emoji ($p < 0.01$).

The eye tracking possibilities in visual acuity measurement

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The Preferential looking test using for preverbal children but has some weaknesses, in particular because it is examiner dependent and at best half-objective. We tested a new automated method in a pilot study.
Materials and methods. In our Preferential looking setting we project Landolt's ring, which change the size and position of the gap. An infrared oculography system documents objectively and reproducibly whether or not the stimulus is seen. Then we compare the results of visual acuity with data received with wall chart.
Results. In 75 participants we found a good correlation between visual acuities determined with the new method and wall chart.
Conclusion. This new technique permits one to perform and preferential looking test without need verbal answers.

Ontogeny of the periallocortex and its role in the genesis of neurodegenerative diseases

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Неблагополучный период гестации, недоношенность являются факторами риска сниженных когнитивных функций детей, что связывают со структурно-функциональными отклонениями развития систем гиппокампа, амигдалы и периаллокортекса. Последний состоит из субикулум, пре-, парасубикулум и энторинальной коры, которые отделяют древнюю и старую кору (они же в совокупности аллокортекс) от новой коры (или изокортекса). Интерес к периаллокортексу крайне высок, что объясняется функциональной специализацией его нейронов: клеток сети в медиальной энторинальной коре, положения головы и границ окружающего пространства в пре-, парасубикулум. Эти нейроны, связанные друг с другом, гиппокампом и амигдалой создают систему ориентации, памяти, целенаправленной навигации, основу когнитивных карт, эмоционально обусловленного поведения. Структуры критичны в генезе ряда заболеваний: эпилепсии, аутизма, СДВГ, дислексии и др. Однако, большая часть того, что известно о них, исследовано на грызунах, у человека они изучены слабо, хотя их видоспецифические особенности очевидны. Объясняется это тем, что в зрелом мозге человека топография данных структур крайне сложна, но многое в их организации может прояснить плодный период. В настоящем исследовании методами флуоресцентной иммуногистохимии, с применением маркерных белков цитоскелета и слой-специфичности нейронов, исследовали критические периоды развития периаллокортекса мозга плодов человека. Всего исследовано 10 полушарий мозга плодов в возрасте 20-26 недель гестации. Субструктуры периаллокортекса проходят критический период развития раньше неокортекса, он наиболее длителен для нейронов, инициирующих перфорантный тракт к гиппокампу.

First experience of visual acuity screening using smartphone

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Mobile technology developments and adoption rates by clinicians may potentially provide more convenient methods of assessing visual acuity.
Objective: To evaluate the assessment of distance visual acuity using smartphone against the commonly used 5-metre Golovin- Sivtsev chart and 1.5- metre chart.
Materials and methods: The visual acuity of 50 participants was assessed using a Golovin-Sivtsev wall chart (5 m), short distance chart (1.5 m) and smartphone (1.5 m) with Snellen's optotypes.
Results. The results show a high level of general agreement (r=0.93) between wall chart (1.5 m) and smartphone test and between wall chart (5 m) and smartphone test (r=0.91).
Conclusion.The high level of agreement of visual acuity results between the both wall charts and smartphone test suggests that clinicians can use this technology in practice.

Costs of kinetic energy of the visual system during working with different types of stimuli

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The human eye is a biomechanical system that ensures the movement of the human eye over the field of view, in order to optimally enter information into the brain. Moving the gaze requires a certain kinetic energy, which, presumably, differs depending on the type of visual task. These differences can lead to dramatic consequences for various pathologies of the eye, at various stages of the postoperative period. Recommendations to the patient should be determined by knowledge about these differences and about the loads that the eye experiences in various activities. For example, can you allow reading in the postoperative period? We compare the kinetic energy of the eye during reading text, during examining pictures, fixing the gaze at a single point.
We have shown changes in many parameters depending on the task posed to the observer. The most pronounced change is the change in the number of saccades. Based on the results of measurements of eye deviation values and speed changes during saccade, the time dependence of the kinetic energy consumed during the saccade was established. Thus, knowing the number of saccades for a certain period of time, we can estimate the kinetic energy of the eye during this period.

Brain Computer Interface Using Phase-Tagged Steady-state Visual Evoked Potential

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Patients suffering from severe motor disabilities, such as amyotrophic lateral scleroses (ALS), severe cerebral palsy, head trauma, multiple sclerosis, and muscular dystrophies, are incapable of communicating with external environments. This study presents a new steady-state visual evoked potential (SSVEP)-based brain computer interface (BCI). SSVEPs, induced by phase-tagged flashes in eight light emitting diodes (LEDs), were used to control four cursor movements (up, right, down, left) and four button functions (on, off, right- and left- clicks) on a screen menu. EEG signals were measured by one EEG electrode placed at Oz position, referring to the international EEG 10-20 system. Since SSVEPs are time-locked and phase-locked to the onsets of SSVEP flashes, EEG signals were bandpass-filtered and segmented into epochs, and then averaged across a number of epochs to sharpen the recorded SSVEPs. Phase lags between the measured SSVEPs and a reference SSVEP were measured, and targets were recognized based on these phase lags. The current design used eight LEDs to flicker at 31.25 Hz

with 45° phase margin between any two adjacent SSVEP flickers. The SSVEP responses were filtered within 29.25-33.25 Hz and then averaged over 60 epochs. Owing to the utilization of high-frequency flickers, the induced SSVEPs were away from low-frequency noises, 60 Hz electricity noise, and eye movement artifacts. As a consequence, we achieved a simple architecture that did not require eye movement monitoring or other artifact detection and removal. The high-frequency design also achieved a flicker fusion effect for better visualization. Seven subjects were recruited in this study to sequentially input a command sequence, consisting of a sequence of eight cursor functions**,** repeated three times. The accuracy and information transfer rate (ITR) (mean ± std.) over the seven subjects were 93.14 ± 5.73 % and 28.29 ± 12.19 bits/min, respectively. The proposed system can provide a reliable channel for severely disabled patients to communicate with external environments.

Structural analysis and the principle of adaptive resonance in artificial neural networks

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The artificial neural networks became currently one of most popular tools of signal processing and image analysis. The Perceptron of Rosenblatt considered the images to be fed into its input layer as indivisible whole, and this was one of the main reasons of its weakness. Thus, the structural matching neural networks and convolutional neural networks appeared two decades later that turned out to be much more powerful in the field of image recognition. The last ones became champions in annual image recognition competitions, and their success is to large extent based on borrowing some neural architectures from the living vision systems. Nevertheless, the important principles of structural decomposition and adaptive resonance implemented four decades ago in Neocognitron of Kunihiko Fukushima were forgotten for long years and are not implemented in explicit form in the most popular types of deep convolutional neural networks. At last, the capsule networks proposed recently by Geoffrey Hinton implement these two important principles. The author does not mention these principles explicitly, and we analyze here the capsule networks from this view point in detail.

Speech and video data for study of communication skills of atypically developing children: a new approach

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Atypical development implies the use of special approaches for the study of child's speech and communication skills. It is required to create special databases containing speech samples and video recordings of the informants behavior during the interaction situation. The goal of our study is to reveal acoustic features of speech and the elements of nonverbal behavior in "mother-child" dyads with children with autism spectrum disorders (AD), Down syndrome (DS) and typically developing (TD) peers, and communications between TD children and children with mental retardation (MR). We have developed an algorithm for assessing the verbal and nonverbal behavior of children in the process of interaction with the mother and each other. The obtained data of speech features, verbal and nonverbal behavior of children can be used to create a stimulus for computer training programs for children with atypical development. The study is financially supported by Russian Fund for Basic Investigations (projects №№ 16-06-0024a, 17-06-00503a, 18-03-01133a).

Neurotechnology. Image recognition and modeling the response of neurons in the Inferior temporal cortex

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Understanding how information is coded, transferred and stored in the brain is an essential part of neuroscience. Lately, invariant recognition, one of the fundamental properties of human visual system, has been observed in deep neural networks, providing exceptional results in object recognition tasks. In this work, I show how convolutional neural networks (CNNs) and Generative Adversarial Networks (GANs) can be used to study latent representations, coded by neurons in high visual areas. To explain neural preferences, I train a deep network to simulate the response of the neurons in the Inferior temporal (IT) cortex of macaque monkey. The model has high performance and explain > 0.65% of the variance in the neural data. Then, I visualize latent representations of artificial neurons using a generative adversarial network. The approach allows to find an input signal that maximizes activation of an individual unit without limitations introduced by a dataset.

How representations coded by neurons in deep neural networks differ from neural data

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Categorization of objects and events is an essential ability for decision making and effective operating in the environment. Lately, Convolutional Neural Networks are widely used to solve complex recognition tasks. In this work explore how categories are represented in a deep neural network using an approach from signal detection theory to identify sensitive detectors. I show that category-selective filters can be observed from the first layers of deep neural networks. I also show that a tuning curve of a category-selective filter differs from what is usually seen in a neural data. Representations of objects in weights of convolutional layers do not necessarily reflect the perceptual similarity of images. Instead, they are strongly dependent on a choice of a training set and cost function. This properties of neural networks may be a reason for the unstable behavior when a model detect objects in their absence and fails to recognize obvious cases from a human-observer point of view.

Deep learning for image recognition under severe noise condition

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Deep neural networks trained on large dasates that contain only high quality images are inaplicable to the tasks where severe noise appears. At the same time large datasets are nesessary to cover large variation on objects types and their appearence under different shooting conditions. The report considers the problem by investigating several approaches, including the dataset augmentation and preparation, the primary image filtration of noisy images, and neural network architecture choises.

Optical coherence tomography is a non-invasive approach to planning laser treatment of retinal diseases

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Optical coherence tomography (OCT), which was recently introduced into clinical practice, allows high-resolution noninvasive visualization of the posterior eye segment structures. OCT is not only an important part of multimodal approach in ophthalmology but also incorporates a number of distinct imaging options which make OCT a multitask tool for retinal pathology. Now OCT includes cross-sectional structural imaging, retinal thickness mapping, en face imaging, and optical coherence tomography angiography (OCTA). Concomitant to noninvasive visualization, OCTA represents a powerful tool for quantitative characterization of retinal microvasculature. The most clinically applicable parameters of OCTA are the vessel density in superficial capillary plexus and deep capillary plexus, as well as the shape and size of the foveal avascular zone. En face imaging provides data about spatial distribution of intraretinal and subretinal fluid as well as retinal aneurisms while thickness mapping indirectly indicated a source of the retinal exudation. All of these OCT modalities not only provides new information about the pathophysiology of retinal vascular diseases but also can be used as a highly effective navigation tool to plan retinal laser therapy.

Evaluation of the working area of the motion capture system Optitrack Prime13

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Motion capture systems are used to create animations and to transfer body movements to virtual reality. VR applications require real-time capture with a low level of errors. The purpose of this work is to estimate the number of errors in the Optitrack system. 16 cameras Prime13 were placed around the room 6x6 m. The captured area was devided into squares 50x50 cm. A man in suit with 50 passive markers walked all over the room, 80 000 frames were recorded with 120 fps. Errors in this work are the absence of some marker in the record. The average number of markers was calculated for each square, also the standart deviation and other statistics were evalulated. As a result, it was found that the number of errors is distributed unevenly across the zone of capture. The heat maps of errors distribution were compiled.

Magnetic Resonance Images Processing Based on Automatic Segmentation and Fractal Analysis

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Purpose of this work was to develop methods contour and volume of areas of interest definition in tomographic images of the breast. The study included images of the breast of 13 patients obtained on an open electronic resource The Breast-MRI-NACT-Pilot image collection. Statistical processing of the data was carried out, the reliability of the results of calculating the volumes of the breast areas was estimated, a visual evaluation of the obtained numerical values was provided – a linear graph.
A program for automatic determination of breast volume and volume of pathology has been developed and tested. For segmenting areas of the breast, a threshold segmentation and a managed watershed method programs were written in Matlab package. The developed programs allowed to obtain reliable data when processing MRI images of the breast of 13 patients. Results of using Hurst exponent show that in the case of a pathology, the exponent is less than 0.4, and for the tissue without pathology the Hurst

index is greater than 0.4. This method is implemented in dynamic programming mode, which allows to adjust the algorithm for a task of examining images.
The developed methods of definition of contours and calculating volumes allow an automatic quantitative evaluation of the ratio of the volumes of different identified areas of interest in the postprocessing of MRI images. Also, the results have established that it is possible to use the Hurst exponent as an additional tool for identifying pathologies in areas of interest.

The research on methods of a skeletization of the digitized biometric data by using OpenCV technology

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The research on methods of a skeletization of the digitized biometric data by using OpenCV technology. Nowadays there often appears a need of recognition and verification of images of biometric data. Obtaining the affirmative or negative answer in similarity of images is usually got with a certain error, but often, it enough for identification of the personality. The algorithm of verification of the image breaks into four stages: 1) Elimination of noise in the image; 2) Binarization of the image – reduction of the image from a color format in black-and-white; 3) Skeletization the image – removal; 4) Allocation of the main points of the image; 5) Comparisons of images on the main points.
In this work the attention is paid to the third stage of verification of the image. While working on the research five algorithms of skeletization of converted images have been found: an algorithm of thinning of areas, a wave method, the Algorithm Zonga-Sunya, Shchepin's Algorithm, the modified Rosenfeld's algorithm. Throughout working on a project the key parameters of efficiency of algorithms of a skeletization in respect of temporary and qualitative characteristics are revealed, recommendations about the choice of an algorithm for a skeletization of images of fingerprints are also formulated.

Development of visual cortex modules: optical mapping data

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Prominent characteristic feature of the visual cortex of some mammalian species is the tangential packing of neurons with similar functional and biochemical properties into the so called cortical columns or modules. Numerous studies historically related to the works of T.Wiesel and D.Hubel showed that the formation of the functional structure in visual cortex depends on the individual's visual experience during the critical period of early postnatal development. It has been suggested that the development of cortical columns is sensitive to a temporary pattern of excitation at the retinal input. Electric or rhythmic light stimulation allows to modify experimentally the nature of the stimulation of the retina that leads to the artificially correlated activity of axons of ganglion cells at the output from the eye. Until now, there is no unequivocal opinion that such stimulation contributes to the separation (segregation) of the columns or, on the contrary, prevents it. In the present work the development of the orientation cortical columns in animals reared under conditions of prolonged rhythmic light stimulation was investigated by optical imaging technique. Despite the safety of the global structure of the columns, a 3-5-fold decrement in optical signal from orientation columns and drastic decline in contrast sensitivity were observed in both areas 18 and 17 suggesting the modification of cortical functional architecture under artificial correlated synchronization of the retinal input. Work was supported by the Russian Foundation for Basic Research (RFBR grant №16-04-01791).

Development of the Y cells of the cat lateral geniculate nucleus in relation to the visuotopic map

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The study is devoted to the development of the morphometric features of Y cells of the lateral geniculate nucleus (LGN) in relation to the visuotopy. Y cells are the part of the visual system responsible for the processing of visual movement. It's known that the soma size of the retinal Y cells is gradually dependent upon the retinotopy, but there is no detailed information about the same dependency within the LGN - the next level of processing of visual information. Using the SMI-32 antibodies, we visualized Y cells of the LGN and analyzed the dynamics of their soma size along the vertical and horizontal meridians of the visual field representation. Cats aged 10, 28, 62, and 123 postnatal days were used. Independent of age, the soma size of Y cells was decreased from center to periphery of visual representation along the horizontal but not vertical meridian. That pattern of Y cell size changing has not been shown earlier on both retinal and thalamic level. It was proposed previously that the soma size of Y cells can be related to the conduction velocity of their axons. Thus possibly the perception of motion within the vertical periphery is higher than within the horizontal periphery.

Effect of learning on the evoked potentials characteristics in classification tasks

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The research purpose was to study how the repeated participation in the study of the subjects affected the evoked potentials characteristics upon presentation of the same images stimuli set, but different instructions to the observer.
The study involved 21 healthy subjects aged 20 to 38 years. Using a cognitive evoked potentials method, 2 experiments series were carried out. In both series from a distance of 1.5 m from the subject's eyes to the monitor screen images of live and inanimate objects filtered at high and low spatial frequencies by means of wavelet filtration were displayed. The angular dimensions of the objects images on the screen were 3 angular. deg. In both series, the observer's instruction was to classify the images into clear and blurry. Time of images presentation is 100 ms with an interval of 1 second. Registration of evoked potentials was carried out according to the scheme 10-20 with reference ear electrodes.
The role of late evoked potentials components in the parietal, temporal and occipital regions of the brain in training is shown.

New methods of assessing visual acuity

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The research purpose was to study the unconscious processes images of animate and inanimate objects classification by the method of cognitive evoked potentials. The study involved 21 healthy subjects aged 20 to 38 years with normal and corrected glasses to normal vision. Experiment was carried out using cognitive evoked potentials. From a distance of 1.5 m from the subject's eyes, images of animate and inanimate objects, filtered by wavelet filtration at high and low spatial frequencies, were presented to the monitor screen. The angular objects images dimension on the screen was 3 angular. deg. Time of images presentation - 100 ms, interval - 1 second. Evoked potentials registration was carried out according to the scheme 10-20 with reference ear electrodes. The observer's instruction was to classify the object images into «clear/

blurred». The evoked potentials amplitude was analyzed for feature of an «animate / inanimate» and «sharp / blurred».
It was found that in the components N170 of the lower-temporal and occipital cortex and P200 in the frontal cortex, despite the instruction to observers to "classify images according to physical characteristics (sharp / blurred)", we registered responses in the brain according to the semantic feature (animate/ inanimate) object, those unconscious images classification.

Application of Neurotechnologies with interactive virtual environment for the correction of disturbances of cognitive function in patients with schizophrenia and depression

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The aim of this study was to evaluate the effectiveness of the application of neurotechnology with an interactive virtual environment for the correction of cognitive impairment in patients with schizophrenia and depression. In the Vision Physiology Laboratory was created a neurotechnology using virtual reality for the rehabilitation of patients with neurocognitive disorders. The virtual environment used at the second stage of the analysis represented a video of natural scenes that simulated a bike ride through the landscape with a varying relief completely synchronized with the movement of the patients. The observer's task included a thorough review of both spatial images (magno-system) and separate objects (parvo-system) presented on the panoramic monitor, but also the fulfillment of the cognitive task. For example, focusing on individual video elements in order to search and account objects with certain characteristics set at the beginning of the session. The effectiveness of the methodology was assessed using the electrophysiological (cognitive visual evoked potentials). Comparative analysis of evoked potentials amplitude during the perception of images, which filtered via digital filtration for selective effect on the magno- (low frequency) and parvo- (high frequency) - channels of the visual system, was used. It was shown that in patients with schizophrenia and depression, exhibited a decrease in the amplitude of the components to stimuli filtered at high spatial frequencies and reduced contrast sensitivity at high spatial frequencies. The difference between these pathologies is the different localization of disturbances. In schizophrenia – the localization of disturbances in the occipital, parietal, central, frontal areas and the right temporal region. In depression – the localization of disturbances in the central parietal, central and frontal areas. According to the obtained data, activation of the parvo system was observed in patients of two pathologies after application to the visual system of interactive virtual environment. And also the improvement of the processes of concentration of attention, early sensory processing, working memory and in-depth analysis of information.
Accordingly, this methodology using an interactive virtual environment can be effectively used in patients with neurocognitive disorders.

Influence of virtual environment with small and large images on the magno- and parvo- pathways of the visual system of patients with schizophrenia

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In this paper, we present the results of the experiments in which we assessed the impact of the interactive virtual environments in combination with a cognitive task performance on the visual system in patients with schizophrenia. Two different angular sizes of 2D monitor (19.2 and 46.7 degrees) screens were used for the image display. For the assessment of the impact we used visual evoked potentials measurement technique during the perception of the images of two types, containing either low- or high-frequency band

of the spectrum. We found that, with the use of the smaller angular size screen, the high-frequency analysis is improved at the early stages of visual processing. The use of the larger angular size screen leads to the improvement in processing of both types of the images at the early stages, and at the later stages as well. An assumption was made that, the changes in evoked potentials are related to the difference in nature of stimulation of central and peripheral visual fields, due to the changes in angular size of the screen. However, as a result of stimulation by both screens, data were obtained on the dominant stimulation of the parvo system, namely, the system whose disturbances are observed in patients.

Masking of moving sound in the vertical plane

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Sound localization in the vertical plane is determined by spectral cues, arising from the acoustic filtering of the pinna. In the case of stationary sound presentation these cues are strongly affected by background noise, resulted in the increasing of localization errors. We tested for extent to which the motion of a target sound source against a background static sound source might improve the recognition of the target compared to when the target does not move. Experiments were carried out in a anechoic chamber using 49 loudspeakers positioned along the arc placed in the vertical sagittal plane. The stationary masking signal was presented from the loudspeaker located over the subject's head in the vertical plane. The target signal moved along the arc at different locations and directions. The sound motion was created by successive switching of the loudspeakers. Test and masking signals were delivered with the delay varied within 0 to 1200 ms. Results show that the signal detection improves when the target was moving vs. when it was stationary. Masking effects decreased with increasing time delay and spatial separation between the masker and moving target, and with stimulus motion directed away from the masker location. This study was supported by the Grant RFBR 17-04-02180 and the Program of Fundamental Scientific Research of State Academies for 2013-2020 (GP-14, section 63.3).

The influence of physical rehabilitation on the characteristics of verbal and non-verbal communication of children with cerebral palsy

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Results of the study of the influence of physical rehabilitation on the characteristics of communication of children with cerebral palsy are presented. Parameters of speech (reading, reproduction of senseless words) and of nonverbal communication before and after the course of rehabilitation were analyzed. The compare was conducted in two groups: (1) the children who underwent only a course of mechanotherapy (exercises in a robotic complex) and (2) the children who additionally passed procedures with electrical stimulation of the spinal cord through the skin. For assessment of influence the indicators obtained by acoustical, audition, and expert analysis methods were used. The results indicated a positive effect of physical rehabilitation on the speech characteristics and nonverbal communication components, which was most pronounced in the second group of children (mechanotherapy with electrical stimulation of the spinal cord).

Study of visually controlled behavior of white rats in the Morris water maze with olfactory bulbectomy

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The experiments were carried out on white rats divided into 2 groups by sex, n = 10 in each group. Purposeful behavior was developed according to the usual scheme in the Morris maze. EXPERIMENT 1. An unseen platform was submerged 2 cm below the surface of the water. Before the surgery on olfactory bulbectomy (which was aimed at creating a model of Alzheimer's disease-AD), as a result of prolonged training, the detection time of the platform was reduced from 2-3 minutes to 2 ± 5 ms. On the 10th day after surgical bulbectomy, there was observed not expected deterioration of memory, but, in contrast, its improvement. The explanation of this fact is probably the expression of the neurotrophic factor, which revealed the presence of neurogenesis in the hippocampus, olfactory bulb and the neocortex of adult rats. Expected neurodegenerative manifestations appeared only 3 months after bulbectomy - signs were found that confirmed a violation of visual memory. Rats either ran into the platform only after a long 2-3 min or did not find it at all. This allowed us to consider that the task of creating an experimental BA model was successfully accomplished. EXPERIMENT 2. After the complete loss of memory was established, a solution of the Curcuma Longa L. was orally administered to the animals. rats immersed in water after taking curcuma, found the platform in the shortest time (2-7 s). It is concluded that the initial expression of the neurotrophic factor, which resulted in an improvement in visual spatial memory, is due to neuroanatomic and behavioral reconstructions of the visual-amygdalar and olfactory-amygdalar neuronal network: damage to the olfactory tract and its links with corticomedial amygdala led to an increase in the stimulating effect of the basolateral amygdala on the visual cortex. As a result, the actualization of a biologically significant signal was observed. It has also been established that curcuma improves and restores visual memory in bulbectomized animals.

The position of the standard stimulus affects the interhemispheric asymmetry of the auditory evoked potentials in human

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The EEG was recorded while the sound stimuli were binaurally presented in a passive oddball paradigm. Different sound positions and auditory motion were simulated by introducing interaural time differences (ITDs). Stationary standards were presented with ITDs = 0 or ±200μs in different blocks; the deviants in each block moved gradually leftward or rightward from the standard. The amplitude of the N1 component clearly demonstrated left-hemispheric dominance for the stimuli located in the right hemifield of the acoustic space and near the head midline, while the left hemifield stimuli evoked similar responses in the left and right brain hemispheres. These data support the neglect model of asymmetry for the responses to lateralized auditory stimuli. We have also found a tendency for a right-hemispheric bias of the MMN amplitude for deviants moving leftward from the left and midline standards. This finding is consistent with previous reports of MMN contralaterality. The MMN peaked later when the deviants moved leftward from the right standard than in other cases. The present study suggests different hemispheric predominance for the ERPs and MMNs elicited by the moving sounds.

Event related potentials in rhesus monkeys in response to face presentation

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Event related potentials (ERPs) were recorded from a macaque rhesus monkey (macaca mulatta) during the presentation of images form the three groups - human faces, monkey faces and objects. Waveform peak components in responses to all three types of stimuli showed similarities in their spatial distribution. The amplitude of early components (P1, N1) over occipital and parietal sites did not differ significantly for the three stimulus groups. However, over central and frontal sites larger amplitude N1 component was elicited in response to monkey faces compared to human faces and objects, this effect was more pronounced in the left hemisphere. An opposite trend was observed for the P3 component, which amplitude was significantly larger for objects than for faces (both human and monkey) with maximal difference along midline electrode over frontal sites. This result is consistent with the previous data [Pineda et al., 1994] and implies that on some early stages (about 100 ms) of visual information processing the most biologically important signal is extracted and later (over 300 ms) general categorization is performed.

Object Detection via Structural Matching of 3D Image Data

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The report focuses on the problem of object detection in three-dimensional space using structural image matching. Modern approaches for objects detection based on neural networks are considered. An object-independent hierarchical structural juxtaposition algorithm based on the segmentation of RGB-D images is proposed. The basic principles of 3D structural description and matching of images are described, and the examples of object detection are presented. Quantitative estimates of the effectiveness of the proposed algorithm are presented and discussed. The developed technique can be used for automatic navigation of extremely low flying unmanned vehicles or autonomous terrestrial robots.

Automatic classification of visual stimuli based on EEG signal processing

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The report is devoted to the problem of image recognition based on analysis of EEG signals. The study involved 21 healthy subjects aged 20 to 38 years. We used cognitive evoked potentials method. In the experiments images of animate and inanimate objects were displayed to the subjects. The images were filtered at high and low spatial frequencies by means of wavelet transform. Time of images presentation was 100 ms with an interval of 1 second. Registration of evoked potentials was carried out according to the scheme 10-20 with reference ear electrodes. Two types of tasks were considered: recognition of animate / inanimate objects and sharp/ blurred images. For classification, both classical methods of machine learning with hand-designed features and neural networks for automatic extraction of features were used. Support Vector Machine classifier was trained with manually constructed features, such as raw EEG signal, mean amplitude and statistical parameters of discrete wavelet transform. We have also trained recurrent and convolutional architectures of neural networks to recognize raw signal. The accuracy of recognition depending on the selected features, EEG channels, time intervals and approach was analyzed. The results show the classification accuracy of 79% for cleared/blurred images and 61% for animate/inanimate objects.

Modelling ripple oscillations as pyramidal neurons-interneurons interactions

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A crucial issue in the elucidation of the microcircuits that are substrate to neuronal oscillations is to understand how the intrinsic properties of the participating neurons (e.g., ionic current, morphology) interact with the network properties (e.g., topology, excitation/inhibition) to produce these rhythms. We address these issues in the context of the hippocampal area CA1 microcircuits. Pyramidal neurons (PYR) have been shown to exhibit subthreshold (membrane- potential) resonance in the theta frequency band (4 - 10 Hz) (Hu et al.) Two distinct mechanisms have been identified. One, primarily somatic, depends on two currents: M- and persistent sodium. The other, primarily dendritic, is h-current-dependent. INT have also been shown to exhibit resonance at gamma frequencies (~40 Hz) (Pike et al). The mechanisms that govern the interaction between the different types of resonances combined with the filtering properties of the neuronal morphology and the network topology remain to be understood. Here we combine mathematical modeling and numerical simulations to address these issues. Our minimal model consists of (i) PYR with small number of compartments, (ii) INT, and (iii) OLM cells. PYR includes the ionic currents mentioned above distributed in such a way as to produce the subthreshold resonances observed experimentally. INT include the ionic currents necessary to produce gamma subthreshold resonance (e.g., persistent sodium and slow potassium). We show (i) the effects of simultaneous phasic inputs onto the PYR somatic and dendritic compartments mimicking the GABA inhibitory inputs from INT and OLM, respectively, (ii) the effects of AMPA excitation onto INT in two different scenarios: gamma subthreshold resonance and low-pass filter, and (iii) how the combination of these two effects contribute to the generation of network oscillations.

An algorithm for detection artificial objects on natural backgrounds

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A new algorithm for extraction artificial and natural objects from images is presented. The images are approximated by graphic elements, which are similar to receiptive fields of V1 neurons. Research shows that the distribution of approximation error for natural objects is shifted to larger values in comparison with the distribution for artificial objects. This difference enables artificial objects on the natural background to be detected.

Approach to reducing the amount of data in the tasks of hydroacoustic monitoring based on machine learning

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The present paper discusses tasks of detection and classification of hydroacoustic signals. These signals have complex time-varying noise. Therefore, for high-quality detection and classification, it requires many training data, which represent different useful signals and noises. We propose an approach for data reduction, based on preliminary filtration. This approach is illustrated on whale detection and classification tasks.

Perception thresholds for sound stimuli with delayed motion onset.

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Human ability to spatial discrimination of moving sound stimuli was investigated in a psychophysical experiment. Healthy adult participants (N=13) performed a “yes-no” task. Hit rates and mean reaction times were calculated separately for each of the conditions. Sound motion was produced by linear changes of interaural time differences (ITDs). Sound stimuli consisted of two parts: a stationary 1000-ms fragment perceived near the head midline and moving fragments of various duration which shifted from midline to the left or right side. We employed 7 velocities of sound motion (60, 90, 120, 150, 180, 240 and 360 deg/s) and obtained individual psychometric curves for each velocity using stimulus ITD as a dependent variable. A linear regression was performed for the dependence of minimum audible movement angle (MAMA) and motion detection time upon sound velocity. This made it possible to estimate the value of minimum audible angle (2.8±0.2 deg) and minimum motion detection time (10.2±1.3 ms). Maximal reaction time was observed at each of motion velocities near the minimum ITD corresponding to the perceived displacement of sound stimulus.

MR voxel-based morphometry in complex radiological diagnosis of childhood epilepsy

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Epilepsy is one of the most common neurological disorders. Approximately 50 million people worldwide have epilepsy and entails a major burden in seizure-related disability, mortality and comorbidities. At least 50% of onsets occurs in childhood and adolescence. The diagnosis and treatment gaps comprise the barriers to timely identification and appropriate treatment of people with epilepsy.

City population dynamics prediction based on artificial neural networks

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For making research there has been a dataset collected including the important values starting from the period of 1970 year till 2018. The population number, birth rate, death rate, migration indexes were chosen as a set for training the network. As input values there were birth rate, death rate and migration value chosen and the output values was the population number throughout the period. While working with dataset, it was divided into three sets: training, testing and validating. The type of the neural network was Nonlinear autoregressive exogenous model. By experimenting with different numbers of hidden layers and delays the best appropriate number of layers was identified. The algorithm of training was based on Bayesian regularization. The quality of the training was checked by correlation coefficient. Deviation of the result from the true data was 4%.

Heterogenic Systems for Maintaining Climate Control in Museum Environment

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The museum environment is not only a tool for preserving, presenting and broadcasting historical, cultural, and natural heritage, but is also cultural and educational platform for the younger generation.
The museum like any social institution had undergone certain transformations during their historical development. In the process of genesis and historical evolution it become open-public, non-profit institution, that carries out its social functions for the benefit of society.
The need of climate control in the museum environment is conditioned by various requirements for presentation of exhibits and at the same time maintaining comfortable environment for visitors.
Creation of the heterogenic systems will solve the problem of maintaining climate control via following parameters: illumination, temperature, humidity, carbon dioxide (CO2) levels.
The aim of this work is the creation of Architecture and Anthology for the integration of heterogeneous devices into the single systems.

Influence of alternative communication on the understanding of texts by children with dyslexia

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The study is devoted to the effects of textual information visualization formats on the oculomotor activity and reading efficiency of dyslexic and non-dyslexic children. The word length, frequency and part of speech effects on the eye movements of the children were also observed. Subjects were children, studying in the second classes of elementary schools. Control group consisting of 55 kids with normal reading skills (average age 8.25) was compared to 16 children with dyslexia (average age 8.13). Subjects were given a task to read aloud five texts and complete a comprehension test. Eye movements were registered using eyetracker VT3 mini with sampling rate of 60 Hz, using MangoldVision software. Greater number of fixations and shorter length of saccades can be observed for dyslexic children in comparison to non-dyslexic children. Children with dyslexia spend more time on reading and have difficulties with understanding the text. Text visualization format effects on children's eye movement, reading time and text comprehension: the most effective was the text on the black background and the text with chromatic accentuation. Illustrated text was the least effective. Word frequency, length and part of speech effect on children's eye movement: long words with low frequency tend to have bigger number of fixations, observations and longer observation times, compared to high-frequency short words. Same relation can be found between verbs compared to nouns and adjectives.

Features of the filtration of visual information in burnout

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The aim of this study was to examine the functional state of magnocellular and parvocellular visual pathways, features of their interaction in a chronic stress condition on model of professional burnout. Burnout was measured with diagnostic methods of the emotional burnout. Contrast sensitivity thresholds were measured with the visual contrastometry. The contrast sensitivity thresholds for a range of low,

medium or high spatial frequencies were measured during Gabor a gratings was presented. We have found a change in the selectivity of the filtration of visual information in chronic stress that characterized by increased activity of the magnocellular system providing a global analysis of information, as well as reduction in parvocellular system activity which determines the mechanisms of local information analysis and the selective attention function. We have demonstrated the important role of matched functioning of opponent neuronal systems and the possibility of using visual functions as prognostic criteria and markers of the mental state. Additional evidence has been obtained in favor of multiple-channels model for visual information processing. Supported by the Krasnoyarsk Regional Foundation of Research and Technical Activities (Grant No. 2017052402493) and the Program of Fundamental Scientific Research of State Academies for 2013-2020 (GP-14, section 63).

The effects of physical activities on psychophysical characteristics of the subject within a virtual environment

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The significance of physical activities for the virtual environment trainings is a new and poorly studied field of scientific research which is potentially helpful for the future therapeutic and rehabilitation techniques. There is a sufficient number of clinical studies dedicated to the influence of moderate physical activity on psychophysical state of schizophrenia and dementia patients. However, there is very little evidence on any effects of the virtual environment trainings in healthy subjects. In this study, we evaluated the influence of physical activities on specific psychophysical characteristics of the subjects in two groups: (1) after a training course within virtual environment; (2) after a physical training course alone, using contrast sensitivity and evoked potential tests. We found a number of significant effects of the virtual environment trainings on psychophysical state of the subjects, whereas physical activities alone didn't show any impact. Our results clarify the view on the effects of physical activities on healthy population.

Foveola and foveolar avascular zone diameter measurement and comparison using enface images of the fundus and line scans obtained with spectral domain optical coherent tomography

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We showed previously, that individual diameter of the foveola may affect the efficiency of the Landolt C element classification in some viewing condition. In this research we applied new technique, allowing us to measure more precisely the foveola diameter, and we compared those data with foveolar avascular zone (FAZ) diameter. Both diameters shows correlations with contrast sensitivity, but only for high spatial frequency domain. The effect was slightly different than supposed according to Landolt C classification data. The role of spatial spectral components of the Landolt C element and grating used for contrast sensitivity measurements will be discussed.

Unsupervised Identification of Sound Stimuli with AWGN by the Impulse Activity of the Auditory Nerve Model

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By means of peripheral coding, environmental information enters the central nervous system. Because of evolutionary processes, such representation of information was formed, which allows to effectively identify objects and phenomena in a variety of physical contexts. Thus, in contrast to automatic recognition systems, a listener is able to successfully extract acoustic information and identify sound events in a wide range of conditions. Thereby, the further progress of speech technologies can be associated with the integration of knowledge about the physiology of auditory perception and the neural coding. In the presented study, an analysis of the evoked impulse activity of the auditory nerve fibers was performed, in order to identify pure tone stimuli by their frequency. Response of the auditory nerve was obtained using the auditory periphery model. The influence on the quality of recognition of additive white Gaussian noise at various signal-to-noise ratio (SNR) is investigated. A neural network approach, based on self-organizing maps for processing of big and multidimensional data to knowledge discovery under conditions of a priori uncertainty is proposed. The approach allowed to draw conclusions on the presence of a complex cluster structure in the original data set and to identify the input signals at different SNR.

Pattern of eye movements when perceiving spatial modulations of textures

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The second-order visual mechanisms detecting spatial modulations of contrast, orientation, and spatial frequency are generally described with the "filtering-rectification-filtering" model. According to the literature, both second stage filters and preceding simple striate neurons are bandpass, but with significantly different settings. During the development of the realistic computer model, it became necessary to clarify the weight function configuration of the second-order filters. It's logical to assume that the mechanism at the top of the preattentive perceptual level can participate in bottom-up attention control. If second order filters have some predominant organization (e.g. odd- or even-symmetric), then different regions of the modulated image will attract attention in different degree depending on the modulation phase. Subjects (32 people) had to detect the slope of the modulation axis in the texture. We found that when the texture is modulated in orientation, observers preferentially fix the gaze on regions in which the orientation of the carrier does not differ from the original (modulation function value is zero). This suggests that the orientation-specific second-order filters mainly have a symmetrical organization with central subfield and flanks of the opposite sign. For textures modulated in contrast and spatial frequency the results were more ambiguous. Supported by RFBR, project No 17-06-50141-ОГН\18.

Cluster analysis of sequential processing speech signals

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To date, the processing and analysis of speech signals are an actually task in the field of modern information processing methods. Practical application of speech signals is found in biomedicine, robotics, voice control subsystems, etc. However on practice all recorded signals are distorted by interference and noise of varying intensity, and as a result leads to a decrease in the accuracy of solving practical

problems. In this regard, adaptive filtering algorithms become extremely relevant, which make it possible to reduce distorting interference and noise to improve the accuracy of detection of morphologies of speech signals. To improve the accuracy of detection of speech signal morphologies, are used a variety of adaptive approaches, based on the consequently low-frequency, high-frequency, rejection, band-pass and wavelet filtering speech signal. Use sequential connected band-pass filters allow comparatively easy adaptation of their parameters to the amplitude-time parameters of speech signals. Purpose of this work is to confirm the possibility of using adaptive sequential band-pass filtering for sequential detection of speech morphologies in the presence of acoustic and electrical noise. The sequential detection of speech signal morphologies was carried out by two band-pass filters, each of which contains stable Butterworth filters of the second order. The processed speech signals were estimated by quantitative indicators to confirm the effectiveness of the proposed approach. Moreover the quantitative results obtained were compared with known speech signal processing approaches, for example, Two-stage Noise Reduction (TSNR) and Harmonic Signal Regeneration (HRR). To confirm the effectiveness of the proposed approach with statistical validity a cluster analysis of the obtained quantitative processing results is carried out. The dendrogram of the cluster analysis revealed that the proposed approach is much higher a superior known methods processing speech signals.

MRI and histological mapping of the medial temporal region of the human brain

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We studied peculiarities of the structure of human entorhinal cortex at weeks 20-26 of gestation (10 hemispheres). The samples were Nissl-stained and immunohistochemically treated with antibodies to parvalbumin, calretinin, calbindin, and cytoskeleton proteins (MAP2 and N200). 3D-reconstruction of the entorhinal cortex from serial sections was performed, caudomedial and rostrolateral areas were isolated. Parvalbumin+ cells in layer I, discrete distribution of layer II cells with colocalization of MAP2 and calretinin at the border with layer I, and two sublayers Va and Vb with MAP2+ neurons were typical for the caudomedial area. Rostrolateral area was characterized by the homogenous layer II with big amount of cells, high density of MAP2+ neurons only in layer III, and the unique layer V. Reelin+ Cajal-Retzius cells and N200+ fiber plexus in layer I were observed in the caudomedial and rostrolateral areas of the entorhial cortex. Layer IV was represented by a cell-free desiccant.

The perception of the color gradient and the McCollough effect

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The McCollough Effect is a color aftereffect in which colorless gratings appear colored contingent on the orientation of the gratings. We used a different type of adapting stimulus - pictures with the color gradient - black-green and black-red. One adaptation trial lasted 20 s, which included presentation of 2 colored patterns, each for 10 s, trials were presented for 4 min. During the induction three subjects were asked to focus on the center of stimulus. The test stimuli represented black-white picture with horizontal, vertical and diagonal patterns. One participant did not get The McCollough Effect. Two participants had difficulties with perception; they could not explain the exact color that appeared on black-white gratings after adaptation. The reported study was funded by RFBR according to the research project No 18-315-00439.

Predicting visual discomfort

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The human visual system evolved in the natural world and processes natural scenes efficiently with sparse neural coding. The natural world has (1) little flicker, (2) few spatially repetitive contours and (3) only modest colour contrast. In all three respects, images that are unnatural are uncomfortable to view. Images that are uncomfortable generally evoke a large haemodynamic response in the visual cortex, consistent with inefficient neural processing. Electric lighting usually fluctuates in brightness, and although the fluctuation is rarely visible as flicker it gives rise to temporal light artefacts. These artefacts can be seen as a pattern during saccades at frequencies up to 10kHz. The visibility is dependent on the modulation depth of the fluctuation. With modulation at 100 or 120Hz of 5% the artefacts cannot be seen, but they become visible when the modulation is greater than 30%, and typical of gas discharge lighting, which has been associated with complaints. Modular construction of buildings leads to spatially repetitive architecture, but often repetitive patterns are used unnecessarily as features of design, with unfortunate consequences for headache sufferers. Much video material for children is strongly coloured, and a small reduction in the saturation of colours used can make it more comfortable.

Neurophysiological mechanisms of face perception

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The studies of face perception of healthy subjects have shown that the necessity to estimate the spatial and emotional characteristics and the novelty of the face require, in addition to the traditional areas of the brain involved in the perception of faces, the inclusion of a stable complex formations of the brain that are interconnected with the intrahemispheric and interhemispheric connections. We have shown the principle of opponent interaction between areas of the prefrontal cortex involved in decision making. Our study shows opponent dependencies at the global level. This implies that there is a complex system of brain areas working together, each of them making a specific contribution to the implementation of mental processes. Each of these brain areas may be involved in implementing various functions according to the instructions given and other experimental conditions. We emphasize that this opponent principle is extremely important in the mechanism of human decision-making. Violation of reallocation of the so-called opponent systems of the brain indicates the imbalance of the interaction of the various divisions of the cortex, which can lead to violation of conscious activity in the decision-making process. The work was carried out with financial support programs of fundamental scientific research following the state academies for 2013-2020 (GP-14, section 63).

Spectral analysis of brain response during verbal and non-verbal communication

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An EEG study was conducted to study the features of verbal and non-verbal communication between two interlocutors in several modes of real interaction (dialogue, monologue and listening to the interlocutor's speech) and in two conditions - face-to-face and back-to-back. The results show that in "back-to-back" in comparison to "face-to- face" condition, the alpha activity in all modes of interaction is increased, but this effect is most pronounced in the parietal and occipital regions. In this case, there is a clear dependence of the amplitude of the peak on interaction conditions: the maximum amplitude is observed when listening to the monologue, and the smallest in the dialogue. In "face to face" condition, in comparison with "back to back", beta and gamma activity (mainly in the temporal regions) dominate. It can be assumed that these differences are due to the fact that facial expressions during face-to-face communication are more pronounced than in the absence of a non-verbal component, i.e. in the absence of visual contact. Also, when comparing the face-to-face and back-to-back communication conditions, it is shown that non-verbal communication component enhances the coherence of signals. The study was supported by grant №14-18-02135 from the Russian Science Foundation.

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