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Symposia

S.01: Multimodal neuroimaging investigations of sleep. (ID: 130)

Chair(s): Christophe Grova (Multimodal Functional Imaging Lab, PERFORM Centre / Physics Dpt, Concordia University, Canada), Birgit Frauscher (ANPHY Lab, Montreal Neurological Institute, McGill University, Canada)

The MNI open iEEG atlas: in-situ brain physiology to assess regional variations of sleep neurophysiology in the human brain

Birgit Frauscher
Montreal Neurological Institute, McGill University, Canada

Regional variations in oscillatory activity during human sleep remain largely unknown. The ideal tool to address this question is intracranial electroencephalography, as it offers high spatio-temporal resolution to study in-situ brain physiology. We assessed regional variations of sleep activity capitalizing on the MNI iEEG atlas. The MNI iEEG atlas contains open-access iEEG recordings across the sleep wake cycle built from a total of 106 patients from 3 tertiary epilepsy centers (https://mni-open-ieegatlas.research:mcgill.ca). Here we present data for sleep available from 1,468 channels grouped into 38 regions (von Ellenrieder et al., Ann Neurol 2020). Major findings were: (i) There are regional differences in the distribution of sleep transients and spectral content during all sleep stages following a caudo-rostral gradient. (ii) Deep-seated structures show spectral peaks differing from the baseline EEG. The regions with >60% of channels presenting significant rhythmic activity were either mesial or temporal basal structures usually contributing only minimally to the scalp EEG. (iii) During deeper sleep stages, EEG analysis reveals a more homogeneous spatial distribution, with increased coupling between high and low frequencies. In conclusion, analysis of this unique open access database allowed to provide a better understanding of the regional variability of sleep.

EEG microstates of dreams

Lucie Brechet
Université de Genève, Switzerland

Most of us are dreaming every night, although we are unlikely to remember any of our dreams. Here, we questioned which brain states determine whether dreams will occur and what prevents us from waking up during dreaming. We provide evidence that NREM sleep consists of alternating EEG microstates. These brain states' transient temporal dynamics indicate temporary suppression of neural integration and communication within two distinct large-scale networks, one comprising the frontal and temporal brain regions, while the other was located in the occipital areas thalamus and extending to the brainstem. Specifically, we show that "the awakening of the posterior hot zone" brain areas during dreaming is counterbalanced by a deeper local de-activation of prefrontal brain regions. The former may account for conscious experiences with rich perceptual content, while the latter may account for why the dreaming brain may undergo executive disconnection and remain asleep. Another exciting finding of this study is the demonstration that high-density EEG source imaging can illuminate deep brain structures, the thalamus and the midbrain of the brainstem, that play a crucial role in the regulation of local sleep. Future studies should combine simultaneous intracranial recordings in deep structures with scalp EEG to confirm these findings.

Imaging neural, hemodynamic, and cerebrospinal fluid flow dynamics in the sleeping brain

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Sleep is essential for maintenance of healthy brain function. Sleep changes diverse aspects of brain physiology, and exhibits unique electrophysiological oscillations, behavioral states, vascular dynamics, and waste clearance properties. To investigate how these multiple aspects might be coupled during sleep, we used simultaneous fast fMRI and EEG to measure fluid and neural dynamics in the human brain. We found a coherent pattern of coupled electrophysiological, hemodynamic, and cerebrospinal fluid (CSF) dynamics that appears during non-rapid eye movement sleep. Neural slow waves are followed by hemodynamic waves, which in turn are coupled to CSF flow. These results demonstrate that the sleeping brain exhibits waves of CSF flow on a macroscopic scale, and these CSF dynamics are interlinked with neural and hemodynamic rhythms. This approach also illustrates how new techniques for multimodal imaging of diverse aspects of brain physiology can uncover how these interacting systems are coupled during sleep.

Autonomic Contributions to BOLD Signal and Functional Connectivity during In-scanner (Micro) sleep

Michael Chee
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Falling asleep is common in fMRI studies. By using long eyelid closures to detect microsleep onset, we showed that the onset and termination of short sleep episodes invokes a systematic sequence of BOLD signal changes that are large, widespread, and consistent across different microsleep durations. The signal changes are intimately intertwined with shifts in respiration and heart rate, indicating that autonomic contributions are integral to the brain physiology evaluated using fMRI and cannot be simply treated as nuisance signals. Additionally, resting state functional connectivity (RSFC) was altered in accord with the frequency of falling asleep and in a manner that global signal regression does not eliminate. Sleep, breathing and cardiac action are influenced by common brainstem nuclei. Our findings point to the need to develop a consensus among neuroscientists using fMRI on how to deal with microsleep intrusions. Minimally, autonomic and central nervous system contributions to BOLD signal have to be jointly considered when interpreting fMRI and RSFC studies.

S.02: Clinical Neurophysiology of Vigilance and Cognitive Systems in Affective and Dementing Disorders: New Insights. (ID: 121)

Chair(s): Claudio Babiloni (Sapienza University of Rome, Italy), Gorsev Yener (Izmir University of Economics, Faculty of Medicine, Turkey)

Pathogenetic role of brain arousal regulation in affective disorders and ADHD

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The conceptual framework and empirical evidence for the pathogenetic role of arousal and wakefulness dysregulation in both affective disorders and ADHD will be presented. Converging evidence from preclinical as well as clinical studies indicate that in major depression (MD) an upregulated brain arousal and in ADHD an unstable brain arousal regulation play a central pathogenetic role. The hyperactivity and sensation seeking observed in overtired children, ADHD and mania is interpreted as an autoregulatory attempt of the organism to stabilize brain arousal level by increasing external stimulation. Correspondingly the withdrawal and sensation avoidance in MD is interpreted as a reaction to a state of tonically upregulated arousal. The EEG-based algorithm VIGALL 2.1 (Vigilance Algorithm Leipzig) allows to objectively assess the level as well as the regulation of brain arousal within a 20-minutes EEG recording under quiet rest. Further support for this concept is provided by a GWAS showing that the genetic variant most closely associated with upregulated brain arousal (assessed with VIGALL 2.1.) has also been found by others to be associated with depression. An upregulated brain arousal at baseline in major depression predicts response to antidepressants, and low arousal levels are related to hypomanic personality as well as to extraversion and openness to experience in healthy subjects. Wakefulness regulation as assessed with VIGALL 2.1 is an important transdiagnostic, pathogenetic and response-predictive biomarker.

Different abnormalities of EEG markers in quiet wakefulness are related to visual hallucinations in patients with Parkinson's and Lewy Body Diseases

Claudio Babiloni[1,2,] Bahar Güntekin[3,4], Roberta Lizio[1], Susanna Lopez[1], Giuseppe Noce[1], Peter Fuhr[5], Joh-Paul Taylor[6], Ian McKeith[6], Flavio Nobili[7], Laura Bonanni[8], Claudio Del Percio[1],
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Different abnormalities of EEG markers in quiet wakefulness are related to visual hallucinations in patients with Parkinson's and Lewy Body Diseases. The objective was to Investigate the relationships between resting state EEG (rsEEG) rhythms in quiet vigilance and visual hallucinations in Parkinson's (PD) and Lewy Body (LB) diseases with cognitive deficits. We extracted clinical, neuropsychological, demographic and rsEEG datasets in matched LB (N=60), Alzheimer's disease (AD; N=60), PD (N=80), and healthy elderly (Nold, N=60) seniors from an international database. The eLORETA freeware was used to estimate cortical rsEEG sources at individual delta, theta, alpha1, alpha2, and alpha3 bands based on individual alpha frequency peak and fixed beta1, beta2, and gamma bands. As compared to the AD group, the DLB and PD exhibited greater abnormalities in widespread delta source activities and lower abnormalities in posterior alpha source activities. Notably, visual hallucinations were related to abnormal delta and alpha source activities in the DLB and PD patients, respectively. These results confirm previous evidence of abnormalities of rsEEG delta and alpha source activities in PD and DLB patients over controls. As a novelty, they unveiled that in PD and DLB patients, visual hallucinations may be related to different abnormalities in cortical neural synchronization at delta and alpha frequencies suggesting a diverse weight of sleep intrusion and attentional mechanisms.

Event-related oscillatory coherence in patients with dementia and mild cognitive impairment due to Alzheimer's disease

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The Alzheimer's disease spectrum includes patients at mild cognitive impairment (MCI) and dementia (ADD) stages. The main difference between these stages is the preserved daily functioning in MCI. The aim of this study was assessing brain event-related oscillatory response (EROs) functional connectivity of the mild cognitive impairment and dementia due to Alzheimer's disease with healthy elderly subjects. The study included 43 individuals with MCI, 43 with ADD, and 68 demographically-matched healthy elderly controls (HC). Delta, theta, alpha, beta, gamma bands EEG event-related imaginary coherency (ICoh) was measured during an oddball paradigm. Inter-hemispheric, midline and intra-hemispheric ICoh values were compared in ADD, MCI and HC groups. ADD patients display decreased theta, delta, alpha EROs connectivity during the cognitive task compared with MCI and healthy controls. The MCI group shows higher theta EROs connectivity during the cognitive task compared with healthy control. Recent literature suggests hyperconnectivity occurs at the early stages, i.e., MCI stage of Alzheimer's disease, whilst hypoconnectivity develops at dementia stages. Hyperconnectivity may be a compensatory mechanism to maintain brain functional connectivity at the MCI stage.

S.03: Imaging Psychosis from general neuropathology to specific psychopathology. (ID: 142)

Chair(s): Sebastian Walther (University of Bern, Switzerland), Igor Nenadic (University of Marburg, Germany)

Subcortical Circuits in Psychosis and the Psychosis Spectrum

Prof. Jessica Bernard

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Schizophrenia, and psychotic disorders more generally, represent a life changing diagnosis, that for many, dramatically alters quality of life and long-term functional outcomes. Efforts to better understand etiology and symptomatology of psychotic disorders have focused on brain networks, and brain network dysfunction is consistently reported across psychosis-spectrum disorders. Two key subcortical regions, the cerebellum and basal ganglia, play important roles in disease course and symptomatology. While there is now a large body of evidence independently implicating both the cerebellum and basal ganglia in schizophrenia, and across the psychosis spectrum, to this point, these subcortical structures have been considered independently of one another. Recent work in non-human primates demonstrated direct connections between these regions, and it has been suggested that these evolutionarily conserved connections may be important for the emergence of cortical network architecture. These connections between the cerebellum and basal ganglia are also present in the human brain, and we hypothesize that subcortical network dysconnectivity may contribute, at least in part, to the cortical network dysfunction seen in psychosis, and across psychopathology more broadly. Here, using large-scale data sets we investigated subcortical connectivity and how it relates to cortical network organization using graph theoretic measures and symptoms of psychopathology.

Imaging the psychosis spectrum: From schizotypy to high-risk and clinical stages of schizophrenia

Prof. Igor Nenadic

University of Marburg, Germany

Perceived threat - brain imaging of Paranoia in Schizophrenia

Prof. Katharina Stegmayer

University of Bern, Switzerland

Paranoia is a frequent and highly distressing experience in schizophrenia. Modern models of paranoia suggest the limbic system to be involved in the formation of paranoia. We aim to demonstrate weather alterations are found within the limbic network, particularly the amygdala, hippocampus and orbitofrontal cortex in patients with current paranoia compared to patients without paranoia and controls. MRI data was collected in two studies. The first study included 165 subjects (89 patients), and the second study 151 subjects (101 patients). Paranoia was assessed using a Positive And Negative Syndrome Scale composite score as well as specific paranoia scales respectively. We tested rs-fc between bilateral nucleus accumbens, hippocampus, amygdala and orbitofrontal cortex as well as whole brain gray matter density between groups and as a function of paranoia severity. We found altered gray matter volume within and increased rs-fc between hippocampus and amygdala in patients with compared to without paranoia. Likewise, paranoia severity was linked to increased connectivity between hippocampus and amygdala. Our results suggest these brain regions to be relevant for the formation of the experience of paranoia.

Quantitative multiparametric mapping: concordances and differences between periodic catatonia and / vs cataphasia

Prof. Jack Foucher
University of Strasbourg, France

Periodic catatonia (PC) and cataphasia (K) are two highly heritable phenotypes of psychosis. Though two-thirds of both meet the criteria for schizophrenia or schizoaffective disorder, they present specific residual symptoms: semantic and syntactic disorders in K and psychomotor disorganization in PC. Recently, we confirmed our previous rCBF results showing a double dissociation: hypoperfusions of the temporoparietal junctions (TPJ) in K and hyper-perfusions of premotor and sensorimotor cortices in PC. Normal controls (n=38), PC (n=30) and K (n=12) were compared on whole brain gray matter probability (pGM; VBM) and seven quantitative MRI parameters, i.e. R1, R2, R2*, macromolecular proton fraction (f), magnetic susceptibility (χ), fractional anisotropy and diffusivity ($\langle D \rangle$; VBQ analysis, pnc < 10-4; k > 1 cm3). Relative to controls, PC and K had increased pGM and decreased R2 and f in the striatum suggestive of antipsychotic-related neuritic sprouting. A K-specific pattern was observed suggesting an oligodendrocyte loss in both the gray and white matter of the TPJ bilaterally: f and χ decrease, $\langle D \rangle$ increase. This fits with the hypoperfusion of the same regions and the dramatic reduction in their functional connectivity with all peri-sylvian cortices. This meaningful simple dissociation provides new evidence for distinguishing these two phenotypes of psychosis.

S.04: Concurrent EEG-fMRI: Developments in Methods and Applications. (ID: 108)

Chair(s): Mark Steven Cohen (University of California Los Angeles), Agatha Lenartowicz (University of California Los Angeles, United States of America)

Characterizing Resting-state Brain Activity with Simultaneous EEG-fMRI

Dr. Thomas Liu
University of California, San Diego

Resting-state functional magnetic resonance imaging (rsfMRI) is a widely used method to characterize the functional organization of the brain at rest for both research and clinical applications. However, the mechanisms underlying the rsfMRI signal are still poorly understood. There is growing evidence, primarily from simultaneous EEG-fMRI studies, that fluctuations in vigilance and arousal can have a profound effect on the analysis and interpretation of rsfMRI signals and derived metrics. In this talk I will discuss how simultaneous EEG-fMRI has played a critical role in furthering our understanding of the factors that contribute to resting-state brain activity.

Assessment of oscillations and attention in ADHD

Dr. Agatha Lenartowicz
University of California Los Angeles, United States of America

One of the most powerful features of concurrent EEG-fMRI methodology is the complementary nature of signals recorded, offering the opportunity for a richer, more comprehensive perspective on neural systems. In this talk I will discuss new perspectives gained in our understanding of the attention system, through the analysis of network correlates of alpha-range (8-12 Hz) oscillations during working memory encoding, and their modifications in individuals with attention-deficit hyperactivity disorder (ADHD). I will discuss both insights gained regarding the neural circuitry of attention deficits and the knowledge gained in understanding the disorder behaviorally, considering broader progress in this research domain. As part of this effort, I will discuss the unique challenges and potential solutions of application of concurrent EEG-fMRI methodology to pediatric and neuropsychiatry populations.

Methodological development and application for sleep EEG-fMRI studies

Dr. Makoto Uji
Concordia University, Montréal, Canada

Simultaneous recording of electroencephalography (EEG) and functional magnetic resonance imaging (fMRI) is a very promising non-invasive neuroimaging technique. However, EEG data obtained from the simultaneous EEG-fMRI recording are strongly influenced by MRI-related artefacts, namely gradient artefacts (GA) and ballistocardiogram (BCG). When compared to the GA correction, the BCG correction is more challenging to remove due to its inherent variabilities and dynamic changes over time, especially for longer data acquisition of sleep and resting state EEG-fMRI. Conventionally, the BCG artefacts are corrected based on R-peaks detected from the electrocardiogram (ECG), but the ECG is also distorted in the MRI scanner, sometimes becoming problematic. I will discuss two potential solutions, which are software (spatial filtering beamforming technique) and hardware (Carbon-wired loop) solutions. Both solutions appear promising for the BCG corrections without relying on the ECG recordings. Furthermore, I will discuss how to implement these methods for the sleep EEG-fMRI studies, to better understand brain activity during sleep. These methodological developments and applications allow us to advance our understanding of how the sleeping brain works, the functions of sleep and the implications of insufficient sleep. Sleep EEG-fMRI could enable us to push the frontiers of sleep science and unravel the mysteries of sleep.

Future directions from hardware to application

Dr. Karen Mullinger
University of Nottingham and University of Birmingham, UK

We always strive to improve data quality to enable the boundaries of the neuroscience which can be performed with EEG-fMRI to be pushed further. I will highlight the challenge of small artefacts generated in EEG data by head motion, which is now widely accepted. I will present a number of methods which have been developed to remove these motion artefacts from EEG data and discuss the merits of each. I will show the potential that a reference layer EEG cap design affords to improve the quality of the EEG data with the potential of overcoming a number of residual artefacts in EEG data allowing a wider range of EEG neurophysiological signals to be interrogated when performing EEG-fMRI. Laminar fMRI work is rapidly expanding to improve our understanding of feedforward and feedback mechanisms in a variety of tasks. I will show the potential benefits of high-quality EEG when going to ultra-high field (7 T) MRI to gain new insight as to the feed-forward or feed-back origins of neuronal oscillations. I will explore how this approach might compliment other techniques available to broaden our understanding of the functional role of oscillations in the future.

S.05: Neural synchrony and oscillations in neuropsychiatric disorders. (ID: 111)

Chair(s): Brian F. O'Donnell (Indiana University, USA), Bahar Güntekin (Istanbul Medipol University, Turkey)

Oscillatory activities in multiple frequency bands in patients with schizophrenia

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Patients with schizophrenia show impairment in binding stimulus features, which are reflected in disturbed oscillatory activities, into coherent objects. This study aimed to identify disturbances in multiple oscillatory bands during perceptual organization of apparent motion in patients with schizophrenia. EEG was recorded from healthy controls and patients with schizophrenia during continuous presentation of apparent motion stimulus which induces reversals between two endogenously generated perceptions. A control stimulus with exogenous reversals was used to differentiate between endogenous and exogenous perceptual processing. Band-pass filtered and Morlet wavelet transformed event-related oscillations were analyzed in delta (0-4 Hz), theta (4-8 Hz), alpha (8-13 Hz), beta (14-28 Hz), and gamma (28-48 Hz) bands. Patients showed decreased delta and theta activity. Endogenous reversal-related posterior alpha decrease was stronger in patients with schizophrenia. Both groups showed decreased reversal-related beta activity. Gamma activity in endogenous condition was shifted from posterior to central regions in patients. This is the first study that examined activity in all frequency bands to determine dysfunctional integration processing in patients with schizophrenia. Results indicated to impairments in top-down organization of ambiguous percepts in patients with schizophrenia. There seems to be a compensatory increase in bottom-up processing at posterior areas.

Event-Related Oscillatory Responses in patients with Parkinson's disease with and without dementia

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Studies on Event Related EEG Brain Oscillations presented essential results on understanding cognitive brain function and cognitive decline in different pathologies. The present research aimed to show the potential electrophysiological indicators of cognitive decline in patients with Parkinson's disease with and without dementia. EEG of 75 patients with Parkinson's disease (PD without cognitive deficits, PD with mild cognitive impairment, PD with dementia), 14 patients with DLB and 25 healthy controls were recorded during visual, auditory oddball paradigms. Event-related power spectrum and phase locking were evaluated in delta and theta, frequency bands. Event related delta and theta power and phase locking increased with a cognitive load in healthy subjects but these responses decreased in PD patients who have mild cognitive impairment and dementia ($p<0,005$). Delta and theta responses decreased gradually as the cognitive decline increased. The present study showed that PDD have abnormal delta and theta responses compared to healthy controls. PDD had a severe reduction of delta-theta power and phase-locking, which are the essential signs of cognitive decline.

From receptors to neural network oscillations: Multimodal Imaging using PET and EEG in cannabis use

Patrick Skosnik
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Positron emission tomography (PET) is the imaging modality par excellence for the study of neuroreceptors. However, PET typically cannot yield information related to function. Conversely, EEG is one of the few modalities that can directly measure the electrical activity of the brain with high temporal precision. This talk will present data using a combined PET/EEG approach in chronic cannabis users. PET will include data on receptors intimately involved in cannabinoid function (e.g., CB1 and mGluR5). PET data will be integrated with EEG outcomes known to be sensitive to cannabis exposure (e.g., theta and gamma oscillations), thus providing novel insights into the neural correlates of chronic cannabis exposure.

Sensory Entrainment in Schizophrenia Spectrum Disorders

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Despite decades of research, the neurobiological basis of schizophrenia remains elusive. Extrapolating connections between disparate levels of analysis may provide a more comprehensive understanding of at least some aspects of this complex disorder. The auditory steady state response (ASSR) is a measure of neural synchrony and oscillation that has been extensively studied in this population and may represent a potential biomarker of schizophrenia. Moreover, the ASSR can be recorded in rodent and non-human primate models. At the cellular level, the ASSR is thought to rely on the interaction between excitatory glutamatergic and inhibitory GABA systems via the NMDA receptor, which may be disrupted in individuals with schizophrenia. Coordinated neural firing is also likely impacted by higher levels of neuroinflammation found in different stages of the disorder. On a behavioral level, neural oscillations within the gamma (40 Hz) frequency range have been associated with sensory and cognitive functioning, both of which are also disrupted in individuals with schizophrenia. Intriguing rodent studies have shown that gamma range stimulation may have lasting neurophysiological impacts. Therefore, the ASSR is a cross-species paradigm that allows us to probe basic neural network alterations that may be responsible for some of the cognitive and perceptual symptoms found in those with schizophrenia.

S.06: Recent innovations in M/EEG microstate analysis: methodological development and clinical applications. (ID: 107)

Chair(s): Tomas Ros (University of Geneva, Switzerland), Martijn Arns (Brainclinics Research Institute)

Beyond broadband: towards a spectral decomposition of EEG microstates

Victor Ferat
University of Geneva, Switzerland)

Originally applied to alpha oscillations in the 1970s, MS analysis has since been used to decompose mainly broadband EEG signals (e.g. 1-40 Hz). In this study using a large open-access dataset (n=203), we decomposed EEG recordings into 4 classical frequency bands (delta, theta, alpha, beta) in order to compare their individual MS segmentations. Firstly, we confirmed that MS topographies were spatially equivalent across all frequencies, matching the canonical broadband maps (A, B, C, D). Using mutual information, we observed strong informational independence of MS temporal sequences between spectral bands, together with significant divergence in traditional MS measures (mean duration, time coverage). For example, relative to broadband, alpha/beta band dynamics displayed greater time coverage of maps A & B, while map D was more prevalent in delta/theta bands. Moreover, by using a frequency-specific MS taxonomy (e.g. θA, αC), we were able to predict the eyes-open vs closed-behavioural state significantly better using alpha-band MS features compared with broadband ones (80% vs 73% accuracy). Overall, we demonstrate the value of spectral MS analysis for decomposing the full-band EEG into a richer palette of frequency-specific microstates. This could prove useful for identifying new neural mechanisms in fundamental research and/or for biomarker discovery in clinical populations.

Spectral microstate signatures of post-traumatic stress disorder (PTSD)

Braeden Terpou
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We applied the "spectral" microstate (MS) framework recently proposed by Férat et al (2020) to a clinical population of patients with post-traumatic stress disorder (n=61) and a neurotypical control group (n=61). Direct comparisons of classical microstate measures (time coverage, mean duration, occurrence) between broadband (1-30 Hz) and narrow-band (delta, theta, alpha, beta) segmentations demonstrated band-specific signatures of PTSD that were not fully captured by broadband analyses. This was confirmed by results from classification analyses, which were used to predict PTSD vs control group subjects using machine learning. Overall, predictive accuracy was higher using narrow-band compared to broadband MS metrics. Our findings demonstrate the value of spectral MS analysis for accessing finer-grained information contained in multi-channel EEG, which may improve the discovery of functional biomarkers in clinical disorders.

MEG cortical microstates: spatiotemporal characteristics, dynamic functional connectivity and stimulus-evoked responses

Luke Tait
University of Birmingham

EEG microstate analysis is a useful approach for studying brain states - nicknamed 'atoms of thought' - and their fast transitions in healthy cognition and disease. A key limitation of conventional microstate analysis is that it must be performed at the sensor level, and therefore gives limited anatomical insight into the cortical mechanisms underpinning these states. In this study, we generalise the microstate methodology to be applicable to source-reconstructed electrophysiological data. Using simulations of a neural-mass network model, we first established the validity and robustness of the proposed method. Using MEG resting-state data, we uncovered ten microstates with distinct spatial distributions of cortical activation. Multivariate pattern analysis demonstrated that source-level MEG microstates were associated with distinct functional connectivity patterns. Using a passive auditory paradigm, we further demonstrated that the occurrence probability of MEG microstates were altered by evoked auditory responses, exhibiting a hyperactivity of the microstate including the auditory cortex. Our results support the use of MEG source-level microstates as a data-driven method for investigating brain dynamic activity and connectivity at the millisecond scale.

S.07: Connecting to the networks of the human brain by EEG-guided closed-loop TMS. (ID: 110)

Chair(s): Risto Ilmoniemi (Aalto University, Finalnd), Laura Marzetti (University of Chieti-Pescara, Italy)

Hardware and software for multi-locus TMS

Timo Roine
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In transcranial magnetic stimulation (TMS), a magnetic pulse induces brain activity which can be measured in real time with electroencephalography. TMS has been approved widely for therapeutical applications. Traditionally, the stimulation coil is moved manually with the help of a camera-guided navigation system. However, moving the locus or orientation of the stimulation this way is slow and user dependent, and does not allow for feedback-controlled stimulation. In the ConnectToBrain project, we are developing a multi-locus TMS (mTMS) system that can electronically control the locus, direction, intensity, and timing of the stimuli. The current prototype of the multi-locus transducer consists of five overlapping coils and can control the orientation and move the locus of the stimulation within an area with a diameter of three centimeters. The electronics are based on H-bridge circuits that can drive pulses with less energy and less coil heating compared to conventional TMS electronics. The software architecture is a modular publisher–subscriber model and connects the mTMS stimulator control, neuronavigation, electroencephalography, user interface, and real-time algorithms. The system enables efficient feedback-controlled stimulation protocols, automatic mapping of cortical excitability and connectivity, and stimulation of multiple sites simultaneously, which may lead to improved therapeutic efficacy in multiple brain diseases.

Real-time electrophysiological brain connectivity for brain stimulation

Laura Marzetti
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Concurrence of several brain areas is required to instantiate a specific behavior/functioning. Modulations of brain functional connectivity metrics have been observed as a consequence of stimulus processing, task execution or brain stimulation (e.g. Transcranial Magnetic Stimulation-TMS). Less is known about the impact of TMS on brain and/or peripheral signals in correspondence of different degrees of functional connectivity of a specific network. To this aim, we evaluate whether and how functional connectivity is related to cortico-spinal excitability, as indexed by MEPs induced by TMS at the human hand area in 9 right-handed participants undergoing a concurrent EEG−TMS experiment. EEG analyses were conducted in the pre-stimulation interval and seed-based (left primary motor area) single-trial functional connectivity in source-space at the individual mu frequency (iPLV) was assessed. For each participant, average MEP values in trials with high functional connectivity (FC) and low FC, median split, were extracted and their relative deviation with respect to MEP average across all trials was calculated. Group averaged FC highlighted a statistically significant coupling of lM1 to Supplementary Motor Area and to right primary motor area. For both regions, MEP values in high FC trials were higher than MEP values in the low connectivity trials (of about 4%).

Looking through the windows: a study on real-time functional connectivity estimation

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Being able to perform a reliable real-time functional connectivity (FC) analysis would allow for a deeper characterization of brain connectivity state (BCS) dynamics, thus potentially allowing for dynamic adjustments of the stimulation settings in a non-invasive closed-loop EEG–TMS framework. Real-time FC estimation requires shorter (than usual) data to rapidly track BCS changes. The aim of this talk is that of showing the methodological aspects and the results of a study focused on quantifying (by means of biologically realistic simulations) the minimum data length required for performing a reliable FC estimation through a sliding-window approach. In particular, I will focus on the performance of seven phase-coupling methods (including the imaginary part of phase locking value, orthogonalized phase locking value, weighted lag index, etc) in different situations and parameter settings (e.g. data length, output signal-to-noise ratio, spectral analysis approach, and fractional bandwidth). In terms of the number of cycles of a given oscillatory signal component (e.g. 5 cycles at 10 Hz corresponds to a window of 500 ms), I will show that 5-8 cycles are generally required to achieve reliable FC estimates. Finally, I will also show some practical implications of using a finite data length in a synthetic experiment.

Brain-state-dependent EEG-rTMS for plasticity induction

Gabor Kozak
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Transcranial magnetic stimulation (TMS) allows us to instantaneously modulate brain activity by activating neurons via induced electric fields. Repetitive stimulation of a specific network of neurons might induce long term changes in those networks. However, such a change is only expected if the stimulation interferes with the network internal state, i.e. when brain activity is analysed in real time to guide the intervention. Within the scope of the ERC synergy ConnectToBrain project we are developing, based on this, new and therapeutically more effective, EEG-dependent TMS protocols for neuromodulation of dysfunctional brain networks in stroke, Alzheimer's disease and depression. We present the methodological basis of analysing EEG signals in real time to trigger TMS, based on a spatially and temporally targeted brain-state, with a special outlook on the induction of plasticity effects in the human motor cortex. We present an experimental set-up based on MathWorks Simulink Real-Time along with high-density resting-state EEG data from healthy participants. A variety of approaches for localization and extraction of different oscillatory sources will be discussed along with the real-time estimation of the phase of brain-oscillations and relationship to cortical excitability states. Finally, we will discuss possible neurophysiological mechanisms of phase-synchronized repetitive TMS for effective therapeutic neuromodulation.

S.08: Clinical applications of neurophysiology for addiction. (ID: 152)

Chair(s): Giulia Maria Giordano (University of Naples, Italy) and Salvatore Campanella (University of Brussels, Belgium)

Executive functions in addiction: new tool for assessment applied to gambling behavior

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This study examined the application of a novel neuropsychological battery for assessing executive functions (EFs) in patients with gambling disorder (GD). The experimental (EXP) group of patients with GD and the control (CNT) group of healthy participants were balanced for age, years of education, anxiety, and depression levels. The neuropsychological battery was digitally administered and included five neuropsychological tests (measuring long- and short-term verbal memory, working memory, cognitive flexibility, verbal and non-verbal fluency, and attention), as well as a modified Go/NoGo task with addiction-related stimuli. EXP patients showed significantly higher scores for repetition mistakes than controls at the short-term verbal memory test and displayed lower scores in the verbal fluency test. In the Go/No-Go task, the EXP scored slower reaction times than the CNT, with significant differences for neutral and addiction-related stimuli. In addition, EXP had greater impulsive ratings than controls. Despite the exploratory nature of the study, findings suggest the validity and suitability of this new digital tool for remote testing. Current results support the hypothesis that memory impairment and attentional bias in inhibitory control tasks may play a role in GD, and impulsivity may be a key component in the relationship between EF impairment and GD.

Impulsivity control in methamphetamine addicts and its repetitive TMS intervention

Jiajin Yuan
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Impulsivity during periods of abstinence is a critical symptom of patients who use methamphetamine (MA). Yet, how the deficits of impulsivity control in MA users are manifested in behavior and what neuromodulation protocol may produce a reinstatement effect await clarification. To this end, the current randomized clinical study used a two-choice oddball task to measure the performance of impulsivity control in MA users compared to healthy controls, and further, examined how repetitive rTMS over the left prefrontal cortex modulates impulsivity control in this population. We observed that 1) patients with MA addiction exhibited greater impulsivity compared with the control group, manifested by enhanced error commission and reduced response time in the task; 2), the single session of 1-Hz rTMS over the left prefrontal cortex significantly increased accuracy and reaction time delay for deviant trials that require impulse inhibition;3), these intervention effects were seen consistently after 10 sessions of 1-Hz rTMS treatment, and the behavioral improvement was maintained at least for 3 weeks after treatment (measurd on day 31). These intervention effects of impulse inhibition were coupled with a reduction in addictive symptoms as measured by cue-induced craving. The pretest accuracy cost was positively correlated with the change in impulse inhibition and change in craving, suggesting that these 2 behaviors may be modified simultaneously.These findings suggest that the two-choice oddball task can be used to depict the profile of impulsivity control in substance use disorder and repeated rTMS sessions have sustained effects on impulse inhibition in patients with MA addiction.

EEG Microstates in Early Phase Psychosis: The Effects of Acute Caffeine Consumption

Jenna Bissonnette, T-Jay Anderson, Katelyn J. McKearney, Philip G. Tibbo, Derek J. Fisher
Dalhousie University, Canada)

Individuals with schizophrenia use on average twice as much caffeine than the healthy population, but the underlying cortical effects of caffeine in this population are still not well understood. Using resting electroencephalography (EEG) data, we can determine recurrent configurations of the electric field potential over the cortex. These configurations, referred to as microstates, are reported to be altered in schizophrenia and can give us insight into the functional dynamics of large-scale brain networks. In the current study, we used a placebo controlled, randomized, double-blind, repeated measures design to examine the effects of a moderate dose of caffeine (200 mg) on microstate classes A, B, C and D in a sample of individuals within the first five years of psychosis onset compared to healthy controls. The results support the reduction of microstate class C and D, as well as the increase of microstate class A and B in schizophrenia. Further, acute caffeine administration appears to exacerbate these group differences by reducing class D, and increasing occurrences of class A and B states in the patient group only. The current results support the hypothesis of a microstate class D reduction as an endophenotypic maker for psychosis, and provide the first descriptive account of how caffeine is affecting these microstate classes in an early phase psychosis sample.

Prognostic value of smoking cue-reactivity for the efficacy of smoking cue exposure in virtual reality

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The active addictive memory is expressed as cue-reactivity, an automated response to substance-related cues, evolved by the means of conditioning processes. It is manifested at various levels like subjective craving, approach behavior and an autonomous response, with high interindividual differences in its intensity. As a predictor for relapse, it is highly relevant for addiction research. Cue exposure therapy is an intervention for relapse prevention, aiming at the inhibition of the automated response to substance-related cues based on the principles of extinction learning. Nevertheless, clinical outcomes are heterogenous, raising the question, which individual profits from the intervention. In our approach we focus on interindividual variability to identify markers with prognostic value for the treatment of smokers with smoking cue exposure. Individuals with high cue-reactivity are expected to profit from cue exposure therapy in relapse prevention in smokers during a smoking cessation program. In the current study, cue-reactivity was assessed during smoking cue exposure in n=246 smokers before the assignment to a group-based 6 weak smoking cessation program with either smoking cue exposure in virtual reality (n=122) or progressive muscle relaxation (n=124) as add-on. Cue-reactivity measures immediately after the therapy and in a 6 months follow-up are provided. Abstinence rates between groups did not differ according to the add-on therapy. This raises the question, whether EEG-based cue-reactivity markers have prognostic value to identify smokers that will profit from smoking cue exposure in virtual reality. Insights from analysis challenges will be provided.

S.09: New horizons in EEG microstates research. (ID: 156)

Chair(s): Thomas Koening and Bastian Schiller

The self-controlled brain: Resting network stability is associated with trait, neural, and behavioral measures of self-control

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Among the most fundamental phenomena of neural processing are large-scale networks that shift on a millisecond scale in the resting brain (i.e., EEG microstates). Although individuals show a reliable tendency for higher (i.e., longer durations, fewer occurrences) or lower (i.e., shorter durations, more occurrences) network stability, it remains unclear how these differences in spontaneous neural processing affect behavior and cognition. In Study 1, we found that network stability was positively associated with self-control and a neural index of inhibitory control. Source localization revealed that network stability was related to stronger task-related activity in inhibition-related brain areas (insula, inferior frontal gyrus). In Study 2, we followed a preregistered analysis plan and replicated the positive association of network stability and self-control. Furthermore, we applied a conceptual extension by demonstrating a negative association with risk-taking behavior. Overall, our findings provide evidence that self-controlled people have a less volatile neural processing style at rest.

Microstates in complex and dynamical environments: Unraveling situational awareness in critical helicopter landing maneuvers

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The EEG microstate analysis embeds features that increase the robustness to external noise, since it disregards momentary variations and favors globally observable patterns. These properties, allied to evidence that specific microstates may be associated with perception and attention, led us to explore for the first time the application of the microstate model in an ecological, dynamic and complex scenario.

More specifically, we evaluated elite helicopter pilots during engine-failure missions in the vicinity of the so-called "dead man's curve'', which establishes the operational limits for a safe landing after the execution of a recovery maneuver (autorotation). We assessed these neural correlates during maneuver execution, comparing it with baseline epochs before and after flights.

We show that the topographies of our microstate templates resemble the literature, and that a distinct modulation characterizes decision making intervals. Moreover, the source reconstruction result points to a differential activity in the medial prefrontal cortex, which is associated with emotional regulation circuits in the brain. Our results suggest that microstates are promising neural correlates to evaluate realistic situations, even in a challenging and intrinsically noisy environment. Furthermore, it strengthens their usage and expands their application for studying cognition under more realistic conditions.

EEG microstates at the transition of sleep and qualities of conscious experiences

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The transition to sleep is a heterogeneous state with respect to both neurophysiological and mental processes: The quality of consciousness can markedly differ from wakefulness, with decreasing situational awareness, loss of control over thoughts and the occurrence of perceptive images (hypnagogic imagery or micro dreaming). Psychophysiologically, the level and content of consciousness is assumingly realized by large-scale brain networks that can be studied using EEG microstates. At the transition to sleep, the level and quality of consciousness and presence of particular EEG microstates are thus likely to interact, which permits us to study the functional role of particular neurocognitive networks for particular qualities of conscious experiencing. We recorded multichannel EEG in 45 subjects that freely moved between states ranging fom fully awake, relaxed, drowsiness to the border of sleep. The quality of conscious experience was questioned at pseudo-random intervals. Wakefulness levels were estimated using a semi automated classification algorithm (VIGALL). Compared to fully awake states, stages of reduced wakefulness were marked by different profiles of microstate classes. Against our expectations, when correlating microstate profiles with the momentary quality of consciousness, loss of control, reduced situational awareness and presence of hypnagogic imagery were associated with an increase of a microstate class that assumingly corresponds to frontocentral sources, and with a decrease of a microstate class associated with visual processing. These observations offer intriguing questions for the functional role of EEG microstates in the regulation of the content of conscious experience.

EEG global time domain descriptors, EEG microstates and their temporal dynamics in intraoperative multichannel EEG: Secondary exploratory analysis of a randomized controlled trial

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To date, global EEG parameter as well as microstates and their changes during anesthesia have not been studied. Aim of this study was to analyze these parameters in patients with and without postoperative delirium (POD). Overall 73 intraoperative multichannel EEGs from the randomized controlled Surgery Depth of Anesthesia and Cognitive outcome (SuDoCo)-study (SRCTN 36437985) were available. Altogether, 512 artefact-free 1-minute intervals, of these 292 (57%) in suppression, were analyzed. Global time domain descriptors (sigma, phi, omega) as well as microstates and their temporal dynamics (duration and occurrence) together with the global field power (GFP) were analyzed by linear mixed effects models. Mean age of patients was 71 ± 7 years, 29 (40%) were females, and 38 (52%) had American Society of Anesthesiology (ASA)-Physical Status III and IV. The median anesthesia time was 210 (range: 75-675) minutes and 47 (64%) had inhalational anesthesia. During seven post-operative days 21 (29%) developed POD. All three global time domain descriptors varied over anesthesia time and were associated with significant interactions between anesthesia time and suppression. Likewise, duration, occurrence and GFP varied over anesthesia time and were associated with significant interactions between anesthesia time and suppression, while duration and occurrence were additionally associated with significant interactions between anesthesia time, microstates and suppression. Under general anesthesia, multiple changes in global EEG parameter and in dynamics of microstates occur. These changes are pronounced during suppression.

S.10: Emerging source estimation methods for analysing MEEG data: from dipolar neural sources to neural networks. (ID: 123)

Chair(s): Annalisa Pascarella (Institute of Applied Mathematics M. Picone, National Council of Research, Rome, Italy), Christian Benar (Aix Marseille Univ, INSERM, INS, Inst Neurosci Syst, Marseille, France)

Rao-Blackwellized Sequential Monte Carlo for multi-dipole estimation in Magneto/Electro-encephalography

Alessandro Viani
Department of Mathematics, University of Genoa, Italy)

We present a substantial improvement to a Bayesian multi-dipole estimation algorithm previously described, and known as SESAME. SESAME is a Bayesian Monte Carlo algorithm capable of automatically estimating the number of dipoles and their parameters from either M/EEG topographies, M/EEG time series or M/EEG frequency bands. In its previous version, SESAME needed two input parameters: the SNR and the expected strength of the dipolar sources (prior). The substantial improvement consists in the introduction of a hierarchical Bayesian model that virtually removes dependence on the prior. The resulting method is highly stable and provides better and consistent results across different scenarios. The method is freely available at (https://github.com/pybees/sesameeg), and is also available in a commercial version within the BESA software package under the name SESAME. An application to localisation of epileptiform discharges is also described.

MEG/EEG source imaging within the Maximum Entropy on the Mean

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The purpose of this presentation will be to introduce the framework of Maximum Entropy on the Mean (MEM), as a Bayesian probabilistic approach offering the possibility to perform EEG/MEG source localization within interesting spatial properties. One of the key aspects of the methods is that it relies on an underlying parcellation of the cortical surface, where hidden variables are controlling the activity of each parcel, therefore allowing the possibility to switch off inactive parcels during source localization estimation. After reviewing the theoretical basis of the methodology, we will demonstrate how MEM applied in the temporal domain offers unique possibility to localize the generators of EEG activity together with the underlying spatial extent of the generators, a feature that is particularly important when localizing activity distributed within a network, as in epilepsy. We will then present the extension of the MEM framework within the time-frequency domain, the wavelet-based MEM (wMEM), as a method dedicated to the localization of brain oscillatory patterns. We will illustrate this concept by showing localization of oscillatory patterns at epileptic seizure onset, during transient fast and high frequency oscillations, but also when investigating resting state oscillations, in comparison with the atlas of healthy intracranial EEG data.

Mitigating the Inverse Problem: Contextual MEG and EEG Source Estimates Using Spatiotemporal LSTM Networks

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Most commonly used source estimation methods in magneto- and electroencephalography (M/EEG) use time-invariant spatial filters for localizing neural activity. It is, however, well-known that the brain is heavily interconnected which implies that neural activity depends on past activity. This fact is being used to constrain the inverse problem and thus mitigating its ill-posedness in spatiotemporal source estimation approaches. Such approaches have so far mainly relied on a priori modeling of the spatiotemporal dynamics that govern the relationship between current and past neural activity. In our recent work, we applied a recurrent neural network composed of a sequence of Long Short-Term Memory (LSTM) cells for predicting neural activity based on prior activity estimates, thus creating a model for activity propagation that is learned from the recorded M/EEG data instead of being based on a priori modeling. This activity prediction is then used to correct the estimate. Although this approach is general and can be applied to any data set that exhibits spatiotemporal dynamics, we applied it here to noise-normalized minimum norm estimates (MNE) and therefore call it Contextual MNE (CMNE). We tested CMNE on simulated epileptiform activity and recorded auditory steady state response (ASSR) data, showing that the CMNE estimates exhibit a higher degree of spatial fidelity than the unfiltered estimates in the tested cases (Dinh et al., 2021). Although initial, these results are promising and warrants further investigation on the application of machine learning techniques to the M/EEG inverse problem.

Insight from simultaneous recording Seeg-Meg

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Simultaneous intracranial - magnetoelectroencephalography data offer a unique opportunity to explore the origin of the signal recorded on the surface by comparing it with the simultaneous signal recorded directly from the brain. Independent component analysis (ICA) applied to this dataset showed impressive capability to unmask on the surface signals coming from deep generators during epileptic activities or cognitive responses. Moreover, by applying beamforming methodology and subsequent ICA we are testing the possibility to separate physiological activities from pathological ones.

S.11: In-Silico Applications in Neuroscience. (ID: 164)

Chair(s): Nevzat Tarhan (Uskudar University), Maheen Adamson (Stanford University)

Biomarkers' Significance on Pharmaco-EEG

Mohammed Nami
Stanford University

The application of EEG and qEEG in demonstrating the effects of pharmacological compounds has been regarded as pharmacoEEG. The spontaneous synchronized postsynaptic neuronal activity of the cortex at a high temporal resolution allows the real time tracking of EEG/qEEG biomarkers in relation with the effect of a medicine. The International Society for Pharmaco-Encephalography has laid down guidelines and instructions to standardize, unify, and facilitate the comparability of pharmaco-EEG data across laboratories, which would enable data-pooling and meta-analyses at large scale. While pharmaco-EEG studies have so far been focusing on the monitoring of psychotropic drug toxicity at the central nervous system level, as well as the prediction of clinical response to treatment with psychotropic drugs, further dimensions have remains underattended. Expanded research on pharmaco-EEG can provide the cornerstones for the personalized neuromedicine approaches when it comes to the electrical neuroimaging. Nonetheless, though pharmaco-EEG retains the potential for important clinical applications, none of such applications has entered clinical routine. The ability to deploy pharmaco-EEG research methods into larger studies represents a future challenge

Deep Learning Approaches to Evaluate Sex Differences in Response to Neuromodulation in Major Depressive Disorder

Maheen Adamson
Shiraz University

The present study aimed to investigate sex differences in response to repetitive transcranial magnetic stimulation (rTMS) in Major Depressive Disorder (MDD) patients. Identifying the factors that mediate treatment response to rTMS in MDD patients can guide clinicians to administer more appropriate, reliable, and personalized interventions. In this paper, we developed a novel pipeline based on convolutional LSTM-based deep learning (DL) to classify 25 female and 25 male subjects based on their rTMS treatment response. Five different classification models were generated, namely pre/post-rTMS female (model 1), pre/post-rTMS male (model 2), pre-rTMS female responder vs. pre-rTMS female non-responders (model 3), pre-rTMS male responder vs. pre-rTMS male non-responder (model 4), and pre-rTMS responder vs. non-responder of both sexes (model 5), achieving 93.3%, 98%, 95.2%, 99.2%, and 96.6% overall test accuracy, respectively. These results indicate the potential of our approach to be used as a response predictor especially regarding sex-specific antidepressant effects of rTMS in MDD patients.

Distinct neural correlates of attention problems and delay discounting deficits in ADHD

Barış Metin
Uskudar University

ADHD is associated with problems with sustained attention as well as alterations in delay gratification. The neural mechanisms of these alterations are not entirely elucidated. In this study we administered to a group of individuals with adult ADHD as well as healthy controls an oddball task and a delay discounting task during functional magnetic resonance imaging. The results showed that during the oddball task the ADHD individuals activated their anterior cingulate and anterior frontal regions less as compared to the controls. However during delay discounting task, they activated left inferior frontal gyrus and premotor areas more as compared to the controls. These preliminary results indicate that the neural mechanisms of delay discounting alterations and sustained attention deficits are distinct in ADHD. The attention problems might be caused by decreased employment of cognitive control areas during information processing. On the other hand the impulsive pattern in delay discounting might be related to increased employment of motor and premotor areas.

S.12: EEG-markers for treatment in psychiatry: from preclinical insight to clinical usage. (ID: 144)

Chair(s): Pim Drinkenburg (Janssen Pharmaceutica NV, Pharmaceutical Companies of Johnson & Johnson, Beerse, Belgium), Marcel Zeising (Sleep Center, Hospital of Ingolstadt, Germany)

EEG in drug discovery and for identification of relevant biomarkers

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The lack of translation from basic research into new medicines is a major challenge in CNS drug development. Diagnostic biomarkers with predictive, face, and/or construct validity are critical in facilitating this endeavor. Quantitative EEG has become recognized as a valuable tool in drug discovery given putative translatability from preclinical studies to clinical trials. EEG has offered evidence of predictive validity and holds within models of CNS disorders face or construct validity. We will present on the utility of EEG in drug discovery with emphasis on its utility at multiple stages of drug development on assessing drug response, safety, and identifying clinically-relevant biomarkers.

Mismatch Negativity to Multiple Deviants are Associated with Different Features of Auditory Hallucinations in Schizophrenia

Natalia Jaworska
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Auditory hallucinations (AHs) are common in schizophrenia (SZ). Research into the neural mechanisms of AHs could refine interventions, which are currently inadequate a third of patients. The mismatch negativity (MMN) is an auditory event-related potential that represents pre-attentive detection of stimulus deviance. However, granular investigations of MMN deficits and their relation to AH features are SZ are lacking. Electroencephalographic activity was recorded from 14 SZ patients and 16 non-SZ controls (HC). MMNs to five deviants were elicited using two paradigms (five speech & five sound deviants). AHs features were assessed with the Voices Acceptance & Action Scale (VAAS), Voice Power Differential Scale (VPDS) and Beliefs About Voices Questionnaire (BAVQ). SZ patients had smaller MMNs to sound and speech frequency, as well as sound and speech intensity deviants. Higher VPDS scores were associated with smaller MMNs to frequency, intensity, location, and gap deviants. VAAS-Command Hallucination scores were inversely related to MMN latency to sound location deviants. Finally, higher BAVQ-Resistance sub-scores were positively correlated with MMN latency to speech frequency deviants; higher BAVQ-Engagement sub-scores were associated with larger MMNs to speech constant deviants. SZ patients had MMN deficits to intensity/frequency deviants, regardless of paradigm. Specific AHs features were associated with unique MMN deviants.

QEEG predictors of responsiveness to antidepressant therapy

Martin Brunovsky
National Institute of Mental Health, Czech Republic

Electrophysiological assessment of brain functions in patients with affective disorders reveals various state- and trait-dependent findings, as well as changes induced by various therapeutic approaches, revealing complex regional and network-based interactions that are topographically distributed across the heterogeneous brain areas. Various QEEG predictors of responsiveness to antidepressant therapy in individuals with major depressive disorder have been the focus of our research over the last 15 years. The decrease in prefrontal theta EEG cordance after one week of new therapy constitutes a strong and promising technique for predicting the response to different antidepressive treatment, according to ROC analysis of data from more than 200 patients. Alpha asymmetry and alterations in intracortical connectivity between the mediofrontal region and the posterior cingulate are also potentially possible predictors of antidepressant response.

Predictive EEG biomarkers in Psychiatry: From Replication Studies to the Deep Learning Horizon

Sebastian Olbrich
Sebastian Olbrich, Deputy Chief Center for Social Psychiatry

The research in the field of EEG biomarkers for prediction of treatment outcome in psychiatry in recent years has consolidated the range of valid and reliable parameters. Especially, the lack of replication studies has partly been overcome and first markers have proved their predictive value in the analysis of out of sample datasets. The presentation will cover some of the most promising EEG biomarkers such as EEG-vigilance and EEG-alpha power asymmetry. Further, the talk will look at the road ahead in this field and new approaches for the identification of new predictive markers will be introduced. Especially the usage of powerful tools that use deep learning techniques will be highlighted, including their potential in EEG biomarker research but also the possible pitfalls.

S.13: Sensor/Source space functional connectivity of brain disorders on the basis of realistic head modeling. (ID: 109)

Chair(s): Marios Antonakakis (School of Electrical and Computer Engineering, Technical University of Crete, 73100, GR, Institute for Biomagnetism and Biosignal Analysis, University of Muenster, 48149, DE), Stavros I. Dimitriadis (Integrative Neuroimaging Lab, GR, The Greece, 1st Department of Neurology, G.H. "AHEPA", School of Medicine, Faculty of Health Sciences, Aristotle University of Thessaloniki (AUTH), 54124, GR)

Influence of head model accuracy on EEG/MEG source and connectivity analysis

Johannes Vorwerk
Institute of Electrical and Biomedical Engineering, UMIT - Private University for Health Sciences, Medical Informatics and Technology, Hall in Tirol, AUS)

The estimation of source space functional connectivity from EEG/MEG measurements can only be successful, if it is based on accurate estimates of the observed source activity. To obtain estimates of the source activity, it is necessary to solve the EEG/MEG inverse problem. The accuracy of the resulting inverse solution is influenced by various factors. Here, the accuracy of the volume conductor model of the patient's/subject's head, which is incorporated in solving the inverse problem, was shown to have a significant influence. This accuracy is not only determined by the level of detail and a precise representation of the geometry of the different conductive compartments of the human head, but also by the correct choice of the electric parameters of the head's tissues, i.e., the conductivities. In this talk, we will analyze how inaccuracies of the used head model, such as model simplifications and conductivity uncertainties, affect the source estimation and will demonstrate how this affects the subsequent estimation of functional connectivity.

Potential of randomized multiresolution scanning (RAMUS) in source localization: Targeting reconstruction of SEP components

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We investigate reconstructing the sequential components of somatosensory evoked potentials (SEPs) at different latencies between 14-30 ms. We focus on randomized multiresolution scanning (RAMUS) technique in the framework of hierarchical Bayesian, conditionally Gaussian approach which is proposed recently as a potential technique to reconstruct cortical and simultaneous subcortical activity. Our goal is to detect the simultaneous cortical and weak deep activity in reconstructing the generator of SEP components of median nerve stimulation using three different realistic head models and experimental measurement datasets. RAMUS is a maximum a posterior estimation technique aiming to reduce optimization and discretization errors via randomized source spaces and coarse to fine reconstruction strategy. The source space is decomposed into random subsets during a refinement process which is repeated for several randomized configurations and the final reconstruction is obtained as an average over the multiple resolution levels. RAMUS constitutes with sparse source space to distinguish deep activity. RAMUS found weakly distinguishable deep activity for earlier components while simultaneous cortical and subcortical activity was detected for components after 20 ms. Our findings reveal RAMUS as a promising method for localizing cortical and weakly distinguishable deep activity in the case of realistic and multicompartment head model and experimental measurements.

Dynamic effective connectivity of combined EEG/MEG sources in pharmacoresistant epilepsy using finite element realistic head modeling

Marios Antonakakis
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Epilepsy accounts largely for one of the most common brain disorders affecting almost 50 million people worldwide. Recently, epilepsy had been characterized as a network disease. In this regard, electroencephalography | EEG, and magnetoencephalography | MEG have been used for dynamic connectivity analysis to identify time-varying networks of neuronal activities due to the very high temporal resolution that EEG and MEG can offer. It is also known that EEG and MEG share complementary content and their combination may lead to more accurate source reconstructions. This combination, however, is essential to be applied on the basis of realistic head modeling with individually estimated dielectric properties, e.g., conductivity in order to mitigate the so-called volume conduction effects. The purpose of this work is to (1) show differences in source reconstruction level between single EEG/MEG and combined EEG/MEG and (2) how time-varying effective networks for combined EEG/MEG can indicate hub nodes as the region of epilepsy surgery for three patients with focal epilepsy, retrospectively to the surgery outcome.

Functional connectivity metrics and volume conduction effects in Alzheimer's disease

Marcos Revilla-Vallejo
Biomedical Engineering Group, University of Valladolid, Valladolid, Spain

Electroencephalographic (EEG) recordings measure the neural activity. Functional connectivity computed from EEG signals is affected by unwanted effects, which lead to volume conduction and cause spurious patterns. This study intends to determine which connectivity metrics are less disturbed by these effects and to evaluate how functional connectivity is modified along Alzheimer's Disease (AD) continuum. The functional connectivity metrics: magnitude squared coherence, corrected imaginary coherence, phase lag index (PLI), weighted PLI (wPLI), amplitude envelope correlation (AEC), and leakage corrected AEC, were evaluated. Firstly, synthetic signals obtained with a Kuramoto model and a real head model were used in free volume conduction and real volume conduction scenarios. Secondly, real EEG data from 51 controls, 51 mild cognitive impairment patients, and 150 AD patients were analysed. The connectivity metrics less disrupted were used to assess AD alterations. PLI and wPLI were less affected by volume conduction, both in synthetic and real data. They also showed altered patterns due to AD. All the measures were affected by volume conduction, but PLI and wPLI showed better behaviour. This could be due to their definition and higher dynamic range. AD alterations in PLI and wPLI could be related with structural brain changes.

Posters

ID: 112 Endogenous neurovascular coupling in preterm neonates

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The neonatal brain is an extremely dynamic organization undergoing essential development in connectivity and function. The developmental course of cortical hemodynamics in the neonatal brain reflects, to a certain extent, the gradual maturation of neurovascular coupling. Several functional imaging investigations of the developing brain have found patterns of hemodynamic responses that contrast from adult. This discrepancy is partly due to that neurovascular coupling that is still developing in the neonatal brain. We simultaneously recorded (EEG, HbO, HbR, TOI, CBF and estimated CMRO2) in 32 preterms (normal n=18, pathological conditions n=14), to determine how the changes in the hemodynamic responses were coupled to the occurrence of spontaneous bursts of cerebral electric activity. The bursts of electroencephalographic activity in neonates in resting state were found to be coupled to a transient hemodynamic response involving different types of hemodynamic response including (a)positive stereotyped hemodynamic responses (increases in HbO, decreases in HbR together with increases in CBF and CMRO2), (b)negative hemodynamic responses (increases in HbR, decreases in HbO together with decreases in CBF and CMRO2), (c)Increases and decreases in both HbO-HbR and CMRO2 together with no changes in CBF. High coherence was observed between the cerebral hemodynamic and electrical oscillations in the frequency range of 0.003–0.125 Hz in the non-encephalopathic newborns than in two pathological groups (intraventricular-hemorrhage). Conclusively, different patterns of cerebral hemodynamic response to the neuronal burst of activities coupled with dynamics in neurovascular coupling with ages, reflect the immaturity and complexity of both neonatal vasculature and neuronal networks.

ID: 118 Towards standardization of rodent EEG multi-electrode systems

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The future of psychopharmacology lies in its ability to design tools capable of screening new drugs in preclinical trials. EEG is currently gaining diagnostic power as the latest trends indeed come with signal analysis capable of detecting biomarkers of serious mental illnesses, as well as capturing the therapeutic effects hardly detectable by other methods. Rodent EEG models, however, faces many technical and consensual shortcomings.

Given that studies generally use small number of electrodes, disparate electrode layouts and perform recording under various conditions, our long-term effort headed to design implantable multi-electrode EEG implants capable of recording signal in a high quality manner under standardized conditions.

First, we designed hard-wired 14-electrode system covering the entire surface of the upper part of the skull from the frontal to the temporal region. To make this system more translative, we increased the number of electrodes up to 21 and placed them at the homological areas of human 10-20 system. These electrodes were placed epidurally, thus required skull penetration. In parallel, we have developed less invasive approaches. We produced two different prototypes (polyimide and PET) of printed implants with the same electrode layout. Finally, we come with miniaturized hard-wired implant of 40 leads capable of reaching also lateral sides of the rat skull.

Homogeneously distributed multi-electrode system allows advanced signal analysis such as source localization, global connectivity measures etc. Here, we will overview ten years of our methodological advance, pros and cons of the developed systems and also future perspectives.

ID: 119 WeBrain v1.0: A Web-based Data Processing Platform for Large Scale EEG Applications

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Currently, with combing the capabilities of the advanced IT and neuroimaging techniques, it is resulting a number of electroencephalography (EEG) datasets and tools. It further generates "cloud neuroscience" to accelerate brain science discovery, especially in large scale EEG studies. However, there is few specific cloud platform for large-scale EEG applications that may best benefit the EEG community. A web-based EEG data management and cloud computing platform, named WeBrain v1.0, was therefore designed and developed. A Docker virtualization technique (https://www.docker.com/) was used to virtualize physical computing nodes to create a number of virtualized containers, and a sub-system was then developed for automated container management and batch schedule using Kubernetes (k8 s, https://kubernetes.io/). And, a new approach of microservice architecture was used to develop the service system. The cloud platform named WeBrain v1.0 is current free and available on https://webrain.uestc.edu.cn/. It provides an easy-to-use cloud system for novice users (even no computer programming skills), as well as IT administrators and tool developers. A number of the basic or specific EEG tools/pipelines have been integrated in the WeBrain system, ranging from raw EEG preprocessing to EEG network analyses. Noting that it is not necessary for users to install any software or system, and all need is a modern web browser. The cloud platform is sponsored and driven by the China-Canada-Cuba international brain cooperation project (CCC-Axis, http://ccc-axis.org/). We hope that the WeBrain v1.0 is a promising cloud platform for exploring brain information in large-scale EEG applications in the future.

ID: 120 Spatio-Spectral EEG Correlates of fMRI Resting State Networks in Simultaneous EEG-fMRI Recordings: Comparison of Electrode and Source Space

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Recently, it was found that in resting-state EEG there are power fluctuations patterns occurring across joint frequency-electrode space correlating with BOLD resting-state networks (RSNs)[1,2,3,4]. In another study, ICA components of source-reconstructed power fluctuation correlated with the DMN [5]. A combination of EEG spatio-spectral decomposition in the source-reconstructed space improves sensitivity of the EEG-fMRI fusion compared to the electrode-space-based approach.

1. To propose an EEG-fMRI pipeline of spatio-spectral decomposition in the source-reconstructed space.
2. To compare electrode and source space approach with respect to similarity of EEG spatio-spectral signatures and fMRI maps within and between datasets.

We preprocessed two datasets of concurrent EEG-fMRI resting-state data. EEG source time courses were estimated via eLORETA algorithm. Band-limited power fluctuations were computed in 4 frequency bands. Spatio-spectral patterns were obtained by temporal ICA and correlated with BOLD signal. Similarity of spatio-spectral signatures and fMRI maps between datasets was computed as well as similarity of temporal profiles and corresponding fMRI maps between electrode and source space within the same dataset. We found significant correlation between temporal profiles and fMRI maps between electrode and source space within the same dataset ($r_{Dat1} = 0.40, r_{Dat2} = 0.29, p<0.05$). Furthermore, we found significant correlation between source-space spatio-spectral signatures and fMRI maps between datasets ($r = 0.25$, $p<0.05$) for 10 strongest ICA components. We proposed an EEG-fMRI pipeline of spatio-spectral decomposition in the source-reconstructed space and compared to electrode space decomposition. Observed similarity supports the idea of source-space decomposition being more sensitive to EEG-fMRI fusion.

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ID: 122 Reduced duration mismatch negativity (MMN) in early-phase psychosis

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Mismatch negativity (MMN) is an EEG-derived event-related potential elicited by a deviant sound in an otherwise standard auditory environment. MMN is thought to be a prospective biomarker for schizophrenia, as the amplitude of MMN is often reduced in those with schizophrenia compared to healthy controls. The goal of this study was to determine whether MMN is altered in individuals at an earlier stage of schizophrenia called early-phase psychosis. EEG activity was recorded while participants were presented with a multi-feature 'optimal' paradigm with five deviant types (gap, duration, location, intensity, and pitch). Clinical measures (i.e., PANSS, PSYRATS, BNSS) were additionally analyzed. The early-phase psychosis group showed significantly reduced duration deviant amplitudes compared to the control group. Several significant correlations were also found between the early-phase psychosis group and the clinical measures.

Conclusions: These findings suggest that a reduction in MMN is present in early-phase psychosis, particularly with the duration deviant. These results also suggest that MMN is associated with specific clinical symptoms.

ID: 124 Load-Dependent Functional Connectivity Deficits During Visual Working Memory in First-Episode Psychosis

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Aberrant network connectivity is increasingly viewed as a core dysfunction in psychosis and may underly many of its associated cognitive deficits. Previous work in first-episode (FE) populations suggests a preservation of working memory network function during low-load conditions with disruptions becoming apparent as task complexity increases.The present study assessed visual network connectivity and its contribution to load-dependent working memory impairments. Magnetoencephalography was recorded from 35 FE and 28 matched controls (HC) during a lateralized change detection task. Impaired alpha desynchronization was previously identified within bilateral parieto-occipital regions (PO) during high, but not low-load conditions. Whole-brain connectivity with bilateral PO was assessed using phase-locking values (PLV). Regions exhibiting significant connectivity modulation by load across participants were compared between groups. Across groups, bilateral PO exhibited significant modulation with 8 regions (FDR-corrected $p<.05$). Among these, FE exhibited less PLV enhancement between right PO and left inferior frontal gyrus (IFG; $p=.005$), occipito-temporal sulcus ($p=.006$), and anterior intermediate parietal sulcus (AIPS; $p<.001$) compared to HC. Smaller PLVs between right PO and both left IFG ($r=-.53$, $p=.001$) and AIPS ($r=-.51$, $p=.002$) during high-load condition were associated with increased SAPS Reality Distortion scores in patients. Compared to HC, FE are unable to enhance communication between perceptual and executive networks in response to increasing cognitive demands during visual working memory. Furthermore, the degree of impairment in this communication was associated with reduced positive symptoms. This deficit highlights the role of network connectivity in cognitive control deficits and symptoms in early psychosis.

ID: 125 Frontal midline theta rhythm and other frequency bands activity measured by the wearable electroencephalograph HARU-1: Proof of the usefulness of HARU-1 in occupational therapy

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The HARU-1 is newly developed wearable and wireless electroencephalograph (EEG) device with flexible sheet-type electrodes covering forehead area. So far there has been no studies measuring the Frontal Midline Theta rhythm (Fmθ) induced by the attentional focus state or examining the characteristics of other frequency bands with HARU-1. To measure Fmθ using HARU-1 and elucidate the characteristics of other frequency bands and prove its usefulness in occupational therapy. The frontal EEG signals was measured from 20 healthy subjects for 2 minutes each in the resting state and the simple calculation task state using HARU-1. Time-frequency analysis was performed on the EEG data of each state every 2 seconds, and the results were statistically subtracted between the two states. A p-value less than 0.05 was considered statistically significant. In 12 out of 20 subjects, Fmθ was observed during the calculation task. The 12 subjects with Fmθ showed a significant increase in the theta and gamma bands activity and decrease in the alpha band activity during the calculation task. The 8 subjects with no Fmθ showed a significant decrease in the alpha and beta band activity during the calculation task, with no significant differences in theta and gamma bands activity. We proved that the HARU-1 could measure robust Fmθ and gamma band activity. Further experiments are needed to analyze EEG during activities of daily life and occupational therapy using HARU-1 and to clarify the mechanism of electrical activity in the brain during sustained attention activities.

ID: 126 Relationship between neuroelectric microstates and subjective experiences

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Microstates approach offers a way to evaluate resting-state electroencephalogram (EEG), where recorded oscillations are defined as "states" with unique fixed spatial distribution. These microstates qualify for basic building blocks of mental and emotional processes, are changed in clinical conditions and under task demands; however, the relationship of microstate parameters to subjective resting state experiences is not clear. EEG of 197 subjects were collected during resting with closed eyes. It was further subjected to standard microstates analysis and related to subjective experiences collected using Amsterdam Resting-State Questionnaire (ARSQ). Bayesian Analysis of Pearson linear correlation was used to assess relationship between EEG-based microstates and subjective measures. One strong interaction ($BF10 > 10$) and five moderate correlations ($10 > BF10 > 3$) between microstate parameters and subjective experience were found, covering domains of Somatic Awareness, Comfort and Self and microstate classes B, C, D, E, F and G.

The spatially similar but functionally different topographies displayed distinct correlation patterns with different subjective experiences during the resting state. Use of resting state questionnaire assessing subjective experiences can potentially help to improve the interpretation and increase the sensitivity and specificity of microstate biomarkers in clinical and pharmacological studies.

ID: 127 Reduced left hemisphere A1 MEG MMN despite "healthy" scalp EEG MMN in first episode psychosis

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Mismatch Negativity (MMN) is an auditory event-related potential reflecting the pre-attentive detection of novel non-predicted stimuli and is considered a biomarker of cortical dysfunction in schizophrenia (SZ). MMN to pitch (pMMN) and to duration (dMMN) deviant stimuli are impaired in chronic schizophrenia, but it is less clear if MMN is reduced in first episode schizophrenia, and if MMN shows progressive impairment with disease course. Here, we investigated the neural generators of pMMN and dMMN combining EEG and MEG recordings in 31 first episode SZ patients (FE) and 31 healthy controls. We projected MEG inverse solutions into different areas within the auditory cortex, parcellated using Human Connectome Project pipelines, as well as conducted a whole volume source localization, non-cortical-restricted. Preliminary results revealed pMMN is not significantly different between controls and FE, neither at the scalp EEG (FCz) nor at the MEG source level. However, while dMMN did not differ between groups at the scalp EEG (FCz) level, we found significant group differences in A1 restricted to the left hemisphere. Moreover, source solutions using whole brain volumes suggested posterior cingulate and inferior frontal gyri as potential contributors to scalp recorded MMN responses. Our results indicate that left hemisphere selective pathophysiology is present at first psychotic episode, revealed by MEG-based source solutions, and suggest past negative findings might be explained by scalp level midline EEG, reflecting summed activity of several sources, not being sensitive to detect the actual left hemisphere A1 impairment observed at the source domain.

ID: 128 EEG-indexed Sensory Gating Alterations in Schizophrenia

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Previous studies have suggested that individuals with schizophrenia demonstrate deficits in sensory gating, a process that can be measured through electroencephalography (EEG) derived event-related potentials (ERPs). The aim of this project was to compare sensory gating, as indexed by P50, N100, and P200 waveforms, in individuals with schizophrenia. We hypothesized that those with schizophrenia would exhibit greater deficits in sensory gating compared to healthy controls. It was also expected that sensory gating would worsen as schizophrenia symptoms increased (indexed by PANSS and PSYRATS). A paired click paradigm was used to elicit sensory gating processes as indexed by three ERPs of interest (P50, N100, P200) in individuals with schizophrenia (n = 16) and healthy controls (n = 10). Individuals with schizophrenia exhibited deficits in P50 and P200 waveforms compared to the healthy control group. Furthermore, increased PANSS Positive Symptom Scale scores and PANSS General Psychopathology Scale scores were correlated with decreased amplitudes of the N100-P200 complex elicited by the second click (i.e. S2). Our results suggest that individuals with schizophrenia display deficits in sensory gating processes of inhibition, attention capture, and attention allocation relative to healthy controls. Furthermore, our results indicate that increased symptoms relate to alterations in attention triggering aspects of the stimulus filter process. This study provides preliminary evidence that symptoms of schizophrenia may be associated with alterations of specific ERP-indexed components of sensory gating. Future studies should incorporate a larger patient sample with greater symptom variability to measure this.

ID: 129 Differential effects of cannabis use on event-related potential (ERP)-indexes of cortical inhibition in cannabis users and non-users

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Cannabis has psychoactive properties due to the presence of delta-9-tetrahydrocannabinol (THC). THC has been suggested to cause neurocognitive changes in brain structure and function with early and heavy use; these changes can be observed using electroencephalography derived event-related potentials. Previous research suggests cannabis users (CU) vs. non-users (NU) have deficits on mid-latency auditory evoked responses (MLAER) and visual evoked potentials (VEP), indexing behavioural and cognitive inhibition. The current study used a paired click paradigm and a visual Go/NoGo paradigm to examine inhibitory functioning in CUs (n = 14; 9 male) vs. NUs (n = 16, 4 male). Effect sizes suggest CUs have impaired N100 measures of sensory gating compared to NUs, implying CUs may have worse early-attention processing. Additionally, a trend level interaction and latency findings for the P200 suggested CUs had smaller amplitudes and quicker latencies to S1 compared to NUs. Go/NoGo findings revealed enhanced P100 amplitudes in CUs (vs. NUs) suggesting an overactive primary visual cortex. Measures of behavioural inhibition suggest no differences between groups, furthermore, no other between-group differences or sex differences were observed. While our findings suggest no differences between biological sexes, we were unable to examine male (vs female) users (vs. non-users), due to limited sample size. Future work should examine whether sex moderates the effects of cannabis use group in a larger sample. This study provides further support for cannabis-induced deficits on early-attentional processing as indexed by the N100 and novel findings regarding enhanced P100 amplitudes to the Go/NoGo paradigm.

ID: 131 Magnetoencephalography can reveal deep brain network activities linked to cognitive processes

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Recording from deep neural structures such as hippocampus non-invasively and yet with high temporal resolution remains a major challenge for human neuroscience. Although it has been proposed that deep neuronal activity might be recordable during cognitive tasks using magnetoencephalography (MEG), this remains to be demonstrated as the contribution of deep structures may be too small to be detected, or they might be eclipsed by the activity of large-scale neocortical networks. The goal of this work is to disentangle mesial activity from the MEG signals and to validate the origin of the different components using intracerebral EEG (iEEG) signals recorded simultaneously. Simultaneous iEEG and MEG signals were recorded in patients during presurgical evaluation of epilepsy during a memory task involving the recognition of old and new images. Blind source separation (BSS) methods were applied to MEG data to separate sources from mesial structures and cortical activities. In the MEG signals, we identified with BSS a putatively mesial component, which was present in all patients and volunteers. This BSS component was modulated by the stimulus, with higher responses to the old images. Importantly, the time course of the component selectively correlated with SEEG signals recorded from hippocampus and rhinal cortex, thus confirming its mesial origin.

We confirmed, thanks to BSS, that mesial activities can be identified by MEG during cognitive processes. This finding complements previous studies with epileptic activity and opens new possibilities for using MEG to study deep brain structures in cognition and in brain disorders.

ID: 132 Epileptic Seizure Detection Using CNN-Aided Factor Graphs and Information Theoretic Measures

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Epilepsy is among the most common neurological disorders affecting about 50 million people worldwide. It is characterized by abnormal neural activity in the central nervous system known as epileptic seizures. Although electroencephalogram (EEG) is the most common tool used to diagnose epileptic seizures, a neurologist's review of EEG signals is necessary in many cases, which is a time-consuming process. This study develops a new seizure detection algorithm over EEG signals that employs a hybrid model-based and data-driven approach for seizure detection. The proposed seizure detection scheme combines three novel aspects, integrating deep learning mechanisms with mutual information (MI) extraction and model-based factor graph inference. In particular, a carefully designed 1D convolutional neural network (CNN) is first used to extract features from the EEG signals. As each extracted feature corresponds to a single EEG epoch, we exploit the temporal correlation between epochs by using these features as a learned factor graph capturing the temporal dependence, using which we infer via message passing. Using the CHB-MIT database and 6-folds leave-4-patient-out evaluation, it is shown that this CNN-aided factor graph algorithm reduces computational complexity by a factor of 2 while improving detection performance by 5% compared to prior work. To further improve the performance and explainability of the algorithm, we utilize the fact that there is a relatively high correlation among EEGs at the beginning and during the ictal block. Therefore, MI is used to represent the dependence between EEG channels.

ID: 134 Assessing Ventricle Volume and Periventricular Functional Connectivity in Shunt Treated Pediatric Onset Hydrocephalus

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Shunting is a common treatment for pediatric hydrocephalus (PH); however, there exists no consensus on how to best predict postoperative neuronal health. Preliminary studies have examined postoperative lateral ventricle volume (LVV) as a predictor, though results were conflicting and often only assessments of white matter integrity were included. The objective of this study was to further elucidate the impact of postoperative LVV by characterizing its relationship with postoperative gray matter functional connectivity.

Methods: Patients with shunt-treated PH underwent structural magnetic resonance imaging (MRI) and resting-state functional MRI. Functional connectivity of various periventricular structures was characterized using graph analysis. Regression models were used to assess effects of LVV on functional connectivity and a corrected p=.002 was considered significant. Six patients with PH completed the study (age M=9.03 years, SD=1.58 years). Local efficiency of the left caudate was positively predicted by LVV (R2Adj=0.9466, p=0.0003). The remainder of the linear regressions using LVV as a predictor were not significant; however some models approached significance (p<0.01, though greater than corrected p=.002), specifically participation of the left caudate and local efficiency of the left pallidum. Multiple regression models using LVV, percent LVV of total brain volume, and age at assessment as predictors were not significant. While there were few significant findings with the current study, models approaching significance may suggest an underpowered sample. Future directions include increasing the sample size, including preoperative to postoperative change in LVV, and informing regions of interests from structural connectivity measures.

ID: 135 Comparing electroencephalographic and magnetoencephalographic data quality in healthy school-age children – a head-to-head race?

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Electroencephalography (EEG) and magnetoencephalography (MEG) are valuable tools to measure human brain functioning due to their excellent temporal resolution and their ease of administration. Both neurophysiological methods have their pros and cons regarding data quality, with the MEG being probably more affected by head motion artifacts as a result of a fixed-sensor array not directly placed on the participant`s head requiring study participants to maintain their head in a fixed position. This might be especially difficult for childhood populations, compromising data quality despite correction attempts, and consequently the reliability and validity of study results and scientific conclusions. So far, no direct comparison between EEG and MEG data quality in healthy children has been conducted.

Therefore, the aim of the current study is to explore EEG/MEG data quality in healthy, school-age children, directly compare the two methods, and identify factors that differentially affect EEG/MEG data quality.

A group of healthy, school-age children (n=40) between 6 and 11.11 years is explored using EEG and MEG. Resting-state data during an eyes open and eyes-closed condition, as well as during a Continuous Performance Task (CPT O-X) are collected. A data quality index is calculated reflecting the number of segments/trials remaining after standard preprocessing. Data quality will be compared between methods using paired-samples t-tests. Further, mixed-effects models will be fitted.

Comparisons regarding data quality, replication of robust landmark effects from the EEG/MEG literature, and effects of data quality on EEG and MEG results obtained from spectral power analyses in children will be reported.

ID: 136 Aging of sleep spindles is related to changes of the thalamus and thalamocortical tracts – preliminary findings

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Sleep spindle activity changes as a function of aging. Concurrently, changes in brain structure occur also. As thalamic reticular nuclei and thalamocortical projections interact to generate and propagate sleep spindles, age-related structural brain changes may affect the characteristics of sleep spindles. This study aimed to find whether age-related sleep spindle changes are associated with changes in the thalamocortical system including decreased thalamic volume (TV) and a loss of tracts in anterior thalamic radiation (ATR).

Healthy older (N=22, aged 60-80 years, mean = 68, 12 women) and young (N=19, aged 19-27 years, mean = 12 women) adults underwent overnight polysomnography and an MRI scanning session. We correlated sleep spindle parameters (12-15 Hz) during NREM sleep including density, duration, power, and amplitude with TV analysis and fixel-based analysis for diffusion-weighted imaging data in the two groups of young and older subjects. We found a robust local age-related decline of sleep spindle duration and power, a decrease in the overall volume of the thalamus, and reduced fibre density of the ATR in older adults. Frontal sleep spindle density and power significantly positively correlated with thalamic volume (bilaterally) and fibre density of the ATR (bilaterally). Preliminary analyses revealed altered sleep spindle characteristics and concurrent specific thalamocortical alterations in healthy aging, which were related. The results point to the interlinked nature of sleep oscillations and structural brain changes which may be implicated in sleep-dependent memory consolidation processes and long-term memory decline in aging.

ID: 138 Potential of randomized multiresolution scanning (RAMUS) in source localization: Targeting reconstruction of SEP components

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We investigate reconstructing the sequential components of somatosensory evoked potentials (SEPs) at different time latencies between 14-30 ms. We focus on randomized multiresolution scanning (RAMUS) technique in the framework of hierarchical Bayesian, conditionally Gaussian approach which we have proposed recently as a potential technique to reconstruct cortical and simultaneous subcortical activity by marginalizing errors due to optimization and discretization. The sensitivity of RAMUS follows from sensitivity decomposition of the source space into well-detectable component and numerical or noise-induced null space and the observation that the former can be approximated through a sparse set of sources.

Our goal is to detect the simultaneous cortical and weak deep activity in reconstructing the generator of SEP components of median nerve stimulation using three different realistic head models and experimental measurement datasets. RAMUS is a maximum a posterior estimation technique aiming to reduce optimization and discretization errors via randomized source spaces and coarse to fine reconstruction strategy. The source space is decomposed into random subsets during a refinement process which is repeated for several randomized configurations and the final reconstruction is obtained as an average over the multiple configurations and resolution levels. RAMUS found weakly distinguishable deep activity for earlier components while simultaneous cortical and subcortical activity was detected for components occurring after 20 ms. Our findings reveal RAMUS as a promising method for localizing cortical and weakly distinguishable deep activity in the case of realistic and multicompartment head model and experimental measurements. The outcome of RAMUS was compared to that of classical approaches.

ID: 139 MC-tES in Zeffiro Interface: Sparse Optimized and Regularized Stimulus

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In this work, we present mathematical methodology for Multi-Channel Transcranial Electrical Stimulation (MC-tES) for finding a focal optimized current pattern applied to a realistic head model. The implementation is executed using Zeffiro Interface (ZI). We approach on the formulation of forward and inverse problem for neurostimulation studies combining Finite Element Method (FEM)-based using Complete Electrode Model (CEM) boundary conditions and L1-norm regularized that can satisfy a formulated dual-simplex linear programming problem using metaheuristic conditions.

Formulate an optimization problem to find an appropriate applied stimulation current that can produce both a focal distribution in a targeted region and to provide the required components that yields a small current dose as possible. We devise an algorithm that aims to locate a set of optimization parameters which yields a feasible region wherein the candidate solutions are of least total dose and minimal requirement of active channels. The optimization outcome was found to be sensitive to the parameter selection. Multiple candidates that satisfy constraints require different electrode placement with different potential values. Parameter settings that yields minimal solution requires low-current contribution from almost all available channels, in contrast, a setting with an slightly increased current dose demands less number of channels, enhancing a focal solution. The implementation of the forward solver was a straightforward task and particularly well-suited. The optimization-based inverse solver applied to penalize the current pattern promote sparsity in order to reduce current dose concentrations in a limited area.

ID: 140 Attentional Modulation of the Auditory Steady State Response (ASSR) in First-Episode Psychosis

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Psychosis is characterized by broad auditory deficits that may be exacerbated by difficulty modulating attention. The gamma-band auditory steady state response (ASSR) is evoked by local auditory cortex circuit activity and enhanced by attention, making it ideal for investigating the combined effects of these process. Investigate whether ASSR is attenuated in first-episode psychosis (FEP), and differentially modulated by attentional processes. Matched FEP (n=32) and healthy comparison participants (n=32) underwent MEG recording during an auditory task which required them to either attend or ignore 40 Hz click train stimuli. Average ASSR evoked power was calculated in a narrow gamma band (35-45 Hz) from 100-500 ms post-stimulus using the Morlet wavelet transform then applied to a common source model using Human Connectome Project parcellation. Regions of interest were the primary auditory cortex (A1, lateral belt, medial belt, parabelt, retroinsular) and the auditory association cortex (A4, A5, dorsal posterior superior temporal sulcus). General Linear Models showed stronger ASSR during attention (versus ignore) ($F_{1,65} = 6.20$, $p<.01$, $\eta 2 = .09$) and in the right hemisphere ($F_{1,65} = 7.77$, $p<.01$, $\eta 2 = .11$) for primary auditory cortex regions. There was a hemisphere by group effect for auditory association cortex regions, with reduced ASSR in left hemisphere of FEP ($F_{1,65} = 4.55$, $p<.01$, $\eta 2 = .06$). A three-way interaction of group x attention x hemisphere was observed across all regions, with power modulation greatest in right hemisphere during attend for controls ($p<.05$, $\eta 2 = .08$-10). Auditory gamma deficits are present in early psychosis, with reduced modulation of lateralized response and attention processes that could contribute to perceptual distortions.

ID: 141 Adaptation-related changes in neural oscillations during exposure to left-right reversed audition

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Long-term human exposure to unusual sensory spaces exhibits adaptation related to perception and behavior. In the auditory modality, we have found neural activity associated with adaptation to left-right reversed audition using a wearable system, as reported in past BaCI. However, adaptation-related changes in neural oscillations during the exposure are not fully understood. This study aims to examine changes in neural oscillations during exposure to left-right reversed audition along with adaptation. We analyzed magnetoencephalographic data acquired every week during four- or five-week exposure to left-right reversed audition. The data was measured under the audiovisual matching task in which participants were asked to discriminate spatially congruent and incongruent combinations of a tone delivered to either ear and a white square cue displayed in either visual hemifield. Along with reduction of a feeling of strangeness that occurred over the exposure period, gamma power coupled with theta phase began to be generated and was gradually increased for the congruent stimuli in the temporal association cortex. Conversely, initially-observed theta-gamma coupling was decreased for the incongruent stimuli. While behavioral priority of stimulus congruency was changed over the period, no oscillatory activity correlated with this change was detected. These findings suggest that the structured oscillations correspond to perceptual adaptation to left-right reversed audition and are involved in error processing of audiovisual information, where the errors are calculated between prediction based on frequently-exposed space and input.

ID: 143 Separating background brain activity from oscillations and epileptic spike for connectivity analysis: Denoising algorithm based on discrete wavelet transform and graph theory

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Describing how brain regions interact with each other is fundamental to understand physiological and pathological processes. In resting state and sleep recordings, the electrophysiological traces can be split into background activity and superposed rhythmic or sporadic activity (such as alpha oscillations, epileptic spikes or high-frequency oscillations). Connectivity analysis is generally applied to the global signal, and it is therefore not possible to know the different contribution of the background activity and grapho-elements to the functional connectivity. We propose an algorithm which permits to extract grapho-elements which stand out from the background activity regardless of their frequency or oscillatory nature while reconstructing the background activity. Discrete wavelet transform is used to decompose the signal into different frequency scales. For each scale a robust normalisation is applied. Sets of neighbouring coefficients which are above a given threshold are found using a graph-theory-based method. Only sets with a sufficient size are kept. We evaluated this method on realistic iEEG simulations (Roehri et al. 2017) containing epileptic spikes, high-frequency oscillations, and alpha oscillations by calculating the normalised root mean square error. We showed that removing small sets improve denoising especially for high frequencies and that this method manages to extract both spikes and oscillations (independently of their frequency). We also report that the reconstructed background conserve its spectral characteristic. The application of this method as a pre-processing step could provide insight into how background activity and grapho-elements separately contribute to functional connectivity.

ID: 145 The Cluster Depth Tests: Toward Point-Wise Strong Control of the Family-Wise Error Rate in Massively Univariate Tests in M/EEG

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The cluster mass test has been widely used for massively univariate tests in M/EEG and fMRI. It is a powerful method for detecting effects while controlling weakly the family-wise error rate (FWER), although its correct interpretation can only be performed at the cluster level without any point-wise conclusion. It implies that the discoveries of a cluster mass test cannot be precisely localized in time or in space. We propose a new multiple comparison procedure, the cluster depth tests, that both controls strongly the FWER while allowing an interpretation at the time point level. A permutation scheme computes the joint null distribution of the cluster depths and a multiple comparison procedure (step-wise min-p) corrects for the number of tests. It can be extended to designs with several within- and between-subjects factors

Results: The simulation study shows that the cluster depth tests achieve large power and guarantee the FWER even in the presence of physiologically plausible effects.

Conclusions: By having an interpretation at the time point/voxel level, the cluster depth tests make it possible to take full advantage of the high temporal resolution of EEG recording to precisely time the appearance of an effect. More info : http://arxiv.org/abs/2105.07514.

ID: 146 Maximum Downward Slopes Of Sleep Slow Waves As A Potential Marker Of Attention Deficit Hyperactivity Disorder Clinical Phenotypes

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Sleep problems are common in children with Attention Deficit Hyperactivity Disorder (ADHD) [Cortese, 2015], possibly due to shared pathophysiology. However, few differences in the macrostructure of the sleep EEG have emerged between ADHD and healthy children [Díaz-Román et al., 2016]. We wanted to verify that the slope of Slow Waves (SW) was a potential predictive parameter of psychiatric comorbidities and neuropsychological dimensions in ADHD. 70 children (8.76 ± 2.77 y) with ADHD, with no epilepsy and no intellectual disabilities, underwent psychiatric and neurologic evaluation and were assessed through the CBCL 6-18, the CPRS-R, the WISC-IV rating scales, and a standard 10-20 EEG during naps. We grouped the extracted SW in bins of equal amplitude and then measured associations, through generalized linear regression, between their maximum downward slopes (MDS) and the clinical scores. Sorted by degree of significance: negative association between the Processing Speed Index and the MDS (0–30μV) in anterior and temporal right areas; positive association between the Processing Speed Index and the MDS (20–50μV) in temporal and posterior left areas; positive association between autistic traits and the MDS (50–90μV) in anterior and temporal left areas; negative association between internalizing symptoms (CBCL 6-18) and the MDS (0–40μV) in temporal and posterior left areas; positive association between comorbid multiple anxiety disorder and the MDS (50–60μV) in posterior and temporal left areas. Consistency of clusters' localization suggests that alterations in local cortical synchronization, revealed by MDS, could underlie specific neurodevelopmental trajectories resulting in different ADHD clinical phenotypes.

ID: 147 MEG source imaging of resting state oscillatory patterns in healthy subjects: validation with intracranial EEG atlas of healthy brain

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Due to the ill-posed nature of the EEG/MEG source reconstruction problem, the accuracy of EEG/MEG estimated sources requires further validation, especially before considering resting-state connectivity analysis for clinical applications. The motivation of this work is to determine the limits of resting-state MEG (rsMEG) source analysis in defining intracerebral sources and validate with intracranial EEG (iEEG) data. We aim to assess the rsMEG source imaging of oscillatory patterns in healthy subjects and validate with iEEG atlas developed by Frauscher (2018). RsMEG data acquired on 30 healthy participants, resting eyes-closed, were considered (Pellegrino2021). A source imaging technique specialized for localizing oscillations (Lina2012), the wavelet-based Maximum Entropy on the Mean, was applied on MEG sensor data. To quantitatively compare the MEG derived results with iEEG atlas, an iEEG forward model was applied to MEG source maps to estimate potentials at virtual iEEG electrodes, ViEEG (Grova2016), at the iEEG electrode positions of the atlas. Preliminary results from 8 subjects show the MEG estimated ViEEG spectra can retrieve the oscillations in alpha band in occipital regions similar to iEEG spectra. However, to preserve accurately beta oscillations found in iEEG in frontal regions in estimated ViEEG, removal of aperiodic components of the spectra (Donoghue2020) was necessary. Our preliminary results allow assessing what brain regions and for what frequencies, MEG source analysis is likely to be reliable. This study has the potential to resolve the uncertainty regarding the type of intracerebral activity that can be confidently recovered from non-invasive MEG studies.

ID: 148 EEG microstates as novel functional biomarkers for attention-deficit hyperactivity disorder

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Research on the electroencephalographic (EEG) signatures of attention-deficit hyperactivity disorder (ADHD) has historically concentrated on its frequency spectrum or event -related evoked potentials . We investigate EEG microstates, an alternative framework defined by the clustering of recurring topographical patterns, as a novel approach for examining large-scale cortical dynamics in ADHD. Using k means clustering, we studied the spatio -temporal dynamics of ADHD during rest condition by comparing the microstate (MS) segmentations between adult ADHD patients and neurotypical controls, across 2 independent datasets: the first dataset consisted of 66 ADHD patients and 66 controls, while the second dataset comprised of 22 ADHD patients and 22 controls and was used for out-of-sample validation. Spatially, ADHD and control subjects displayed equivalent MS topographies, indicating preservation of prototypical EEG generators in ADHD. However, this concordance was accompanied by significant differences in temporal dynamics. At the group level, and across both datasets, ADHD diagnosis was associated with longer mean durations of a fronto-central topography (D), indicating its electrocortical generator(s) could be acting as pronounced "attractors" of global cortical dynamics. Lastly, in the larger dataset, we also found evidence for decreased time coverage and mean duration of microstate A, which inversely correlated with ADHD scores, while microstate D metrics were correlated with sleep disturbance, the latter being known to have strong relation with ADHD. Our study underlines the value of EEG microstates as promising functional biomarkers for ADHD, offering an additional lens through which to examine its neurophysiological mechanisms.

ID: 149 Beyond broadband: towards a spectral decomposition of EEG microstates

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Originally applied to alpha oscillations, MS analysis has since been used to decompose mainly broadband EEG signals. We hypothesized that MS decomposition within separate, narrow frequency bands could provide more fine-grained information for capturing the spatio-temporal complexity of multichannel EEG. Using a large open-access dataset (n=203), we decomposed eyes open and eyes closed resting state EEGs recordings into 4 classical frequency bands (delta, theta, alpha, beta) in order to compare their individual MS segmentations using mutual information as well as traditional MS measures (e.g.global explained variance, mean duration, time coverage). We confirmed that MS topographies were spatially equivalent across all frequencies, matching the canonical broadband maps (A, B, C, D, C'). Interestingly however, we observed strong informational independence of MS temporal sequences between spectral bands, together with significant divergence in traditional MS measures. For example, relative to broadband, alpha/beta band dynamics displayed greater time coverage of maps A & B, while map D was more prevalent in delta/theta bands. Moreover, by using a frequency-specific MS taxonomy (e.g. ΘA, αC), we were able to predict the eyes-open vs closed-behavioural state significantly better using alpha-band MS features compared with broadband ones (80% vs 73% accuracy).

We conclude from this study that (1) MS topographies are spatially equivalent across all frequencies, (2) there is a strong informational independence of MS temporal sequences between spectral bands and (3) narrow-band MS segmentation may provide higher sensitivity/specificity in differentiating behavioural state relative to a broadband one.

ID: 150 Spontaneous thought and microstate activity modulation by social imitation

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The human mind wanders spontaneously and frequently, revisiting the past and imagining the future of self and of others. External and internal factors can influence wandering spontaneous thoughts, whose content predicts subsequent emotional states.

Objectives. Social imitation increases well-being and closeness by mechanisms that remain poorly understood. We propose that imitation impacts behavioural states in part by modulating post-imitation mind-wandering and underling microstate temporal dynamics. Using high-density EEG we measured resting-state activity before and after the social imitation task consisting of imitating the arm movements of an actor. Additionally, we measured salivary oxytocin, self-reported stress and well-being levels, and mind wandering spontaneous thoughts using the ARSQ 2.0 questionnaire. In 43 young subjects, we find that social imitation induces less mind discontinuity and self-related and somatic content of subsequent resting-state spontaneous thoughts. Imitation-sensitive features of spontaneous thoughts correlate with perceived stress and personality traits. EEG microstate analysis reveals that global patterns of correlated neuronal activity in posterior default mode, central executive, and verbal-auditory associated with microstates predict imitation-induced changes in spontaneous thoughts as a function of personality traits. Exploratory analyses indicate a possible modulatory effect of social imitation via the endogenous release of oxytocin. Social imitation can induce selective modulations of ongoing activity in specific neural networks, and change in spontaneous thought patterns as a function of personality traits and to ultimately orchestrate behavioural states.

ID: 151 EEG spatiotemporal patterns underlying self-other voice discrimination: Neural underpinnings of self-other voice discrimination

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There is growing evidence showing that the representation of the human 'Self' recruits special systems across different functions and modalities. Compared to self-face and self-body representations, few studies have investigated neural underpinnings specific to self-voice. Moreover, self-voice stimuli in those studies were consistently presented through air and lacking bone conduction, rendering the sound of self-voice different the one heard during natural speech. This study aims at characterizing the electrophysiological processes involved in the discrimination of self-voice and to investigate the link with behavioral performance.

Methods: We combined psychophysics, voice-morphing technology, and high-density EEG in 26 healthy participants. EEG segmentation was used to define the scalp EEG topographies underlying self-other voice discrimination (SOVD), both with air- and bone-conducted stimuli. Inverse solution allowed to define the brain sources associated to the topographies. Correlation between the parameters of EEG topographies and behavioral variables was investigated. We identified a self-voice specific EEG map occurring around 345 milliseconds reflecting the activation of a network formed by insula, cingulate cortex, and medial temporal lobe structures. Occurrence of this map was modulated both with SOVD task performance and bone conduction. Specifically, the better participants performed at SOVD task, the less frequently they activated this network. In addition, the same network was recruited less frequently with bone conduction, which, accordingly, increased the SOVD task performance. This work could have an important clinical impact. Indeed, it reveals neural correlates of SOVD impairments, believed to account for auditory-verbal hallucinations, a common and highly distressing psychiatric symptom.

ID: 153 Individual gamma frequency based neurofeedback

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Neurofeedback (NFB) is used to improve the aberrant cognitive and perceptual processes in neuropsychiatric disorders. EEG gamma activity is related to cognitive processes and is impaired in these disorders. The gamma activity-based NBF showed a potential previously; however, it lacks an individualized approach. The development and pilot testing of NBF system relying on 1) the non-invasive assessment of the individual gamma peak frequency (IGF) and 2) the application of feedback based on auditory steady-state response (ASSR). IGFs were extracted from responses to chirps and phase-locking was used as a target measure. During NBF training (N=14) the phase-locking of gamma response was continuously extracted and converted to the frequency of auditory stimulation and the size of a ball displayed on the screen. Subjects were instructed to increase the diameter of the ball. The control group (N=8) received feedback based on the other person's EEG. The backward digit span task is used as a behavioral control measure. An IGF increase was observed in the experimental group (35.8 Hz vs 39.4 Hz) but not in the control group (36.1 Hz vs 36.3 Hz) after a NBF session. This was accompanied by an increase in working memory capacity in the experimental (5.8 vs 7) but not the control group (5.1 vs 5.7). In this work, we demonstrated the results of the initial evaluation of the capabilities of the proposed NBF system to modulate IGFs. The study was supported by the Research Council of Lithuania (LMTLT agreement No S-LJB-20-1).

ID: 155 Bizarreness in Immersive Virtual Reality Differentially Affects EEG Microstate Dynamics

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Consciousness can be described as the result of interactions between large-scale brain networks. The evaluation of conscious experience as being real, however, turns out differently during different functional states of these networks. Despite the absence of sensory input, experience during sleep and psychosis is evaluated as real even in the light of bizarre elements. If conscious experience depends on large-scale brain networks, can we find a neural mechanism to describe the evaluation of the realness of the experience? As a first step, we examine large-scale brain networks during the experience of realness and bizarreness within the normal waking state. We tested 39 participants in an immersive Virtual Reality paradigm manipulating the degree of reality using dream bizarreness as a model for natural bizarreness and recorded EEG simultaneously. We analyzed EEG microstate dynamics during experience of dream-like bizarre (BizarreVR) and realistic elements (RealisticVR) in a virtual copy of our actual experimental room. We found four microstates explaining 81.01% of variance and they are similar in both conditions. During experience of bizarre elements in BizarreVR, contribution of the third microstate C was stronger than when experiencing realistic elements in RealisticVR (Fig. 1). In a previous source localization study, this microstate topography has been related to frontal network areas. Processing bizarre elements in VR elicited stronger contribution of microstate C and potentially involves areas of the frontal networks. This finding points towards the involvement of frontal areas in the evaluation of an experience as real.

ID: 158 Testing associations between negative symptoms and resting-state functional connectivity of the ventral tegmental area in subjects with schizophrenia

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Negative symptoms (NS) have long been regarded as a core aspect of schizophrenia due to their severe impact on real-world functioning. Dysfunctions involving dopaminergic cortico-striatal circuits have been documented in subjects with schizophrenia (SCZ) and hypothesized as possible neurobiological mechanisms underpinning NS. We investigated relationships between the resting-state functional connectivity (RS-FC) of the ventro-tegmental area (VTA) and NS domains. Resting-state fMRI data were recorded in 35 SCZ, recruited within the Italian Network for Research on Psychoses. We performed partial correlations between RS-FC and NS (evaluated with the Brief Negative Symptom Scale) controlling for the possible bias of secondary negative symptoms. We found that RS-FC of the VTA with the left ventro-lateral prefrontal cortex was correlated with the Experiential domain of NS; RS-FC of the VTA with the left dorsolateral prefrontal cortex was correlated with the Expressive deficit domain. Taking into account the subdomains, only the Avolition ($r = 0.418$, $p=0.019$) and the Blunted affect ($r = 0.465$, $p=.008$) showed the same correlations of the domains to which they belong. According to our findings, separate dysfunctional neuronal circuits could underlie distinct negative symptom domains and subdomains. A better understanding of the neurobiological bases of NS could help to design new treatments, targeting more specifically different aspects of NS.

ID: 159 Multivariate approach for the investigation of EEG markers to predict clinical and functional outcome of schizophrenia

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Impairments in real-life functioning in subjects with schizophrenia (SCZs) remain a substantial unmet need in patients' care. Recently, abnormalities in different electrophysiological indices have been linked to real-life functioning in SCZss. It is still not clear whether this relationship is mediated by other variables, and how the combination of different neuronal abnormalities as measured by EEG parameters, influences the complex outcome of schizophrenia.

This study aims to find EEG patterns which can predict the outcome of schizophrenia and identify recovered patients. Illness-related and functioning-related variables were measured in 61 SCZs at baseline and after four-years follow-up. EEGs were recorded at the baseline in resting-state condition and during two auditory tasks. We performed Sparse Partial Least Square (SPLS) Regression, using EEG features, age and illness duration to predict clinical and functional features at baseline and follow-up.

Through a Linear Support Vector Machine we used electrophysiological and clinical scores derived from SPLS regression, in order to classify recovered patients at follow-up. We found one significant latent variable ($p<0.01$) capturing correlations between independent and dependent variables at follow-up (RHO=0.56). Among individual predictors, age and illness-duration showed the highest scores; however, the score for the combination of the EEG features was higher than all other predictors. Within dependent variables, negative symptoms showed the strongest correlation with predictors. Scores resulting from SPLS Regression classified recovered patients with 90.1% of accuracy. A combination of electrophysiological markers, age and illness-duration might predict clinical and functional outcome of schizophrenia after 4 years of follow-up.

ID: 161 Investigating the relationships of P3b with negative symptoms and neurocognition in subjects with chronic schizophrenia

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Negative symptoms (NS) and neurocognitive impairment are amongst the major causes of the marked functional disability observed in subjects with schizophrenia (SCZs), however their neurobiological background remains unclear. P3b is considered an optimal electrophysiological candidate biomarker of neurocognitive impairment for its association with the allocation of attentional resources to task-relevant stimuli, as well as in motivation-related processes. Furthermore, associations between P3b deficits and NS have been reported. The study aims to investigate the differences in P3b parameters between SCZs and healthy controls (HCs) and the associations between these parameters with age and neurocognitive domains in both groups. Associations between P3b and NS in SCZ were also investigated. The study included 114 SCZs and 63 HCs. P3b was elicited through an auditory odd-ball task. Mann-Whitney U Tests were used to detect differences in P3b parameters between groups; Spearman's rank correlations were performed to test associations with age, neurocognitive domains and negative symptoms. P3b amplitude was significantly reduced and P3b latency prolonged in SCZs as compared to HCs. In SCZs, a positive correlation was found between P3b latency and age and between P3b amplitude and the attention-vigilance domain, while no significant correlations were found between P3b parameters and the two negative symptoms domains. In HCs, age was negatively correlated with P3b amplitude, and positively with P3b latency. Our results indicate that the effortful allocation of attention to task-relevant stimuli, an important component of decision-making, is compromised in SCZ, independently of motivation deficits or other NS.

ID: 163 Following the path to propofol-induced unconsciousness with EEG microstates

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EEG microstates are being increasingly used to parse neuronal activity into a sequence of discrete spatiotemporal patterns of transient brain states. Here we hypothesize that microstate dynamics may be used to describe pathologies-induced brain states alterations and is therefore ideally suited to track brain activity along the path to unconsciousness during surgical anesthesia.

Here we aim to discover simple yet informative and holistic microstate features that allow to detect transitions into altered states of consciousness. We continuously recorded high-density EEG in 23 surgical patients from their awake state to unconsciousness, induced by step-wise increasing concentrations of intravenous anesthetic propofol. We preprocessed the data and extracted the corresponding microstate sequences for each patient during baseline (no injection of propofol) and at different levels of unconsciousness. We then extracted, for each condition and subject, features such as average duration, density of microstates. The results show that transitions from fully alertness to deep unconsciousness elicited by propofol-based surgical anesthesia are not linear but rather accompanied by an initial increase/decrease and subsequent decrease/increase in density/duration of microstates respectively, in a characteristic "U-shape", probably linked to a state of paradoxical excitation before the transition to unconsciousness. The results demonstrate the importance of using microstates to describe transient brain states and support the idea that flexibly switching from one state to another is not due to random fluctuations of brain activity, but rather the result of a critical balance between stability and transitions as an expression of altered states of consciousness.