



CEITEC
MAFIL



BULLETIN

VOL. 7

MAFIL Core Facility

INTRODUCTION

Dear readers,

the end of 2020 brought us an anniversary. It has been 20 years since a method called functional Magnetic Resonance Imaging (fMRI) began to be used in neuroscience research in Brno. Due to the limitations related to COVID-19, we could not organize the planned

promotional and professional events in the autumn of 2020 or in the winter of 2021. In the online version, we returned to the topic of our anniversary at least as part of the event „Brain Week“ in the spring of 2021, and we provide some insights into the historical development of fMRI in Brno in this newsletter.

On behalf of the MAFIL laboratory

Michal Mikl



CEITEC

Central European Institute of Technology
BRNO | CZECH REPUBLIC

Information Bulletin of MAFIL

NEWS IN THE CZECH-BIOIMAGING AND EURO-BIOIMAGING INFRASTRUCTURES

Last year, the Brno Euro-BioImaging node successfully expanded to include a microscopy facility from CEITEC BUT, which was already part of the national Czech-BioImaging infrastructure. A new Euro-BioImaging website was launched in 2020. In January 2021, the Brno node was presented at the Euro-BioImaging virtual pub event. Two new projects were supported to our lab prior to Euro-BioImaging open access. One is focused on neurolinguistics and the other on the study of neuroplasticity in the context of motor learning.

The national Czech-BioImaging infrastructure (hereinafter referred to as the CzBI), together with other infrastructures, was evaluated in a large interim evaluation by the Ministry of Education, Youth and Sports. This evaluation by international evaluators took place from December 2020 to the summer of 2021. The results were published in July. CzBI was ranked in the highest category, which means confirmation of the correct functioning of the infrastructure and a promise of funding for the next period (2023-2029). Within

the CzBI infrastructure, an internal evaluation of individual laboratories took place at the same time, namely by members of the CzBI Advisory Committee who have a long-standing interest in the work of CzBI and have carried out similar evaluations in the past. Our laboratory ranked very well in the evaluation and overall the Advisory Committee perceived positive developments in the whole CzBI infrastructure. We want to continue to focus on improving our services. At the same time, however, both evaluations have shown an increasing importance in terms of working with research data, especially in terms of its progressive openness, an area that we have already started to address both at the level of MAFIL and the entire CzBI infrastructure during 2020, and it is one of our priority areas for the future. The most recent contribution is a publication dedicated to wide public describing the imaging methods in CzBI. It was published as a supplement in the Czech edition of Scientific American journal, and readers can learn about the methods and instruments that CzBI laboratories offer to researchers.



20 YEARS OF fMRI IN BRNO

Functional brain mapping using MRI tomographs (fMRI) has been developing in the world since 1990, when Seiji Ogawa introduced the so-called BOLD effect (i.e. the principle where the level of blood oxygenation in individual parts of the brain changes according to the neural activity in a given area and through a change in the homogeneity of the magnetic field in the monitored area, we can observe a change in brightness in suitable MR images). In Brno, fMRI began to be introduced during the year 2000 and at the end of the year the first measurements were made. It was a rather demanding process, during which it was necessary to solve many technical problems and to learn how to understand the measured data - i.e. how to process them appropriately and how to evaluate the results. Although over time (especially with increasing experience) the use of fMRI has become somewhat routine and is now inherently used for neuroscience research and some clinical applications, it is in fact still a dynamically evolving method. Even after 20 years, we are still facing new challenges. New MR tomographs and new measurement sequences are able to provide new types of fMRI data that need to be processed appropriately. As an example, we can mention measurement sequences that can take the necessary images of the brain faster, or at different stages of



the BOLD effect (so-called Multi-echo sequences). Specific cases of fMRI are also hyperscanning and real-time fMRI neurofeedback, which we have written about in previous issues of our newsletter. In this issue, you can learn about an extremely fast imaging method called MREG. The principle of fMRI and a brief history of 20 years in Brno was presented in an online lecture during the European Brain Week. Unfortunately, the COVID-19 pandemic prevented us from the planned professional and popular events for the public for this anniversary. Anyway, fMRI is moving forward and so we hope that the original intentions will be realized on the next anniversary, e.g. in 2025 when we will celebrate a quarter of a century.

EVENTS OF THE YEAR 2021

Brain Week

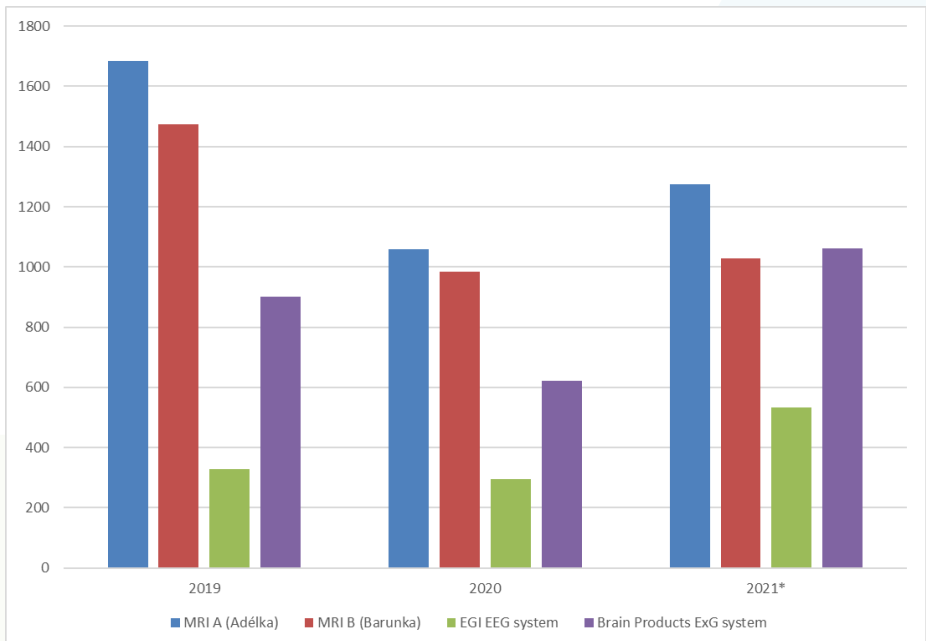
In March 2021, our laboratory, together with other neuroscience researchers from CEITEC MU, participated in the European Brain Week. Due to COVID, it took place in an online version. There was a 3D tour of the lab (which is still available from our website), a lecture on the 20th anniversary of fMRI in Brno, neuroscience lectures on various topics and a special neuroscience quiz.

Autumn training course

23.11.2021 - 25.11.2021 the traditional autumn training course Neuroimaging: Mapping the function and structure of brain will take place.

A LOOK BACK AT 2020

CF MAFIL equipment usage in 2019-2021* (number of hours)



In 2020, 1,634 measurements with a total length of 2,962 hours were performed on MAFIL's core devices. Compared to 2019, it is a drop of about 1/3. Measurements were performed for 47 unique projects. The following graph shows the overall evolution of measurement hours over the last 3 years on selected devices. The graph shows that the COVID pandemic significantly affected the operation of the laboratory in 2020 and partly in the early 2021, where an upward trend is already apparent (2021 is not yet complete).

The traditional Neuroimaging training course took place in November 2020. This time due to restrictions in the online form.

Due to the COVID-19 pandemic, virtually all planned physical events in 2020 were cancelled, e.g. the Spring Neuroimaging Workshop, a lecture by Prof. Ugurbil's of the University of Minnesota, and the Open day could not take place.

MAFIL OPERATION IN THE CONTEXT OF THE COVID-19 PANDEMIC

The COVID-19 pandemic has significantly affected our laboratory. The laboratory was closed during the most critical periods. Since the beginning of the pandemic in spring 2020, we have implemented additional hygiene measures following the rules and recommendations issued by the relevant institutions.

The Laboratory of Multimodal and Functional Imaging is subject to the regulations of the Government of the Czech Republic concerning health care facilities and also universities. For this reason, it is still necessary to wear a covered airways in our premises. We carry out daily disinfection of the laboratory premises with ozone, as well as disinfect the premises se-

parately after each participant. Participants are required to have their airways covered by a respirator; if the respirator contains metal parts, the participant is offered an MR-compatible respirator without metal components.





MAFIL helps

During the closure of the lab, we printed headbands for protective shields for doctors using a 3D printer. They were distributed to those who needed them with the help of the Masaryk University Volunteer Center MUNI helps!

NEW CF EQUIPMENT

LCD glasses (NordicNeuroLab)

Detailed info here: <https://nordicneurolab.com/fmri-solution-vshd/>

Main parameters of the system:

- Dual Full HD OLED, one for each eye
- Possibility of an independent image for each eye
- 1920x1200 resolution at 60 Hz
- Correction of dioptric eye defect from -10D to +5D
- Integrated eye movement tracking system
- Image resolution 640x480 at 60 fps



INTRODUCING INTERESTING PROJECTS IN CF

The effect of stress factors and the role of leadership

This is a project that was implemented for the University of Defence and focused on assessing stress reactions and monitoring the impact of military leadership. The fMRI with stress stimuli presented in different contexts was used as the main method. In addition, eye movements were monitored and electrophysiological signals such as skin conductance and heart rate were measured to evaluate physiological responses.

Assessment of body composition from whole-body MRI

The pilot project aimed to establish an optimal procedure for scanning the entire human body using magnetic resonance imaging and its use in the evaluation of body composition. The finalized procedure is used in an ongoing study - whole-body MRI scanning, which is part of the activities of the A.D.A.P.T. - Anthropological Body Proportion Database project. This project is carried out at the Department of Anthropology, Faculty of Science MU and its aim is to obtain information on the shape, dimensions and internal composition of the body in the Central European population. This data will be incorporated into a secure database to be used by experts in ergonomics and design of everyday objects. At

present, such data are, for example, much needed for the development of respiratory protective equipment such as respirators or gas masks.

Influencing working memory by synchronizing brain networks through non-invasive brain stimulation in healthy elderly and patients with mild cognitive impairment

A new multicenter study in collaboration between CEITEC MU and a Swiss partner (Swiss Federal Institute of Technology Lausanne) started in January 2021 and will run in different phases until 2023. Its aim is to influence working memory in seniors using non-invasive brain stimulation methods such as transcranial alternating current stimulation and transcranial magnetic stimulation. The project aims to bring neuromodulation closer to the natural physiology of the brain. Great emphasis is placed on individualization for a particular participant using fMRI and EEG data. In the first part of the project, the ideal setting for brain stimulation in order to maximize the effect on performance in memory tasks is found. Each participant undergoes several single stimulations, which individually have an effect of about 70 minutes. Later, the best stimulation protocol is applied to seniors with cognitive problems.

Memory and consciousness

The project is carried out in collaboration with several European and non-European sites supported by the international COST Action CA18106 project „The neural architecture of consciousness“. It aims to study functional activity and neural characteristics in creating of a conscious experience using an extremely large dataset of healthy participants (1,000 people). Each participant undergoes a extensive series of examinations using neuroimaging (magnetic resonance imaging - MRI), electrophysiological (electroencephalography - EEG) and other methods (DNA analysis of oral swabs, eye-tracking), together with an extensive battery of psychological questionnaires and behavioral tasks.

These data will be mutually correlated, on the basis of which detailed neuroarchitectonic models of human consciousness will be created. The results of this research may have significant impact on understanding the mechanisms of human consciousness, which may also increase the predictability of prognosis in neurological patients with disorders of consciousness.



SELECTED PUBLICATIONS

Holštajn Zemánková, P., Gajdoš, M., Světlák, M., Bareš, M., Širůček, J., & Kašpárek, T. (2021). **Processing of emotionally ambiguous stimuli in eating disorders: an fMRI pilot study.** *Eating and Weight Disorders - Studies on Anorexia, Bulimia and Obesity*. <https://doi.org/10.1007/s40519-021-01130-7>

Demonstration of the application of fMRI in the study of eating disorders.

Kraus, J., Roman, R., Jurkovičová, L., Mareček, R., Mikl, M., Brázdil, M., & Frick, A. (2020). **Social support modulates subjective and neural responses to sad mental imagery.** *Behavioural Brain Research*, 380. <https://doi.org/10.1016/j.bbr.2019.112433>

Results in the field of social neuroscience. One of the first projects using multi-echo multi-band sequences.

Latta, P., Starčuk, Z., Kojan, M., Gruwel, M. L. H., Tomanek, B., Trattnig, S., & Juras, V. (2020). **Simple compensation method for improved half-pulse excitation profile with rephasing gradient.** *Magnetic Resonance in Medicine*, 84(4). <https://doi.org/10.1002/mrm.28233>

An example of the results of the development of new imaging methods in collaboration with other Czech and foreign institutions.

Novakova, L., Gajdos, M., & Rektorova, I. (2020). **Theta-burst transcranial magnetic stimulation induced cognitive task-related decrease in activity of default mode network: An exploratory study.** *Brain Stimulation*, 13(3). <https://doi.org/10.1016/j.brs.2020.01.015>

Results of a study investigating the effect of transcranial magnetic stimulation on the activity of selected neural networks in the brain.

Filip, P., Vojtíšek, L., Baláž, M., Mangia, S., Michaeli, S., Šumec, R., & Bareš, M. (2020). **Differential diagnosis of tremor syndromes using MRI relaxometry.** *Parkinsonism & Related Disorders*, 81. <https://doi.org/10.1016/j.parkrel-dis.2020.10.048>

One of the first results using new methods transferred from the CMRR (Center for Magnetic Resonance Research, University of Minnesota) within the international project H2020 RISE MICROBRADAM.



An overview of all publications can be found on our website:
<https://mafil.ceitec.cz/en/>

INTERESTING TECHNICAL SOLUTIONS

MR-encephalography

In the last year, we have included the MR-encephalography method. This, not very well known, method uses an alternative approach to collect and reconstruct MR data in order to reduce the measurement time and thus achieve a temporal resolution similar to classical electroencephalography (EEG). By combining parallel imaging, based on signal processing from each element of a multichannel MR coil,

and the use of a spiral trajectory for efficient k-space undersampling, it is possible to obtain images with a 3mm isotropic voxel and a TR of around 80ms. With such fast scanning, it is possible to separate the BOLD signal from pulsations arising from respiration and cardiac activity or, for example, to better monitor the dynamic variability of resting state networks. This method is also used in the study of epilepsy and the glymphatic system.

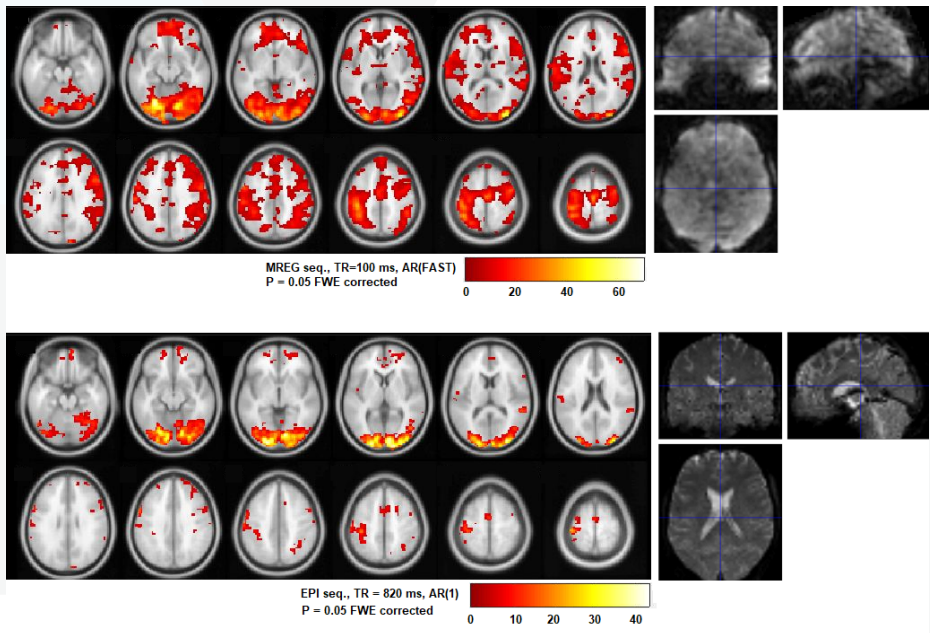
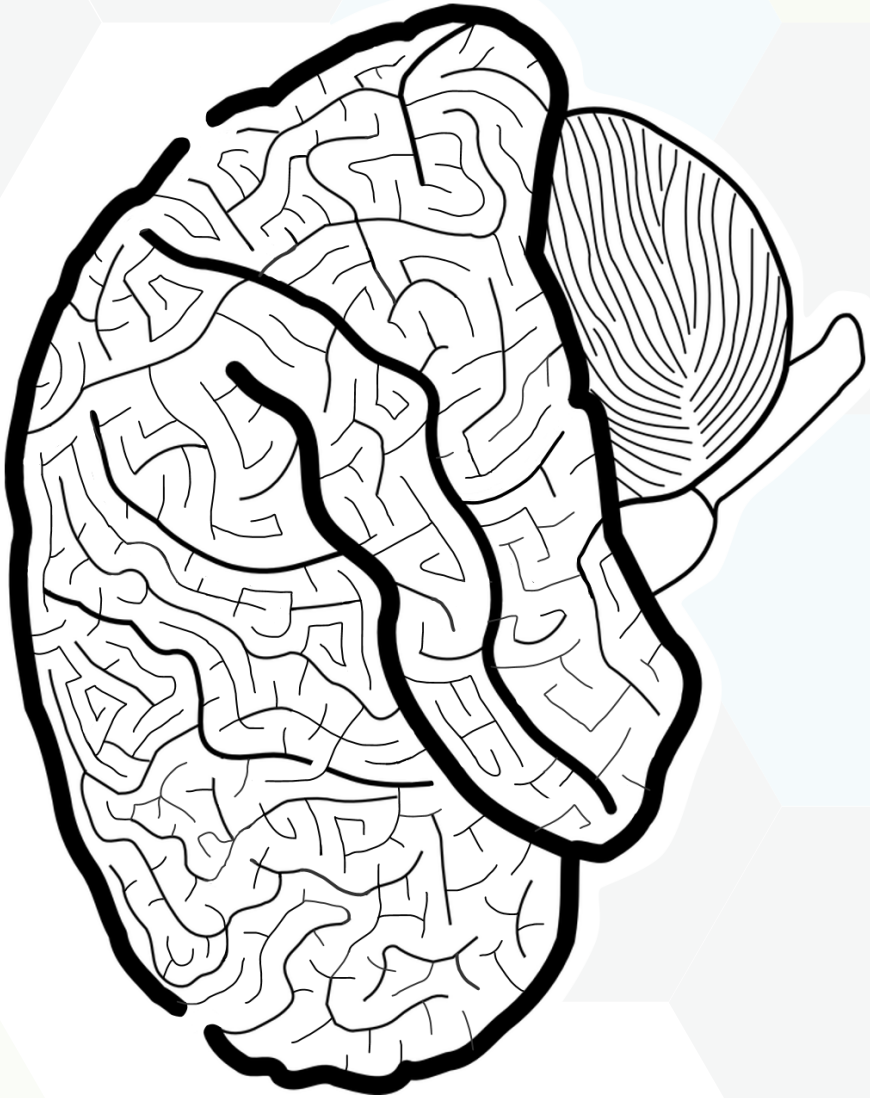


Fig. 1: The figure shows the brain activation of a participant performing a visual-motor task. When using MREG sequences, an increase in statistically significant areas of activation can be seen. On the right, a sample of the raw functional data can be seen when imaging using MREG sequences and using conventional EPI images.

LET'S END WITH A RIDDLE





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