Book of abstracts

Keynote sessions

Decoding rhythmic and arrhythmic brain dynamics: New adventures in MEG

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Can I also do this with fMRI or with EEG? The answer is no. This is the reason why despite its cost and its inability so far to find its "killer" clinical application, magnetoencephalography (MEG) continues to provide a unique source of high quality brain data with uncomparable combination of temporal, spectral and spatial precision. In this talk, I will overview recent progress that highlights the contributions of MEG to basic and cinical neuroscience. In particular, I will focus on recent MEG investigations of rhythmic (oscillatory) and arrhythmic (scale-invariant) brain dynamics. The contributions of multi-modal studies that include MEG to resolve basic systems neuroscience questions will also be addressed. In addition, I will discuss several methodological issues related to measuring long-range connectivity in MEG source space. Analyzing MEG data using a brain decoding framework via artificial intelligence tools will be highlighted throughout the presentation. Finally, time permitting, I hope to discuss some current trends and future opportunities/challenges for MEG research.

Opening remarks: Neuroimaging in Aarhus – and why BOLD brain-mappers need MEG

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Professor Leif Østergaard, MD, PhD, is the CFIN Director and is largely responsible for creating, together with other colleagues in Aarhus, one the best imaging infrastructures in this part of the world. In this welcome address, he will overview the multifaceted research carried out at AU and will give his perspective on integrating different strands of clinical and basic neuroscience in a cooperative, creative and innovative environment.

Nordic MEG site sessions

MEG of language function: beyond univariate analysis of evoked responses

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Phase-locked evoked responses, compared across experimental conditions, are the reliable workhorse of MEG. We now know what kind of evoked responses to expect in spoken or written word perception, and specific spatiotemporal cortical activations have been associated with processing stages postulated in behaviourally based language models. But what kind of computations are required for our brains to process speech, to parse letter strings into relevant chunks, or to understand item meanings? Combination of neurophysiologically and cognitively inspired computational models, machine-learning-based evaluation, and time-sensitive neuroimaging is key to elucidating such questions. This talk will address our recent work, e.g., on a specific time-locked nature of cortical processing of speech acoustics, and temporospatially distinct semantic representations of concrete and abstract words. In another line of work, we seek to uncover cortical representation of natural connected language. The right hemisphere was strongly highlighted in our recent study of real-life connected speech production and perception, in multiple frequency ranges. Connectivity analysis has importantly facilitated study of increasingly naturalistic language function. As an example, hand movements ranging from simple motor patterning to handwriting were supported by a widely distributed cortical network, integrated via coherence of time courses of activation. The tasks were distinguished by fine-tuned phase synchrony within modules that mediate hand coordination, core cognitive and linguistic-audiovisual functions. Future work will need to bring together the views afforded by local evoked responses, multinodal networks and distributed cortical representations proposed by computational models, as well as studies using isolated stimuli and more naturalistic experimental designs.

Large-scale functional networks underlying language and speech

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Large-scale cortical networks are thought to support the dynamic integration of information across functionally specialized brain regions. Time-sensitive MEG recordings together with recent advances in network analysis allow for sub-second snapshots of the brain's functional networks. Here, I will show that such networks are reorganized in a task-relevant manner during speech production and in reading. I will also show that MEG and fMRI networks overlap in functionally relevant pathways, pointing towards a neural origin of networks obtained from haemodynamic measures.

Relating MEG signals to behavior and computational models

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How do our brains interpret visual information to make sense of the world around us? Magnetoencephalography (MEG) provides millisecond time resolution for noninvasive mapping of human cortical dynamics during natural visual behavior. The visually evoked responses show, however, great inter-individual variability, making the interpretation of the MEG signals challenging. Applying representational similarity analysis (RSA; for a review, see Kriegeskorte and Kievit, 2013) framework, we can interpret the evoked MEG responses as distributed representations of the stimuli. That is, instead of studying the shape of the response or the level of activation, we can make predictions on the similarity of the brain-activity patterns elicited by the stimuli. I will show how we can make predictions on the MEG response-pattern similarity based on computational models, and finally, how we can use eye-gaze data to interpret MEG signals during natural visual behaviour.

High-resolution, real-time and hyperscanning MEG

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MEG is currently measured almost exclusively with SQUID sensors that require superconductivity to operate. The necessary cryogenics significantly adds to the cortex-sensor distance and precludes sensor arrays adjustable to head size and shape, which deteriorates MEG signals. However, recent improvements in the performance of optically-pumped magnetometers (OPM) make them a viable alternative to SQUIDs as MEG sensors. OPMs are compact and do not need cryogenics, allowing them to be placed almost directly on scalp. Here, I will discuss our high-resolution MEG project that employs OPM sensors for a malleable MEG sensor array that should also improve spatial resolution for cortical sources. The good temporal and spatial resolution of MEG make it highly suitable for closed-loop, or neurofeedback, experiments where subject's brain activity is used to influence stimulation in real time. I will discuss the rationale, our recent results and technical solutions, including real-time machine learning, for such experiments. The above qualities of MEG also lend it for studying brain processes that support rapidly-evolving social interaction. To this end, we have constructed a hyperscanning set-up that enables simultaneous MEG measurements of two interacting subjects. I will present this set-up, the challenges in the analysis of hyperscanning data, and some initial findings.

Forward and inverse models for MEG signal interpretation

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To analyse measured MEG signals in source space, we need 1) a forward model that characterises the relationship between the cortical elementary sources and measurement, and 2) an inverse model that utilises measurement data, forward model, and prior information or assumptions about the brain activity. All inverse-modelling approaches project measured data on the forward model; a sufficiently accurate forward model is thus a prerequisite for successful source analysis. With unbiased simulations, we have recently shown (Stenroos & Nummenmaa, PLOS ONE 2016) that the cerebro-spinal fluid (CSF) has as large effect on MEG and EEG signal topographies, and that MEG might benefit more from modelling of the CSF than EEG does. The importance of modeling the CSF or other head tissues, however, depends on the signal-to-noise ratio, prior information, and the methods chosen for inverse modelling. In this talk, I will present recent results and work-in-progress on forward and inverse models, including four-compartment head models and novel beamformer and MUSIC algorithms.

MEG signals as probes of genetic functions

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Neuroimaging can provide stable measures of human brain functions non-invasively. However, the correspondence of the measured signals with molecular-level phenomena remains difficult to explore. Advances in genome-wide mapping provide tools to identify genetic loci involved in human cortical processes and, thus, a potential means of linking macroscopic cortical phenotypes with molecular-level processes controlled by specific genes. In a series of combined magnetoencephalography and genome-wide linkage studies in >200 healthy siblings we have shown that auditory cortical activation strength, the parieto-occipital 10-Hz alpha rhythm, and the 20-Hz component of the rolandic somatomotor rhythm are highly heritable (Renvall, Salmela et al. 2012, Salmela, Renvall et al. 2016, Renvall et al., in prep). Furthermore, these cortical phenotypes appear to be regulated oligogenically, with linkages to chromosomal areas with several plausible candidate genes of known neuronal functions. Identification of robust, heritable neurophysiological phenotypes and subsequently their genetic variants provides an interesting platform for interpreting neuroimaging data, and for characterizing brain functions in general.

Towards better accuracy and reliability: Hybrid MEG–MRI technology

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Although MEG technology is already of very high quality, errors in signal interpretation are caused by inaccurate knowledge of the location of the brain with respect to MEG sensors (coregistration problem) and by inaccurate knowledge of the conductivity pattern in the head that guides the intracranial current flow. Also, high-field magnetic resonance imaging (MRI), which informs us about the internal structure of the head, may produce distorted images, leading to further compromized accuracy and reliability of source localization.

We are developing a hybrid technology where the same SQUID sensors measure both MEG and MRI: both the structure of the head (MRI) and the electrical activity of the brain (MEG) can be measured essentially at the same time. The MRI will be performed at ultra-low-field levels of about 100 microtesla, which is possible thanks to the extremely good sensitivity of SQUIDs and a prepolarization technique we use. There is no fundamental image distortion in ultra-low field MRI. The combination of MEG and MRI will improve workflow, remove the coregistration error, and may allow new kinds of measurements such as current-density imaging (CDI). Reliable registration and CDI-enabled accurate determination of individual tissue conductivities will, for the first time, allow reliable use of geometric constraints such as the requirement that source currents may reside in gray matter only or that primary current is predominantly perpendicular to the cortex. If there is sufficient a priori information, the inverse problem will have a unique solution that can be trusted.

A 7-channel high-Tc SQUID-based MEG system

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Recently, several theoretical as well as practical works have shown the high potential of on-scalp magnetoencephalography [1-5]. In addition to technical advantages that come with abstaining from the use of liquid helium (most importantly less extreme temperature difference), by coming closer to the head on-scalp MEG can offer a new perspective of the brain. The reduced distance results in higher signals from the brain - which could prove advantageous especially when trying to measure activity from shallow sources.As a step towards full-head on-scalp MEG based on high-Tc SQUIDs our group is currently developing a system with 7 sensors housed in a single, liquid nitrogen-cooled cryostat. We use 8 mm x 8 mm bicrystal dc-SQUID magnetometers made from YBa2Cu3O7-x. The cryostat is designed to achieve minimal sensor-to-head distance (ca. 1 mm) combined with dense spatial sampling of a small area. To minimize crosstalk between the tightly packed SQUIDs we use a direct injection feedback scheme. To regulate the temperature, the cryostat has an option to pump on the liquid nitrogen. We are going to present the design and development of our 7-channel high-Tc SQUID-based MEG system and show first measurements performed on a head phantom.

[1] Schneiderman, Journal of Neuroscience Methods 222, 42-46 (2014) [2] Boto et al., PLoS One, doi:10.1371/jornal.pone.0157655 (2016) [3] Ivanainen et al., bioRxiv, doi: 10.1101/073585 (2016) [4] Xie M et al., IEEE TBME PP(99) (2016) [5] Boto et al., NeuroImage 149, 404-414 (2017)

High-Tc SQUID magnetometers for densely packed on-scalp MEG

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Simulations show that an MEG system based on high-Tc SQUID magnetometers with noise levels of 50 fT/sqrt(Hz) can theoretically extract more information than a state-of-the-art low-Tc system ? provided that the sensors are densely packed and placed in close proximity to the scalp (so-called on-scalp MEG) [1]. Our group has successfully made on-scalp MEG recordings with single-channel high-Tc SQUID systems [2] and is currently building a prototype multichannel on-scalp MEG system with 12 mm sensor separation. We present magnetometers based on YBCO grain boundary Josephson junctions with an 8.6 mm $\times$ 9.2 mm pickup loop directly coupled to the hairpin SQUID. The magnetometers have flat noise spectra from 2 Hz with effective magnetic field noise levels down to 86 fT/sqrt(Hz). One key issue with the integration of several magnetometers into a dense array of sensors is the crosstalk between neighboring sensors arising from the feedback scheme used for the read-out. We test different feedback options and find that the crosstalk between two sensors with direct injection of the feedback current into the SQUID loop is below 0.5 %, even for the minimal possible separation, hence enabling dense spatial sampling of the magnetic field. We are also exploring alternative approaches to improve the sensitivity of high-Tc magnetometers, e.g., via increasing the effective area with multilayer flux transformers and reducing the magnetic flux noise with nanoSQUIDs.

[1] Schneiderman. J. Neurosci. Methods 222, 42-46 (2014) [2] Öisjöen et al. Appl. Phys. Lett. 100, 132601 (2012)

High-Tc SQUID-based on-scalp and conventional MEG R&D in Gothenburg, Sweden

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The main MEG-based research and development activities in Gothenburg focus on high critical-temperature superconducting quantum interference devices (high-Tc SQUIDs) for on-scalp MEG as well as conventional MEG studies that, in the long run, may advance the shift to research using on-scalp MEG. High-Tc SQUID-based on-scalp MEG: MEG was introduced in Gothenburg in 2008 with the FP7 project MEGMRI. Early experimental work included proof-of-principle high-Tc SQUID-based MEG recordings of spontaneous brain activity [1] and benchmarking vs. the Elekta system at KI's NatMEG Center [2]. We have furthermore developed a theoretical framework for exploration and demonstration of the potential benefits of on-scalp MEG in general and high-Tc SQUIDs in particular [3].Conventional MEG: We are running four studies with the NatMEG Center: (i) Autism spectrum disorders with focus on face processing and gamma-band reactivity. Patients are recruited from the Gillberg Neuropsychiatry Centre and have been characterized with a number of longitudinal assessments. (ii) Stress response and its relation to hypertension. Healthy adults have been characterized on a hypertension risk spectrum with microneurography investigations. (iii) CT-fibers and pleasant touch. CT-afferent nerve fibers have been associated with pleasant touch to human hairy skin. (iv) Radiation therapy's effects on cognition and the hippocampus. We recruit patients that, as children, were treated for brain or head tumors or received prophylactic radiotherapy to the head. 1. Oisjoen, F., et al., Applied Physics Letters, 2012. 100(13). 2. Xie, M., et al., IEEE Transactions on Biomedical Engineering, 2016. DOI: 10.1109/TBME.2016.2599177 (99): p. 1-1. 3. Schneiderman, J.F., Journal of Neuroscience Methods, 2014. 222(0): p. 42-46.

Modulation of visual gamma oscillation by excitatory drive and the excitation/inhibition balance in visual cortex

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Cortical gamma oscillations are sensitive to the balance between excitation (E) and inhibition (I) in neural networks and their power usually rises with increasing external drive. In a recent study in children (Orekhova, 2015), we observed paradoxical suppression of visual gamma response with increasing excitatory drive that was modulated by the velocity of visual motion stimuli. Here we aimed to replicate this phenomenon and to assess its developmental stability and functional correlates. Based on previous simulation studies (Borgers and Kopell, 2005), we hypothesized that gamma suppression during strong excitatory drive reflects efficient trade-off between increasing excitation in excitatory and inhibitory circuits. Gamma oscillations were measured with magnetoencephalography in 50 children (6-15 years) and 27 adults (19-40 years) while we modulated the excitatory drive via varying the velocity of visual motion (1.2, 3.6, 6.0°/s) of high-contrast annular gratings. We found a substantial developmental slowing of induced gamma oscillations in parallel with increase of their power. In both children and adults, increasing stimulus velocity/excitatory drive led to a drastic reduction in gamma response and a shift to higher frequencies. The developmental stability of velocity-related gamma perturbations suggests an effective regulation of the E/I balance throughout the broad age-range. In children, the stronger gamma suppression correlated with higher IQ, which agrees well with the previous evidence for the importance of an optimal E/I balance for cognitive functioning. Our experimental paradigm enables noninvasive assessment of the E/I balance in the visual cortex of both typical individuals and in those with neuro-psychiatric disorders.

Neuromodulation of temporal and spatial correlations of intrinsic cortical activity

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Brain activity fluctuates continuously, even in the absence of changes in sensory input or motor output. These intrinsic fluctuations exhibit a characteristic temporal structure, which is evident as 1/f-like power spectra and long-range temporal autocorrelations, as well as an intricate correlation structure across space (i.e., correlations between different brain regions). Recent research points towards the idea that both the temporal as well as the spatial structure of intrinsic activity fluctuations are partly under the control of arousal-related brainstem systems. These systems release modulatory neurotransmitters (such as noradrenaline and acetylcholine), which alter the ratio between excitatory and inhibitory activity in the brain and profoundly shape the spatio-temporal dynamics on the level of cortical microcircuits. However, it is unknown how these microcircuit effects manifest in large-scale (co-)fluctuations of entire cortical regions in humans. Unraveling these effects is critical for understanding how neuromodulation-induced alterations of specific circuit elements translate into the gross changes in cognition and behavior that are associated with changes in neuromodulation levels.Using a combination of computational modelling, selective pharmacological manipulation and whole-brain magnetoencephalographic (MEG) recordings of cortical activity, I will show how catecholamines (dopamine and noradrenaline) as well as acetylcholine shape the temporal structure of brain activity within and across cortical regions during rest and task.

Helium recovery, forward calulation without MRI and bicoherence - an overview of current topics at University Medical Center Hamburg-Eppendorf

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This talk consists of three completely unrelated parts. At first, I will shortly present our helium recovery system. It costs around 200.000 Euros and recovers around 95% of the Helium. I will present the needs to install it and address additional workload to run this system. At second, I will present a quick and dirty solution for MEG forward calculation in an individual volume conductor without MRI data. Here, a template head model is matched in a crude approximation to the individual head using only positions of the fiducials (nasion and left and right preauricular points). These points lack any information on the scale along the z-direction, for which an average scale along x and y-direction is used. At third, I will talk about localization of bicoherence inside the brain using estimates of source direction by maximizing bicoherence. In resting state with eyes closed the strongest signal of bicoherence corresponds to the first higher harmonic of the alpha rhythms representing alpha-beta-coupling. The main experimental finding is that in the lower alpha band bicoherence is mainly localized in occipital-parietal while in the high alpha band we observe clear signals from left and right motor areas. Most importantly, we did not observe corresponding signals in motor areas when localizing power of alpha or beta activity.

Computer vision approach to video-MEG

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Traditionally, MEG research placed emphasis on recording and analyzing the brain signals while paying rudimentary attention to the participant's behavior. In a typical MEG experiment, behavior is reduced to a small number of variables recorded with simple instruments, such as response buttons. One of the most straightforward ways to significantly increase the wealth of behavioral information available for the analysis is by recording the video of the participant during the experiment. Such video recordings have for a long time been an established practice in the field EEG and have recently been gaining popularity in the MEG research as well. Although video provides a rich source of information on behavior, effectively using this information presents a formidable challenge. There is no straightfoward algorithmic approach for relating video to EEG or MEG traces in a meaningful fashion. Hence, in most cases the combined analysis of video and EEG/MEG data relies on visual inspection of the video by a human expert—the approach that is expensive, subjective, and unreliable.Here we describe our experiments towards developing video-MEG analysis techniques that rely on the methods from the field of computer vision. We start with a relatively simple computation of the optical flow—the measure that quantifies the apparent motion in the video. We demonstrate that already this basic method can extract relevant information from the the video. We proceed to discuss potential applications and outline possible directions for future research.

MEG research in BioMag laboratory

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BioMag laboratory, founded in 1994, focuses on development of clinical applications of bioelectromagnetism. It houses a 306-channel whole-head magneto-encephalography MEG system (Elekta TRIUX) in a high-performance magnetically shielded room (MSR) with EEG-mapping and first-in-the-world internal helium recycling. MEG is combined with various options for sensory stimulation (incl. eye-tracking, advanced video-MEG, and monitoring devices for clinical studies under sedation or anesthesia). MEG research in 2014-17 includes deep brain stimulation effects on Parkinson's disease, identification of biomarkers for stroke rehabilitation, and participation in Magic-AD consortium to identify MEG biomarkers in Alzheimer's disease. The development on MEG in preoperative workup of epilepsy surgery has made BioMag a world leader in studies of ictal MEG. In addition, basic brain research probing, e.g., brain connectivity during working memory or properties of the developing brain, is run in BioMag. Methodological development, e.g., new artifact filtering paradigms and time-locked video recordings are done in BioMag jointly with Elekta. The navigated TMS system (nTMS) includes EEG-mapping (nTMS–EEG, Nexstim eXimia and NBS4) and tools for speech nTMS and versatile additional stimulations. BioMag has extensive experience in combining MEG and nTMS in preoperative workup of epilepsy surgery. A novel breakthrough in 2016 is the use of nTMS in rehabilitation of spinal cord injury patients and monitoring its effects with MEG. A 99-channel flat-bottom magnetometer in a MSR is available for magnetocardiography and fetal brain studies. A 16-channel purpose-built NIRSI applied in the MEG and TMS settings is available as well.

Advances in applying naturalistic stimuli in MEG

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Understanding how time-resolved sensory information processing works in the brain can greatly benefit from naturalistic, ecologically valid stimuli in neuroimaging experiments. Real-world stimuli characteristically unfold over time serially as sequential patterns with contextual bindings. Typical repetitive stimuli efficiently probe the functions of the early sensory cortices, but naturalistic stimuli may involve hierarchically-organized sensory-processing chain more widely from early sensory areas to higher-order cognitive areas in the range from milliseconds to tens of seconds. Methodologically, as real-world stimuli are characteristically one-time-only signals, reliable detection of ongoing brain activity can be challenging. In this talk, some of our advances in probing time-resolved sensory information processing in the brain are presented showing, for example, replicable entrained brain activity in MEG with movie and narrative speech stimuli.

Roles of neural oscillations and scale-free dynamics in cognition and behavior

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Neuronal oscillations and oscillatory synchronization are thought to coordinate anatomically distributed processing across cortical regions. We aim at understanding the functional significance of local and large-scale oscillatory network synchronization in mediating perception, attention, and working memory functions. To this end, we use source reconstructed MEG data and the correlation of these data with individual behavioral variability. As a model system, we have used a visual working memory (VWM) in which sensory information must be represented and sustained online for some seconds. Our work shows that local gamma oscillations underlie the maintenance of VWM contents and that concurrent large-scale network synchronization from theta- to gamma-frequency bands characterizes VWM performance. Importantly, we recently showed that cross-frequency phase synchronization connected alpha- with beta/gamma- and theta- with alpha/beta-band networks in visual and frontoparietal attention systems. These novel results suggest that large-scale assemblies of phase coupled cortical oscillations and their cross-frequency interactions may underlie the integration of sensory and attentional functions during VWM.As another line of research, we have investigated the functional significance of scale-free neuronal fluctuations in coordinating behavioral performance dynamics. In time scales from seconds to hundreds of seconds, psychophysical dynamics and the amplitude fluctuations of neuronal oscillations are governed by power-law-form long range temporal correlations (LRTCs). Our work also shows that such scale-free amplitude fluctuations in neuronal activity are predictive of those in the behavioral activity. Finally, we have observed the scale-free neuronal dynamics and oscillatory coupling to have co-localized modular structures at multiple levels of network organization, which indicates a novel association among scale-free neuronal dynamics, functional connectivity, and behavioral fluctuations.

Cortical activation in self-paced and reaction-time movements differ in MEG

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Voluntary movements demand advance preparation. Self-paced (SP) voluntary movements are internally prepared well in advance their execution however, there is an inhibitory phase preceding reaction-time (RT) movements. We compared SP and RT movements in the vicinity of movement onset. Our data consists of 18 healthy subjects performing RT and SP movements registered with 306-sensor magnetoencephalography (MEG). SP movements were fast right hand index finger abductions and analogous RT movements were performed cued with cutaneous electrical stimulation delivered on radial nerve area on the dorsum of the hand. Movement fields (MF) and movement evoked fields 1 (MEF1) corresponding to activations in the sensorimotor cortical areas during motor action execution and also afferent feedback after movement were analyzed with Brainstorm's scouts as a regions of interest analysis. During both movement types motor (M1) and sensory (S1) cortices contributed to activations before and after movement onset. In RT task, M1-S1 cortices showed higher activation compared to SP condition. Origins of the detected fields are suggested based on current density maps and peak coordinates. Significant location difference in anterior-posterior direction between MF and MEF1 activities imply about 10 mm more posterior activation in MEF1 than in MF. MEF1 in SP was deeper than MF, which allows speculation about possible MEF1 generator location in area 3a. During the period before RT stimulus, SP task already displayed stronger preparatory activity in M1. It appears that a precise form of estimation of activation is involved in M1-S1 cortices which may predict the sensory consequences of motor tasks.

Neuronal processing of eye contact

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Gaze is an important social cue, but neuronal processing of eye contact is relatively unknown. We studied the effects of gaze direction its social relevance by experimentally contrasting eye contact with diverted gaze and non-social direct gaze. 20 volunteer subjects observed gaze shifts of a live model person while MEG was recorded. In the beginning of each trial, the model's gaze was directed 15 degrees to the side of the volunteer. A horizontal saccade shifted the gaze to either in the eyes of the subject ('towards') or 30 degrees off to the side ('away'). Trials were performed in two conditions: in the 'direct' condition the model and subject had an unobstructed view of each other, in the 'mirror' condition the subject was deceived that the model was behind a one-sided mirror and couldn't see the subject. Epochs were triggered on saccades of the model, recorded with MEG-synchronised EOG. All subjects admitted being fooled by the mirror deception. Our preliminary analyses of the MEG data revealed minor responses in the visual cortices, elicited by the gaze shifts, and a long-lasting response in the parietal cortex. Also frontal regions were activated in later stages of processing. The largest differences between conditions 'towards' and 'away', signalling eye contact, were found in the parietal cortex at around 400 ms after saccade onset. The differences between 'direct' and 'mirror' conditions, signalling social relevance of eye contact, seemed most notable in the temporal-frontal regions at around 300-600 ms.

Effects of Physical Activity on Inhibitory Control in Adolescents.

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Physical Activity (PA) seems to produce selective benefits for processes requiring inhibitory control (Verburgh et al., 2014). However, the neural mechanisms implicated are still unknown. The main goal of this research project is to determine whether level of PA influence neural processes underlying attention and inhibitory control in the brain. We used whole-head magnetoencephalography (Elekta Neuromag) to record neural responses during a visuospatial covert attention paradigm (Vollebregt, 2015) in a group of 22 high-fit and 40 moderate-to-low-fit teenagers (13-16 years old). During this task, targets in the left or right hemifield were preceded by valid (75%) or invalid cue and subjects had to report the position of the target. The physical activity level was determined based on Accelerometer measurements. We computed the modulation of alpha activity in parietal and occipital regions during anticipation of forthcoming information either to left or right visual fields. Inhibitory processes measured by the Modulation Index (MI) of alpha power (ipsilateral - contralateral alpha values to the cued hemifield) showed the expected stronger ipsilateral than contralateral alpha values during pretarget interval. This effect was stronger for the higher-fit group. In the behavioral analysis higher-fit group also showed significantly stronger benefit from cueing, measured by differences in reaction times (incongruent - congruent). In conclusion, physical activity level seems to influence inhibitory processes in the brain by means of a more efficient suppression of distracters and release from inhibition which results in a more effective performance in an inhibition task.

Jyväskylä Centre for Interdisciplinary Brain Research (CIBR)

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Jyväskylä Centre for Interdisciplinary Brain Research (CIBR) was established in 2012, and the MEG laboratory was opened in May 2015. The centre is located in the Department of Psychology, Faculty of Education and Psychology, but it provides research facilities and support for neuroscientific research across different disciplines. CIBR facilitates the use of state-of-the-art techniques for measuring and stimulating brain, ranging from single neuron level to the brain and body functions. Research activities focus especially on understanding brain changes throughout the lifespan in context of learning and development, interventions and wellbeing, and physical exercise. The MEG laboratory in CIBR is being tailored to support research projects within these strategic focus areas of the university. We will provide an overview of the research environment in CIBR and give examples of research projects that have started during the two years of our MEG laboratory.

Audio-visual association learning studies at the University of Jyväskylä

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Audio-visual association learning is important for many skills, including reading. Long-term effects of this learning process is relatively well known. However, studying how the brain activity changes when auditory and visual material are learnt to be associated is not well understood. We have studied reading and audio-visual associations in several experiments. In the first one, the well-established audio-visual associations are studied in a group of native Chinese speakers and native Finnish speakers. In the second experiment, the cognitive processes related to audio-visual learning are investigated. Our results indicate that the left auditory areas are strongly affected by long-term exposure to systematic audio-visual associations of written characters and heard syllables. The effect is present 400 ms after stimuli onset. In contrast, when the associations are being learnt the frontal and temporo-occipital cortices show increasing activation as training progresses. This activation starts to diverge around 350 ms from control stimuli. Further experiments are planned to understand how activity during training of audio-visual associations leads to effortless multi-modal representations.

Evidence for a tactile omission response: Distinctive responses to actual and omitted stimulation

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It is well known that the brain builds up expectations to future events based on past regularities. This has been studied extensively in the auditory and visual domains using oddball paradigms. Only little exploration has been done of the tactile domain though. Here we investigate the brain responses to complete omissions of otherwise expected tactile stimulations. We find that there are early magnetoencephalographic time-locked responses (~140 ms) to omissions of expected stimuli relative to extended periods of non-stimulation even for long inter-stimulus durations (3000 ms). These can be source localized to the secondary somatosensory cortex. We furthermore find pre-expected-stimulus oscillatory responses that potentially reflect the neural representation of tactile expectations, and post-expected-stimulus oscillatory responses reflecting the disappointed expectation in the cingulate cortex. Exploratory coherence analyses suggest that the middle cingulate cortex plays a unique role in detecting omissions driven by differences in the theta and beta bands. On the other hand, the anterior cingulate cortex seems to mainly represent the presence of tactile expectations in the brain.

NatMEG–building a national MEG community from scratch

Daniel Lundqvist[1]

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NatMEG is the first and only research laboratory in Sweden for whole-head MEG measurements. The NatMEG lab was inaugurated as a national facility in October 2013, against a background of little national experience or expertise in MEG, much interest and very varied expectations. Already within 1 year after opening, research teams from Gothenburg, Umeå, Lund, Linköping, and Stockholm had begun accessing the facility, and today users are researching on a wide array of topics across the five domains of cognitive neuroscience, clinical neuroscience, instrumentation, clinical applications and computational modelling. What did it take to initially attract users to NatMEG and build a national user community from scratch? Here's the story.

Disturbed cortical processing of proprioceptive signals in Parkinson's disease

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The loss of dopaminergic neurons and the associated depletion of the neurotransmitter dopamine is a defining feature of Parkinson's disease (PD). This depletion has been linked to an abnormal oscillatory neural activity in the sensorimotor system, particularly pronounced in the beta-band (12–30Hz). In PD, such beta-band abnormalities may influence the neural processing and integration of sensory and proprioceptive information, a process which is critical for maintaining motor control. The disturbances in the beta-band in PD are believed to reflect the integration of proprioceptive signals from the peripheral nervous system within the sensorimotor system.We used proprioceptive stimulation in MEG and to measure the beta-band activity related to proprioceptive feedback in PD patients on and off medication. PD patients and healthy controls were subjected to proprioceptive stimulation by means of passive movements of the index finger elicited by pneumatic artificial muscles. The analysis depicted the stimulus-related beta desynchronization and so-called beta rebound following the movement. The results show that the beta rebound was significantly diminished in PD compared to healthy controls. The results demonstrate that integration of proprioceptive information carried by the beta band within the sensorimotor cortex is reduced in PD.

Selective Attention In A Musical Cocktail

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The Cocktail Party Effect (CPE) refers to our ability to selectively attend to a single conversation present among other ongoing speeches, thereby allowing us to extract behaviourally relevant information amidst noisy distracters. Using a frequency-tagging method, we extract the auditory steady-state response (ASSR) cortical signals to binaurally presented melody streams within a mixture containing melodies of different pitch range. By instructing subjects to selectively attend to one melody at a time, while ignoring the others, we determine the effect of selective attention on the respective ASSR powers. In addition, we can further exploit the millisecond temporal resolution of MEG to capture attentional shifts and wavers across time during selective listening tasks. Using musicians as a model of auditory expertise, we explore the potential of enhancing selective listening ability via training based on neuroplasticity grounds, a direction which can have powerful implications on learning.

Clinical MEG projects in Aarhus

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Visualizing spikes in source-space: Rapid and efficient evaluation of magnetoencephalography OBJECTIVE: Reviewing magnetoencephalography (MEG) recordings is time-consuming: signals from the 306 MEG-sensors are typically reviewed divided into six arrays of 51 sensors each, thus browsing each recording six times in order to evaluate all signals. A novel method of reconstructing the MEG signals in source-space was developed using a source-montage of 29 brain-regions and two spatial components to remove magnetocardiographic (MKG) artefacts. Our objective was to evaluate the accuracy of reviewing MEG in source-space. METHODS: In 60 consecutive patients with epilepsy, we prospectively evaluated the accuracy of reviewing the MEG signals in source-space as compared to the classical method of reviewing them in sensor-space. RESULTS: All 46 spike-clusters identified in sensor-space were also identified in source-space. Two additional spike-clusters were identified in source-space. As 29 source-channels can be easily displayed simultaneously, MEG recordings had to be browsed only once. Yet, this yielded a global coverage of the recorded signals and enhanced detectability of epileptiform discharges because MKG-artefacts were suppressed and did not impede evaluation in source-space. CONCLUSIONS: Our results show that reviewing MEG recordings in source-space is accurate and much more rapid than the classical method of reviewing in sensor-space. SIGNIFICANCE: This novel method facilitates the clinical use of MEG.

Focal epileptiform discharges detected by magnetoencephalography and simultaneous electroencephalography Objective: To compare the diagnostic yield of magnetoencephalography (MEG) and electroencephalography (EEG) for detecting interictal epileptiform discharges (IEDs) in patients referred for epilepsy surgery evaluation. Method: One-hundred-and-forty-one patients undergoing epilepsy surgery evaluation were prospectively analyzed. A MEG whole-head 306-channel Elekta Neuromag® system, and simultaneous high density EEG (70 electrodes, range 58 to 80) using a non-magnetic cap (EASYCAP) were recorded in 115 consecutive patients. Eight patients were investigated with an array of 19 EEG electrodes, according to the 10-20 system. Due to large head circumference or inability to cooperate, 18 patients were investigated without EEG. Spontaneous electric and magnetic brain activity was recorded for 1.5 h. The data were offline band-pass filtered 0.5 to 70 Hz. MEG-EEG was visually inspected by trained physicians (LD, SB) for well-defined IEDs using CURRY 7 Neuroimaging Suite and BESA-MEG. Results: Ninety-six different clusters of IEDs were identified in 85 patients. In 73% (70/96) of the foci the IEDs were visible both in MEG and EEG. In 15% (14/96) of the foci the IEDs were visible only in EEG. In 13% (12/96) the foci were visible only in MEG. There was no statistical difference in the number of IEDs detected only by EEG compared to IEDs detected only by MEG (p-value 0.6731). Conclusion: Although the majority of IEDs are detected in row data by both modalities, in about one third of the cases the discharges were detectable in only one modality. Simultaneous recording of MEG and EEG signals supplements each other and optimizes diagnostic yield.

Effect-mechanism of deep brain stimulaiton and dopaminergic medication on sensorimotor function in advanced Parkinson's disease

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Deep brain stimulation (DBS) of the subthalamic nucleus (STN) alleviates motor symptoms in Parkinson's disease (PD) when dopaminergic medication is no longer a viable treatment. Sensory processing, being part of the sensorimotor loop, is important for robust motor output, but the effect of treatments on this processing is not well understood. Both DBS and doparminergic medication effectively improve motor symptoms, however their underlying mechanisms are unclear. We recorded magnetoencephalography (MEG) and electromyography (EMG) from PD patients in two studies: (i) during median nerve stimulation and (ii) while performing phasic contractions (hand gripping). The two studies focused on somatosensory processing and movement-related cortical oscillations, respectively. The measurements were conducted in DBS-treated, untreated (DBS washout) and dopaminergic-medicated states.While both treatments ameliorated motor symptoms similarly in both studies, they showed differentiated effects on: (i) somatosensory processing with higher gamma augmentation (31-45 Hz, 20-60 ms) in the dopaminergic-medicated state compared to DBS-treated and untreated states, and (ii) hand gripping with increased motor-related beta corticomuscular coherence (CMC, 13-30 Hz) during dopaminergic medication in contrast to increased gamma power (31-45 Hz) during DBS.Taken together, we infer that DBS and dopaminergic medication employ partially different anatomo-functional pathways and functional strategies when improving PD symptoms. Keywords: Parkinson's Disease, Magnetoencephalography, sensorimotor function

Stimulus- and person-related factors affecting encoding, discrimination and transmission of sounds in human brains

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Electromagnetic time-locked responses to sounds reflect several aspects of information processing, including the fast, automatic encoding of acoustic features, the formation of predictions based on feature probability of occurrence, and the hierarchical violations of these predictions. Moreover, these different aspects of information processing predict the way sounds are culturally transmitted and learned. A number of factors influence information processing, learning and cultural transmission. Stimulus-related properties such as spectral entropy, fluctuation patterns, pulse clarity and mode are differentially encoded and discriminated in sensory-motor cortices. Further, person-related factors, such as expertise working-memory capacity, general intelligence, depression trait, modulate the electromagnetic evoked responses to sounds. Our recent studies aimed at testing these claims use both controlled multifeature paradigms (repeated sounds with varying levels of specific features) as well as ecological paradigms (free listening to real musical pieces or vocalizations), and combine psychological testing, computational acoustic-feature extraction and genetic mapping with electromagnetic and anatomical magnetic resonance recordings.

The Retina as a Window to the Brain

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Many neuroscientists consider the retina to be an extension of the brain. Retinal activity can be measured with the electroretinogram (ERG), a routine technique in eye clinics, but its application to human neuroscience research has been exceedingly rare. This is a rather crucial oversight, as we now know that the retina carries out sophisticated pre-processing on visual scenes, even including motion detection. Intriguingly, the retina has long been known to respond to visual stimuli with a high-frequency burst, reminiscent to visual cortex.

Our project aims to elucidate how retinal and cortical oscillations interact to communicate visual information in humans. Our initial experiments aimed to characterize the basic neural responses to simple light flashes across the visual pathway from retina to cortex. We employed 1 ms light flashes while we simultaneously measured ERG and MEG.

Our results support the view that high-frequency activity (approx. 70-130 Hz) reflect the precise timing of information processing across the entire visual pathway: the latency of the ERG response is consistent with retinal output, a plausible thalamic response occurs a few milliseconds later, and finally, after another short delay, a massive response spreads throughout visual cortex. These responses occurred much earlier than the classic visual evoked response, with the first central brain responses already appearing between 25-35 ms.

We have also conducted experiments investigating retinocortical interactions upon light offset (Westner et al., MEG Nord) and presentation of photographs (Zeiller et al., MEG Nord). Taken together, measuring ERG together with MEG/EEG provides important clues as to the role of the retina in visual processing and may even allow us to infer thalamic activity.

Neocortical representations for language: E/MEG studies of memory trace build-up, activation and decay

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Humans learn new words rapidly, both as children acquiring their native tongue and later in life when learning other languages – an essential feature of our communication system that ensures its high efficiency. However, the neural bases of this important skill are poorly understood. As part of the neurolinguistic research programme at AU, we have used MEG and EEG to demonstrate rapid development of perisylvian cortical memory circuits for novel words over a short session of exposure to them, manifest as a temporo-frontal response enhancement correlated with behavioural learning outcomes. This effect (i) is independent of attention, reflecting a largely automatic nature of initial word acquisition stages, (ii) operates in both visual and auditory modalities, and (iii) is most efficient for native language. Fast learning effects can even be seen for morphologically complex words, suggesting rapid lexicalisation of new derivational forms. An even more flexible lexical system exists in children, in whom brief intensive exposure to novel materials leads to ultra-rapid neural acquisition of not only different native word types but also of non-native and non-speech sounds. This rapid learning capacity is, however, impaired in a dyslexic brain. These experiments demonstrate that our brain is capable of immediately forming new cortical circuits online, as it gets exposed to novel linguistic patterns in the sensory input, and suggest E/MEG as a useful tool for tracking dynamic processes of neural memory-trace build-up and activation, as well as for investigating neurolexical deficits - a focus of a range of studies currently developed at AU.

Blitz presentations

Added diagnostic value of magnetoencephalography (MEG) in patients suspected for epilepsy, where previous, extensive EEG workup was unrevealing

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Objective: To elucidate the possible additional diagnostic yield of MEG in the workup of patients with suspected epilepsy, where repeated EEGs, including sleep-recordings failed to identify abnormalities. Methods: Fifty-two consecutive patients with clinical suspicion of epilepsy and at least three normal EEGs, including sleep-EEG, were prospectively analyzed. The reference standard was inferred from the diagnosis obtained from the medical charts, after at least one-year follow-up. MEG (306-channel, whole-head) and simultaneous EEG (MEG-EEG) was recorded for one hour. The added sensitivity of MEG was calculated from the cases where abnormalities were seen in MEG but not EEG. Results: Twenty-two patients had the diagnosis epilepsy according to the reference standard. MEG-EEG detected abnormalities, and supported the diagnosis in nine of the 22 patients with the diagnosis epilepsy at one-year follow-up. Sensitivity of MEG-EEG was 41%. The added sensitivity of MEG was 18%. MEG-EEG was normal in 28 of the 30 patients categorized as 'not epilepsy' at one year follow-up, yielding a specificity of 93%. Conclusions: MEG provides additional diagnostic information in patients suspected for epilepsy, where repeated EEG recordings fail to demonstrate abnormality. Significance: MEG should be included in the diagnostic workup of patients where the conventional, widely available methods are unrevealing.

Comparing multilayer brain networks between groups

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Numerous studies have applied complex network approaches to analyse single layer networks from neuro-imaging datasets. Recent work extended this approach towards a multilayer framework1,2, which allows us to integrate information from different frequency bands in case of M/EEG networks. However, group comparisons using traditional graph theoretical metrics can be influenced by biases for example, due to differences in network density or average functional connectivity3. Here, we seek to understand if multilayer approaches may ameliorate these problems, addressing in particular: 1) Do biases from single layer networks generalise to multilayer networks? 2) Can we apply existing and new approaches (minimum spanning tree (MST)4 and efficiency and cost optimisation,5,6) to multilayer networks to correct for differences in average connectivity and network density? For weighted networks, we introduce a new approach to correct for average connectivity based on singular value decomposition (SVD). Based on a multilayer preferential attachment model, as ground truth and also empirical multilayer networks obtained from MEG and fMRI datasets. Results show that the biases of single layer network comparisons also extend to multilayer networks. To extract important links in a network MST can be applied to the single layers separately, but not to multilayer networks as a whole as it might lead to an imprecise representation of the multilayer network. Normalisation based on SVD shows high correlation with the underlying network. Current analysis support the use of (SVD) weight normalisation for the whole multilayer network compared to filtering approaches that result in unweighted multilayer network.

Working memory performance predicts the neural discrimination of sound deviants as indexed by frontal mismatch negativity: an MEG study

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Objective: Working memory is a cognitive system with a limited capacity that is responsible for the transient retention, processing, and manipulation of information. In neurophysiological studies, it has been related to the accuracy of sensory memory traces formation. Methods: Using magnetoencephalography (MEG), we recorded magnetic mismatch negativity responses (MMNs) to six acoustic feature deviants (pitch, timbre, location, intensity, slide and rhythm) inserted in a 4-tone sequence in 86 Finnish adult participants while they were concentrating on watching a silenced movie. After the MEG recordings, participants were administered the working memory subscales (Spatial Span and Letter Number Sequencing) of Wechsler Memory Scale (WMS). Results: We found significant correlations between frontal MMNs to intensity and slide deviants and working memory performance, specifically concerning the visual spatial span task. In the case of intensity, the relation was revealed in all participants, while for slide only in individuals with a musical expertise. Conclusions: Automatic neural responses to auditory feature changes are increased in individuals with higher visual working memory performance. This evidence suggests that conscious, modality-general working memory abilities might be linked to pre-attentive sensory-specific neural skills of prediction and brief-term storage of environmental regularities.

Expectation violation and attention to pain jointly modulate neural gain in somatosensory cortex

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The neural processing and experience of pain are influenced by both expectations and attention. For example, the amplitude of event-related pain responses is enhanced by both novel and unexpected pain, and by moving the focus of attention towards a painful stimulus. Under predictive coding, this congruence can be explained by appeal to a precision-weighting mechanism, which mediates bottom-up and top-down attentional processes by modulating the influence of feedforward and feedback signals throughout the cortical hierarchy. The influence of expectation and attention on pain processing can be mapped onto changes in effective connectivity between or within specific neuronal populations, using a canonical microcircuit (CMC) model of hierarchical processing. We thus implemented a CMC within dynamic causal modelling (DCM) for magnetoencephalography in human subjects, to investigate how expectation violation and attention to pain modulate intrinsic (within-source) and extrinsic (between-source) connectivity in the somatosensory hierarchy. This enabled us to establish whether both expectancy and attentional processes are mediated by a similar precision-encoding mechanism within a network of somatosensory, frontal and parietal sources. We found that both unexpected and attended pain modulated the gain of superficial pyramidal cells in primary and secondary somatosensory cortex. This modulation occurred in the context of increased lateralized recurrent connectivity between somatosensory and fronto-parietal sources, driven by unexpected painful occurrences. Finally, the strength of effective connectivity parameters in S1, S2 and IFG predicted individual differences in subjective pain modulation ratings. Our findings suggest that neuromodulatory gain control in the somatosensory hierarchy underlies the influence of both expectation violation and attention on cortical processing and pain perception.

An evaluation of kurtosis beamforming in magnetoencephalography to localise the epileptogenic zone in drug resistant epilepsy patients

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Purpose: Kurtosis beamforming has shown to be a useful technique for analysing magnetoencephalograpy (MEG) data containing epileptic spikes. However, the implementation varies across MEG centres and few studies measure concordance with subsequently resected areas. We evaluated kurtosis beamforming as a means of localising spikes in a clinical cohort of drug-resistant epilepsy patients. Methods: We retrospectively implemented the kurtosis beamformer in MEG recordings of 22 epilepsy patients that had been analysed using standard clinical equivalent current dipole modelling (ECD). Virtual electrodes were placed in the kurtosis volumetric peaks and visually inspected for spikes to select a single candidate source. The candidate source was compared to the previous ECD localisations and the subsequent resection areas.Results: The kurtosis beamformer and (the original ECD analysis) produced interpretable localisations in 18/22 (20/22) patients, of which the candidate source coincided with the resection lobe in 9/13 (10/13) seizure-free patients and in 3/5 (5/7) patients with persistent seizures. The sublobar accuracy of the kurtosis beamformer with respect to the resection area was higher than ECD (56% and 50%, respectively), however, ECD resulted in a higher lobar accuracy (75%, 67%). Both methods localised the resected area in a few seizure-free patients, in whom the other method was discordant. Significance: Kurtosis beamforming performs comparably to ECD with fewer subjective steps. Kurtosis beamforming may support ECD analysis, especially when spikes are not visible in the physical sensors. We propose that kurtosis beamforming should be integrated with existing clinical protocols to assist in generating a hypothesis about the epileptogenic zone.

Theta power decreases predict spatial accuracy of subsequent active navigation: a combined intracranial EEG/MEG study

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MEG and EEG studies have reported increases in MTL theta power during mnemonic encoding that were associated with better subsequent episodic memory and spatial navigation performance. However, recent invasive studies have shown that successful encoding of items and associations are mainly characterized by broad decreases in theta activity (3-8 Hz). We performed a combined intracranial EEG/MEG study and explored how theta activity, time-locked to the encoding of item-place associations, relates to subsequent navigation accuracy. The task was implemented inside computer-simulated scenarios and administered as a video game. Pictures of buildings were presented at given locations that participants were asked to remember. Analyses in healthy participants showed that slow-theta (2-5 Hz) power negatively correlated with spatial accuracy for locations. Sources were localized in MTL and cortical structures involved in spatial cognition. Similar effects (3-8 Hz) were observed with intracranial EEG recordings from epilepsy surgery patients. We had the rare opportunity to simultaneously record MEG from an epilepsy surgery patient who was implanted in the left parietal and temporal cortex. With this dataset, we found that during power effects, slow-theta in right anterior hippocampus and left inferior frontal gyrus phase-led the left lateral temporal cortex and predicted spatial accuracy. Taken together, our findings indicate that decreased slow-theta activity reflect local and long-range neural mechanism underlying the encoding of detailed spatial information and item-context associations. They are in line with the view that local suppression of low-frequency activity is essential for more efficient processing of detailed information.

Faster than the brain's speed of light: Retinocortical interactions differ in high frequency activity when processing darks and lights

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Visual responses to dark stimuli are processed by different pathways than light stimuli in the visual system, and some studies suggest the processing of darks benefits from greater neural resources and potentially occurs faster. However, evidence from the human brain is still sparse, especially with respect to retinocortical interactions. We recorded retinal and cortical responses to 480 ms light flashes simultaneously with electroretinography (ERG) and magnetoencephalography (MEG) in ten participants. To analyze the high frequency responses to the flash onsets and offsets, a combined approach of beamforming and the Hilbert transform was used in order to yield the analytic amplitude and intertrial coherence (ITC) of five frequency bands between 55 and 195 Hz.High frequency oscillations for flash offsets occurred earlier than flash onsets in the cortex, as measured by peak ITC latencies (light offset: 57 ms in the 75-95 Hz band, light onset: 71.5 ms and 77 ms in the 75 to 125 Hz range, Wilcoxon signed rank test: R=49, p=0.0254 and R=40, p=0.0352), but not in the retina. Here, the light onset oscillatory potential emerged earlier compared to the light offset response (light onset: 27 ms (105-125 Hz) and light offset: 34 ms (75-95 Hz), R=0, p=0.0312). Interestingly, while the onset activity involved a wide range of frequencies (55-195 Hz in the retina, and 55-145 Hz in the cortex), the offset response was restricted to the 75-95 Hz frequency band in both retina and cortex. The results suggest faster propagation times but not earlier retinal processing for darks than lights, suggesting a thalamic role. They also support previous findings that the retinal high frequency activity is transmitted to cortex. Furthermore, the outcomes add to the ongoing discussion about the function of narrowband oscillations in the human visual system.

Spatiotemporal characteristics of auditory activation in children with typical and atypical (SLI) language development

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Cortical development of auditory perception is reflected in the evoked responses measured with electro- and magnetoencephalography (EEG/MEG). Specifically, activation at ~250ms (N250) has been reported predominantly in children and it reflects level of language skills. Specific language impairment (SLI) is linked with deficient processing of auditory information and with atypical brain responses to sounds. There are however conflicting findings regarding morphology of auditory evoked responses in children with SLI compared to typically developing children. Children often miss the clear peaks visible in the adult waveform, emphasizing the need to include spatial information in the analysis. This study aims to test the hypothesis that children with SLI have atypical brain responses to sounds and to map typical and atypical variation in auditory evoked fields (AEFs) that extend beyond the generally reported amplitude or latency differences. To better understand this variation for language, it is important to analyze underlying source information of the AEF, possibly varying in time and between hemispheres. Using MEG, we compared the AEFs of children (9-10 years) with SLI (n=10) and with typical language development (n=10) in response to passively listening to sine-wave tones (1kHz, 50ms) presented alternately to the right and left ear. The results indicate increased symmetry in SLI children compared to controls, possibly due to a maturational lag in the left hemisphere. We focus on the N250m, a considerably underreported component that is argued to be absent in the adult waveform and likely a signature of brain maturation.

Frequency-resolved directed neural interactions support expectation and detection of visual target stimuli

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The recognition of expected visual stimuli is associated with neural activity particularly in the inferior temporal and fusiform gyri, as well as the inferior and superior parietal cortex. Moreover, efficient detection of target stimuli is mediated by frontal and parietal regions. Here, we characterized how network interactions between the brain regions involved in attentional and visual processing are modulated in the detection of human faces in a temporal stream. In a magnetoencephalography experiment, we presented sequences of human faces to the subjects whose task was to detect a target face among this sequence. Activation (evoked and oscillatory responses) and cortico-cortical coherence analyses were conducted to identify the set of brain regions that were participated in the perception of the faces, and in which the pre-target and target faces elicited differential responses. Frequency-resolved analysis of directed neural interactions was then conducted within this network using conditional Granger Causality. Our results revealed very similar networks in the left and right hemisphere, comprising nodes, e.g., in the precuneus, the superior parietal cortex as well as the fusiform and middle frontal gyri. The perception of target faces was associated with increased bottom-up influences in the gamma-band, whereas the processes related to attention and the expectation of target stimuli manifested as wide-spread top-down as well as bottom-up interactions in both the beta- and gamma-band, especially in the right hemisphere. Our results demonstrate the role of frequency-specific directed neural interactions in the recognition of visual stimuli and in guidance of executive attention resources towards expected inputs.

Dynamic processing of musical features at different MEG frequency bands in continuous music listening: a correlation study

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The combination of MEG and advanced audio signal processing could potentially highlight the brain processes of dynamic music features. MEG evoked responses to musical stimuli have pinpointed brain areas responsible for different aspects of music processing whereas correlations between musical features and functional MRI data have revealed large-scale networks activated in continuous music listening. However, induced responses to continuous, real-world musical stimuli have not yet been explored with MEG. We collected MEG from 45 healthy adult subjects during continuous, passive listening of three musical pieces representing Argentinian tango, progressive rock, and contemporary classical music. After artifact suppression, we applied Hilbert transform and cortically-constrained sLORETA to estimate source envelopes in theta, alpha, beta, and gamma frequency bands. From the acoustic signal, we extracted 20 low-level features representing the musical timbre with spectrum shape (e.g., centroid, spread), zero-crossing rate, RMS, and spectral change (flux), as well as five high-level features representing rhythmic periodicity, mode, key clarity, and pulse clarity. We estimated the features from successive 25ms to 3s long 50% overlapping time windows. We then correlated the downsampled source envelopes of the different frequency bands and the musical features for each subject, mapped the obtained correlations to a common cortical space, and performed group-level analysis. We will illustrate the preliminary findings of the first group-level analysis.

Combining EEG and non-invasive brain stimulation methods to investigate cerebellar language function

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Recent years have seen an emerging consensus on cerebellar involvement in non-motor as well as motor function. In line with this development, the cerebellum is also increasingly seen as relevant to the understanding of several neurodevelopmental and neuropsychiatric disorders with prominent cognitive symptoms, such as dyslexia, ADHD, autism and schizophrenia. However, the precise nature of cerebellar contributions to higher cognitive function remains elusive. Using fMRI, we previously observed cerebellar activations related to prediction generation and predicition error processing in a reading task, a findig which supports a generalization of computational models from the motor to the cognitive domain (Moberget et al., J Neurosci., 2014). The current project aims to extend this work by investigating the temporal dynamics of cerebellar contributions to language processing. We will approach this research question by combining non-invasive cerebellar stimulation (tDCS & TMS) with electroencephalography (EEG) during the same reading task. Our use of non-invasive stimulation techniques will allow us to assess the causal influence of the cerebellum in language processing, while EEG will give us a window onto the fast temporal dynamics of this influence. Importantly, pilot data (N = 20) demonstrate robust modulations of ERP-signals related to linguistic predictability (N400 & P600) during this task. Further, the cerebellar regions activated in our fMRI-experiment are accessible by by both TMS and tDCS, which has been shown to affect behavioural measures of linguistic prediction (Lesage et al., Curr Biol, 2012; Miall et al., Neuropsychologia, 2016). Based on these previous findings, we predict that cerebellar stimulation will modulate ERP-components related to linguistic predictions, but remain agnostic as to the nature of this effect (latency shifts and/or amplitude modualtions of specific components). To our knowledge, this will be the first study combining EEG and non-invasive brain stimulation methods to investigate cerebellar language function.

Reproducible science and MEG

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The reproducibility crisis has been and is a major topic in psychology and related disciplines ("Estimating the reproducibility of psychological science," 2015) and brain imaging has also been a part of this crisis (Button et al., 2013). While there has been some debate regarding fMRI, MEG has, on the other hand, not been debated much. I will in my talk give suggestions for how the ideas of reproducible science can be applied for MEG research. This includes the disclosure of materials and analysis pipelines, a priori hypotheses, and the use of simulation, which can be useful when data cannot be shared and further to explain methods.

Learning in the Open? Open education resources for MEG/EEG teaching and learning

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Most MEG sites recognise the challenge of providing adequate training opportunities to scientists and students with different backgrounds. In addition to in-house protocols, which may work best for sites with large and diverse user populations, some public resources have also been made available–perhaps most notably the "Learn about MEG" (http://natmeg.se/) video lecture series produced and shared by NatMEG. In this talk, I will present a possible framework for the collaborative development of an open education resource (OER) for learning MEG/EEG. It is anchored on two well-establised open source and open science platforms: Github and the Open Science Framework. As a brief demonstration of the possibilities, I will point to a Matlab-based GUI developed for illustrating the origin of the Equivalent Current Dipole (ECD)-concept, and an associated video demonstrating its use. The former is available under the public "meeg_training" repository (https://github.com/cjayb/meeg_training.git), and the latter is hosted by the OSF: "MEG/EEG Biophysics" (https://osf.io/z46cf/).

Posters

A survey on methods skills in cognitive neuroscience

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Analysing complex neuroimaging data sets involves advanced scienfitic computing and signal processing methods. A thorough understanding of these methods is essential for the choice of appropriate analysis procedures, their accurate application, and for the correct scientific interpretation of results. Recently reported 'crises' in psychology and cognitive neuroscience - e.g. with regard to reproducibility, false positives, and publication bias - may in part be due to insufficient understanding of data analysis methods.Here, we present results from an on-line survey of methods skills among over 300 participants, mostly students and post-docs working in the cognitive neurosciences. These results are intended as a starting point for an evidence-based dicussion of current skills-levels in cognitive neuroscience, and for the development of future skills-oriented training opportunities.We obtained error rates of 20% or more, even among self-rated experts. Error rates varied with undergraduate and current academic degree, as well as gender. This will not only affect practical aspects of data analysis, but also the ability to choose optimal analysis methods and to interpret results. Biologists and medical students undergo basic training in maths, physics etc. This might be beneficial for cognitive neuroscientists, too. We found significant gender differences, presumably due to different exposure to methods-related training at school and university level. Skills-oriented training may help to close this gender gap in cognitive neuroscience.

Hippocampal Mismatch Negativity: A hippocampal electric potential measured with non-invasive EEG/MEG reflects short-term memory ability

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Mismatch-Negativity (MMN) occurs when a stimulus deviates from a preceding regular pattern of stimuli. The amplitude of MMN reflects semantic memory performance in language and music perception. It is generated by synchronous, postsynaptic, electric potentials in cortical networks of the human brain. Here, by applying non-invasive EEG and MEG methods and a new music stimulation paradigm we show novel evidence of a hippocampal MMN (hMMN). We find that hMMN is a middle latency response in the range of ~25-75 ms, which occurs earlier than the cortical MMN (cMMN) latency range of ~100-250 ms. We apply dSPM, LORETA and MNE source modeling estimates, which suggests that the hMMN is elicited from bilateral hippocampal regions. Also, we replicate and extend previously observed relationships between hippocampal structure, age-related changes, genetic variation, and short-term memory performance. First, we find that higher hMMN amplitude is related to better short-term memory for lists of words. Second, we observe that hMMN amplitude decreases with age. Third, an approaching significant interaction suggests that val66met (rs6265) polymorphism is related to decreased hMMN amplitude in left hippocampal regions. We observe no comparable effects for cMMN amplitude. This suggests that hippocampal memory function can be measured non-invasively with EEG and MEG.

Entrainment of brain oscillations facilitates event-related power modulations in the alpha band - A concurrent tACS-MEG study

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Transcranial alternating current stimulation (tACS) has emerged as a novel method capable of modulating endogenous brain oscillations in a frequency specific manner. While there has been a substantial amount of work on behavioral and aftereffects of tACS, only few studies were able to uncover the effects on brain oscillations during stimulation, due to a large artefact that is introduced to the data. Here, we present recent results from a combined tACS MEG study, utilizing source space projection by means of linearly constraint minimum variance beamforming, a method that has been demonstrated to substantially suppress the stimulation artefact observed during transcranial electrical stimulation. Twenty-five participants performed a classic mental rotation task while MEG was recorded. They received 20 minutes of tACS or sham stimulation after 10 minutes of baseline measurement. Another 40 minutes of MEG were recorded after stimulation. Results replicated the previously observed performance increase in the group receiving stimulation and revealed a strong increase in event-related modulation of alpha power during tACS application as compared to sham. Data suggest, that tACS exhibits highly state-dependent effects and cannot counteract top-down suppression of intrinsic oscillations, but rather selectively enhances oscillatory power during periods with sufficiently strong intrinsic oscillations.

Task-free non-invasive E/MEG paradigm for comprehensive assessment of neural language processing in health and disease

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The aim of our study is to investigate the neural foundations of language processing deficits in Parkinson's Disease. For this purpose, we have developed two auditory paradigms for neuromagnetic recordings in the absence of directed attention towards sound stimuli and without relying on any overt responses from participants. Both paradigms include meaningful and correct spoken Danish words, meaningless pseudowords and syntactic violations. The first paradigm is a conventional oddball sequence (>45 minutes) in which linguistic stimuli are divided into frequent standards, presented with a 70% probability, and random deviants of different types. Oddball paradigms typically produce the so called mismatch negativity response, known to reflect automatic linguistic (phonetic, lexico-semantic, syntactic) processes in the brain. The second paradigm uses the same stimuli but is optimised for time (30 minutes) by presenting all stimuli equiprobably. E/MEG responses to both paradigms were recorded in a group of healthy young participants. Preliminary analysis of data revealed that our novel equiprobable protocol produced lexically and syntactically specific responses, which were similar to the conventional oddball results but higher in amplitude, allowing us to choose this time-efficient and thus more patient-friendly protocol for recordings in PD patients and possibly other vulnerable population groups in the future.

Perceptual processing of a complex musical context: Developing a more realistic musical mismatch negativity (MMN) paradigm

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The mismatch negativity (MMN) is a brain response elicited by deviants in a series of repetitive sounds. It reflects the perception of change in low-level sound features and reliably measures auditory memory and predictive processes. MMN is a valuable tool for the study of music perception. However, most designs use simple tone patterns as stimuli, failing to represent the complexity of everyday music. We aim to develop a new MMN paradigm using more real-sounding stimuli. We want to determine how the complexity of the context affects auditory predictions as reflected by the MMN. For this purpose, we will modify a previous design based on the Alberti bass by adding a melody on top of it. We will use magnetoencephalography (MEG) to record nonmusicians' responses to four types of deviants (mistuning, intensity, timbre and slide), while they watch a silent film under four conditions: listening to bass only ('bass'), listening to melody only ('melody'), listening to bass in the pitch range of the melody ('bass high'), and listening to bass and melody together ('together'). We expect MMNs for all deviants in all conditions. Moreover, since pitch complexity is higher in the melody than the bass, we expect a reduced MMN to pitch-related deviants (mistuning, slide) in the 'melody' compared to the 'bass high' condition. Finally, we expect a reduction of all MMNs in the 'together' condition, due to competition between sound streams. This paradigm could be used to address fine-grained questions about music perception and learning in more realistic sound contexts.

Verbal fluency in Parkinson's disease patients after deep brain stimulation of the subthalamic nucleus: neuromagnetic investigations

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When dopaminergic medication is no longer a viable treatment option for advanced Parkinson's disease (PD) patients, treatment with deep brain stimulation (DBS) of the subthalamic nucleus (STN) may effectively alleviate their motor symptoms. There are, however, reports of mild cognitive adverse effects from the treatment for a subset of DBS-treated PD patients. These pertain most consistently to declines in verbal fluency (both phonemic and semantic), yet the risk profile of the PD patients experiencing these treatment-related cognitive declines are still not well understood, nor are the underlying mechanisms of the adverse effects. In a recent review, our group concluded that either the stimulation itself (and thus electrode positioning) or lasting ablations from the surgery were the best potential explanations of the reported declines in verbal fluency after DBS, whereas individual differences in cortical projections to STN likely contribute to differentiating those patients whose verbal fluency is negatively affected after DBS from those with unaffected verbal fluency. Even though the verbal fluency task is highly relevant in the neuropsychological assessments of patients, it taps into a multitude of cognitive processes including lexical search, memory retrieval, and response monitoring and selection, which entails that the task is not easily amenable to standard experimental paradigms. Here, we present an experimental paradigm using the verbal fluency task during MEG recordings for which we combine coarse modeling of the verbal responses in order to inform the neuromagnetic analyses of specific cognitive processes during the verbal fluency task in DBS-treated PD patients. These analyses furthermore include data from different stimulation points (contacts), as well as tractography data for the cortical projections to STN. We present preliminary results showing proof-of-concept of the combination of these versatile analyses.

Retinal Triage of Cortical Picture Processing: Insights in the Retino-Cortical Interplay

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To date, studies investigating the neural correlates of picture processing have predominantly focused on cortical responses. Many studies place special significance on the variance of cortical response latencies across stimuli or trials, making the implicit assumption that visual information leaves the retinae at the same time. However, retinal responses also have variance across stimuli, and cortical assemblies may simply inherit any retinal processing delays. Furthermore, retinal responses to photographs have never been previously reported. Therefore, the present study re-examines visual evoked responses to a classic database of photographs, taking retinal responses into account. Nine healthy subjects viewed 18 IAPS photographs of high-arousing (pleasant or unpleasant) content and low-arousing (neutral) content during a combined electroretinographic-electroencephalographic (ERG-EEG) recording. The image luminance was matched for all pictures via the SHINE toolbox (Willenbockl et al., 2010). Photopic electroretinograms were recorded from both eyes with DTL fiber electrodes. The results suggest that variable delays in retinal processing could indeed explain the corresponding variance in the latencies of visual evoked potentials, as demonstrated by a marginal correlative relationship between the latencies of the a-wave and N75 ($p<0.06$) for the 18 photographs. Further analysis is in progress to examine how high-frequency oscillations relate to cortical gamma band activity, and whether picture categories may influence retinocortical delays. For the first time, this study gives insights in the ERG response to pictorial input and underscores the importance of considering retinal measures in the analysis of neural picture processing. Moreover, the paradigm confirms the feasibility of ERG for experiments based on photographic imagery.

Reducing power line noise in EEG and MEG data via spectrum interpolation

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Electroencephalographic (EEG) and magnetoencephalographic (MEG) signals can often be exposed to power line interference at 50 or 60 Hz. A widely used method to remove line noise is the notch filter, but it comes at the risk of potentially severe signal distortions. Among other approaches, the DFT filter had been developed as an alternative to notch filtering, but it fails to remove power line noise of fluctuating amplitude. Here we introduce spectrum interpolation as a new method to remove line noise in the EEG and MEG signal. This approach had been developed for electromyographic (EMG) signals, and combines the advantages of a notch filter, while preserving the signal outside the frequency range of the artifact. The effectiveness of this method is compared to the notch filter and the DFT filter. In order to quantify the performance of these three methods, we simulated power line noise exhibiting nonstationarities (fluctuating in amplitude) and added it to an MEG dataset free of line noise. In addition, all methods were applied to EEG data prone to massive power line noise due to unshielded measurements. We show that spectrum interpolation outperforms the DFT filter when power line noise is nonstationary. At the same time, spectrum interpolation performs equally well as the notch filter in removing line noise artifacts, but does not distort the passband.

Evaluation of new magnetoelectric sensors via source localization of phantom head recordings

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Several groups at the University of Kiel have been pursuing different concepts for the development of new magnetic sensors from magnetoelectric (ME) composites that will be operated at room temperature in unshielded environments. These new sensors will have applications in the measurement of magnetic fields of neurological or cardiac origin. At the current stage of development, a new head phantom was designed to evaluate the possibility of source localization from magnetic field measurements with the new ME-sensors. The new head phantom contains six cortical (frontal, temporal, central, parietal and occipital) and two subcortical sources (putamen and thalamus) in form of electromagnetic coils. The orientation of each coil is tangential to the cortical surface. A computed tomography (CT) scan of the head phantom was used to obtain the head geometry and the coil positions. Additionally, the measurement points were coregistered to the head geometry. Magnetic field measurements on the specially-designed head phantom have been made with help of a non-magnetic mechanical scanner placed into a Mu-metal magnetically-shielded chamber. The pneumatically-driven scanner uses fiber-optic sensors for setting the measurement points. Only one sensor has been used for measuring three orthogonal field components at every measurement point owing to mechanically-switchable sensor holder. For performing a source analysis, the initial phase of the experimental signal (a 10-Hz sine wave) is synchronized for every single measurement at every measurement point. Source localization will be performed using dipole fit and sLORETA. We will report localization results for different sensor types with different signal-to-noise ratios (0-38 dB).

A paradigm for registering multiple levels of language processing in the brain

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One of the main issues in disorders of consciousness (DOC) (coma, vegetative and minimally conscious state) is to establish whether patients can perform conscious processes. Clinical assessments rely on behavioural methods though patients have no means to report their experiences, leading to a high rate of misdiagnosis.Passive studies have investigated residual brain activity in DOC patients, putting forward the idea that a subset of patients was able to perform specific language-related tasks such has basic semantic and auditory processing. Nonetheless, very little is known about the extent of the preservation of patients' language abilities.The aim of this project is to test the validity of a complex task-free paradigm to simultaneously assess cortical abilities to (a) perceive sounds, (b) perform specific language processes and (c) shift attention. Using EEG, we will assess five levels of word processing on healthy participants and attention shift through the occurrence of novel sounds. We expect to observe a P50-N100 complex for sound onsets, an MMN to phonologically distinct speech sounds (native vs. foreign), lexical enhancement for meaningful words (vs. pseudowords) and a P3 response to unusual sounds in the case of automatic attention shift.

Audio-visual perception of familiar and unfamiliar syllables: a MEG study

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During speech perception listeners rely on multi-modal input and make use of both visual and auditory information. When presented with contrasts of syllables, the differences in brain responses are not caused merely by the acoustic or visual differences however. The familiarity of the syllable i.e. whether it appears in the viewer-listener's native language or not, may also cause distinct brain responses. We investigated how the familiarity of the presented stimuli affects brain responses to audio-visual speech in Finnish native speakers and Chinese native speakers. They watched videos of a Chinese speaker pronouncing syllables (/pa/, /pha/, /ta/, /tha/, /fa/) during a MEG measurement. The stimuli presented were either Audio-Visual, Audio only, or Visual only. The cover task was to press a button when the /fa/ stimulus was presented. Comparisons were made for familiarity: For Finnish participants, only /pa/ and /ta/ are familiar because they are part of their native phonology, For Chinese participants all four syllables are familiar. Source waveforms were examined in three time-windows: 75 - 125 ms, 125 - 300 ms, 300 - 475 ms. We found significant differences between responses to syllables familiar and unfamiliar to the Finnish for comparisons of audio-visual stimuli in all three time-windows. Since we found no significant differences for the Chinese group, we assume that the differences found for the Finnish are resulting from familiarity.

Does alpha-tACS reliably boost endogenous alpha rhythms?

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Modulation of brain oscillations using non-invasive brain stimulation techniques is a promising intervention in brain pathologies associated with abnormal neural synchrony. However, the underlying mechanisms and most effective protocols that give rise to oscillatory changes are not well understood yet. Transcranial alternating current stimulation (tACS) at alpha frequencies (8 - 12 Hz) can produce a prolonged increase of endogenous alpha activity when applied over the posterior cortex continuously for several minutes. In a previous experiment, we found that intermittent tACS just below participants' individual alpha frequency (IAF) was also effective in producing lasting alpha power enhancement. The current experiment aimed to test whether stimulating intermittently (with an alternating 8 s on/off pattern) at either ~0.75 Hz below or above IAF results differentially in either alpha power enhancement or suppression (as predicted by a spike-timing dependent plasticity hypothesis of tACS aftereffects), and whether continuous stimulation is more effective than intermittent tACS. However, despite a similar design and analysis, we observed no alpha power enhancement in any active tACS condition compared to sham. This result highlights the problems with (typically) small sample sizes, the challenge of defining robust baseline and outcome measures, and the importance of replication studies.

Critical dynamics in resting state oscillatory brain activity is associated with dopamine-related polymorphism

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Scale-free fluctuations are ubiquitous in human behavior and neuronal activity. In neuronal time series, such scale free fluctuations are characterized by enhanced long-range temporal correlations (LRTC). LRTCs are thought to be indicative of critical dynamics that allows optimal information processing capacity. In the brain, information processing capacity is reflected in cognitive flexibility relying on activity in the prefrontal cortex (PFC). PFC activity is dependent on the dopamine levels that are regulated by the Catechol-O-methyltransferase (COMT, rs4680). A single nucleotide polymorphism (Val/Met) in the COMT affects dopamine levels and thereby neuronal activity of the PFC mediated executive functions. Here, we tested whether COMT polymorphism influences brain scale-free dynamics during resting state (rs). We recorded rs magnetoencephalography (MEG) data from 83 healthy volunteers, genotyped using Infinium PsychArray-24 v1.1 (Illumina). The sample consisted of 18 Val/Val, 49 Val/Met, and 16 Met/Met carriers. The LRTCs were quantified as the exponents of the detrended fluctuation analysis (DFA) calculated for cortically reconstructed sources at 31 frequency-bands ranging from 3 to 120 Hz. The genotypes differed in rs brain dynamics in the gamma (40-120 Hz) band. Compared to Met/Met or Val/Val homozygotes, Val/Met heterozygotes exhibited greater scaling exponents in the gamma band, especially in the visual and frontoparietal networks. These differences were not explained by the amplitudes of the gamma oscillations. As the Val allele is associated with less synaptic dopamine compared to Met allele, our data show that intermediate brain dopamine levels are associated with largest LRTCs in rs oscillatory activity, suggesting enhanced cognitive flexibility.

Chair for physical exercises in Jyväskylä MEG lab

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The aim of the project is to develop a specifically designed MEG-compatible chair for the study of brain processes related to muscle control and proprioception. The project is a close collaboration between the Center for Interdisciplinary Brain Research (CIBR) and the Faculty of Sport and Health Sciences. The chair has been modified in-house from an older MEG chair designed and made by Elekta. Currently, the chair consists of integrated devices allowing measurement of force in knee and ankle flexors and extensors and generating passive movement of the ankle-joint. The output from the force sensors can either be recorded to the MEG data acquisition stream and/or directed to a computer for visual feedback. The addition of several non-elastic straps stabilizes the participant firmly to the chair during measurements, allowing rigid isometric contraction and minimizes unwanted, concurrent postural muscular activity. Passive movement over a range of velocities is achieved by using an in-house-designed actuator based on pneumatic artificial muscles of Festo. The concept was inspired by the ankle actuator of Aalto University MEG lab. In the future, there is a desire to extend the force measurements and passive movement generation to upper limbs.

Proprioceptive stimulation using continuous and intermittent passive ankle movements in young and older individuals before and after 14 weeks of strength training

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Corticokinematic coherence (CKC) mainly reflects movement-related proprioceptive afference to the cortex (Piitulainen et al., 2013), whereas beta-band oscillations reflect activation of the sensorimotor cortex. The present study consisted of two protocols to, 1) to quantify cortical proprioceptive afference during passive ankle-joint movements and 2) to study stretch-induced beta-band suppression/rebound in young and older individuals. Eight young (18-30yr) and 10 older (65-75yr) men and women with no history of neurological disease were measured before and after 14 weeks of strength training focused on the lower limbs. All subjects were right leg dominant. Passive dorsiflexion-plantarflexion movements of the ankle joint were performed continuously at 2Hz for 4 min using a novel MEG-compatible stimulator. Thereafter, 75 passive, rapid dorsiflexion stretches (~10° at ~200°/s, ~6s between stretches) were performed. Peak CKC at 2Hz was determined for 32 gradiometers in the sensorimotor cortex for the foot. For the rapid stretch trials, modulations of beta-band (15-30Hz) oscillations were determined for 12 gradiometers in contra-lateral sensorimotor cortex for the foot. For CKC analysis, results suggest that older subjects demonstrated greater CKC compared to young, and the non-dominant leg (i.e. left) demonstrated greater coherence compared to the dominant leg (i.e. right). Analysis of the stretch-induced beta-band oscillations is ongoing, but the preliminary results indicate possible differences between the legs in older subjects. These preliminary results (from ongoing analyses) suggest that there may be differences in cortical proproioceptive processing/afference between dominant and non-dominant limbs, particularly in older adults.

Neural predictors of learning, transmission and regularization of auditory signals in a laboratory model of cultural evolution

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Several recent studies argue that regularities in human symbolic systems such as language and music may emerge during cultural transmission as adaptations to aspects of brain function. This hypothesis has not yet been investigated using neurophysiological methods. Here, we address the issue whether individual differences in neural information processing capacity, as revealed by a neurophysiological marker of the central auditory system, can predict individual behavior in a laboratory model of cultural transmission. We conducted two experiments on the transmission of auditory rhythm sequences associated with affective meanings. We first show that cognitive biases for structural regularity manifest in rhythms when those are culturally transmitted in the laboratory across individuals. Then, we demonstrate that structural regularization behaviour can be predicted based on individuals' neural information processing capabilities, as revealed by electrophysiology. These results support the hypothesis that aspects of symbolic systems are a consequence of neural information processing constraints.