CEITEC MAFIL

BULLETIN VOL. 5

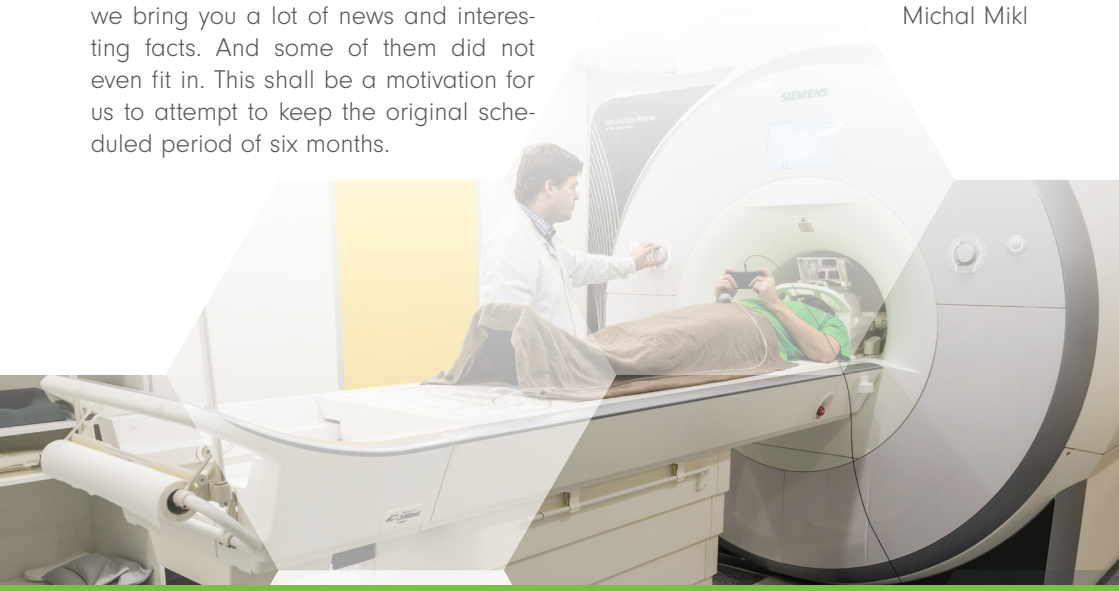
MAFIL Core Facility

INTRODUCTORY WORD

Dear researchers, colleagues, partners interested in the services of our core facility, the current information bulletin has been prepared after quite a long pause. Almost one and a half year has passed since the last issue. We started the preparation process already at the end of 2018, with the expectation to issue it in January 2019. However, the reality is that the final version of the bulletin is available to you in the spring 2019. Since one and a half year is a long time, we bring you a lot of news and interesting facts. And some of them did not even fit in. This shall be a motivation for us to attempt to keep the original scheduled period of six months.

In the current issue you can find news on infrastructural projects, on new hardware equipment and on measuring sequences. We will introduce to you so called multi echo sequences used for functional brain mapping and will present you an overview of interesting numbers and facts about our laboratory. And in the last part, you will find a small surprise.

On behalf of CF MAFIL,
Michal Mikl



NEWS IN INFRASTRUCTURE PROJECTS

Regular readers of this bulletin know that our laboratory participates in the national (https://www.czech-bioimaging.cz/) and international (http://www.eurobioimaging.eu/) projects for research infrastructures. Through these projects, our laboratory offers open access to all users. In 2017, an evaluation of national projects of research infrastructures took place. Czech-BioImaging ranked among the best evaluated infrastructures, which is an important factor in relation to the financial support of this infrastructure. We should therefore be able to provide the same level of user access support during the period from 2020 to 2022. Thanks to the project Operational Programme – Research, Development and Education, we were able, within the scope of the national consortium, to make some investments in the laboratory development. The newly acquired equipment is described in a separate chapter. In the first half of 2019, we are planning to finalize the acquisition of several additional items of equipment financed from the current project. At the same time, we are already working on the preparation of a new application for investment support of the Czech-BioImaging infrastructure which should cover the years of 2020 to 2022.

During 2018, the European infrastructure EuroBioImaging was also being developed. The infrastructure commenced a process necessary to establish the "ERIC" legal form. ERIC stands for "European Research Infrastructure Consortium". A successful obtaining of ERIC is expected at the beginning of 2019 and will imply a transformation from the preparation phase to the full functioning of the infrastructure. Together with the promotion of the international infrastructure EuroBioImaging, a special call of our laboratory for access of new users through EuroBioImaging currently continues – please find the details in a separate article in this bulletin.

ONGOING SUPPORT OF ACCESS FOR NEW EXTERNAL USERS

Support of user access through EuroBioImaging continues also in 2019. The support is aimed for the first access of the particular user through the EuroBioImaging project (see https://www.eurobioimaging-interim.eu/). If the project successfully passes the evaluation, the user gets a default number of free measurement hours (approximately 20-25 hours, depending on the type of required devices/services and the project complexity). Further measurement and services are subsequently charged at a reduced rate for the infrastructure (same as applies for the standard access within the scope of the Czech-BioImaging open access).

EVENTS AND ACTIVITIES IN 2018

- **March 2018** – Applied course on use of SPM12 software – a course designed, above all, for local researchers, realized in 4 time blocks in one month.
- **5 April 2018** – Workshop – Multicentric studies, meta-analyses and data comparison – a traditional spring workshop organized in relation to the international fMRI workshop in Olomouc.
- **24 May 2018** – Meeting of CF MAFIL users (so called "user meeting")
- **16 October 2018** – CF MAFIL open day for individuals interested in neuroscientific research
- **5–7 November 2018** Educational course Neuroimaging: Mapping the function and structure of Brain – the event was organized with the support of the infrastructure project Czech-Bioimaging and it was conducted in English.

EVENTS PREPARED IN 2019

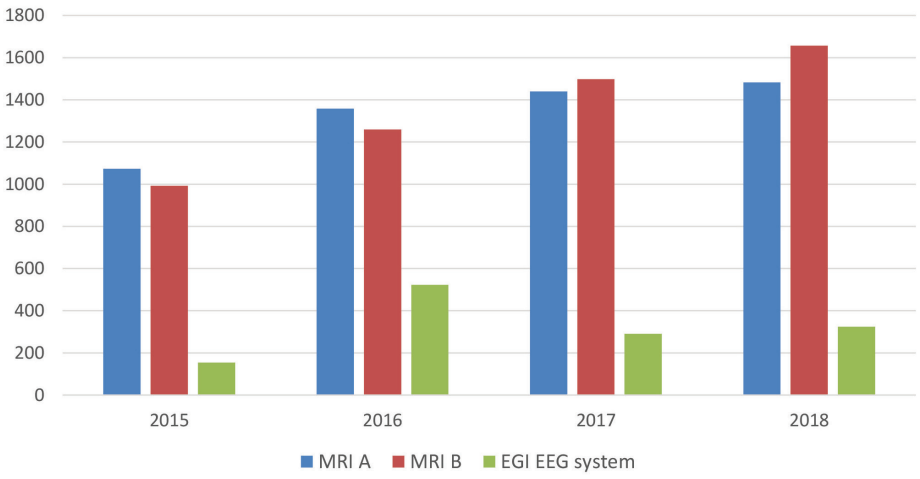
- **April 2019** – Practical course of SPM12 software
- **28 March 2019** – Meeting of CF MAFIL users – so called "user meeting" where some news from the laboratory will be presented to the users. The users will also be able to discuss different factors of CF MAFIL use with the laboratory employees as well as with each other.

- **4 April 2019** – another edition of the spring workshop organized in relation to the international fMRI workshop in Olomouc. This year's topic is neurofeedback and neuromodulation.
- **15–16 May 2019** – Czech-Bioimaging conference in Lednice
- **24–25 October 2019** – 66th Czech and Slovakian meeting of clinical neurophysiology – this year, the neurophysiological meeting will be held in Brno and CF MAFIL participates in the organizational part of the realization. It is an important event offering a broad interdisciplinary meeting place for scientists working in brain mapping area. Detailed information can be found at http://www.ta-service.cz/neurofyziologie2019/.
- **November 2019** – another run of a traditional educational course on "Neuroimaging: Mapping the function and structure of Brain" will take place. The exact dates will be specified during the course of the year. The course will take place over three days again, will be open to all interested individuals and will be conducted completely in English.

MEASUREMENT AND SERVICES REPORT

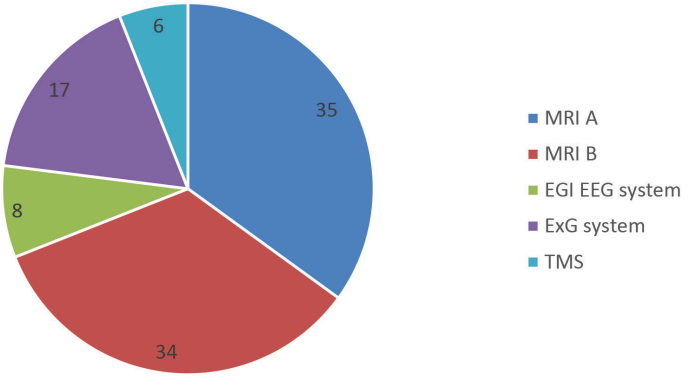
In 2018, the total of 3,175 measurements for 67 unique projects (excluding testing and experimental measurements) were realized in the laboratory. A complete overview of the numbers of measurement hours performed at selected devices in the last three years can be found in the following chart.

CF MAFIL equipment usage in 2015-2018 (number of hours)



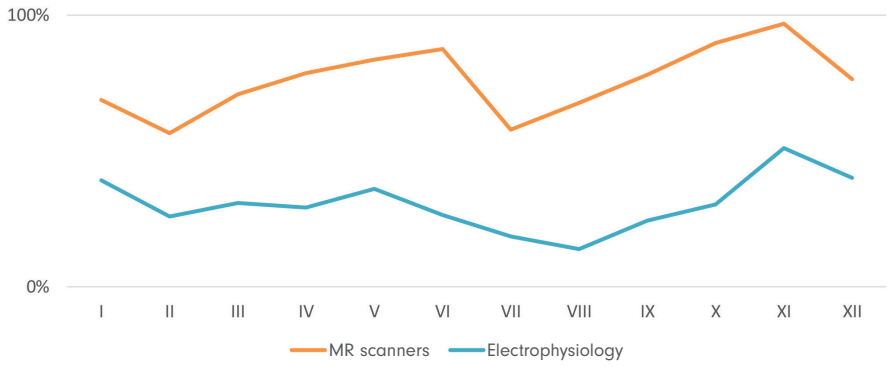
The distribution of realized projects based on the used devices is shown in the following chart. The data of some projects is recorded with combination of more devices, typically this includes MRI + electrophysiology.

CF MAFIL number of realized projects based on the device usage in 2018



The following chart shows the usage of laboratory devices through all calendar months. This is an average between the years 2016-2018 divided according to the modalities of the devices. The decrease during the summer vacation is related to the lack of volunteers willing to participate in research in this period as well as with the increased amount of vacation time off taken by the researchers who realized the projects.

CF MAFIL device usage in specific months, average value in years 2016–2018 (percentage of usage in relation to the working hours)



NEW EQUIPMENT OF CF

Over the course of 2018, we managed to further modernize and expand the CF equipment in order to increase the quality of provided services and enable new possibilities for the realized projects. From among the news, we can mention for instance the following:

New audio system for MRI

We have acquired a new top-quality communication audio system for both MRI scanners, with active noise reduction feature, from the Israeli company Opto Acoustic. This audio system allows a much better presentation of audio stimuli, more comfortable communication between proband and operator and mutual two-way communication of probands in both scanners (hyperscanning measurement).

Flat headphones allow its use in combination with all of our head coils, the level of gradient noise reduction is usually 60dB (max. 104 dB) in real time, with the transmitted frequency band of 50 – 15,000 Hz. It is possible to record the real sound heard by the proband during the measurement.

The system enables realization of projects which were impossible to realize or feasible only with significant limitations due to the audio quality needs.

MRI compatible tablet

An MRI compatible tablet was acquired to serve as a positioning device allowing the proband lying in the MRI scanner to interact with the stimulation task. In cooperation with the already used stimulation software Eprime, it enables us to record the stylus position, thus broadening the current possibilities of the proband to respond to the presented stimulation.

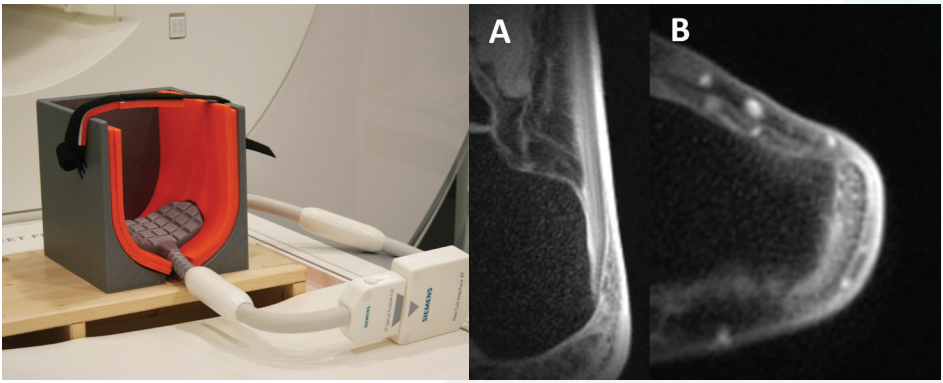
The acquisition of the tablet increases, above all, the possibilities of realization of projects focusing on graphomotor skills.

Fixation device for MRI measurement of the Achilles tendon

A prototype of a fixation device for MRI measurement of the Achilles tendon was designed and tailor-made in the CF. It consists of a wooden bed and a holder in the form of "U" shaped template made with 3D printing technology for direct allocation of the scanned ankle. The holder construction allows the use of either a small flexible coil or a special coil, if better signal to noise ratio and more narrow localization are needed. Both coils are standard 4-channel flexible coils Siemens (Siemens Medical Solutions, Erlangen Germany).

The holder was used and tested during a pilot study dedicated to T2* mapping of the Achilles tendon and insertions performed in cooperation with the High Field MR Centre in Vienna.

The picture shows the described equipment and examples of MRI images of the Achilles tendon scanned by an adjusted 2D UTE pulse sequence in sagittal (A) and axial (B) cut.



The figure shows the equipment and examples of MR images of the Achilles tendon scanned by the modified 2D UTE pulse sequence in sagittal (A) and axial (B) sections.

Additional coils for MRI measurement

— **4-channel surface coil for special use**
Non-tuneable receiving coil developed for imaging of small volumes, tiny structures close to the coil surface. Dimensions: 477 mm × 143 mm × 35 mm.

— **15-channel receiving – transmitting knee coil**
A coil designed for knee imaging with high resolution, openable. Suitable for in vitro measurement where an appropriate receiving/transmitting coil is requested. Coil inner diameter is 155 mm.


— **Coil for arm and wrist imaging**
16-channel coil was designed for the purpose of arm and wrist area imaging with high resolution, but it is also suitable for small in-vitro samples. Dimensions: 32 mm × 215 mm × 115 mm.

— **Round coils**
Two multipurpose coils with the diameters of 4 cm and 7 cm. Particularly useful for small structures close to the surface and small samples which can be inserted into the coil opening. Thanks to the simple form and design of the coil, it is suitable for experiments dealing with the principles of MRI physics and pulse sequences design.


NEW METHODS AND SEQUENCES IMPLEMENTED IN 2018

T1rho, T2rho, RAFF1 – 5 (Sequences using relaxation during HF pulses, so called experiments in rotating frame methods)

GRE_prep is a sequence based on gradient echo implementing multiple optional preparatory pulses creating a contrast. It is used for T1rho and T2rho mapping with the use of adiabatic preparatory pulses and methods of "relaxation along a fictitious field" of higher levels. Simultaneously, rectangular pulses for accurate measurement of MT (magnetization transfer) are being implemented. Generally, these methods are sensitive to changes in microstructure of imaged tissue.

Pulse sequences implementing mcDESPOT method (multicomponent Driven Equilibrium Single Pulse Observation of T_1 and T_2)

A fast method for quantification of the water/myelin ratio. SPGR and bSSFP sequences serve as a base and offer better SNRm, shortening of the measurement time and better resolution in comparison with the standard T2 approach. Nevertheless, the price for this is a more complicated data processing including "water exchange".

QSM

Recently the Quantitative susceptibility mapping method - QSM has been introduced in our laboratory. It is possible to use this quantitative method for a calculation of the distribution of magnetic susceptibility from phase images of multi-echo GRE sequences. Through the solution of an inverse problem, it is therefore possible to obtain information from the magnetic field on the distribution of magnetic susceptibility sources in a tissue. The tissue can for instance be influenced by a pathological storing of iron in the tissue of deep brain structure, which is typical for Parkinson' disease.

PRESENTATION OF SELECTED PROJECTS

Credibility as a factor of online marketing communication

The aim of this project was to monitor differences in brain centres' activity with the use of fMRI experiment when evaluating the credibility and attractivity of web pages. Within the fMRI task, the participants browsed different web pages prepared based on real web

pages from various categories (online shops, financial website, education, health, ...). The project conducted by researchers from Mendel University was started at the end of 2017 and then in 2018 the measurements and basic data processing were finished. CF MAFIL further cooperates on final analysis and results interpretation which shall be finished in spring 2019. So called multi echo sequences (ME-MB-EPI) were used during the project realization.

Reading and visual motor adaptation task in adults with developmental dyslexia: international study in different orthographic system

The project was realized based on the support of Czech BioImaging grant scheme. At the beginning of 2019, the last measurements took place. This is the first project using the eye-tracking system (system allowing observing eye movements) within the MRI field. The principal investigarot of this project is a neuroscientist from Brazil. The experts from Palacký University in Olomouc are responsible for the recruitment of suitable participants from the nearby surroundings. Therefore, this is a Brazilian-Czech cooperation project. The main part consists of fMRI combining the parts with the task focused on reading and the parts with the resting-state fMRI. From the viewpoint of our laboratory, this project brings new research topics and possibilities of cooperation with other Czech and foreign institutions.

Use of advanced MRI techniques for the detection of pathophysiology and improving the diagnostics and applied management of degenerative compression of cervical spinal cord.

The study is focused on the use of advanced imaging and quantifying methods in order to achieve more accurate diagnostics and detection of early processes related to the cervical spinal cord compression due to the degenerative processes of the cervical vertebrae. This is a disease with a high prevalence among the population the occurrence of which gets more probable with the higher age. In some patients, it can lead to the clinically symptomatic degenerative cervical myelopathy (DCM) and permanent severe neurological disability. Due to the fact that standard anatomical MRI imaging does not allow for detecting functional changes of the spinal cord, the differentiation of the functional disability level is currently based exclusively on clinical signs or on neurophysiological methods (evoked potentials). Modern imaging techniques enable quantification of microstructural and neurochemical changes with the help of diffusion tensor imaging and proton spectroscopy methods. These can be a suitable diagnostical instrument necessary for detection of early changes in the cervical spinal cord. This way it can extend the diagnostic possibilities of standard MRI techniques and make the decisions on surgical intervention in early or mild cases more accurate.

LABORATORY WEBSITE

During 2018, a new website of the whole CEITEC institute was launched and subsequently, in autumn, we moved the CF MAFIL presentation to a so called microsite. This gives us more freedom in the content creation and, at the same time, it is fully integrated in the graphic environment of the CEITEC website. It also allows us to adopt some automatically generated data. On the new website, there is a section dedicated to volunteers participating in various studies measured at CF MAFIL. Great part of the information is intended for researchers. We still continue to add more information and try to arrange it better, so our visitors can still expect further changes before the website reaches its final version.

mafil.ceitec.cz

SPECIFIC SERVICES AND INTERESTING TECHNICAL SOLUTIONS: FMRI WITH THE HELP OF ME-MB EPI

One of the key methods of neuroscientific research in our laboratory is the functional magnetic resonance brain imaging or fMRI. A big part of protocols is currently based on the so called multi-band sequences adopted from the Center for Magnetic Resonance Research (CMRR) of the University of Minnesota. These sequences allow simultaneous excitation of various layers from which we then measure the data. The measurement time of one brain volume is therefore significantly reduced. Such sequences also enable another useful function - measuring of various echoes of the signal from each layer (so called multi echo). This process is demonstrated in Figure 1. Both functions can be combined (the method is then marked with the abbreviation ME-MB-EPI, where ME means multi echo, MB means multi-band and EPI is an abbreviation of echo planar imaging method). This way, we can get multiple information on measured brain in a shorter time than with the use of common fMRI sequences. The advantage of multi echo sequences is obtaining optimal signal to noise ratio in each point of the brain. In some parts a sharp drop in the measured signal can occur. This drop is evident particularly in a long delay between the layer excitation and response measurement (an example of the signal failure can be seen in Figure 2). For this reason, it would be suitable to measure the response as soon as possible. But for the sake of correct functioning of fMRI, it is more convenient to measure the response later. When measuring one echo (single echo) we are forced to find a compromise between the conflicting requirements. If there is a possibility to measure the multi echo data, we can subsequently create new data resulting from the combination of individual echoes, thus getting a better-quality image. Even in places where no visible signal drop occurred, the signal to noise ratio has improved, which allows for more accurate evaluation of the activation map. An example can be seen in Figure 3. Currently, the ME-MB EPI method is already being used for some projects in our laboratory.

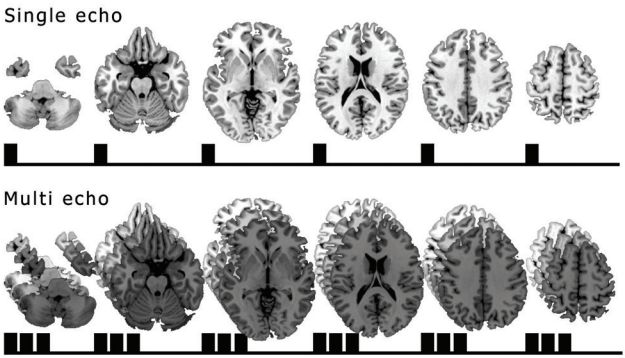


Figure 1 – fundamentals of multi echo measurement. During the common measurement (single echo) we always excite the measured layer and in a suitable moment we measure the data. This is performed in all layers - layer by layer. During the multi echo measurement, we excite the required layer and subsequently we get various measured echoes. In time, the signal drops and the images are therefore darker.

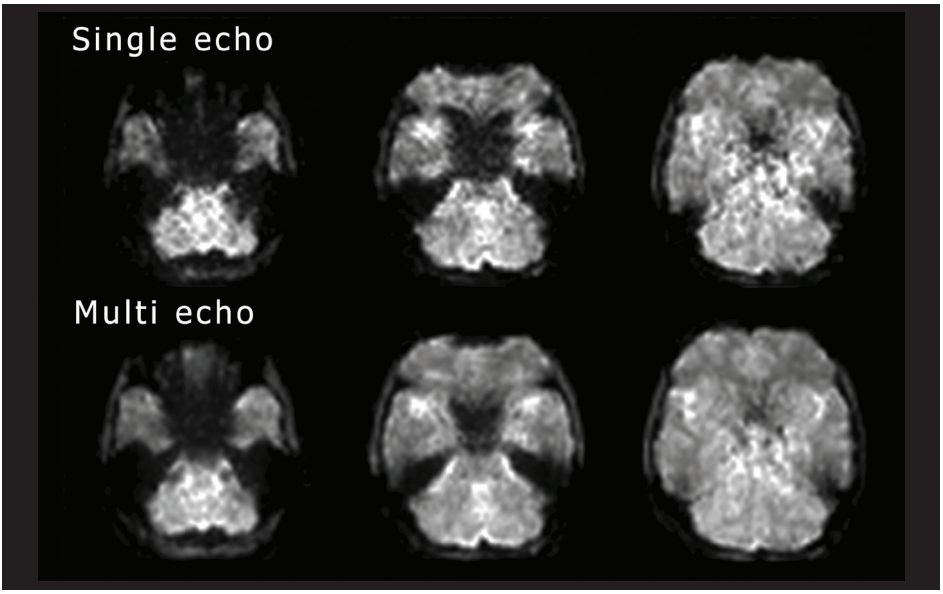


Figure 2 – An example of three fMRI cuts of brain data with the use of single echo method (upper line) and multi echo method (lower line). Multi echo data was created by combining three individual echoes. We can see a significant reduction of the signal loss.

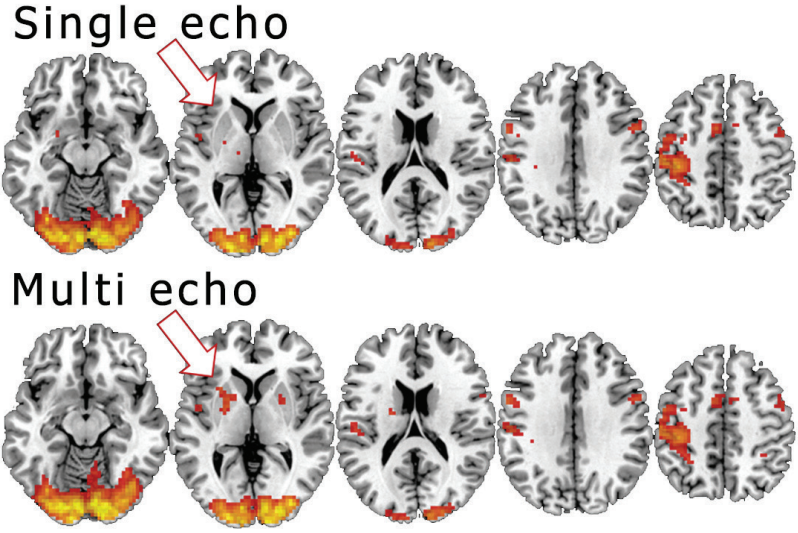
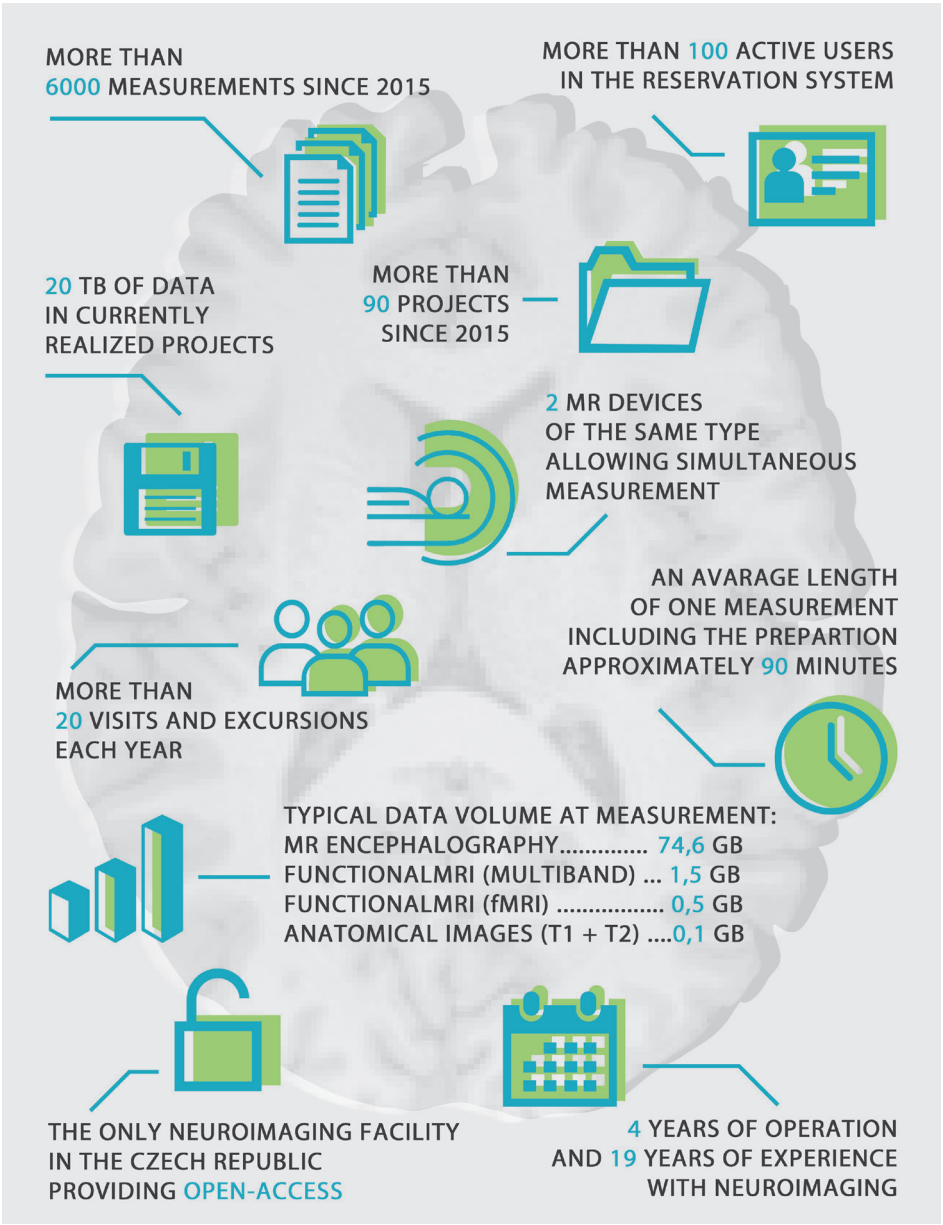


Figure 3 – An example of fMRI group activation map. The task used in the study was activating the visual area and motor centres. The main difference between the single echo and multi echo data is marked with arrows. In the traditional data (upper line), we cannot see any activity in the basal ganglia area at all, but it is visible in the multi echo data because of the better signal to noise ratio.

MAFIL IN NUMBERS



FINAL SURPRISE: COLOURED CROSSWORD

Your task is to find and colour the correct fields and then find a hidden picture in the grid. The numbers at the borders state the number of coloured fields. The numbers are ordered according to their order in which they are located in the grid. Between two clusters of fields (each cluster corresponds to one number in the clue) there is always at least one empty field.

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								4			3		3		1	4			
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