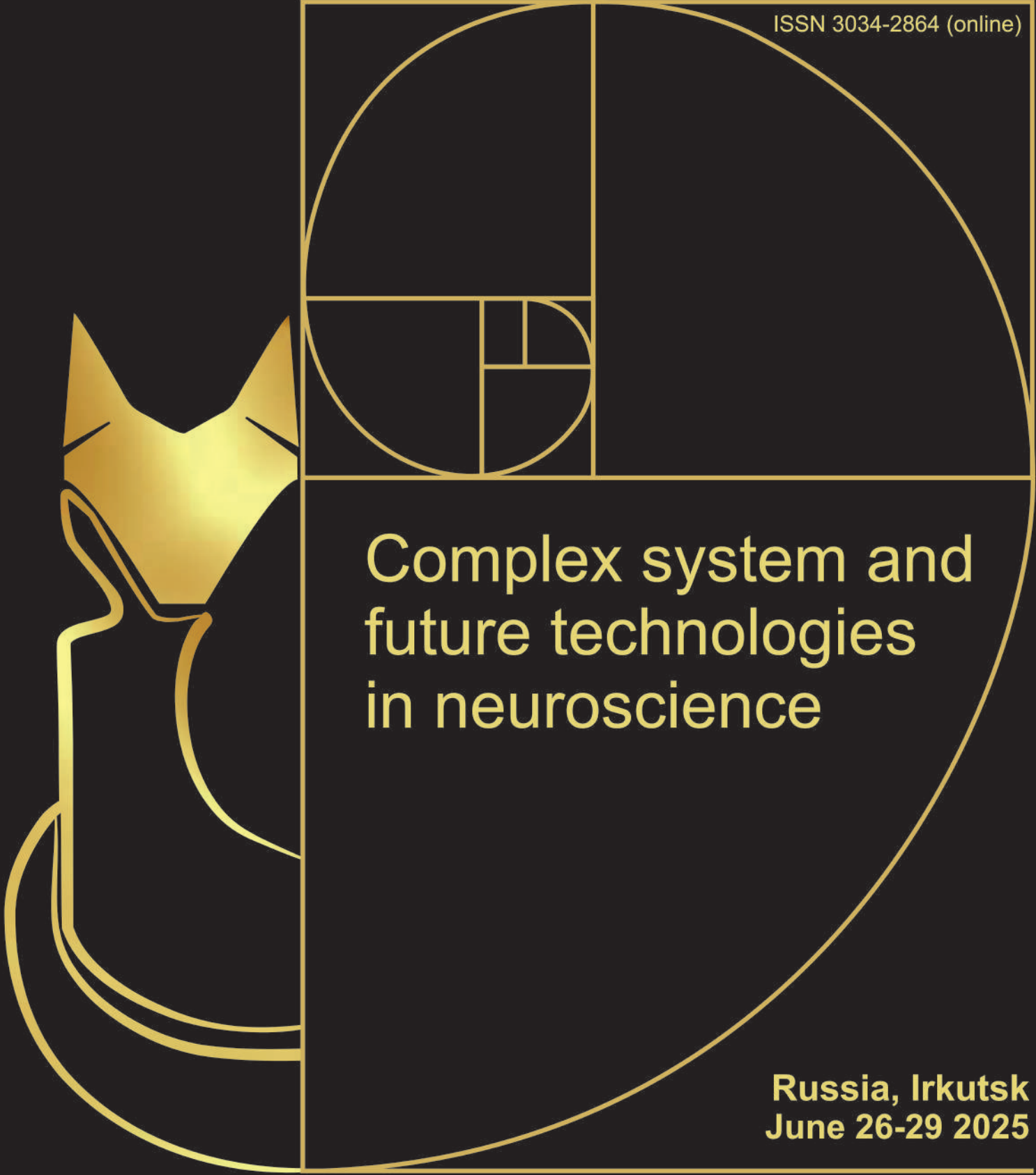


ISSN 3034-2864 (online)



Complex system and
future technologies
in neuroscience

Russia, Irkutsk
June 26-29 2025

ABSTRACT BOOK

Саратовский национальный исследовательский государственный
университет имени Н. Г. Чернышевского

КОМПЛЕКСНЫЕ СИСТЕМЫ
И БУДУЩИЕ ТЕХНОЛОГИИ
В НЕЙРОНАУКЕ

Сборник тезисов докладов

Выпуск 2

Материалы международной летней школы «Комплексные системы и
будущие технологии в нейронауке – CSFTN'25»

Иркутск, 26–29 июня 2025 г.

Саратов
2025

Saratov State University

COMPLEX SYSTEM
AND FUTURE TECHNOLOGIES
IN NEUROSCIENCE

Collection of abstracts

Issue 2

Materials of the International Summer School on “Complex System and Future
Technologies in Neuroscience – CSFTN’25”

Irkutsk, June 26–29, 2025

Saratov
2025

УДК: [[612.82:577.25]+616.831-08](082)

ББК: 28.70+56.12:53.5я43

С73

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Комплексные системы и будущие технологии в нейронауке:

С73 сборник тезисов докладов / редакционная коллегия: О. В. Семячкина-Глушкова (ответственный редактор), В. Б. Дорохов, Э. И. Кайбелева (ответственный секретарь). – Саратов: Саратовский университет [издание], 2025. – Выпуск 2 : Материалы международной летней школы «Комплексные системы и будущие технологии в нейронауке – CSFTN’2024», Иркутск, 26–29 июня 2025 г. – 56 с. : ил. URL: <https://www.sgu.ru/nauchnye-izdaniya-sgu/sborniki-i-prodolzhayuschiesya-izdaniya/complex-system-and-future/CSFTN-2025>. – Режим доступа: свободный. Продолжающиеся издания СГУ на сайте www.sgu.ru. ISSN 3034-2864 (Online). – Изображение. Текст: электронный. DOI: <https://doi.org/10.18500/CSFTN-2025>

В сборнике представлены тезисы докладов конференции CSFTN’25, посвященные будущим технологиям в нейробиологии для изучения мозга как сложной системы и разработки перспективных терапевтических стратегий лечения заболеваний головного мозга во время сна. В книге приведены тезисы приглашенных устных и стендовых докладов. Официальным языком конференции является английский.

Для студентов медицинских, биологических и биофизических специальностей, а также для ученых и врачей, работающих в области нейрофизиологии.

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Российский
научный
фонд

Сборник издан при поддержке Российского научного фонда
(проект № 23-75-30001).

Работа издана в авторской редакции

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Сборник тезисов конференции CSFTN’25 доступен на веб-сайте конференции

<https://lymphacomplex.com/en/publication>

ISSN 3034-2864 (Online)

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UDC: [[612.82:577.25]+616.831-08](082)
BBK: 28.70+56.12:53.5я43
C73

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Complex System and Future Technologies in Neuroscience :
C73 collection of abstracts / editorial board: O. V. Semyachkina-Glushkovskaya (executive editor), V. B. Dorokhov, E. I. Kaybeleva (executive secretary). – Saratov: Saratov University [edition], 2025. – Issue 5: Materials of the International Summer School “Complex system and future technologies in neurobiology – CSFTN’24”, Iskutsk, June 26–29, 2025 – 56 p. : il. URL: <https://www.sgu.ru/nauchnye-izdaniya-sgu/sborniki-i-prodolzhayuschiesya-izdaniya/complex-system-and-future/CSFTN-2025>. – Access mode: Continuing publications of the SGU on the website www.sgu.ru.
ISSN 3034-2864 (Online). - Image. Text: electronic.
DOI: <https://doi.org/10.18500/CSFTN-2025>

The collection presents abstracts from the CSFTN’25 conference, dedicated to future technologies in neurobiology for studying the brain as a complex system and developing promising therapeutic strategies for treating brain diseases during sleep. The book contains abstracts of invited oral and poster presentations. The official language of the conference is English.

The collection is intended for students of medical, biological and biophysical fields of training, as well as for scientists and doctors involved in the field of neurophysiology.

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The collection was published with the support of the Russian Science Foundation (project No. 23-75-30001).

The work was published in the author's edition

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CSFTN’24 conference collection of abstracts are on the conference website <https://lymphacomplex.com/en/publication>

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Cognitive performance in pediatric obstructive sleep apnea: What and why can change?

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Speaker: Olga Berdina is PhD, Leading researcher of Laboratory of Somnology and Neurophysiology of Scientific Centre for Family Health and Human Reproduction Problems, Pediatrician and Functional Diagnostics Specialist of Innovation Center of Scientific Centre for Family Health and Human Reproduction Problems. She has been conducting research in the field of fundamental and applied aspects of sleep disorders and associated conditions in pediatrics, developing innovative technologies for their early diagnosis, prevention and prognosis. She has owned more than 100 peer-review

papers in Sleep Medicine, Journal of Sleep Research, Sleep and Biological Rhythms, Frontiers in Pediatrics, The European Physical Journal, Canadian Respiratory Journal, Archives of Disease in Childhood et al., and 100 sectionally or invited talk on international conferences, including Forum BRICS, ECOG, Europaediatrics, Congress of the Asian College of Psychosomatic Medicine IPA Congress & PEDICON et al.

Abstract: Obstructive sleep apnea (OSA) is a very serious and multifactorial sleep disorder including in relation to the risk of developing cognitive impairment. There are main pathogenetic mechanisms of OSA such as remittent nocturnal hypoxemia and altered sleep homeostasis, which through a cascade of pathophysiological reactions (endothelial dysfunction, oxidative stress, neuroinflammation, cerebral hypoperfusion et al.) could initiate disruptions in cellular and biochemical homeostasis to metabolic and morphofunctional changes in the brain. It is known that childhood obesity aggravates cognitive impairment in OSA. Based on the above relationships, the study aimed to evaluate the cognitive performance and their potential associations with polysomnographic (PSG) variables in OSA adolescent samples aged 15-17 years with different weight status. One-night in-lab PSG was carried out to estimate sleep data. The Wechsler Intelligence Scale for Children fourth edition (WISC-IV, Russian Version) was applied to evaluate the participants' cognition. Full-scale cognitive ability quotient (FSCAQ), visual-spatial index, fluid reasoning index, working memory index, and processing speed index (PSI) scores were significantly lower for obese OSA adolescents. Nonobese OSA participants had significantly lower FSCAQ and PSI scores compared with those in controls without OSA but were similar who was obese by all WISC-IV indexes. Multiple linear regression analysis revealed that k-complexes (KK) density, «sleep spindles» (SSs) duration and wake after sleep onset for nonobese adolescents, as well as apnea-hypopnea index, oxygen desaturation index, number of awaking, Ks and SSs densities, and sleep fragmentation index for obese peers were negative associated with cognitive functions. In conclusion, the cognitive performance in pediatric OSA is decreasing with a predominant deterioration of non-verbal abilities, due to alteration of sleep homeostasis in OSA without obesity, and the potentiated effect of hypoxia severity and sleep fragmentation in obesity.

Keywords: Obstructive sleep apnea, hypoxia, sleep fragmentation, cognitive performances, obesity, adolescent



Decongestant lymphostimulating therapy for traumatic brain injury

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Speaker: Olim Sh. Eshonov – Associate Professor of the Department of Anesthesiology and Reanimatology, Bukhara State Medical Institute. He underwent specialization and advanced training at the Institute of Emergency and Emergency Care named after Sklifosovsky in Moscow 1984-1986, 1991 on the basis of the Moscow Medical Academy in the “Clinical Lymphology” cycle. In 1991, he defended his PhD thesis at the Moscow Medical Academy on the topic “Endolymphatic antibiotic therapy for acute septic brucellosis.” His research focuses on developing new treatments for traumatic brain injury, stroke and other cerebrovascular

diseases. Dr. Eshonov is the author of more than 150 publications and textbooks “Anesthesiology and Resuscitation” and “Emergency Conditions”, the manual “Anesthesiology, Resuscitation and Intensive Care”, received three patents for new methods of treating and diagnosing diseases.

Abstract: Secondary damage after traumatic brain injury is a serious problem in neurocritical care, which leads to increased neuroinflammation and cerebral edema. It is known that secondary brain lesions play a significant role in the pathogenesis of severe closed traumatic brain injury, leading to edema, increased intracranial pressure, dislocation of vital centers and unfavorable outcome. Despite a number of factors influencing the high mortality associated with traumatic brain injury, the development of cerebral edema is the most significant predictor of unfavorable outcome. Various pharmacological treatment options have not demonstrated benefit in traumatic brain injury. In this presentation, I will review clinical developments to target neuroinflammation and cerebral edema in traumatic brain injury in the context of recent progress made in the field of the glymphatic system of the brain.

Keywords: traumatic brain injury, glymphatic system, neuroinflammation



Low throughput multi-omics analysis methods for brain tissues

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Speaker: Xiangwei Zhao is a professor of State Key Laboratory of Digital Medical Engineering, Southeast University. He graduated from Zhejiang University with a doctoral degree in 2006. He has successively served as a visiting scholar at the Institute of Laser Engineering, Osaka University, Japan; the Department of Biomedical Engineering, University of Michigan, USA; the Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign, USA; and Harvard Medical School. Currently, his research focused on bio-barcode technology. The research themes include spatial omics, brain organoids, POCT, DNA information storage, biomedical big data, etc. He was PI of more than 10 projects, such as the National Natural Science Foundation of China grant, the National Key R & D Program projects, and the Science and Technology Support Program of Jiangsu Province. He has published more than 100 SCI papers and transferred 9 invention patents. He has won the First Prize of the Natural Science Award from the Ministry of Education, the Second Prize of the Technological Invention Award of the “Huang Jiasi Biomedical Engineering Award” by the Chinese Society of Biomedical Engineering, and the Gold Medal at the Geneva International Invention Exhibition. He has been selected as an Excellent Talent in the New Century by the Ministry of Education, a Middle-aged and Young Academic Leader in the Qinglan Project of Jiangsu Province, a High-level Talent in the “Six Talent Peaks” Project of Jiangsu Province, and a “Zijin Young Scholar” and a “Huaying Scholar” at Southeast University.

Abstract: Spatial multi-omics technology is of great significance for understanding the interactions between cells and the influence of spatial location on cellular omics in brain tissues, which has become a research hotspot in recent years. Currently, a variety of spatial multi-omics technologies have emerged, and how to balance sample throughput, omics throughput, and cost is an important issue to be considered in spatial multi-omics analysis. In this work, we explored the low-throughput spatial sampling and encoding methods based on the principle of microdissection, and on this basis, achieved the acquisition of low-to-medium throughput and low-cost multi-omics data. The research results show that our method has a relatively high cost-performance ratio and has potential application value in neuroscience.

Keywords: multi-omics analysis, low-throughput spatial sampling, brain tissues



In vivo optical clearing skull window for cortical imaging

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Speaker: Dan Zhu is Distinguished Professor of Huazhong University of Science and Technology, SPIE/OPTICA Fellow, Director of Advanced Biomedical Imaging Facility, Vice-director of Wuhan National Laboratory for Optoelectronics. She has been developing tissue optical clearing methods for obtaining in vivo cortical neurovascular structure and function, as well as 3D structure of organs. She has owned more than 200 peer-review papers in Science Advances, Nature Communications, Light: Science & Applications et al, and 100 plenary or invited talk on international conferences, including SPIE Bios Hot Topic. She is an Associate editor of Journal of Biomedical Optics, except

executive Editor-in-Chief of Frontier of Optoelectronics : Biomedical Photonics, Editorial Member or Guest Editor of Biomedical Optics Express, Scientific Reports, Journal of Innovative Optical Health Sciences, and Frontier of Optoelectronics etc.

Abstract: Modern optical imaging techniques provide a powerful tool to observe cortical structure and functions with high resolution. Various of skull windows have been established for different applications of cortical imaging, and each has advantages and limitations. Even none of current skull windows can be suitable for observation of the responses to some acute craniocerebral injuries at large scale and high resolution. We developed a “Through-Intact-Skull (TIS) window”, which promises us to observe immune response after traumatic brain injury at bilateral cortical scale and single-cell resolution without affecting the pathological environment of the brain. Meanwhile, TIS window has all advantages of current skull windows, including craniotomy free, centimeter-field of view, synaptic resolution, large imaging depth, long-term observation capability and compatibility for awake mice. Therefore, TIS window will be a promising new approach for intravital cortical microscopy for basic research in neuroscience.

Keywords: optical clearing, optical imaging techniques, cortical imaging



Advanced signal processing techniques for the brain as a complex system

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Speaker: Atul Kumar conducts cutting-edge research in interdisciplinary areas and specializes in developing advanced medical technologies, including wireless medical devices, high-speed ASIC design, biomedical signal processing with advanced AI-based techniques, and 5G/6G wireless technologies. In addition, the group has two leading medical experts with expertise in neurological disorders and drugs. Moreover, he has founded two startup companies; 1) AtlaMedico TechSolutions Pvt Ltd. to develop a wireless medical device for intensive care units, an India-based technology startup for the design, optimization, and operation of a medical device

(Atul Kumar et al., “Multifunctional system and method for remote monitoring of multiple physiological parameters in real time.” Patent No. 337646); 2) Delbrone Innovation Pvt Ltd for designing and developing anti-drone systems to protect against drones in various applications such as public safety, military and others.

Abstract: The human brain exemplifies a highly nonlinear, dynamic, and multiscale complex system, presenting profound challenges for interpretation and real-time monitoring. This talk presents recent advances in signal processing techniques designed to analyze brain dynamics through modalities such as EEG, MEG, and fMRI. We explore modern approaches including time-frequency decomposition, entropy and fractal-based complexity analysis, graph signal processing, and deep neural architectures for extracting high-resolution insights from neural signals.

A significant focus will be on the convergence of joint bio-sensing with secure communication, a critical paradigm for future neurotechnology applications such as brain-computer interfaces, cognitive load estimation, and remote neuro-health monitoring. Here, the fusion of advanced signal processing with secure wireless protocols ensures real-time, privacy-preserving transmission of sensitive brain data across embedded and mobile systems.

Furthermore, the talk will highlight the transformative potential of machine learning in decoding brain states, classifying neurological conditions, and enabling adaptive cognitive systems. We also introduce the role of quantum technologies—particularly in quantum sensing and quantum-secured communication—for achieving ultra-high sensitivity in bio-signal detection and quantum-safe data transfer. This integration unlocks new frontiers in scalable, secure, and intelligent neuro-sensing infrastructures.

Keywords: signal processing techniques, neurotechnology, bio-signal detection



Transcranial photobiomodulation for improving therapy of brain diseases

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Speaker: Shaojun Liu is a postdoc of Wuhan National Laboratory for Optoelectronics, Huazhong University of Science and Technology. He graduated from Huazhong University of Science and Technology with a doctoral degree in 2024. Currently, his research focuses on the biomedical applications of in vivo tissue optical clearing methods and near-infrared photobiomodulation to improve brain diseases. He has published more than 10 peer-review papers in Nature Communications, Communications Biology, Analytical Chemistry and other journals.

Abstract: Transcranial photobiomodulation (tPBM), a non-invasive neurostimulation technique using near-infrared or red light, has emerged as a promising therapy for various brain disorders. By targeting specific brain regions, tPBM is hypothesized to modulate mitochondrial function, reduce neuroinflammation, and promote neurogenesis, thereby accelerating recovery processes. Here, we will introduce our progress in tPBM to promote the prognosis of ventricular hemorrhage, enhance microglial function in diabetic mice, and improve cognitive function in Alzheimer's disease mice. In addition, we provide preliminary evidence of a potential mechanism of tPBM that promotes dilation of meningeal lymphatic vessels to improve their drainage function, thereby improving brain function.

Keywords: photobiomodulation, neurostimulation, Alzheimer's disease



The development of hyperspectral frontier technology and microscopic spectral imaging

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Speaker: Xudong Luo is the founder and general manager of NBL IMAGING SYSTEM LTD., graduated from Wuhan Huazhong University of science and technology, has been engaged in the application and promotion of hyperspectral imaging and related technologies for many years. In 2007, he participated in and completed the key technology research of spectral imaging, a national science and technology support program of the Ministry of science and technology of the people's Republic of China during the 11th Five Year Plan period, and formed the transformation achievement: spectral image analysis software for material evidence identification imaging. In 2010, he participated in the research project "

identification of human individual and key technology of material evidence traceability" with the topic of key technology of examination and traceability of material evidence and equipment development under the national 12th Five Year Plan science and technology support. In 2015, he participated in the sub topic of "development technology of multi spectrum fusion on-the-spot detection equipment of biological evidence" of the project "key technology of investigation on the scene of the case and analysis of target correlation of the National key R & D plan of 13th Five Year period. At the same time, he is also a member of the Committee of hyperspectral imaging for remote sensing detection, a member of the China Association of criminal science and technology, and a member of Expert Committee on Biomedical Engineering Photonics and holding a number of applied / authorized invention patents.

Abstract: Hyperspectral technology, as a non-destructive, non-contact optical detection method that integrates image and spectral information, has expanded its application scope from the traditional field of remote sensing to advanced machine vision and microscopic imaging technologies. This report provides a detailed analysis of the latest advancements in the field of hyperspectral technology, with a particular focus on the unique characteristics of different spectral dispersion techniques and their most suitable application fields. Through a series of comprehensive case studies, the report highlights the innovative applications of microscopic spectral imaging technology, especially near-infrared spectral imaging, in life science research. These advancements offer new analytical tools and development opportunities for the field, opening up entirely new research directions.

Keywords: hyperspectral technology, spectral dispersion techniques, microscopic spectral imaging



Pattern of “Sleep spindles” in obstructive sleep apnea patients

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Speaker: Irina M. Madaeva, MD, PhD, is a Head of Irkutsk Somnological center, chief researcher of somnological and neurophysiological department of Federal State Public «Scientific Center for Family Health and Human Reproduction Problems», Irkutsk, Russia. She obtained her Ph.D. (1994) and D.Sc. (2009) in sleep medicine. Research interests include relationship between aging and sleep, modifying factors of sleep disorders, molecular mechanisms of sleep disorders, melatonin circadian rhythms, ethnic aspects of sleep disorders. Madaeva I.M. is scientific supervision of 7 scientific theses. She is member of World Association of Sleep Medicine. She is the Head of Scientific Committee of Russian Society of Sleep Medicine. She is author more than 200 scientific papers in peer-reviewed journals, from them 162 publications in bases Web of Sciences and Scopus, Q 1-2.

Abstract: Obstructive sleep apnea (OSA) is very serious and multifactorial sleep disorder which closely related with disruption of sleep homeostasis. It is known that such sleep encephalographic (EEG) phenomenon as sleep spindles (SSs) support sleep stability and may display a sleep protective function. Thus, it is of particular interest to assess the SSs pattern in OSA patient that was the aim of the present research. We investigated whether SS activity could be altered in patient with moderate degree of OSA compared with non-OSA subjects. 35 middle-aged OSA patients and 30 controls underwent full-night polysomnography (PSG). SSs were automatically detected during stage 2 (N2) of non-rapid eye movements. The SSs activity characteristics involved: total number, mean density, mean maximum amplitude and mean frequency. All differences were considered statistically significant at $p < 0.05$. We noted a significant decrease in the density and number of central SSs in patients with OSA compared to controls, however, the amplitude is significantly higher in OSA subjects. To summarize, our results show that OSA lead to significant disruption of SSs density, reduction of their number and frequency in N2 sleep stages. These findings can be evidence of the extinction of a brain protective mechanism against exciting stimuli during apnea episodes in OSA patients with a long duration of sleep disturbances.

Keywords: obstructive sleep apnea, sleep spindles, sleep disorders



The importance of sleep investigations for clinical neurology

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Speaker: Mikhail Poluektov works as an associate professor at the Department of Nervous Diseases at Sechenov University in Moscow. He is also the head of the sleep medicine department at the same institution and the acting president of the Russian Society of Somnologists. In 1993 he graduated from the Medical University by I.M. Sechenov, then specialized in neurology. His PhD, received in 1998, was devoted to studying the effect of autonomic neuropathy on sleep-disordered breathing. As an associate professor, Mikhail Poluektov teaches sleep medicine in neurology and general medicine, organizes conferences on somnology, and publishes regular issues on sleep disorders in «S.S. Korsakov Journal of Neurology and Psychiatry» and «Effective pharmacotherapy». Serves as a reviewer editor in «Frontiers in Psychiatry», «Frontiers in Neurology». Author of more than 250 publications in Russian and foreign journals, 5 monographs in Russian, 3 popular books about sleep.

Abstract: The concept of sleep medicine implies that our knowledge on the human body functioning during sleep can help in developing new methods of diagnosis and treatment. Since sleep is a product of the central nervous system, it is obvious that nervous diseases can have a greater impact on its occurrence or continuation. This can be registered by objective methods. An example of the importance of such approach can be the differentiation of the psychogenic neurological signs (pseudotremor, pseudodystonia, functional hemiparesis). They disappear during sleep, since voluntary control of motor functions is lost. Sleep can be disturbed for years (more than 50) before the clinical manifestation of a neurological disease. In the study of REM sleep behavior disorder 95% of cases of synucleinopathy (Parkinson's disease or dementia with Lewy bodies) develops within 20 years.

It is possible to achieve a better control of the course of nervous disease by improving sleep. The use of CPAP therapy in patients with ischemic stroke with obstructive sleep apnea leads to a 2.9-fold decrease of recurrent strokes. Improved sleep after the course of cognitive-behavioral therapy of insomnia is accompanied by a decrease of systemic inflammation. The activation of the glymphatic drainage system of the brain during sleep was discovered ten years ago. It looks promising that the pharmacological or nonpharmacological stimulation of this system leads to the maintenance of cognitive reserves in the elderly.

Keywords: sleep medicine, CPAP therapy, glymphatic drainage system



Dizziness and vertigo: Causes, diagnosis, principles of treatment

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Speaker: Tatyana Pronko, MD, PhD is a Head of the Department of Propaedeutics of Internal Diseases of Grodno State Medical University, Belarus since 2012. She defended scientific degree (PhD) "Study of endothelial dysfunction and blood oxygen transport system in patients with arterial hypertension and coronary artery disease" in 2003. Pronko T. is scientific supervisor of 1 scientific theses "Study of arterial stiffness in patients with arterial hypertension after ischemic stroke". In the near future, two more people are planning to defend their thesis completed under her supervision. Current research interests include platelet aggregation, clinical

and laboratory factors influencing high and low residual platelet reactivity in patients with myocardial infarction. She has over 290 publications, 22 of them are in Web of Sciences and Scopus bases. She is member of European Cardiology Society and Russian Cardiology Society.

Abstract: Dizziness is a nonspecific symptom that describes a sensation of abnormal rotation of the head, or the sensation of the external environment spinning. It affects 50% of elderly patients and is the commonest cause of complaint in patients over 75 years of age. It may be physiological, occurring during or after a sustained head rotation, or pathological, due to vestibular dysfunction. It divided to peripheral and central. Peripheral vertigo is due to disorders that affect the labyrinths or vestibular nerves. Central vestibular causes are multiple sclerosis, migraine, epilepsy. Vertigo may be paroxysmal or chronic. In diagnosing the vertigo causes, we will use the data of physical examination, special tests, data of laboratory and instrumental examination. Treatment depends on the causes of dizziness.

Keywords: dizziness, vertigo, vestibular dysfunction



Low speed flow mapping with MRI Aladdin spinal magnetically labeling

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Speaker: Pavel Rudych is an engineer and project manager at Novosibirsk State University and the International Tomography Centre of Novosibirsk. Pavel received his M.S. in Physics from Novosibirsk State University, Russia, in 2005 and his second B.S. in Clinical Psychology in 2021. His research interests are in functional MRI and coregistered EEG experiments, experiment stimulus gamification and environmental transparency based on web, EEG/MRI data aggregation and automated processing, machine learning analysis. Pavel is the author of more than 30 peer-reviewed publications.

Abstract: MRI imaging with spinal labeling are widely used in brain perfusion. The idea is in label the thin slice of liquid and check it's distribution after some time. The water molecules are magnetically labeled (tagged) by using a radiofrequency pulse that saturates water protons and enhance its visibility in magnetic resonance imaging. Subtraction between labeled image and the control non labeled image with the static tissue signals eliminate the non labeled static signals. The resulting image is proportionate to the liquid flow. Arterial spinal labeling (ASL) widely used for high speed blood flow registration and uses single water labeling in neck arterias and not suitable for low speed lymphatic flows. For such a flows it's used the inter-slice liquid perfusion MRI called alternate ascending/descending directional navigation (ALADDIN). In ALADDIN protocol not the whole brain, but the single layer is measured and the measured layer is parallel to the labeling layer and shifted in flow direction. To cover all the brain, the multiple labeling and registrations are required. Our enhancement of ALLADIN protocol and its applications I will describe in details.

Keywords: MRI, flow mapping, ALADDIN, lymphatics



Bringing medical technologies to market: Modern trends in the scientific grants

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Speaker: Oxana Semyachkina-Glushkovskaya is the head of Chair of Physiology of Human and Animals at the Department of Biology in the Saratov State University (Russia) and she is Deputy Director for the Commercialization of Scientific Research at the Scientific Medical Center in the Saratov State University. Her research interests are focused in neuroscience and in the development of breakthrough technologies for non-invasive therapy of brain diseases, brain drug delivery and monitoring of the immune system of the brain. She published several pioneering works discovering the promising strategies in

rehabilitation medicine based on the application of the new generation lasers for stimulation of lymphatic clearance of toxins and wastes from the sleeping brain:
<http://lymphasleep.com/publications2>

Abstract: Fundamental science is the foundation for applied technologies. However, it always remains unknown which ideas will be able to transform into technologies and enter the market. Is it possible to make the process of transferring fundamental ideas to the market fast and reliable? How long will it take? What rules should be developed for this?

Based on our RSF mega grant No. 23-75-30001, I will give an example of the life cycle of a medical technology from TRL 0 to TRL 8 in just 2 years. For the rapid transfer of a scientific idea to the market, two factors must be a prerequisite: 1) an industrial partner who is ready to produce a new technology; 2) practicing doctors who will conduct clinical trials, i.e. the medical organization in which doctors work must be accredited to conduct clinical trials. These two conditions will allow the most effective adaptation of the design and composition of the technology to the capabilities of the industrial partner and the medical conditions of its application. This will also help to take into account the necessary requirements for the materials from which the technology will be made, because all medical devices must be made from certified materials, i.e. approved in a particular country for use on humans.

After manufacturing the technology, an important stage is the preparation of documents for its technological and toxicological testing. In this case, it is important to use the services of certified companies, preferably operating on the basis of medical institutions, which will help in the correct preparation of documents. After receiving certificates for technical and toxicological tests, these companies can also help in submitting documents to the Ministry of Health, which issues permission to conduct clinical trials. Approval of the clinical trial plan is approved by the ethics committee of the medical organization appointed for this by the Ministry of Health. Upon completion of clinical trials and receipt of positive results, the Ministry of Health issues a registration certificate for the technology, assigning it the status of medical equipment. After this, the industrial partner launches production of the technology on its site and brings it to the medical

equipment market when it becomes commercially available. Thus, for efficient and fast (in 2-3 years) implementation of the life cycle of the developed technology from TRL 0 to TRL 8, already at the initial stages, the presence of an interested industrial partner ready to produce the technology and qualified doctors ready to apply this technology in their clinical practice is required. With these two factors, the translation of the technology from the idea to its launch on the market becomes reliable with minimal risks.

Key words: medical equipment, commercialization, applied and fundamental grants

Acknowledgments: The research was supported by the Russian Science Foundation (project No. 23-75-30001).



Cerebrovascular control in carotid artery occlusion: Disorders and compensations

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Speaker: Olga Tarasova – Head of the Department of Physiology and Pathology, Faculty of Basic Medicine, Lomonosov Moscow State University (MSU) and chief researcher at the Laboratory of Exercise Physiology, Institute of Biomedical Problems. In 1984, she graduated from the Department of Biology at MSU, qualifying as a physiologist. Received a Candidate of Science degree in 1990 and a Doctor of Science degree in 2005. The field of research interests – physiology of circulation and autonomic nervous system. In 1995, during a visit to Sweden and Denmark, she mastered the method of wire myography, then implemented it in MSU

for experiments tiny arterial vessels. PI of many research projects supported by the Russian Foundation for Basic Research and the Russian Science Foundation. Laureate of the V. V. Parin Prize (Presidium of RAS) for the work “Regulation of blood circulation during adaptation to extreme conditions”. In recent years, her research team has been focused on alterations of vascular control in challenges of perinatal development and hypokinesia (conditions of microgravity), including their detrimental effects on cerebral vasculature.

Abstract: Stenosis or occlusion of carotid arteries because of their atherosclerotic lesions leads to chronic brain hypoperfusion, dysfunctions of the cerebral vasculature and nerve centers involved in the regulation of systemic hemodynamics. In addition, stenosis of carotid arteries disrupts the functioning of the sinocarotid baroreflex, which increases blood pressure variability and can aggravate pathological changes in both systemic and cerebral circulation. In my report, I will present data on the regulation of cerebral and systemic hemodynamics in patients with carotid stenosis, as well as those obtained in an animal model of this pathology (vascular studies with the use of in vitro and in vivo techniques). Importantly, our data show the character of the observed changes may be either detrimental or compensatory, depending on the duration and severity of the disease. This should be considered when assessing the degree of cerebral vasoregulation disorder and predicting the course of this disease.

Keywords: chronic brain hypoperfusion, cerebral vasoregulation, hemodynamics

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 23-15-00331).



Targeted therapy for neuroinflammation in ischemic stroke

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Speaker: Yarashev Akmal Rustamovich – head of the neuroreanimation department of the Bukhara branch of the Republican Scientific Center for Emergency Medical Care, assistant of the Department of Anesthesiology and Reanimatology of the Bukhara State Medical Institute. He completed clinical residency in anesthesiology and resuscitation at the Bukhara Medical Institute in 2002-2004, and postgraduate studies at the Tashkent Institute for Advanced Medical Studies and Postgraduate Education in

2007-2010. In 2010, he defended his Ph.D. thesis on the topic “Monitoring of cerebral perfusion pressure in intensive care for hemorrhagic stroke” at the Academic Council of the Tashkent Medical Academy. During his medical career, he completed an internship in stroke centers in Germany, Turkey, India and Japan.

Scientific activity of Yarashev A.R. focused on studying the problem of neuroinflammation and developing new methods of intensive therapy for cerebrovascular diseases. He is the author of more than 60 publications - theses, articles and methodological recommendations.

Abstract: Acute ischemic stroke affects millions of people every year. Recent research data indicate the involvement of the glymphatic system in the process. The balance of pro- and anti-inflammatory interleukins is one of the pathogenetic mechanisms of the development of neuroinflammation that determines the course and outcome of ischemic stroke. The development of neuroinflammation during the acute phase of ischemic stroke leads to secondary damage and subsequently to various complications. The discoveries of meningeal lymphatic vessels in the human brain have changed our understanding of the mechanisms of neuroinflammation in ischemic stroke, suggesting that glymphatic dysfunction underlies immune dysfunction and central nervous system drainage. In this presentation, I will review methods of influencing the pathogenetic link of neuroinflammation by administering a drug lymphotopically.

Keywords: ischemic stroke, glymphatic system, interleukins



Proaging, antiaging and sleep

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Speaker: Liudmila Yakubova – Head of general practitioner and policlinic therapy department in Grodno State Medical University, Professor, MD, PhD. Author of more than 300 publications. Profiles and identifiers: ORCID <https://orcid.org/0000-0001-7632-9695>

Qualification:

- awarded the degree of PhD 2007,
- By the decision of the Presidium of the Higher Attestation Commission of the Republic of Belarus, he was awarded the academic title of Associate Professor in 2011,
- By the decision of the Presidium of the Higher Attestation Commission of the Republic of Belarus, the degree of Doctor of Medical Sciences was awarded in 2020, he was awarded the academic title of professor in 2021.

I had been the leader or scientific performer of several funded research projects: “Develop and implement a method for the treatment of coronary heart disease and osteoporosis by influencing the general mechanisms of their development”, (2011-2013).

“To develop and implement a new method of secondary prevention and treatment of lesions of the cardiovascular system in case of deficiency /vitamin D deficiency in people with arterial hypertension” (2013-2015). “Identification of risk groups for D-vitamin deficiency”, (2013-2015).

“Research on the impact of palm oil on the health of the population of the Republic of Belarus and the establishment of acceptable medical and biological levels of palm oil consumption” (2017–2018). Grant of the President of the Republic of Belarus (2019) for the development and implementation in general medical practice of recommendations for identifying risk factors, diagnosing and correcting D-hypovitaminosis, the use of which will help increase the primary prevention of vitamin D-associated diseases among residents of the Republic of Belarus.

“To develop new types of chocolate products enriched with protein, calcium and vitamin D, providing an increase in the balance of nutrition of preschool and school children” (2016-2020).

Research work on the project of cross-border cooperation No. RVI 1/0326/16 “Model of the medical program to combat osteoporosis in the Polish-Belarusian border area” (2018–2021).

“Develop and implement a method for assessing the risk of development and progression of atrial fibrillation in patients with arterial hypertension” (2021–2024).

Abstract: The aging process affects all body systems, including the cardiovascular, nervous, skin, etc. With age, the number of diseases per person increases. A number of studies show a relationship between poor quality and insufficient duration of sleep with an increased risk of developing cardiovascular diseases (CVD). Bedtime can increase the risk of CVD, especially in women. Sleep disorders are often accompanied by dyslipidemia, which, in turn, is a factor in the development of increased vascular stiffness, endothelial dysfunction and vascular atherosclerosis. Circadian sleep disorders are considered factors in the increased risk of myocardial infarction, stroke and aortic stenosis.

Every person wants to stay young not only externally, but also to maintain healthy blood vessels, have a good blood pressure profile. The main factor in the primary prevention of premature aging of blood vessels, reducing dyslipidemia, and normalizing blood pressure should be considered improving the quality and duration of sleep. Antiaging is the development of technologies and methods for slowing down or preventing aging. One of the key anti-aging methods can be improving the quality and duration of sleep.

Keywords: aging, cardiovascular system, blood pressure, sleep



Tissue optical clearing for whole-organ imaging in neuroscience

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Speaker: Tingting Yu is an Associate Researcher at the Wuhan National Laboratory for Optoelectronics, Huazhong University of Science and Technology. She is mainly engaged in research on tissue optical clearing methods and applications, focusing on the development of optical imaging techniques based on tissue clearing for obtaining and reconstructing three-dimensional structure information of the central nervous system, peripheral nervous system, and other biological tissues. She has published over 30 SCI papers in journals such as *Science Advances*, *Nature Communications*, and *Theranostics*, and has contributed to the compilation of four Chinese and English monographs, with eight authorized patents. She has led projects including the General Project, Young Scientists Fund from NSFC, International Cooperation and Exchanges Projects from NSFC, and Hubei Province's Key R&D Program, as well as participating in Key R&D projects of the Ministry of Science and Technology and the Key International Cooperation Research Projects of NSFC. She is a Young Committee Member and the deputy secretary-general of the Biomedical Optics Professional Committee of the Chinese Optical Society.

Abstract: Acquiring the three-dimensional (3D) structure of biological tissues is essential for research in life sciences. Modern optical imaging techniques and fluorescent labeling technologies have provided vital tools for obtaining high-resolution information on the 3D structures of biological tissues. However, the turbid nature of biological tissues limits the depth of light penetration, leading to restricted applications for large tissues or whole organs. Tissue optical clearing technology takes a different approach by making the tissues transparent using various physical and chemical strategies to reduce the attenuation of light in tissues, and providing a new approach for the 3D imaging of whole organs. Here, we will introduce our progress in the research of *ex vivo* tissue optical clearing methods and applications, covering the fluorescence labeling, tissue clearing, and imaging of whole organs, as well as the applications in neuroscience.

Keywords: tissue optical clearing, optical imaging techniques, fluorescent labeling



The role of meningeal lymphatic vessels in the effectiveness of photobiomodulation

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Photobiomodulation (PBM) is a promising method for the prevention of early and moderate age-related cognitive impairment. However, the effectiveness of PBM remains unclear. Recent discoveries have shown that the meningeal lymphatic vessels (MLVs) play an important role in removing toxins from the brain and its function decreases with age, which may cause cognitive impairment in older groups. At the same time, the importance of MLVs in the development of Alzheimer's disease has been shown. Furthermore, in our previous work it has been discovered that MLVs are the target for the therapeutic effects of PBM.

The aim of this work was to study the effectiveness of PBM in old mice compared with young and middle-aged mice by studying the level of beta-amyloid (A β) in the brain, brain drainage and cognitive functions.

The studies were performed on male C57BL/6 mice (aged 3, 12, 24 months). To analyze the effect of PBM on the brain A β levels or cognitive functions, a 10-day course of PBM (0.3 kJ/cm², 1050 nm) was used. The content of A β in the brain and the morphology of MLVs were studied using confocal microscopy. To study the effect of PBM on brain drainage in mice of different ages, the confocal analysis of distribution of Fluorescein Isothiocyanate-Dextran (FITCD, 70 kDa, Sigma, 5 μ l, intraventricular injection in rate of 0.1 μ l/min) in the dorsal and ventral parts of the brain after a single application of PBM was performed. The Pavlovian conditioning test (forming the conditioned reflex "light-food") was used for the investigation of cognitive function in mice.

The results revealed a gradual increase in amyloid levels in the brains of mice with age. The 10-day course of PBM effectively reduced the brain A β content in middle-aged mice to its levels seen in young animals. However, PBM did not affect the high A β content in the brains of old mice. Because young mice had the low brain A β levels, PBM had no effect on its brain content in this group.

Study of the morphology of MLVs revealed the development of hyperplasia in old mice, but not in young and middle-aged animals. The expansion of MLVs in old mice was combined with a decrease in brain drainage in these animals, indicating a decrease in the MLV function with age.

In young and middle-age mice but not in old mice, PBM effectively stimulated clearance of A β from the brain and facilitated the formation of a conditioned reflex.

Thus, these results allow us to conclude that the preservation of MLV function is an important mechanism of stimulating effects of PBM on brain drainage, removal of A β from the brain and improvement of cognitive function.

Keywords: age differences, photobiomodulation, brain drainage, meningeal lymphatic vessels

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 25-15-00174).



The effect of plasmalogens on cognitive functions of mice of different ages and with Alzheimer's disease

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Beta-amyloid (A β) is a neuronal metabolite that plays a crucial role in maintaining brain homeostasis. Under normal conditions, intensive A β production in the brain is balanced by its efficient clearance through the meningeal lymphatic system. However, during aging and in Alzheimer's disease (AD), pathological accumulation of A β occurs, contributing to cognitive decline and memory impairment. Emerging evidence suggests that plasmalogens (PIs), key lipid components of the brain, may have therapeutic potential in AD and age-related cognitive dysfunction.

In this study, we investigated the effects of PIs on cognitive performance in adult mice with an AD model, as well as in mice of different ages (6, 12, and 24 months).

The results demonstrate that intracerebroventricular injection of PIs enhances learning performance in 12-month-old mice but does not produce a similar effect in 24-month-old animals. In AD mice, PIs treatment improved general locomotor activity and learning ability, as confirmed by a conditioned "easy food" reflex test using our custom-designed operant wall.

Thus, these findings suggest that PIs may represent a promising approach for alternative or adjunctive prevention of AD and age-related brain disorders to improve cognitive function and memory.

Keywords: Beta-amyloid, Alzheimer's disease, plasmalogens, learning ability

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 25-15-00174).



Technology of lymphatic liposome delivery to glioma in rats

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Acupuncture may be a new method for activating brain drainage and delivering drugs through perivascular spaces to the central nervous system. In this study we tested the hypothesis that photostimulation of acupuncture (GB20) can activate brain drainage and contribute deliver of liposomes as the promising nanocarriers for drug delivery to brain tumors.

Pathogen-free male Wistar rats (200-250g, 2 months old) were used in all experiments and were obtained from the National Laboratory Animal Resource Centre (Pushchino, Russia). Fluorescent liposomes were injected through acupuncture zones with additional application of laser 1267 nm to stimulate GB20. To analyze brain drainage, fluorescence microscopy was used for optical monitoring of the distribution of 70 kDa FITC-dextran (FITCD) along the dorsal and ventral parts of the brain and its excretion into the deep cervical lymph nodes after tracer injection into the right lateral ventricle. The C6 glioma cells (5×10^5 cells per rat) were injected in coordinates (AP - 1 mm; ML - 1 mm; DV - 4 mm) with a Hamilton microsyringe in a volume of 15 μ L at a rate of 1 μ L/min.

The results of the study showed that photostimulation with GB 20 resulted in a more significant distribution of FICTD in the brain and its release into the deep cervical lymph nodes than without photostimulation. After photostimulation with PM20, liposomes from the acupuncture zone reached the glioma and accumulated in the tumor.

Overall, the results of the studies confirmed the hypothesis that photostimulation of the acupuncture zone of GB20 is an active zone, the stimulation of which leads to the activation of brain drainage, which can facilitate the delivery of liposomes to glioma.

Keywords: liposomes; drugs; lymphatic delivery; pharmacopuncture; acupuncture; blood-brain barrier; nanoparticles



Photostimulation of lymphatic clearance of beta-amyloid during sleep from the brain of old mice

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Meningeal lymphatic vessels (MLVs) play an important role in the elimination of toxins and metabolites from brain tissues. It is known that the MLV functions decrease in various brain diseases, including Alzheimer's and Parkinson's diseases. Therefore, the development of innovative technologies to stimulate their functions is a promising area in medicine.

Recent studies suggest that non-invasive transcranial photobiomodulation (PBM) technology can effectively stimulate MLVs and enhance the clearance of toxins like blood and amyloid-beta (A β) from the brain. Deep sleep is a natural factor for the activation of brain drainage. MLVs are the tunnels for removal of the soluble A β from the brain that declines with age, leading to the accumulation of A β in the aged brain. The purpose of the study is to develop an original portable tPBM technology under electroencephalographic (EEG) monitoring of deep sleep in unanesthetized male BALB/c mice of different ages to stimulate the lymphatic clearance of A β from the brain to the peripheral lymphatic system.

The assessment of the effectiveness of the use of PBM in various parameters was studied by photostimulation of the removal of fluorescent A β from the brain into the deep cervical lymph nodes (dcLN). The results showed that stimulation with pulsed light with a wavelength of 1050 nm has stronger stimulating effects on the lymphatic removal of A β than other wavelengths in the pulsed mode (880 nm and 1300 nm), as well as the same wavelength of 1050 nm in continuous mode. Among the different tested doses of (10, 20 and 30 J/cm²), 30 J/cm² was found to be the most effective in lymphatic removing A β amyloid from the brain.

A gradual increase in the soluble form of A β in the brain of mice was found. A study of the sensitivity of mice of different ages to PBM revealed that PBM during sleep in middle-aged mice effectively reduces the A β content in the brain to the level of young mice and is ineffective in relation to old animals.

Thus, the results established the fact that age is a limiting factor in the effectiveness of using PBM to stimulate lymphatic removal of A β from the brain.

Keywords: beta-amyloid, Alzheimer's disease, photobiomodulation, meningeal lymph vessels

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 25-15-00174).



The study of molecular diffusion in murine brain tissue with fluorescence recovery after photobleaching and multiphoton microscopy

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Proper understanding of molecular diffusion in brain tissue and its relation to the structures in the brain, such as the meningeal lymphatic system, can benefit studies of brain properties, functions and disorders, such as Alzheimer's disease. Fluorescence recovery after photobleaching (FRAP) is a technique for determining diffusion properties in biological tissues that is used in biophysical and biomedical studies. In this research we investigate the application of multiphoton microscopy with FRAP in the analysis of diffusion dynamics in murine brain tissue.

Photobleaching was performed in murine brain tissue slabs using a 970 nm titanium-sapphire laser of Nikon A1R MP confocal and multiphoton system. Isothiocyanate-dextran was used as a fluorescent dye. Time-lapse multiphoton imaging with image acquisition over several depth positions (z-stack scanning) of fluorescence recovery in the samples was also achieved with Nikon A1R MP. The concentration of fluorescent dye was assumed as a function of fluorescence intensity and time, while fluorescence intensity was viewed as a function of spatial coordinates in a FRAP image.

Multiphoton microscopy imaging with FRAP shows presence of anisotropy in fluorescence recovery in murine brain tissue over time. The anisotropic properties of molecular diffusion could be related to the structure of meningeal lymphatic system. These results can be used in further studies related to the molecular diffusion and vascular networks in brain tissue.

Keywords: molecular diffusion, brain tissue, multiphoton microscopy, fluorescence recovery after photobleaching, FRAP

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 23-75-30001).



Effects of plasmalogens on brain drainage

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It is known that Alzheimer's disease (AD) is characterized by the accumulation of beta-amyloid ($A\beta$) in the brain. Effective clearance of $A\beta$ from the brain, primarily mediated by meningeal lymphatic vessels (MLVs), is critically important for maintaining homeostasis in the central nervous system (CNS). This study examines the effects of plasmalogens (PLs) as a special class of phospholipids with neuroprotective and anti-inflammatory properties on brain drainage function. This research explores the potential therapeutic effects of PLs in improving $A\beta$ clearance by analyzing their impact on lymphatic drainage in mice.

The results of this study demonstrate that PLs exert an age-dependent influence on the lymphatic clearance of $A\beta$. Specifically, in 14-month-old mice, PLs reduced $A\beta$ levels in the brain and the meninges promoting $A\beta$ accumulation in the deep cervical lymph nodes (dcLNs) that indicates on PLs-mediated increase in lymphatic drainage of the brain. However, there was no effect of PLs on the $A\beta$ levels in the brain, meninges, or dcLNs of young (3- and 6-month-old) or old (24-month-old). Notably, in 24-month-old mice, despite the high brain $A\beta$ levels, the content of this toxin in dcLNs remained low, suggesting impaired lymphatic function in this age group.

By studying the mechanisms, we found that PLs enhance the lymphatic clearance of soluble forms of $A\beta$ through MLVs leading to reduced $A\beta$ accumulation in the brain, the meninges, and dcLNs. This effect is most pronounced in the early stages of ontogenesis when the MLV function is preserved, underscoring the importance of timely therapeutic intervention.

In sum, these data demonstrate the stimulatory efficacy of PLs on brain drainage and the MLV functions providing clearance of $A\beta$ from the brain that can be an important for the development of alternative supporting methods for therapy of brain diseases associated with reduced brain drainage and MLV dysfunction. The presented data open new avenues for developing strategies aimed at improving lymphatic clearance of toxins in neurodegenerative diseases.

Keywords: plasmalogens, lymphatic clearance, neurodegenerative disease, meningeal lymphatic vessels.

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 23-75-30001).



Model of closed head injury in mice induced by a weight-drop device

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The Traumatic brain injury (TBI) constitutes the predominant cause of mortality among populations. Numerous animal models have been established to replicate human closed head injury (CHI). Commonly employed methodologies include lateral fluid percussion, controlled cortical impact, and impact acceleration techniques. Since clinical TBIs are heterogeneous, the choice of an injury model on animals may cause difficulties. In order to approximate mice model to the clinical symptoms in humans we developed of an equipment for an experimental TBI model for mice.

In this study we present a model weight-drop apparatus to induce CHI, generating a focal blunt trauma to the intact skull without prior surgical intervention. This model consistently generates well-defined contusions in the temporal lobe while avoiding prolonged anesthetic exposure and eliminating the need for skull fixation or surgical exposure. The impact intensity can be precisely modulated to induce varying degrees of traumatic brain injury (TBI), ranging from mild to moderate severity. This approach results in a consistent increase in the size of perivascular spaces, indicating the formation of edema. Additionally, a study on a brain water content demonstrates an increased water content in the brain at different time points (4 hours, 1 day, and 10 days) after traumatic brain injury (TBI). Histological examination revealed no morphological changes in the brain tissue, which corresponds to the criteria for mild or moderate TBI. Macroscopic analysis ruled out the presence of skull fractures.

We developed a device for modeling TBI in mice, in which the mouse's head and body remain unrestrained during impact. Anesthesia is administered only 3–5 minutes before the impact, and the injury severity can be adjusted from mild to severe TBI. These features make this murine TBI model highly comparable to human TBI. This experimental model achieves reproducible temporal lobe contusions while circumventing both extended anesthetic administration and invasive cranial procedures. The system permits precise calibration of impact forces to elicit traumatic brain injuries of predetermined severity, spanning from mild to moderate clinical manifestations.

Keywords: Traumatic brain injury, Closed head injury, protocols

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 25-15-00174).



Light source technology prospects for personal wearable brain photobiomodulation device

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Near infrared transcranial photobiomodulation (PBM) of the brain has been proven on animal models as an efficient technology for brain clearance of toxins, Alzheimer disease therapy and cognitive function improvement as well as brain lymphatics stimulation and recovery. The effect of PBM depends on the physiological state of the brain and can be improved when it is applied during deep (NREM) sleep of the patient. But the current approach of ambulatory physiotherapy does not orient on personalized procedures during sleep. Thus, the novel personalized PBM device is needed and welcome in the market to meet the novel PBM technology requirement.

In this paper we discuss fundamental limitations for portable wearable PBM devices and review state of the art technology solutions in highly efficient light sources, light energy distribution, that ensure the best possible device performance.

We presented possible solutions for transcranial PBM with compact wearable devices incorporating NIR light sources like light emitting diodes and lasers with optimal light energy distribution over the head surface to ensure high efficiency of PBM with limited portable battery charge capacity.

Keywords: transcranial photobiomodulation, singlet oxygen, laser, light emitting diode

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 23-75-30001).



Photobiomodulation enhances meningeal brain drainage to mitigate aging-related neurological decline

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The escalating global burden of aging poses significant challenges to socio-economic and healthcare systems worldwide, yet there remains a critical lack of effective, safe, and easily available therapeutic interventions. Impaired brain drainage and the accumulation of toxic metabolites, such as advanced glycation end products (AGEs), are features of aging that are strongly associated with various brain pathologies, including neuroinflammation, redox imbalance, and neuronal damage. Therefore, enhancing brain drainage and clearance efficiency, as well as removing AGEs, holds significant promise for advancing the treatment of aging-related neurological decline and halting the progression of neurodegenerative diseases.

In this study, we utilized a D-galactose-induced aging mouse model (AM) in male mice, as it recapitulates the complex neuropathological changes associated with aging and aging-related neurodegenerative diseases. We found significant damage to the meningeal lymphatic vessels (MLVs), which is associated with impaired brain drainage and the accumulation of metabolites AGEs in the brain. Notably, non-invasive near-infrared II (1275 nm) photobiomodulation (PBM) safely and effectively restored brain drainage and clearance efficacy and promoted lymphatic removal of AGEs through nitric oxide release-mediated dilation of MLVs in AM mice. These improvements contribute to the maintenance of brain homeostasis, as evidenced by attenuated oxidative stress, microglial reactivity and neuronal damage, as well as improved cognitive function.

These findings demonstrate the efficacy and potential mechanisms by which near-infrared II PBM alleviates aging-related neurological decline. Due to its safety profile, clinical accessibility, and non-pharmacological, non-invasive nature, this phototherapeutic approach holds significant promise for rapid integration into routine clinical practice to prevent the progression of aging and age-associated neurodegenerative diseases.

Key words: aging, photobiomodulation, brain drainage, meningeal lymphatic vessel

Acknowledgments: The research was supported by the National Natural Science Foundation of China (NSFC) (Grant Nos. 82361138569, 32361133552, 62375096, 82372012, and 62375095).



Quantitative analysis of images of biological objects using macros in the FIJI environment

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The rapid development of automated microscopy technologies has led to an exponential increase in the volume and complexity of biological imaging data, which required the development of effective computational tools for quantitative analysis. Traditional manual image processing methods are not only time-consuming, but also subject to subjective bias, which limits their applicability in high-performance research. In this study, these problems are solved by developing a customizable macro for batch processing and quantitative analysis of biological images using Fiji (ImageJ), a widely used open source platform for imaging biological objects.

The macro automates important steps such as image preprocessing (including noise reduction and contrast enhancement), creating a binary mask using adaptive threshold adjustment, and particle analysis, allowing you to extract key metrics such as area, average brightness, intensity distribution, and object density. Using the capabilities of Fiji scripting and built-in functions, the proposed solution significantly reduces manual intervention, while increasing the reproducibility and accuracy of large-scale image analysis.

For the subsequent development of this area, several areas were studied to optimize quantitative image analysis, such as parallel processing for more efficient processing of large amounts of data, which reduced the calculation time, dynamic background subtraction for greater image contrast.

This work highlights the transformative potential of computational methods in standardizing and accelerating bioimaging processes. By combining automation with advanced optimization strategies, the developed macro not only increases efficiency, but also opens up new opportunities for data-driven discoveries in cell biology, neuroscience, and related fields.

Keywords: bioimage analysis, Fiji (ImageJ), macro development, threshold value, batch processing, machine learning, parallel computing, 3D reconstruction, quantitative analysis

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 23-75-30001).



Photobiomodulation of brain waste removal system

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Meningeal lymphatic vessels (MLVs) play an important role in clearance of brain metabolites. Disruption of MLV function is associated with the development of neurodegenerative diseases such as Alzheimer's and Parkinson's diseases. In this regard, the activation of MLVs is considered as a promising direction in neurorehabilitation.

Modern research shows that transcranial photobiomodulation (PBM) can be an effective non-drug method of stimulation of the MLV functions. In our previous study, it was found that PBM promotes effective elimination of β -amyloid from the brain of mice with Alzheimer's disease. However, the mechanisms underlying this phenomenon remains unclear. Therefore, in this study we investigated the possible mechanisms of therapeutic effects of PBM.

Our results show that PBM causes dilation of lymphatic vessels, including MLVs and mesenteric lymphatic vessels, which is associated with an increase in endothelial permeability and a decrease in the expression of tight junctional proteins. These proteins play a key role in regulating lymphatic flow, and changing their activity allows metabolites and immune cells to be transported more efficiently with lymph.

WE also revealed that one of the possible mechanisms of the PBM effects on the lymphatic vessels is PBM-mediated stimulation of production of the nitric oxide (NO) in the lymphatic endothelium. NO promotes dilation of the lymphatic vessels by activating guanylate cyclase and protein kinase G, which ultimately leads to vascular relaxation followed by a contraction phase due to the opening of Ca²⁺-channels at the moment of increasing shear stress due to stretching of the vessel wall.

These data suggest that PBM is a promising non-invasive technology to stimulate the MLV functions and brain drainage to remove toxic metabolites from the central nervous system leading maintaining homeostasis of the brain.

Keywords: meningeal lymphatic vessels, photobiomodulation, sleep

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 23-75-30001).



Effect of photodynamic increase of blood-brain barrier permeability on meningeal lymph flow and brain drainage in mice

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Photodynamic therapy (PDT) is a promising method in the current standard of care for patients with various diseases of the central nervous system, including brain tumors.

PDT is based on the use of photosensitizers (PS), such as 5-aminolevulinic acid (5-ALA), which, under the influence of light, generate singlet oxygen that destroys tumor cells. In addition to the direct antitumor effect, 5-ALA reversibly increases the permeability of the blood-brain barrier (BBB). Since 5-ALA, when administered intravenously, can cause an increase in the permeability of the blood-brain barrier, we hypothesized that it can also increase the permeability of the meningeal blood vessels (MLVs), which in turn can lead to damage brain drainage. Testing of this hypothesis is important for a better understanding of the mechanisms of vascular effects of PDT and optimization of current recommendations for PDT using 5-ALA.

In this study, we studied the effects of PDT using 5-ALA on both MLVs and cerebral blood vessels (CBVs).

The results of this study revealed the new vascular effects of PDT with 5-ALA. It was found that upon photoexcitation, 5-ALA causes an increase in the permeability of both MLVs and CBVs, which leads to extravasation of photoexcited 5-ALA from the bloodstream into the meninges, where MLVs are located. This, in turn, provokes photodamage of the MLV endothelium, presumably by the same mechanism by which PDT causes damage to the blood endothelium. PDT-induced damage to MLV leads to a dramatic decrease in brain drainage, which may be accompanied by excessive accumulation of fluid in brain tissues. These results provide an important information platform for a better understanding of the vascular effects of PDT, a reassessment of the advantages and disadvantages of this method, and an optimization of clinical practice recommendations for more effective use of PDT in the treatment of brain tumors and other brain pathologies.

Keywords: photodynamic therapy, brain tumor, photosensitizers, blood-brain barrier

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 23-75-30001).



Role of the meningeal lymphatic vessels in removal of blood from mouse brain

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The meningeal lymphatic vessels were discovered two years ago as the drainage system involved in mechanisms underlying the clearance of brain from waste products. Stroke is accompanied by accumulation of toxic product of blood in the brain tissues associated with inflammatory processes. It well known that the brain activates the recovery processes after stroke but extremely limited information about mechanisms underlying these processes.

To answer the question: “How the brain cleans from the blood after stroke?”, we created the innovative approaches for in vivo monitoring of brain clearing in mice from substances coming to the brain through the opening of blood-brain barrier using confocal and multiphoton imaging.

We found that 60 min after stroke the products of disaggregated blood such as hemosiderin detected in the deep cervical lymph nodes (dcLN) in comparison to the control group support to a strong correlation between the lymphatic and drainage system of the brain. The stroke-related inflammatory processes are accompanied by appearance of macrophages in the meningeal lymphatics, cerebral spinal fluid and perivascular spaces. Our results show that the dcLN gives license for macrophages to come into connective fluid system of the brain but not in parenchyma.

These new fundamental data shed light on mechanisms of brain clearance from the blood and on the role of lymphatic system in these processes that could serve as an informative platform for a development of novel therapy and diagnostics of stroke.

Keywords: photobiomodulation, brain drainage, stroke

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 23-75-30001).



Computational assessment of the contribution of bottlenecks to the pathway of fluid transport from the parenchyma to the meningeal lymphatic vessels

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Brain drainage is an important and actively studied topic today. In particular, there are ongoing discussions about the specific pathways of beta-amyloid transfer from the parenchyma to the meningeal lymphatic vessels.

An important argument in these discussions can be computational quantitative estimates of the change in the hydrodynamic resistance of the most poorly permeable elements, in particular - (1) the parenchyma itself, or more precisely – the intercellular space of the neuro-glia-vascular unit and (2) recent data on the visualization of small lymphatic vessels adjacent to the perivascular space of arterioles. In both of these cases, direct flow measurements are currently unavailable, and the topology of the intercellular space and the shape of the vessel cross-section are too complex for theoretical estimates. In our work, we focus on the problem of computational estimation of the hydrodynamic resistance of these “bottlenecks” on the pathway of beta-amyloid removal. In doing so, we use the available experimental data to create a 3D lattice with a flow geometry similar to living tissue. We then calculate the transport process in terms of both the flow of the fluid itself and the transport of particles within it.

The main result of this stage of the work is the computational tool itself, the first goal of which will be to assess the extent to which changing the geometry can affect the relative contribution to transport of particle diffusion versus advection.

Keywords: meningeal lymphatic vessels, fluid transport, beta-amyloid

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 25-15-00174).



A device network for operant conditioning in the assessment of Alzheimer's disease in mice

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Neurodegenerative diseases, including Alzheimer's disease, are characterized by pronounced cognitive impairments, necessitating the development of accurate and reproducible models for preclinical studies. This work presents the development and validation of a network of devices for operant conditioning, designed to assess the cognitive abilities of mice under standard housing conditions.

The proposed system forms a cluster of individual devices connected via a USB interface into a unified network. Each device operates autonomously and continuously monitors behavioral responses in real time, enabling the parallel collection of high-resolution data from a large number of subjects without restricting their freedom of movement. Two types of operant tasks were implemented: cue-guided choice, where a mouse must respond to an illuminated port to receive a food reward, and lever activation, requiring the mouse to press a lever to obtain reinforcement. These tasks assess learning processes, decision-making capabilities, motivation, and motor-cognitive coordination.

The experimental model involved two groups of male BALB/c mice: a control group and a group with an induced model of Alzheimer's disease through the injection of beta-amyloid aggregates into the hippocampus. The developed device network offers a sensitive and scalable approach for quantitative assessment of cognitive impairments and motor functions. It holds strong potential for standardized preclinical validation of novel therapeutic strategies targeting neurodegenerative diseases.

Keywords: neurodegenerative diseases, Alzheimer's disease, operant conditioning, cognitive assessment, behavioral analysis, preclinical models, USB device network, beta-amyloid model, motor-cognitive coordination, automated behavioral testing, mice cognitive impairments

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 23-75-30001).



Age is a limiting factor for photobiomodulation of brain diseases

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The progressive number of old adults with cognitive impairment worldwide and the lack of effective pharmacologic therapies requires the development of non-pharmacologic strategies. The photobiomodulation (PBM) is a promising method in prevention of early or mild age-related cognitive impairments. However, it remains unclear the efficacy of PBM for old patients with significant age-related cognitive dysfunction. In our study on male mice, we show a gradual increase in the brain amyloid beta ($A\beta$) levels and a decrease in brain's drainage with age, which, however, is associated with a decline in cognitive function only in old (24 months of age) mice but not middle-aged (12 months of age) and young (3 month of age) animals. These age-related features are accompanied by the development of hyperplasia of the meningeal lymphatic vessels (MLVs) in old mice underlying the decrease in brain's drainage. PBM improves cognitive training exercises and $A\beta$ clearance only in young and middle-aged mice, while old animals are not sensitive to PBM. These results clearly demonstrate that the PBM effects on cognitive function are correlated with age-mediated changes in the MLV network and may be effective if the MLV function is preserved. These findings expand fundamental knowledge about age differences in the effectiveness of PBM for improvement of cognitive functions and $A\beta$ clearance as well as about the lymphatic mechanisms responsible for age decline in sensitivity to the therapeutic PBM effects.

Keywords: age, photobiomodulation, brain diseases, Alzheimer's disease

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 24-75-10047).



MRI-compatible device for brain photobiomodulation

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Brain photobiomodulation (PBM) is a promising direction in neuroscience, offering new opportunities for modulating neuronal activity without invasive intervention. Of particular interest is its application in the therapy of neurodegenerative diseases, such as Alzheimer's disease, where PBM can help restore cognitive functions, improve metabolic processes in nervous tissue, and slow the progression of neurodegeneration. To study the mechanisms of PBM and its clinical application, the integration of this method with high-precision neuroimaging tools, primarily magnetic resonance imaging (MRI), is required. However, the use of traditional PBM devices in the MRI environment is associated with several technical difficulties: the intense magnetic field and radiofrequency interference can disrupt the operation of electronic components, reduce the reliability of the system, and affect stimulation parameters. Therefore, there is a need for the development of specialized solutions resistant to the effects of the MRI environment. In this work, a PBM device was created, which is structurally fully compatible with the conditions of MRI studies. The developed system includes a flexible LED matrix, a shielded control module, and a switching block, connected by a flat cable with minimal metal elements. The control signals are transmitted through a 10-meter fiber-optic cable, which eliminates the impact of MRI electromagnetic fields on the control electronics. The device is powered by an autonomous battery, providing complete independence from external power networks in the scanner area. The programmable control module allows for setting a wide range of stimulation parameters, depending on the research or therapy goals.

Experimental tests confirmed that the device remains stable in high magnetic fields and radiofrequency radiation conditions typical for MRI scanning. At the same time, the quality of MRI images was not degraded, no artifacts were present, and the PBM parameters remained within the set values without deviation. The key feature of the device lies in its full electromagnetic compatibility with MRI equipment, which ensures the possibility of performing PBM directly during the scanning process without disrupting the visualization characteristics. Thus, the presented development opens new prospects for the comprehensive study of the neurophysiological effects of PBM in real time, as well as for the implementation of innovative diagnostic and therapeutic protocols aimed at slowing the progression of neurodegenerative diseases, including Alzheimer's disease.

Keywords: photobiomodulation, MRI, Alzheimer's disease

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 23-75-30001).



Analysis of contractility of mouse lymphatic vessels

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Lymphatic drainage is the basis for cleansing brain tissue from toxic metabolites. Meningeal lymphatic vessels (MLV) act as tunnels that remove toxins from the brain with the flow of fluids into the peripheral lymphatic system. Cervical lymph nodes are the first anatomical collection station for brain fluids flowing through the lymphatic vessels. Therefore, cervical lymphatic vessels are considered an important tool in studying the effectiveness of lymphatic drainage processes in the brain, since the analysis of the MLV operation is difficult due to their transparency and fine structure.

In this study, a program was developed for automatic analysis of the contractility of the cervical lymphatic vessels of mice as the main physiological manifestation of the effectiveness of lymphatic drainage based on multiphoton monitoring of stained walls (fluorescent Lyve-1-488 was injected into the large cistern) of the lymphatic endothelium.

The program is based on video analysis using optical flow to track the movement of two user points and calculate the distance between them in each frame.

Key points:

- The OpenCV library is used to process video and track points using the Lucas-Kanade method (function `cv2.calcOpticalFlowPyrLK`).
- The user manually selects two points in the first frame, then the program tracks their movement by frames.
- The distance between these points in each frame is calculated, converted into micromillimeters.
- Distance and median filtering graphs are created and displayed, and the rate of change in distance is calculated.
- The results are saved in CSV files.

The developed program is an important intellectual resource that allows for automated assessment of lymphatic vessel contractility using optical images in order to analyze the effectiveness of the brain's lymphatic drainage function.

Keywords: OpenCV, `cv2.calcOpticalFlowPyrLK`, lymphatic vessel contractility, multiphoton microscopy

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 24-45-00010).



Effect of plasmalogens on beta-amyloid content in brain tissues of mice of different ages

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Alzheimer's disease (AD) is the most common form of dementia affecting the elderly. Beta-amyloid peptides (A β), especially the A β 42 variant, play a key role in the pathogenesis of the disease by forming amyloid plaques in brain tissues. In this work, the effect of plasmalogens (Pls) on the clearance of A β 42 from the brains of mice with Alzheimer's disease and different age groups (3, 6, 14 and 24 months) was studied, the study included 21-day intraventricular administration of Pls. In mice with AD (3 months) and elderly mice (14 months) Pls significantly reduced A β levels in the brain, meninges, and deep cervical lymph nodes, indicating increased lymphatic clearance through the meningeal lymph vessels. The effect was absent in older mice (24 months) due to lymphatic dysfunction and in young/middle-aged mice with low baseline A β 42 levels. The findings highlight the potential of Pls as a therapeutic agent for early AD and age-related cognitive decline with limitations in severe aging.

Keywords: plasmalogens, Alzheimer's disease, age, cognitive functions, amyloid beta, lymphatic clearance

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 25-15-00174).



Multimodal anesthesia during chronic craniotomy and titanium plate fixation in laboratory animals

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A craniotomy is an operation on the bones of the skull, which provides access to the brain and its membranes. This operation is highly invasive and requires a serious approach to anesthesia of the animal. It is known that the severity of the procedure should be proportional to the quality of anesthetic support. The use of one type of drug to introduce an animal into anesthesia is not humane and does not comply with ethical standards. For this, we use a multimodal approach to anesthesia.

Multimodal anesthesia is the most well-founded approach in anesthesia, which includes multi-level, multi-purpose antinociception. This allows you to reduce the dosage of drugs used for sedation, muscle relaxation and anesthesia of laboratory animals, also reducing the risk of complications.

We used NMDA antagonists and α 2-adrenergic agonists in combination with gas anesthesia during cranial trepanation in mice, which enhanced the effect of injectable drugs at minimal dosages, while the animals were in a deep sleep phase, coming out of anesthesia more gently, which had a positive effect on the postoperative period and rehabilitation in general.

Based on this, we can conclude that combined anesthesia is an advantage in performing complex surgical operations on laboratory animals.

Keywords: beta-amyloid, Alzheimer's disease, plasmalogens, learning ability

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 23-75-30001).



Plasmalogens improves cognitive functions in mice with Alzheimer's disease

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Amyloid beta ($A\beta$) is a product of neuronal metabolism playing an important role in maintaining brain homeostasis. In the normal state, intensive $A\beta$ formation by neurons is accompanied by effective removal of this toxin. However, Alzheimer's disease (AD) is associated with significant accumulation of $A\beta$ in the brain leading to cognitive impairment and memory deficit. There is evidence that plasmalogens (PLs), which are the key brain lipids, can be beneficial for AD. In this study, we investigated the efficacy of PLs in improvement of clearance of $A\beta$ from the brain and cognitive function in AD mice.

Male C57BL/6 mice were used in all experiments. PLs were prepared from phospholipids of bovine brain and injected into the right lateral ventricle in an amount of 5 μ L of PLs (~0.15 mg). To induce AD in mice, we used the injection of $A\beta$ (1-42) peptide into the hippocampus. Pavlovian conditioning, new object recognition and Y-Maze tests were used for evaluation of cognitive functions. ELISA analysis of brain tissues was used for analysis of $A\beta$ level in the brain. Brain drainage was studied by confocal imaging of the distribution of fluorescent $A\beta$ in the brain.

The results showed that a 21-day course of PLs administration to AD mice significantly improves brain drainage leading to an increase in $A\beta$ clearance and a decrease in $A\beta$ level in the brain. Furthermore, PLs-related stimulation of brain drainage was accompanied by an increase in general motor activity, improvement of emotional status and learning ability in AD mice.

Thus, these findings suggest that PLs could be a promising candidate for alternative or concomitant therapy of AD by PLs-mediated improvement of cognitive functions through PLs-induced activation of brain drainage and $A\beta$ clearance from the brain.

Keywords: Alzheimer's disease, plasmalogens, cognitive function, beta-amyloid.

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 23-75-30001).



Potential applications of photostimulation of the brain lymphatic drainage system in the therapy of Alzheimer's disease: Rationale and design of a clinical trial

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Introduction. Alzheimer's disease (AD) is the most frequent cause of dementia in the adult population. Due to the active increase in the number of elderly people in the world, the issue of AD treatment is particularly relevant. The role of the brain lymphatic system in the excretion of metabolites of the amyloid cascade has been widely discussed. The technology of photostimulation of the lymphatic drainage system opens new possibilities in therapy of AD.

Objective. To evaluate the efficacy of the brain photostimulation technique among patients with Alzheimer's disease.

Materials and Methods. The multicenter study will include patients from 60 to 85 years old with signs of Alzheimer's disease, cognitive impairment syndrome, reaching a mild degree of dementia, receiving standard symptomatic therapy. The patients will be randomly divided into 2 groups, one of which will receive 10 sessions of photostimulation and the other will receive false (sham) photostimulation. All patients will undergo neurocognitive testing and electroencephalography before and after phototherapy.

Results. Improvement in cognitive function as measured by neurocognitive testing after a course of photobiostimulation is expected, primarily in the attention domain.

Conclusion. The technology of photobiostimulation of cerebral vessels is a promising high-tech method of treatment of Alzheimer's disease, which opens new opportunities in the management of patients with neurodegenerative diseases.

Keywords: Alzheimer's disease, brain photostimulation, neurodegenerative diseases

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 23-75-30001).



Meningeal lymphatic vessels as a target for photobiomodulation

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Photobiomodulation (PBM), a therapeutic approach utilizing red or near-infrared light, has emerged as a promising non-invasive intervention for neurodegenerative disorders such as Alzheimer's disease (AD). Recent research underscores the critical role of meningeal lymphatic vessels (MLVs) in maintaining brain homeostasis by facilitating the clearance of metabolic waste, including toxic amyloid- β ($A\beta$) aggregates. There is evidence that PBM can enhance the function of MLVs, particularly during sleep, offering a novel strategy to combat AD and other conditions linked to impaired brain waste clearance.

Indeed, the effects of PBM on the MLV functions appears to be age-dependent, with significant cognitive improvements observed in young and middle-aged mice but not in older animals. This suggests that the therapeutic window for PBM may be limited by age-related declines in lymphatic function. It is interesting to note that PBM during deep sleep proves more effective than during wakefulness that can be explained by natural activation of MLV during sleep. The many experimental studies demonstrate that the crucial mechanism of stimulating effects of PBM on MLVs are PBM-mediated increase in the MLVs permeability via nitric oxide production leading to an increase in brain drainage.

These findings highlight the potential of PBM as a safe and innovative alternative to pharmacological treatments, which often face challenges related to efficacy and side effects. By targeting MLVs, especially during sleep, PBM could optimize the removal of neurotoxic waste and slow disease progression. Future research should focus on translating these preclinical results into clinical applications, paving the way for PBM-based therapies in neurodegenerative and cerebrovascular diseases.

Keywords: photobiomodulation, aging brain, brain's drainage, cognitive functions, MLVs

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 23-75-30001).



**Detection of the first changes in the dynamics of metabolic characteristics
in the system of increasing consequences of traumatic brain injury**

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There is no doubt that the consequences of a brain injury can greatly affect the further functioning of the entire organism - there is a risk of permanent sleep disturbance, metabolic processes, and behavioral changes. An urgent task is to develop methods for the accurate diagnosis of such abnormalities and treatment. Often, an injury may seem insignificant, but lead to serious deviations of an irreversible nature. In such cases, in the early stages after injury, average daily values cannot serve as indicators of serious health problems.

The need to study local changes on shorter time scales leads to the introduction of new methods for processing biosignals. The work shows that the success in detecting the smallest but significant changes is influenced not only by a comprehensive study of several parameters, but also by the choice of a time window for averaging. This was achieved directly by analyzing the periods within daily rhythms that are associated with the periods of sleep and wakefulness of a living organism. Having developed a traumatization technique with a fully controlled dose of exposure and using an automated modular platform for phenotyping (PhenoMaster), *in vivo* recording of feed intake, fluid and body weight, treadmill activity, indirect calorimetry and gas exchange of laboratory mice during the day was carried out. An analysis method was proposed that takes into account both the average values and the assessment of the “detailed” structure of the recorded signals.

It has been shown that the first changes in metabolism and behavior occur during periods of maximum and minimum activity – periods of sleep and active wakefulness. Hypothetically, changes in these phases serve as predictors of more serious consequences of traumatic brain injuries. Therefore, it can be used in the early diagnosis of cognitive and metabolic diseases, as well as to localize the analysis in assessing the quality of the impact of therapy for post-traumatic conditions.

Key words: neurotechnology, oxidative metabolism, circadian rhythms, medicine

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 25-15-00174).



Time-frequency approach to the analysis of signals of electrical activity of the brain during periods of sleep and wakefulness

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Among the important topics that unite physiologists, physicists, IT specialists, and medical workers is the problem of studying human sleep. Such interest in this problem is due to the fact that timely diagnosis and treatment of sleep disorders allows us to overcome not only neurological diseases, but also a number of systemic disorders of the whole body.

The most common characteristic of brain activity is the electroencephalography (EEG) signal, which is due to its low cost and ease of implementation. However, there are many difficulties associated with a large number of electrodes and lead combinations. For these reasons, home monitoring of a patient seems impossible, and monitoring in a hospital setting requires continuous observation by a doctor. One cannot ignore the fact that the only method that is accepted as a standard for determining deep sleep is a visual assessment of signals by a somnologist and the compilation of a hypnogram. Automation of this procedure is one of the urgent tasks not only for science in general, but also for practical application. One of the potential methods for detecting sleep markers is spectral analysis. Despite the general popularity of this approach, there are still many doubts about its practical application in the conditions of complex non-stationary EEG signals.

Taking these aspects into account, this paper examines the possibilities of the time-frequency approach in the analysis of a limited number of EEG leads. At the same time, a balance was achieved between the speed of processing large amounts of data and preserving biosignal information without knowingly “rough” averaging. The balance was achieved using a fast algorithm for calculating the power in the main physiological frequency ranges and choosing the optimal size of the sliding averaging window. It was shown that the use of time-frequency analysis allows describing the dynamics of the most powerful components of the EEG signal – delta waves (0.5–4.5 Hz) or slow-wave activity. Delta rhythms were found to be maximally reduced during wakefulness and increased during the transition to sleep.

The main line of further research is the analysis of the relationships between the main EEG rhythms. It was shown that the spectral components even within one phase vary significantly. A continuous increase in the power of delta waves was found immediately after the transition to the initial phase of sleep and then during its “deepening” into the NREM3 phase. On the one hand, this conclusion makes it somewhat difficult to identify precise criteria for transition processes between phases, but, on the other hand, it provides potential for the development of dynamic analysis for comparing different pathological conditions and their early diagnosis.

Key words: neurotechnology, time-frequency analysis, medicine

Acknowledgments: The research was supported by the Russian Science Foundation (project No. 24-45-00010).



Improvement of neurophysiology methods: compact EEG system for long-term monitoring and stimulation in small animals

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Electroencephalography (EEG) is a crucial method in neurophysiological research using small laboratory animal models. However, existing commercial EEG systems often have high costs and limited flexibility to adapt to specific experimental needs. This paper proposes a modular approach to designing an EEG system that combines low cost, high performance, and the ability to easily modify components. The developed platform supports wired and wireless operation thanks to the Bluetooth Low Energy (BLE) interface, allowing for simultaneous recording of data from multiple devices.

As an example of the proposed approach's application, we have developed a compact and autonomous tool for photobiomodulation (PBM) of the mouse brain during the non-rapid eye movement (NREM) sleep phase. The system consists of a single-channel analog front-end (AFE), based on the MAX30003 chip, which is placed directly on the animal's head. This allows for high-quality signal acquisition with a noise level of approximately 1 mV.

The control of the system is carried out through the STM32F103 microcontroller, which also detects the NREM sleep state in real time. A light-emitting diode (LED) with a wavelength of 1050 nanometers is used for stimulation, and its intensity is controlled through pulse width modulation (PWM).

The main advantages of this system are its modular design, low cost (under 200 USD), and low weight (up to 43 grams), which minimize the impact on animal behavior. This platform demonstrates high efficiency for closed-loop neuromodulation tasks such as photobiomodulation (PBM) during sleep and can be scaled up to multi-channel configurations with ease. This proposed solution opens new avenues for research in neurodegenerative diseases, epilepsy, and other conditions that require long-term electroencephalography (EEG) monitoring and precise neural network manipulation.

Keywords: electroencephalography (EEG), small laboratory animals (rodents, mice), modular EEG system, Bluetooth Low Energy (BLE), neurophysiological research, photobiomodulation (PBM), slow sleep (NREM), closed-loop neuromodulation, biopotential signals, wireless biomedical devices, STM32 microcontroller, MAX30003 (analog frontend), pulse width modulation (PWM), neurodegenerative diseases

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 23-75-30001).



Gender differences in photobiomodulation of lymphatic vessels of meninges and brain diseases

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Photobiomodulation (PBM) has emerged as a promising therapeutic approach for brain diseases, with growing evidence highlighting significant gender differences in its efficacy. This study explores the role of sex-specific variations in lymphatic function, hormonal influences, and ion channel activity in modulating PBM responses. Women exhibit higher lymphatic vessel density and estrogen-driven lymphangiogenesis, leading to enhanced PBM effects, particularly in conditions like lymphedema. In contrast, men show stronger inflammatory responses mediated by androgens, which may alter PBM outcomes. Additionally, gender differences in nitric oxide synthase (NOS) isoforms and ion channels (e.g., Kv1.2, Cav1.2) further contribute to divergent neuroprotective and metabolic responses to PBM. For instance, premenopausal women demonstrate elevated endothelial NOS (eNOS) activity, offering vascular protection, while men exhibit higher neuronal NOS (nNOS) expression in specific brain regions. Climacteric periods (menopause and andropause) also influence PBM responsiveness, with studies suggesting its potential to alleviate genitourinary symptoms in women and boost testosterone levels in men. These findings underscore the need for sex-tailored PBM protocols to optimize therapeutic outcomes. Further research is warranted to elucidate molecular mechanisms and validate clinical applications.

Keywords: photobiomodulation, gender differences, lymphatic system, nitric oxide synthase, ion channels, menopause, andropause

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 23-75-30001).



Phototherapy of the nervous system of newborn rats with intraventricular hemorrhage

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Laser phototherapy (PT) in the near infrared range (1267 nm) is of considerable interest for neuroscience due to its ability to modulate key processes of neuroplasticity, neuroprotection and neuro-recovery. Furthermore, PT is safe and non-invasive method which makes it attractive for use in newborns. There is growing evidence that PT has significant therapeutic effects on mitochondrial dysfunction, tissue saturation and neuroinflammation, which is especially relevant for the correction of the consequences of hypoxic-ischemic and hemorrhagic brain lesions in the early postnatal period.

The aim of the study was to evaluate the effect of the 10-day course of transcranial laser phototherapy (1267 nm) on the recovery of cognitive and motor functions in neonatal rats (4 days old) with an experimental model of intraventricular hemorrhage.

A neonatal model of intraventricular hemorrhage (IVH) was induced by injecting 7 μL of autologous blood into the right lateral ventricle. PT was performed using a laser (LD-1267-FBG-350, Innolume, Germany) in the dose of 4 J/cm^2 during 10 days in following protocol: 17 min of irradiation, 5 min pause, total 61 min/day.

The development of IVH was accompanied by a neurologic deficit with changes in locomotor functions that were significantly improved after the PT-course. The PS-course 4 J/cm^2 improved the neurological status after IVH in newborn rats. So, the score of the motor tests, such as hind-limb and front-limb suspension, decreased in the IVH group vs. the sham group suggesting the impairment of motor function after IVH. However, the scores of these tests were essentially increased after PS compared with pups without the PS therapy. The neurodevelopment reflexes were impaired in pups with IVH as evidenced by a decrease in score of the cliff avoidance and the gait tests in the IVH group compared with the sham group. After the PS course, pups performed these tests much better than animals without the PS therapy.

In summary, the results showed that the PT course exerted significant therapeutic effects on the recovery of neonatal rats after IVH and can be a promising non-invasive method for neurorehabilitation in the early stage of ontogeny.

Keywords: phototherapy, behavioral tests, intraventricular hemorrhages, central nervous system



A method for modeling obstructive sleep apnea in mice

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Obstructive sleep apnea (OSA) is a common disorder with a significant global socio-economic impact. Patients with OSA are at increased risk of developing cardiovascular disease (heart attack), diabetes, obesity, and chronic respiratory conditions. Lack of proper sleep due to OSA can reduce a person's productivity, cause daytime sleepiness, and negatively affect their quality of life. Sleep deprivation is the main problem of OSA, which leads to impaired drainage of the brain and excessive accumulation of toxic metabolites in its tissues. This contributes to the decline of cognitive function and premature aging of the brain. The study of the mechanisms of development of OSA is hampered by the lack of reliable and effective animal models of OSA.

In this study, we created the new model of OSA on mice based on swelling of the tissues of the tongue and palate. The mouse was anesthetized and tongue was manually pulled as far out of the mouth as possible to provide access to the base of the tongue. 100 µl of polytetrafluoroethylene diluted in a glycerol solution is injected using a 27-gauge cannula into the base of tongue to increase volume. After surgery, the mouse receives postoperative anesthesia using ibuprofen.

This model overcomes many of the limitations of current animal models of OSA. It is practical and accessible to a wide range of researchers, making it an excellent tool for studying the mechanisms of OSA, particularly in genetically modified mice, which could potentially lead to the development of novel treatment approaches.

Keywords: obstructive sleep apnea, sleep disorders, Alzheimer's disease

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 25-15-00174).



Coordination among brain rhythms during sleep-wake transitions

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Over the past decades, many facts have been accumulated confirming change in the characteristics of various rhythms (primarily amplitude) with a change in the functional state. However, along with the study of individual rhythms, the issue of their coordination, i.e., the simultaneous and coordinated response in the characteristics of several rhythms, is actively discussed. Examples of such coordination have been demonstrated for some pairs of EEG waves when studying perception, consciousness, cognitive functions and working memory. Along with the consideration of pairwise interactions, the concept of rhythm coordination as a network is of interest. Recent studies proposed a conceptually different way to the analysis of physiological states and functions, based on dynamic network interactions between various rhythms of the brain and showed that distinct coupling forms and strengths are typical for different pairs of rhythms, and established characteristic positive correlations, anti-correlations and mixed correlations. It was also demonstrated that the type of correlations (for some pairs) can change during transitions between physiological states.

This work discusses the concept of dynamic network interactions between various brain rhythms, which was applied with an emphasis on the study of age-related changes in EEG wave cross-communications. Using the Pearson correlation, significant differences in pairwise rhythm interactions were found for groups of subjects of different ages, most pronounced in the waking state. It is noted that older people demonstrate stronger correlations (or anti-correlations) for all pairs of rhythms under consideration. In the sleep state (especially in the deep sleep phase), age-related changes weaken, which is accompanied by a change in the type of correlations for some pairs of rhythms (i.e. a change in the sign of the average values of the correlation measure). We suppose that the results obtained are of interest in studying not only the effects of healthy aging, but also pathological changes in the electrical activity of the brain. In particular, demonstrating the age-related differences between some EEG frequency bands in various physiological states paves the way for identifying brain age using the applied technique. Also, the method could potentially be extended for early prediction of Parkinson's and Alzheimer's diseases.

Keywords: EEG, brain rhythms, interactions, age-related distinctions, sleep-wake transitions

Acknowledgements: The research was supported by the Russian Science Foundation (project No. 24-22-00015).

Научное издание

**КОМПЛЕКСНЫЕ СИСТЕМЫ
И БУДУЩИЕ ТЕХНОЛОГИИ
В НЕЙРОНАУКЕ**

Сборник тезисов докладов

Выпуск 2

Материалы Международной летней школы «Комплексные системы
и будущие технологии в нейронауке – CSFTN’25»

Иркутск, 26–29 июня 2025 г.

Ответственный за выпуск: *О. В. Семячкина-Глушкова*
Компьютерная верстка и подготовка оригинал-макета: *Э. И. Кайбелева, В. А. Халова*

Подписано к использованию 22.05.2025. Размещено на сайте 26.05.2024.
Формат 60x84 1/16. Усл. печ. л. 3,25 (3,5). Объем данных 20 Мб. Заказ 5-у.

Управление по издательской деятельности Саратовского университета
410012, Саратов, Астраханская, 83
<https://www.sgu.ru/struktura/uprid>