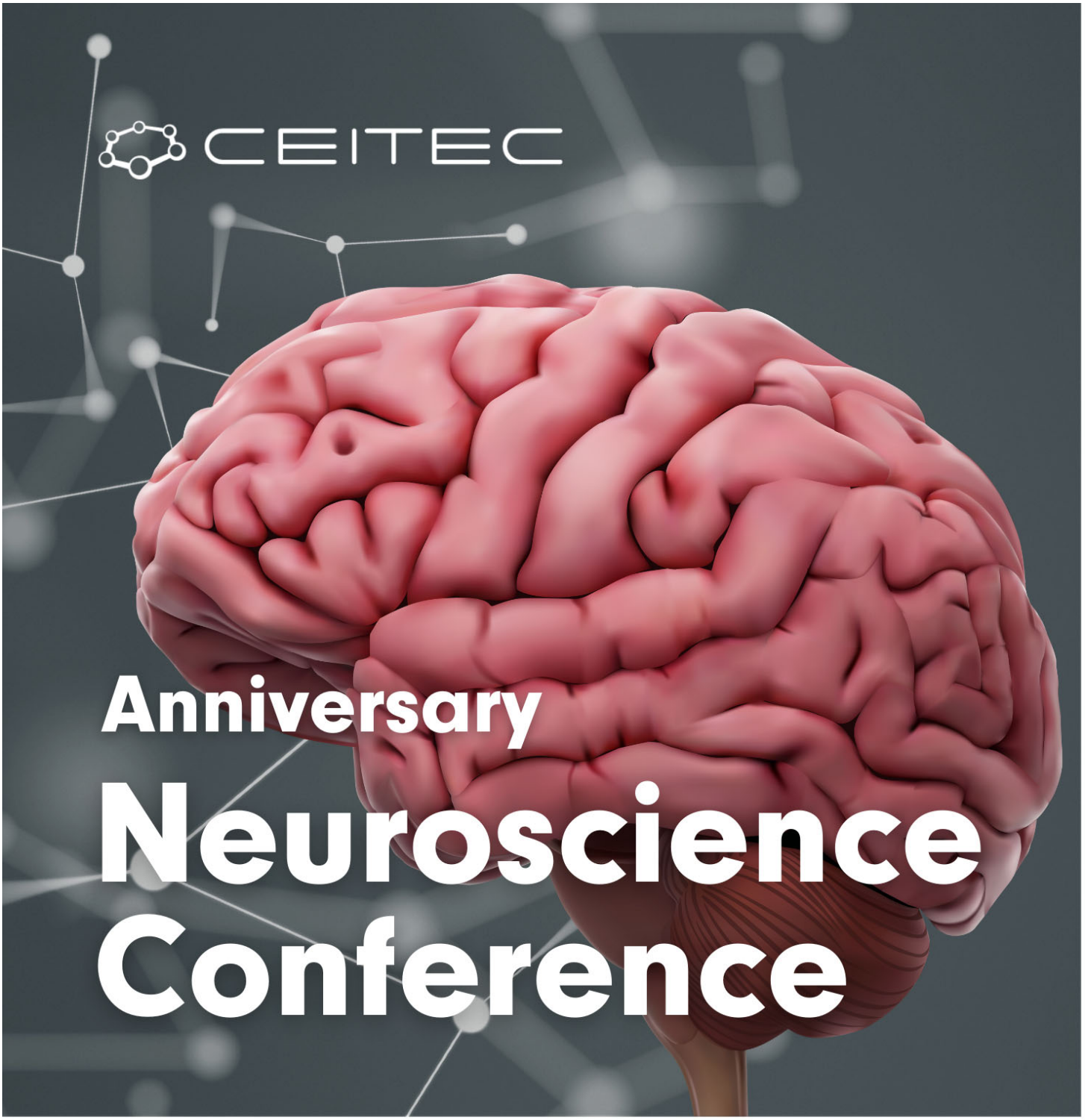

Book of Abstracts

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A whole-brain model of the aging brain during slow wave sleep

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Sleep slow-waves undergo characteristic changes with aging [1], though the underlying mechanisms remain partially unclear. It was previously demonstrated that aging-related changes in slow waves—including reduced frequency, lower amplitude, and increased variability—can be modeled by decreasing excitatory neural drive [2]. Our study [3] investigates whether these excitatory drive reductions align with known age-related white matter deterioration.

We modified an established whole-brain model [4] that connects structural changes to resting state dynamics across healthy aging and extended it to simulate slow-wave sleep states. Starting with a representative connectome from younger subjects (ages 55-63 [5]), we progressively reduced inter-hemispheric connections and simulated sleep-like slow-wave activity using network modeling.

Our results successfully captured key empirically observed trends: decreased slow wave duration and increased variability. By comparing simulated EEG activity with source signals, we propose that the observed amplitude reduction in slow waves results from decreased synchronization between brain regions. These findings support the hypothesis that slow-wave alterations stem from reduced cortical excitatory drive—specifically through diminished inter-hemispheric connectivity.

This model provides a strong foundation for future population studies and intervention research.

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Tools for fMRI data processing developed in CF MAFIL

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Introduction

Functional magnetic resonance imaging (fMRI) represents a unique method for studying brain functions in healthy or pathological conditions. Processing fMRI data is an important step in the way between acquired raw fMRI data and reliable interpretations of the final results. In this work we describe three tools, suitable for quality check of fMRI data and for extraction of information about dynamic functional connectivity.

Methods and results

Two tools, developed for quality control of fMRI data are Mask_explorer and Movement_info. The third tool for estimation of dynamic functional connectivity parameters in the fMRI data is Neuro-TOAST.

Mask_explorer is a graphic user interface (GUI) based tool, designed for exploration of masks with valid data in fMRI analyses. The tool enables computation of group mask, the final 3D space with valid data for group analysis. Additionally, it enables to search for outliers, mostly subjects with abnormal coverage of brain with valid data with respect to the rest of the group. This search could be done manually, or automatically. It can also compute coverage of valid data in specific regions of brain atlases (e.g. AAL atlas). The code is written in MATLAB and is available on the NITRC repository on the page https://www.nitrc.org/projects/mask_explorer/. The software has been published, its usage is under GNU GPL license, conditioned by citation of the tool's publication [1].

Movement_info is similarly to previous tool based on GUI with focus is on exploration of movement parameters, e.g. estimated during the realign procedure. The aim of this tool is to help with identification of datasets excessively influenced with head movement and thus suitable for exclusion from the fMRI analysis. After loading the movement parameters (translations and rotations in three axes), the user can set up thresholds for movement in the datasets. The user is informed about suitable and unsuitable datasets and about translations, rotations in three axes and framewise displacement measure [2], [3], [4] in selected dataset. Moreover, movement in all other datasets is displayed in gray. Users can print list of suitable and unsuitable datasets and additionally also list of unsuitable scans. This is useful e.g. for regressing out the effect of affected scan with general linear model (GLM). The code is written in MATLAB and is available on the NITRC repository on the page https://www.nitrc.org/projects/movement_info. The software is available under GNU GPL license.

Neuro-TOAST tool is focused on specific types of fMRI data analyses called dynamic functional connectivity. The aim of the tool is to enable less experienced users the analysis of dynamics in the fMRI. The user can specify inputs for the analysis in the GUI and subsequently, after successful estimation of the dynamic parameters are displayed results as estimated brain

states and dynamic parameters, e.g. coverage, mean dwell time, etc. The tool was developed in Python and is available on Github under GNU GPL license on following page https://github.com/Neuro-TOAST/app.

Conclusions

Described tools were developed in Multimodal and functional imaging laboratory (MAFIL) on CEITEC, Masaryk university. The tools are designed to help neuroscientists with fMRI data analysis, particularly with the control of data quality and with the analysis of dynamic features of the fMRI data. In the future we aim to contribute to the neuroscience community with tools focused on fMRI related visualizations and simulations.

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Sensorimotor and cognitive brain plasticity in health and disease

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The functional MRI laboratory in Olomouc has been engaged in multiple areas of human neuroscience research. I will report on three recent projects, which were investigated at MAFIL CEITEC MUNI in Brno. First, a project in collaboration with Department of Music Education, Faculty of Education, Palacký University, described perceptual and brain correlates of a novel method training music creativity in young adults (Different Hearing). Second project compared patients with involuntary muscle contractions (cervical dystonia) to healthy controls. Even though several clinical scales did not show statistically significant increases in psychiatric symptoms, fMRI during listening to neutral and negatively emotionally charged words showed more extensive activation in the patients' cerebellum and a spatial shift in activation of Broca's area (left inferior frontal gyrus).

Third, we have taken advantage of MRI-compatible electromyography (EMG) available at MAFIL to acquire simultaneous EMG and fMRI during leg movement with the aim to improve the sensitivity and specificity of movement-related fMRI activation, thanks to quantitative monitoring of task performance.

In summary, collaboration of our team with MAFIL CEITEC allowed us to address several outstanding questions in sensorimotor and cognitive neuroscience.

Beyond the HARNESS protocol, advanced epilepsy neuroimaging in Vienna

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Introduction

The implementation of the HARNESS protocol has standardized epilepsy imaging, optimizing availability of diagnostic resources and lesion detection in structural epilepsy. However, despite these advancements, a substantial number of patients remain MRI-negative, necessitating the use of advanced neuroimaging techniques to identify potential underlying lesions. Given the heterogeneous nature of epilepsy—which encompasses a wide range of etiologies—a diverse array of diagnostic imaging modalities is required to detect subtle pathological and functional changes.

Methods

An overview of advanced neuroimaging techniques employed at the Medical University of Vienna will be provided, highlighting technological advancements ranging from ultra-high field (7T) MRI, metabolic imaging and innovative post-processing techniques to pre-partum detection through fetal MRI.

Results

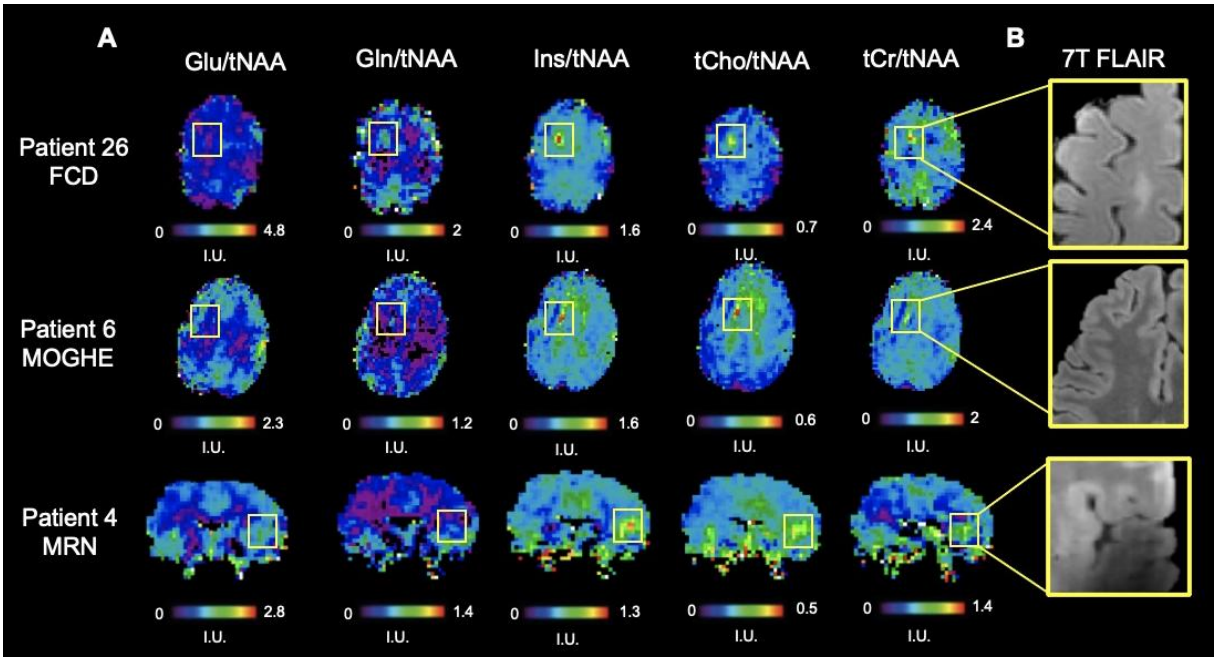
Although symptomatic epilepsy is characterized by brief episodes of neuronal hyperexcitation, the chronic impact of sustained, repetitive seizures is profound and often irreversible. Multiple studies have demonstrated that focal epilepsy is associated with progressive brain atrophy at rates exceeding those attributable to natural aging. In our investigation of predictors of brain volume loss across diverse focal epilepsy etiologies, we found that high seizure frequency is the primary determinant, irrespective of the underlying pathology. These findings support the conceptualization of epilepsy as a distinct disease entity, rather than merely a symptom complex. Beyond volumetric loss, epilepsy is also associated with global microstructural changes, including reductions of DTI-ALPS indices, which correlate with high seizure burden and contrasting atrophy rates, etiology. These structural changes emphasize the critical importance of accurately detecting focal lesions.

To address this, we implemented the 7T Epilepsy Task Force consensus imaging protocol, resulting in improved delineation and lesion detection in 50% of patients compared to clinical 3T. Given the inherently metabolic nature of epilepsy, CRT-FID 7T spectroscopy, generating 3D whole-brain metabolic maps at an isotropic resolution of 3.4 mm further facilitates robust detection of lesional epilepsy and provides valuable insights into neurometabolic processes, particularly of glutamate/glutamine metabolism. For patients with a well-defined seizure onset zone (SOZ) amenable to surgical intervention, intraoperative MRI significantly improved gross lesion resection rates, leading to increased post-operative seizure freedom.

A crucial aspect of epilepsy management lies in understanding its developmental origins. In many cases, epilepsy is not an acquired condition, and therefore the optimal window for disease-modifying interventions occurs before neuronal differentiation, proliferation, migration, and organization are complete. Utilizing fetal MRI, we identified malformations of cortical development (MCDs) at an early stage, demonstrating that frontal lobe involvement is a risk factor for epilepsy development, regardless of MCD subtype. The advent of early neurodiagnostics not only facilitates prompt identification but also opens the possibility for in-utero therapeutic approaches. This is particularly relevant for conditions like tuberous sclerosis complex (TSC) and other mTOR-pathies, where early intervention with mTOR inhibitors could potentially alter disease progression.

Conclusions

These findings underscore the need for advanced neuroimaging techniques in both the diagnosis and management of epilepsy, from early developmental stages to chronic disease states in its use not only as a diagnostic, but also as an explorative tool in disease pathomechanisms.



A Metabolic maps using 7T CRT-FID, alterations are highlighted by the yellow box and the corresponding structural T2-weighted images are provided in **B**.
First row: Axial metabolic ratio maps of patient 26 of Glu, Gln, Ins, tCho and tCr normalized to NAA with histopathologically verified FCD 2a.
Second row: Axial metabolite ratio maps in patient 6 with MOGHE in the left frontal lobe.
Third row: Coronal metabolite ratio maps in patient 4 with MRI-negative focal epilepsy. Based on the extensive clinical work-up, the suspected EZ was located in the right insula, in which MRSI showed metabolite ratios of mIns and tCho, albeit less circumscribed than in the lesional patients.

Processing of complex ME-fMRI data

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Multi-echo fMRI data can be used to optimize sensitivity to the BOLD (blood oxygenation level dependent) response across the brain. The typical data processing pipeline is based on a weighted combination of the time series from individual echoes, followed by standard processing steps used for single-echo fMRI data. However, most fMRI procedures use only magnitude data. The potential of complex fMRI data is not fully exploited, especially in the case of multi-echo data, where phase information is typically discarded, although previous studies show that phase information can improve the identification of non-BOLD signal components. For complex-valued fMRI data, a simple weighted combination cannot be applied to the phase or real+imaginary components. In this work, we introduce a novel approach to preprocess complex multi-echo fMRI data. Our method is based on rotation of complex data with phase range scaling in each voxel to obtain a positive real component.

We used a dataset consisting of 38 healthy volunteers scanned on a 3T Siemens Prisma scanner. Six fMRI runs were acquired during a single session, including a block-designed visual-motor task, an event-related visual oddball task, and resting-state, each with two different repetition times (800 ms and 1800 ms). The three echoes were obtained at the echo times 17, 35, and 52 ms. Data processing was performed in MATLAB 2017b using SPM12 and own scripts.

First, the phase images were converted to radians, and real and imaginary components were calculated from the magnitude and phase data. Motion correction was performed using magnitude data, and the estimated realignment parameters (translations and rotations) were applied to real, imaginary and phase components. Phase time series were temporally unwrapped and scaled to a defined range ($-\pi/4$ to $\pi/4$). Subsequently, maximization of real part for each voxel time-series was applied on real and imaginary component. Temporal SNR (tSNR) maps were computed separately for each echo from the real component. Based on these maps, a contrast-to-noise ratio (CNR) based weighted combination of echoes was performed. The resulting combined complex multi-echo data were used for further preprocessing steps, including spatial normalization to MNI space, spatial smoothing with a Gaussian filter, and activation analysis. Finally, the RETROICOR algorithm was applied to evaluate the variance related to physiological noise.

Activation patterns (FWE-corrected) obtained from complex multi-echo fMRI data closely correspond to those obtained from magnitude-only processing. The imaginary component did not show significant activation. Visual-motor tasks show higher cosine similarity than visual oddball tasks, with values remaining above 0,92, indicating a strong similarity across all tasks and components. Variance explained by motion and physiological regressors in grey matter is lower for the real component than for magnitude data. Variance of imaginary component

can be dominantly explained by physiological or motion artifacts. Complex and magnitude data do not show a difference in tSNR and SNS metrics.

Our results show that processing of complex ME-fMRI data provides meaningful results comparable to those obtained from magnitude data. Variance explained by motion and physiological regressors in the real component is lower than or comparable to the variance in the magnitude data, while imaginary component is highly related to the artificial fluctuations caused by motion or physiological noise, supporting our original hypothesis.

Vertical topography in EEG microstates: Physiology or artifact manifestation?

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Simultaneous recording of electroencephalography (EEG) and functional magnetic resonance (fMRI) is connected with strong artifacts mainly in EEG. Analysis of EEG microstates is very sensitive to residual artifacts in the data and its results can be affected. In addition to the often-reported microstates, or so-called “canonical microstates”, another microstate topography has been reported in the literature – topography with a strong vertical line in the middle (VT).

This topography was also revealed in our simultaneous EEG/fMRI and shielded cabin EEG data collected from 77 participants. We also performed several testing measurements with spherical MR phantom covered with a wet towel and an EEG cap attached on it. EEG/fMRI and cabin EEG data with same protocol as used for humans was recorded with the phantom, VT was the most dominant topography in case of EEG/fMRI, but was not present in cabin EEG data.

Based on our analyses, we consider VT to mainly be a manifestation of artifacts connected with unspecified movements of the EEG cap and its metallic components. This assumption is supported by the significant correlation of the framewise displacement (obtained from human EEG/fMRI) and the spatiotemporal parameters of VT.

We would like to emphasize that microstate analysis is biased by the presence of VT, causing alternations in spatiotemporal parameters of other microstates and their shape distortions. Researchers should pay increased attention if VT is revealed in the data, following analyses can be compromised.

Psilocybin Alters Brain EEG Response to Music

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1.Background: Music drives our attention, induces emotions, inspires us. In the same time, music is hierarchically structured and brain dynamics is closely linked to music during listening. Music is a natural part of spiritual/therapeutic sessions with psychedelics and it is considered to play a central mediating role in psychedelic therapy. In this contribution a broad question how music and psychedelics interact to promote healing is addressed.

2.Methods: We asked two specific questions to the experimental EEG data: How does music entrain neural dynamics and synchronize brain activity? How does the brain entrainment change after psilocybin? EEG data were acquired 100 minutes after psilocybin/placebo administration, each of the 19 participants was subjected to eyes closed listening to 8.5 minutes long psytrance track. The EEG acquisition (Geodesic EEG System 400, HydroCel GSN-256, Fs=1000Hz) was synchronised to the sound presentation. Music was represented by the real cepstral coefficients calculated in a 6.6 seconds long sliding window. Obtained time series of coefficients were correlated to band limited power (Alpha and Beta) fluctuations computed within the same sliding window.

3.Results: In placebo, Alpha power was negatively correlated to presence of longer patterns emerging in the track. The most correlated electrodes corresponded to the occipital region. This phenomenon was not observed after psilocybin. However, significant decrease of Alpha power after psilocybin was observed, which is in correspondence with literature. Strength of EEG-music coupling correlated with 5D-ASC questions related to synesthesia experience.

4.Discussion: The decrease in Alpha power and the absence of the negative correlation with music is suggested to occur due to dysregulation of higher order networks after psilocybin. This explanation is supported by the observation of negative correlations specifically during longer music patterns in placebo condition. In placebo, the occipital cortex is involved in processing of longer patterns while constantly utilised throughout the listening after psilocybin. Still the occipital cortex disinhibition during listening is related to synesthesia experience after psilocybin.

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Activation analysis of T2* time-series from multi-echo fMRI data

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The multi-echo fMRI acquisition provides enhanced sensitivity to the Blood Oxygenation Level Dependent (BOLD) signal by capturing multiple echoes within a single imaging sequence. Moreover, this advanced approach introduces the possibility of incorporating T2* mapping principles into every time point of the imaging data. This abstract explores the pilot study of the multi-echo multi-band (ME MB) fMRI approach coupled with the principles of T2* mapping, as a synergistic strategy for advancing the field of fast functional imaging. This combination may have the potential to enhance the robustness and stability of processed ME MB fMRI data.

Data was collected from 49 healthy volunteers aged 20-38 without any neurological, psychiatric, or mental disorder. The study protocol was approved by the Masaryk University Ethics Committee. The measurements were performed on the Siemens Prisma 3T MR whole-body scanner with 64-channel head-neck coil. The acquisition consisted of high-resolution anatomical images (MPRAGE, voxel size 1x1x1mm, FOV 224 x 224x 240 mm) and then 7 different BOLD runs with block design combining visual stimulation and motor activity (pressing buttons). The acquisition time of each run was 6 minutes, echo times (TE) were 17, 35 and 52 ms, voxel size was 3x3x3 mm. Repetition times (TR), number of scans and flip angles (FA) were different for every run as follows: 1) 3.05 s / 120 / 80°; 2) 3.05 / 120 / 45°; 3) 0.8 s / 450/ 45°; 4) 0.8 s / 450 / 20°; 5)0.6 s / 600 / 45°; 6) 0.6 s / 600 / 20°; 7) 0.4 s / 900 / 20°. Acquired data was processed in as composite ME model data the optimal combinations weighted by the contrast-to-noise ratio in the standard way in SPM12. The second model was calculated as T2* estimation of the same data. The results of activation were verified by using GLM models on single-subject and group levels. We mainly focused on activation level and power of statistics, so we evaluated the differences between multi-echo and T2* models by assessing the number of active voxels, variance of residuals, percent signal change (PSC) and the power of t-statistics. We explored both global and local metrics which were chosen according to the level of activation.

The comparison of ME MB data and T2* data was done using several metrics. For the global level of activation, we computed the number of active voxels, where the T2* model provided similar values as ME model and in runs 3 and 5 the T2* yielded even higher values than ME and these differences were statistically significant. The variance of residuals was slightly worse in T2* model. We also evaluated data in chosen ROIs based on activation and then picked top 50 voxels from each ROI. When comparing the t-values, the T2* model outperformed ME model in some ROIs (Left precentral gyrus), especially in runs 3,4,5,6 where the difference was statistically significant. However, in some other ROIs the T2* model

provided slightly worse results than ME model. Both models provided similar values of PSC in most ROIs, where the T2* model performed significantly better in runs 5, 6 and 7.

The pilot comparison study of ME MB data and T2* mapping showed promising results in terms of acquiring the same or even higher level of data quality in observed metrics. We hope that T2* as a quantitative parameter could contribute to the robustness and stability of the fast fMRI data processing. Although some ROIs gave slightly worse results of T2* than ME model, the overall activation in our data appears to be comparable. We are also planning to verify our theory and results on event-related data or other types of fMRI task data.

Assessment of the reliability of fMRI data from repeated measurements

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Functional magnetic resonance imaging (fMRI) is a key tool in neuroscience and clinical diagnostics, but its utility depends heavily on the reliability and reproducibility of the data, especially when analyzing single-subject or longitudinal data. This study evaluates the test–retest reliability of fMRI data acquired using two methods: single-echo (SE) and multi-echo (ME) BOLD imaging, collected across two sessions using either the same scanner or two identical scanner models.

81 healthy participants (37 women, 44 men, aged 19–59) underwent two fMRI sessions spaced 3–5 weeks apart, using a 3T scanner at the MAFIL laboratory, CEITEC MU. Each session included three cognitive tasks: a motor task (sequential finger opposition, SFO), a verbal fluency task (VFT), and a visual oddball task (VOB). Both SE and ME data were acquired in each session, in randomized order. Participants were grouped into BB (both sessions on the same scanner) or BA (second session on a different but identical scanner model). Data were preprocessed using SPM12 in MATLAB, including motion correction, coregistration, spatial normalization, and smoothing. RETROICOR was applied to a subset of data, and ME-ICA was used for ME datasets. By applying the general linear model (GLM), a model of the relationship between the regressors in the GLM and the BOLD signal time course was created. In this step, five models were constructed:

1. a GLM with the experimental condition as the only regressor (taskonly),
2. a GLM with the experimental condition and motion parameters as regressors (move),
3. a GLM with the experimental condition and motion parameters as regressors applied to data preprocessed with RETROICOR (RTC),
4. a GLM with the experimental condition, motion parameters, and 5 principal components from white matter and cerebrospinal fluid as regressors applied to data preprocessed with RETROICOR (WMCSF_RTC),
5. a GLM with the experimental condition, motion parameters, and 5 principal components from white matter and cerebrospinal fluid as regressors (WMCSF).

Data preprocessed with ME-ICA method were modelled using only the first two previously mentioned GLM. To assess reliability, voxel wise ICC maps were calculated for three metrics: t-maps, contrast maps (con-maps), and percent signal change (PSC), limited to gray matter and averaged within AAL atlas regions. Similarity was also assessed using Pearson correlation, cosine similarity, and Dice coefficients.

The results showed variability between tasks and acquisition methods. Overall, the highest similarity was observed for VFT (avg. 0,527) and SFO (avg. 0,473), while the lowest was for

VOB (avg. 0,418). Similarity for acquisition type was globally higher for ME data (avg. 0,476) than for SE data (avg. 0,469). But the correlation of effects between acquisition types varied by task: ME data showed higher values for VOB (avg. 0,433 vs. avg. 0,404 for SE), whereas SE yielded better results for SFO and VFT (avg. 0,475/0,529 vs. avg. 0,472/0,524 for ME). Type of preprocessing also varied by task, for SFO and VFT the highest similarity was observed for model with task as a sole regressor (avg. 0,539/0,498) followed by WMCSF_RTC, RTC, WMCSF and model with motion regressor having the lowest similarity (avg. 0,456/0,514). For VOB the order was a bit different, RTC yielding the highest similarity (avg. 0,460), followed by move, taskonly, WMCSF_RTC and WMCSF with the lowest similarity (avg. 0,379). Measurement variant BA had slightly better similarity than BB, but without statistical significance. For data processed by PSC this trend was reversed, also without statistical significance. Similar results were obtained with ICC. The highest similarity was observed for VFT (avg. 0,460) and VOB (avg. 0,377), while the lowest was for SFO (avg. 0,329). Similarity for acquisition type was globally higher for SE data (avg. 0,391) than for ME data (avg. 0,386). Similarly, the type of preprocessing varied by task, for SFO and VFT the highest similarity was observed for model with task as a sole regressor (avg. 0,369/0,475), for VOB the highest similarity was observed again with RTC (avg. 0,436). The type of preprocessing was also different for both acquisition types. For ME data, the highest ICC was calculated for RTC (avg. 0,404) and the lowest for taskonly (avg. 0,373), while for the SE data, taskonly showed the highest reliability (avg. 0,432) and the lowest was demonstrated by WMCSF_RTC (avg. 0,359). ICC within AAL atlas regions showed that the highest similarity values were in AAL1 – Precentral_L (avg. 0,548) and AAL19 – Supp_Motor_Area_L (avg. 0,503) and this trend was mirrored within all the general similarity metrics. ME-ICA method did not prove to yield better results, as for all three tasks we have observed ME having higher reliability. Except for ICC calculated from contrast files for VOB, where ME-ICA showed higher reliability (avg. 0,380) than ME (avg. 0,355). Interesting results stem from comparison of scanner variant, where ME-ICA seems to yield better results for BB variant (avg. 0,377 vs. avg. 0,352 for BA variant), while ME yields higher values for BA variant (avg. 0,388 vs. avg. 0,352 for BB variant).

fMRI reliability varies by task, acquisition type, preprocessing, and scanner consistency. VFT showed the highest reliability, while VOB showed the lowest. ME generally outperformed SE for VOB, but SE performed better for SFO and VFT. Simpler preprocessing models (task-only) yielded higher reliability, especially for SE. ME-ICA did not consistently improve results and showed mixed outcomes across scanner variants. The highest regional reliability was observed in motor areas. These findings highlight the importance of optimizing protocols based on task and acquisition specifics.

Prospective Insights into Functional Brain Network Alterations in Early Lewy Body Dementia

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Lewy body diseases are characterized by early alterations in the architecture of brain networks, emerging prior to structural brain degeneration. Although these functional network disruptions are increasingly recognized as early indicators of disease, their contribution to cognitive decline and subcortical atrophy remains unclear. This study investigated whether global graph-theoretical measures of resting-state brain networks are associated with cognitive performance and whether they can predict longitudinal changes in cognition and subcortical brain structure in individuals at the prodromal stage of dementia with Lewy bodies (DLB).

Resting-state functional MRI and structural MRI data were collected from individuals across the prodromal DLB continuum, including those with subjective cognitive complaints and those with mild cognitive impairment exhibiting core DLB features. Cross-sectional associations between graph metrics and cognition were assessed in 112 participants using canonical correlation analysis. Longitudinal outcomes in a subset of 50 participants were evaluated via structural equation modeling to determine whether baseline network metrics predicted subsequent cognitive decline and subcortical atrophy over a two- to four-year follow-up period. In addition, correlations with plasma biomarkers of neurodegeneration (neurofilament light chain) and neuroinflammation (glial fibrillary acidic protein) were explored.

Canonical correlation analysis indicated that greater network segregation—marked by higher modularity and lower clustering—was linked to worse memory performance but enhanced visuoperceptual skills ($Rc = 0.56$, $p = 0.026$), independently of age. Longitudinally, higher modularity was associated with a slower decline in verbal learning ($\beta = 9.31$, $p < 0.001$) and higher neurofilament light levels ($r_p = 0.27$, $p = 0.019$), suggesting a potential compensatory mechanism. Conversely, lower clustering was related to elevated neurofilament levels ($r_p = -0.25$, $p = 0.027$) and predicted greater atrophy in right-sided basal ganglia structures ($\beta = 0.52$, $p = 0.001$), including the putamen, pallidum, and nucleus accumbens—regions implicated in motor and neuropsychiatric symptoms of DLB.

Together, these findings indicate that distinct features of brain network topology may reflect opposing processes of vulnerability and resilience in prodromal DLB. While increased

modularity may help preserve cognitive functions in the face of early neurodegeneration, diminished local connectivity may foreshadow future subcortical structural decline. These results underscore the prognostic relevance of functional network architecture in the early stages of DLB.

Sentence comprehension difficulties in Lewy body diseases: fMRI task and striatal connectivity analysis

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Lewy body diseases, including Parkinson's disease and dementia with Lewy bodies, often involve mild cognitive impairment at diagnosis (mild cognitive impairment with Lewy bodies (MCI-LB). Language dysfunction in MCI-LB patients is often unrecognized. This study aimed toassess syntactic comprehension deficits in MCI-LB patients and to explore their neural correlates. A total of 25 MCI-LB patients (mean±sd: 72±5.6 years old, 10 women) and 25 healthy controls (HC, mean±sd: 66±4.0 years old, 12 women) performed task functional MRI Test of Sentence Comprehension (ToSC). Functional connectivity was analyzed using psychophysiological interaction (PPI) method, focusing on the striatum and language networks. MCI-LB patients had lower ToSC scores than HC (and their PPI analysis revealed decreased connectivity from the striatum to the cuneus, precuneus, and left supramarginal gyrus, and reduced connectivity particularly in the dorsal pathway during noncanonical (syntactically more complex) sentence processing. Taken together, MCI-LB patients showed impaired sentence comprehension related to decreased subcortical-cortical and dorsal language network connectivity. Specific changes in frontotemporal connectivity in LBDs might be a promising indicator of language related cognitive impairment in these a-synucleinopathies.

The Prediction of Seizure Freedom in Non-lesional Temporal Lobe Epilepsy based on Multimodal Imaging data

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Introduction

Accurate prediction of surgical outcomes in drug-resistant epilepsy remains a major challenge, particularly in non-lesional cases. In this study, we present a multimodal, data-driven approach that integrates diverse imaging modalities—structural MRI, fMRI, DWI, and nuclear imaging—to characterize resected brain regions using novel quantitative metrics: Intensity, Ratio, and Extension. These metrics capture local signal deviations, global relevance, and contextual contrast of the resected tissue.

Methods

The study included 19 patients (median age 30, range 17–50; 10 males, 9 females) who underwent temporal lobe surgery. One year surgical outcomes, according to the ILAE scale, included 12 seizure free patients (ILAE 1) and 7 non-seizure free (ILAE > 1).

Imaging methods (IMs), including structural MRI (e.g., gray/white matter volume, cortical thickness, junction), ASL, resting-state fMRI (ALFF, ReHo), DWI (diffusivity and kurtosis metrics), PET, and SPECT, provided a multimodal dataset capturing morphological, perfusion, metabolic, and microstructural properties.

Initially, individual imaging modalities were processed, and resected areas were labeled on postoperative scans. For each imaging method and each operated region, we evaluated three summary metrics: Intensity (mean of voxel values within the resection area), Ratio (ratio of the mean value of the voxels within the resection area to the sum of the values within the whole brain), and Extension (the ratio of the mean values of voxels within the surgical mask and outside the mask).

Based on these metrics, between 2 and 10 of the most informative parameters were selected using ANOVA F-values. These parameters were then used to train supervised machine learning models: Multi-Layer Perceptron (MLP), Support Vector Machine (SVM), and Gaussian Naive Bayes (GNB). Model validation and accuracy assessment were performed using the Leave-One-Out cross-validation method.

Results

90 input parameters were ranked by their ANOVA F-values, and only those with the highest scores were included in the analysis. The highest scores were predominantly achieved by morphological measures (WMC, junction, sulcal depth), fMRI ReHo and ALFF2, and DWI mean diffusivity. Extension was the most frequently selected metric (7×), followed by Ratio (2×) and Intensity (1×).

Among prediction models, the Multi-Layer Perceptron (MLP) yielded the best performance, achieving an average accuracy of 80% for models with 2–10 input parameters, and a maximum accuracy of 89%. Sensitivity ranged from 75% to 92%, and specificity from 57% to 86%.

Conclusion

From a dataset of 90 imaging-derived parameters in 19 patients, we identified key features using F-value scoring and trained machine learning models to predict seizure-free surgical outcomes. The best-performing model, a multi-layer perceptron, achieved up to 89% accuracy, with the most influential features coming from morphological, fMRI, and diffusion imaging metrics.

The Interacting Brain Project: An experimental psychologist's attempt to put the "social" into social neuroscience

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Until fairly recently, social neuroscience has adopted the classic sensory neuroscience approach—to understand the neurocognitive mechanisms underpinning (dys)functional social behaviour, individuals' brains are measured typically while they evaluate experimental social stimuli passively and in isolation. This approach tells us very little about how these neurocognitive mechanisms operate in real-time during social encounters, however; to interact effectively with others, we must process multiple social cues simultaneously in order to infer our fellow interactants' intentions, motivations and emotions, and use this information to continuously adapt our own behaviour in way that steers the interaction towards a desired outcome. In this talk, I present some paradigms that my team have developed to emulate some of the characteristics of naturalistic social encounters and allow us to measure the neurocognitive mechanisms underpinning (dys)functional social cognition and behaviour while they operate online.

Acknowledgements

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Quantitative Neuroimaging: Morphometry, Machine Learning, and Algorithmic Advances

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Modern neuroimaging connects structural brain analysis with computational methods. This talk highlights the evolution of brain morphometry, emphasizing the role of image registration, voxel-wise approaches, and deformation-based techniques. We will also discuss how machine learning is transforming neuroimaging by improving feature extraction and supporting classification tasks. Promising developments in quantitative MRI will be briefly introduced, offering new possibilities for analyzing brain structure at unprecedented levels of detail.

Data FAIRification use case – preparing dataset for OpenNeuro repository

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Introduction

The MAFIL laboratory at CEITEC (Masaryk University) provides advanced imaging services for neuroscientific research. Our aim is to offer complex services and support to our users. Preparation of the data for publication is one of the areas we deal with and in order to implement the necessary tools and procedures, we have used an available dataset as a use-case.

Methods

A sample dataset consisting of MR anatomical and functional data was selected to pilot the FAIRification process in order to verify all aspects, such as technical, legal and practical. Curation processes such as data format conversion, quality check and integrity verification were supplemented by other tasks such as metadata completion, annotation and output validation. Strong emphasis was placed on anonymization, as the original data contain sensitive information. Defacing of high-resolution anatomical images has been performed to ensure the privacy of subjects. Finding a balance between the usability of the data and subject ‘s privacy turned out to be crucial and provided us with valuable insights.

Conclusion

The evaluation of the process showed us tight spots and helped us to look at the task from different angles. Based on this pilot use case, the data handling routines at MAFIL were revised in order to better fit the FAIRification processes. Some of these are currently being implemented to the MAFILDB, the information HUB for data and metadata at MAFIL. Our goal is to provide our users with both expertise and a complex solution for dataset preparation and FAIRification, making upload of their data to the desired repositories as easy as possible.

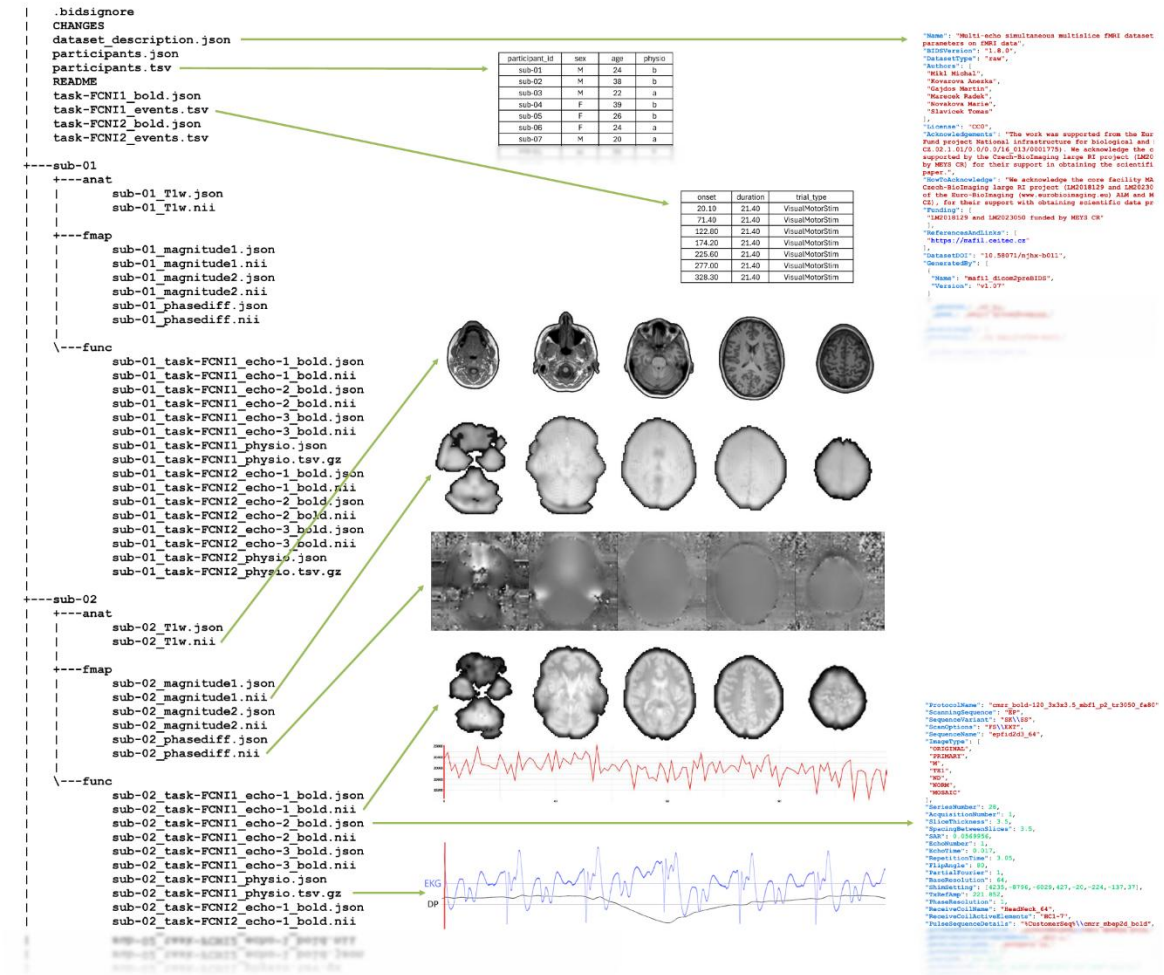

Fig 1. *Scheme of BIDS format structure*

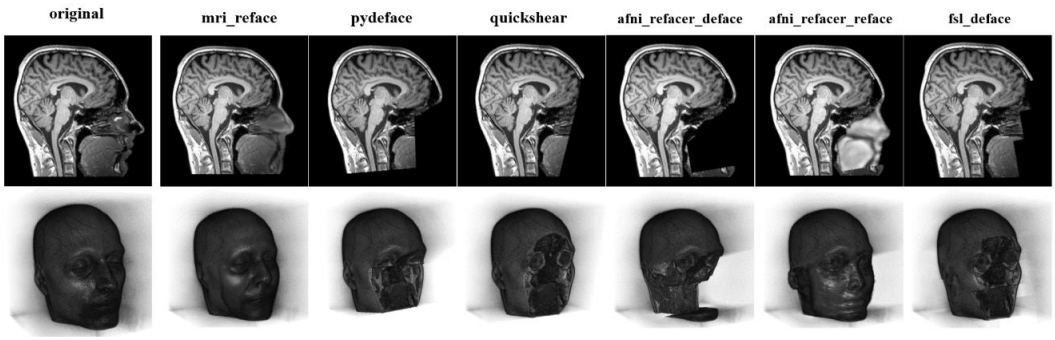

Fig 2. *Result overview of different defacing tools*

Acknowledgement

We acknowledge the core facility MAFIL supported by the Czech-BioImaging large RI project (LM2023050 funded by MEYS CR), part of the Euro-BioImaging (www.eurobioimaging.eu) ALM and Medical Imaging Node (Brno, CZ), for their support with obtaining scientific data presented in this paper.

Evaluation of feature selection for classification of BOLD signal and artifacts in fMRI data

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Multi-echo fMRI data can provide optimal sensitivity to BOLD signals (dependent on blood oxygenation level) and offer different possibilities to suppress some artifacts. One approach is based on independent component analysis (ME-ICA), where the use of multiple echo measurements allows the evaluation of metrics capable of distinguishing the presence of BOLD effects in the data. This method is available in the Tedana software. The aim of this study was to evaluate the ability of automated classification of independent components using machine learning methods, both based on metrics implemented in the Tedana tool and on newly designed metrics.

Two datasets measured on two MRIs were used. The first dataset contains data from 42 healthy subjects and the second contains data from 41 healthy subjects performing 3 types of tasks (block, event-related and rest) and two types of measurements (TR = 800 ms and TR = 1800 ms), i.e. 6 fMRI runs.

The ME-ICA metrics were implemented according to the Tedana tool and new metrics based on data quality assessment (tSNR, SNS) were added (total 15 features). Three raters in each dataset provided expert descriptions of all independent components to create baseline information for experimenting with feature selection and evaluating classification accuracy with different classifiers. Initially, metrics with pairwise correlation coefficients above 0.8 were removed to mitigate multicollinearity. The attribute selection process was based on the information gain metric, which evaluates the importance of individual attributes in relation to the target variable. Information gain values were first calculated for all available attributes in the dataset. Then, a threshold value was determined for classifying an attribute as important based on the standard deviation of these values. Features with information gain values exceeding this threshold were marked as important and included in the final model. Random Forest was used as the classification model.

From the original 13 attributes (after removing highly correlated attributes), 8 attributes were identified using the above method. The most significant features for classification were selected: SNS, kappa, tSNR, signal_noise_t and clustering ratio (CR). According to these attributes, the model was trained on the first dataset and evaluated on the second dataset. The same was done in reverse. The classification results of the trained model, compared to expert evaluation, achieve an average accuracy of 96.6%. Furthermore, a comparison was made using the decision tree in the tedana software and expert evaluation, where an accuracy of 93% was achieved. Our study shows that automatic classification in the ME-ICA method is sufficiently robust and metrics based on data quality assessment can be effectively

combined with the original ME-ICA metrics applicable for preprocessing multi-echo fMRI data.

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Inter-Brain Plasticity Underlies the Development of Social Connectedness

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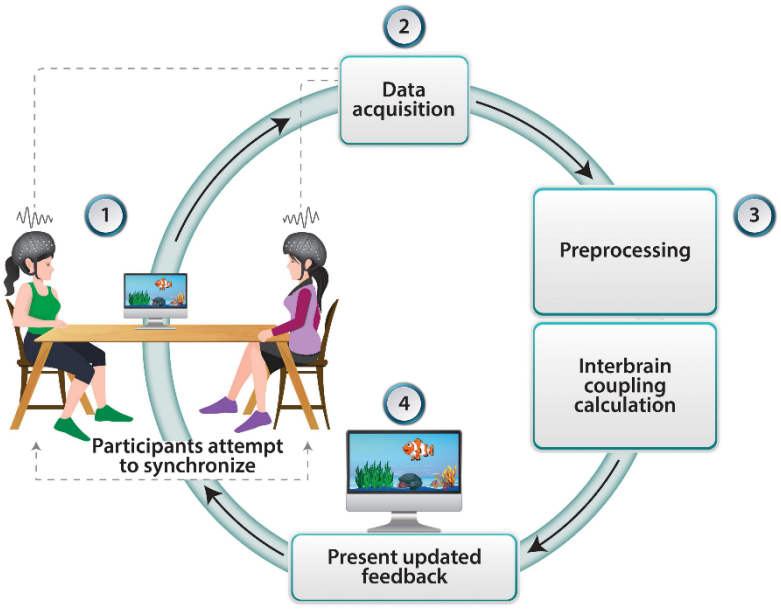
In recent years, inter-brain synchrony has been increasingly recognized as a fundamental mechanism underlying various forms of social connectedness during interactions. In a recent study using functional near-infrared spectroscopy (fNIRS) we demonstrated that inter-brain synchrony between clients and psychotherapists dynamically changes in the inferior frontal gyrus (IFG) over the course of psychotherapy. However, it remains unclear whether inter-brain synchrony can be actively trained and whether such training translates into increased social connectedness and empathy.

To address this question, we developed a dyadic neurofeedback platform using fNIRS to provide real-time feedback targeting the IFG. Ninety-two participants were randomly assigned into dyads and allocated to either an experimental group or a control group. The training consisted of three sessions over one week.

Results revealed that ratings of social connectedness increased more steeply in the experimental group compared to the control group. Crucially, a significant group-by-session interaction was observed in the IFG, such that the experimental group exhibited a progressive increase in IFG synchrony relative to baseline across sessions, whereas the control group showed no significant change in inter-brain synchrony. This evidence advances our understanding of inter-brain plasticity and highlights its potential applications in fostering socio-emotional well-being.



The mediating role of brain development in the intergenerational transmission of risk for mental illness.

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Mental illness runs in the family. A family history of mental illness is the most important risk factor for the development of mental health problems. About 60-70% of children with a parent with severe mental illness (SMI), e.g. schizophrenia, bipolar disorder, major depression, will develop a mental disorder in their life course. This prevalence is much lower in the general population, approximating ~20% of adults; this suggests an intergenerational transmission of disease risk from affected parents to offspring. Despite ample evidence that mental illness can be passed from parent(s) to children, how and when this occurs is still poorly understood. Studies with a variety of family-based designs have suggested that the aetiology of SMI is governed by a complex interplay of genetic factors and environmental risk. Developmental brain features (e.g. intracranial and brain growth, myelination, connectome development) possibly mediate how genetic and environmental factors ultimately materialise into mental disorders. I will present neuroimaging findings showing that across the life course those at familial high risk for schizophrenia or bipolar disorder share common brain abnormalities with patients, albeit with smaller effect sizes, suggesting a role for (early) brain development in the onset of SMI.

Early Changes in Dementia with Lewy Bodies: Locus Coeruleus, Functional Connectivity, and Cognition

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Multidomain cognitive impairments, including fluctuations in cognition and alertness, characterize dementia with Lewy bodies (DLB). DLB is further associated with neuromodulatory dysfunction and changes in electrophysiology and functional brain networks. However, it remains unclear how much these alterations are detectable during the prodromal stages of the disease.

In this study, we investigated both dynamic and static whole-brain functional connectivity (FC) derived from source-reconstructed resting-state electroencephalography, alongside assessments of locus coeruleus (LC) integrity using neuromelanin-sensitive magnetic resonance imaging. Our sample included 58 cognitively normal individuals exhibiting core clinical features of DLB (CN-CCF), 39 patients with mild cognitive impairment due to DLB (MCI-LB), and 29 healthy control participants.

Results revealed a nonlinear trajectory in whole-brain FC connectedness (average node strength) and temporal variability (fluidity) across levels of symptom severity, particularly within the delta frequency band. Both measures were significantly elevated in CN-CCF and MCI-LB subjects who presented with only a single core DLB feature. Moreover, these FC indices were positively associated with executive function performance after controlling for premorbid intelligence. Notably, FC fluidity demonstrated a significant association with right caudal LC integrity, with this relationship being more pronounced in individuals with lower cognitive reserve.

These findings suggest that heightened dynamic reconfiguration and increased connectivity may represent compensatory neural mechanisms in the early stages of DLB, potentially aiding in the temporary preservation of cognitive function. As the disease progresses, these compensatory processes appear to diminish.