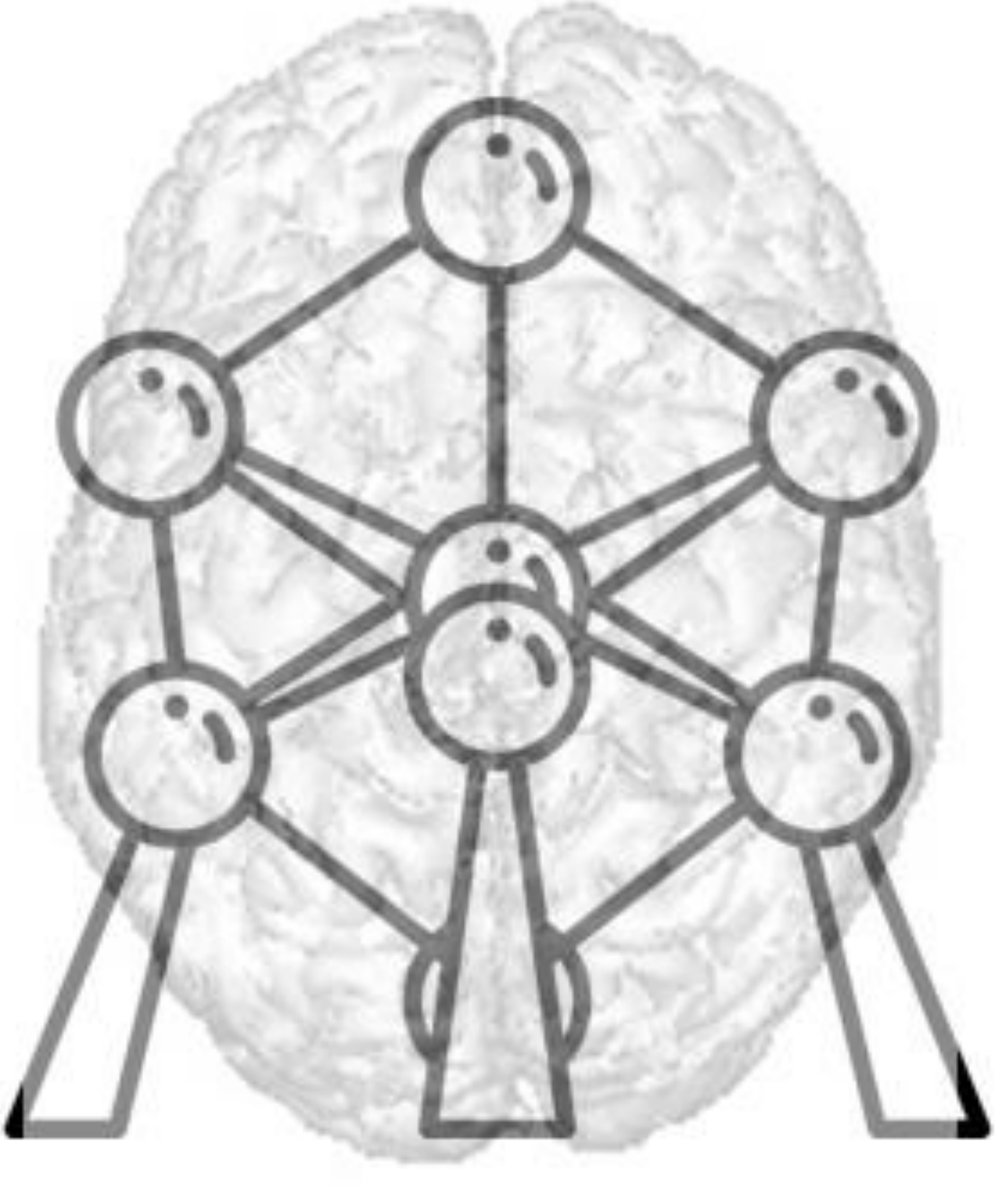
BrainModes

PROGRAM

Coordinated brain activity: Foundations and applications
Brussels, Dec 1-2 2016



PROGRAM OVERVIEW

Thursday December 1st 2016	
09:00	Registration and coffee
09:25	Welcome and introduction
09:30	**Randy McIntosh** (Baycrest Institute) *"Modeling and Measuring Flows between Cognitive Processes"*
10:10	**Andreas Daffertshofer** (University of Amsterdam) *"Scale-freeness or partial synchronization in neural mass phase oscillator networks: pick one of two?"*
10:50	Coffee break
11:20	**Esther Florin** (Heinrich-Heine University Duesseldorf) *"Spontaneous brain activity in healthy subjects and Parkinson's disease"*
12:00	**Marcus Kaiser** (University of Newcastle) *"Connectomes and Epilepsy: Dynamical models of focus location, treatment options, and surgery outcome"*
12:40	Lunch
14:00	**Enzo Tagliazucchi** (Netherlands Institute for Neuroscience) *"Dynamic connectivity states track vigilance changes during rest"*
14:40	**Petra Ritter** (Charité Hospital Berlin) *"Reverse engineering multi-scale processes underlying altered learning across life span"*
15:20	**Mukesh Dhamala** (Georgia State University) *"High-frequency network oscillations in epilepsy"*
16:00	Coffee break
16:30	**Lucilla de Arcangelis** (Second University of Naples) *"On the nature of correlations in the brain"*
17:10	**Gustavo Deco** (University Pompeu Fabra, Barcelona) *"Towards a Whole-Brain Model: Lessons from the Human Connectome"*
18:00	Poster reception and dinner

Friday December 2nd 2016	
09:00	Coffee
09:30	**Dante Mantini** (KU Leuven) *"A multimodal approach to the study of long-range functional interactions in the resting human brain"*
10:10	**Tobias Donner** (University Medical Center Hamburg) *"State-dependent Modulation of Cortical Decision Computations"*
10:50	Coffee break
11:20	**Francesco de Pasquale** (University of Chieti) *"A Dynamic Core Mode and Global Efficiency in the Resting Human Brain"*
12:00	**Adeel Razi** (University College London, UK) *"Dynamic causal models of the connected brain"*
12:40	Lunch
14:00	**Steven Laureys** (University of Liège) *"Brain activity in coma and related states"*
14:40	**Laura Astolfi** (University of Rome) *"Connectivity analysis based on high density EEG recordings: application to motor and cognitive tasks in humans"*
15:20	**Dimitri Van de Ville** (EPFL and University of Geneva) *"The intricate web of intrinsic brain activity uncovered by dynamics of resting-state fMRI"*
16:00	Coffee break
16:30	**Franca Tecchio** (National Research Council of Italy) *"Brain neuronal activity to personalize neuromodulation therapeutic interventions"*
17:10	**Olaf Sporns** (University of Indiana) *"From Spatial Components to Temporal Flows and Dynamics"*
18:00	Closing and goodbye

POSTER ABSTRACTS

P01 – Rana Fayyaz Ahmad (Universiti Teknologi PETRONAS, Malaysia)
Simultaneous EEG-fMRI approach for exploring cognitive functions of the human brain

Higher spatiotemporal resolution of human brain is desirable to explore and understand cognitive functions and brain dynamics effectively. Multimodal neuroimaging can be helpful to get higher spatiotemporal resolution at same time. Electroencephalogram (EEG) and functional magnetic resonance imaging (fMRI) are complementary neuroimaging modalities in terms of temporal and spatial resolution. To get higher spatiotemporal resolution at the same time, simultaneous EEG-fMRI can provide solution to this limitation. EEG signals are able to capture the neural activity inside the brain from the scalp with higher temporal resolution and fMRI records the hemodynamic response which is the delayed response with respect to neural activity with higher spatial resolution. There is common association between these two modalities with respect to any neural activity occurring inside human brain. Multimodal neuroimaging e.g., EEG-fMRI give us high spatial and temporal resolution at the same time which is desirable. Due to high magnetic field inside the scanner, it is impossible to keep the normal EEG equipment inside. MR compatible equipment is mandatory for proper functioning and EEG data acquisition. Multimodal neuroimaging data exists in different domains e.g., EEG data give the information in temporal domain; on the other hand, fMRI data is in spatial domain. To combine these two modalities, data fusion or data integration can be used. In this research work, we have developed and acquired simultaneous EEG-fMRI data on healthy human participants by showing cognitive paradigm experiment. We used MRI compatible EEG equipment with 128 channels inside 3.0 Tesla MRI scanners. EEG data is contaminated with gradient artifacts (GA) and Ballistocardiogram artifacts. Both artifacts have been removed from EEG data. For fMRI data, preprocessing has been done which involves motion correction, slice time correction, segmentation, and normalization and co registration. Brain activation maps were generated from EEG-fMRI data. Simultaneous EEG-fMRI data can help researchers as well as clinician to provide more deep understanding of the cognitive functions of the human brain.

P02 – Jessica Bulthe (Catholic University of Leuven, Belgium)
Multi-method brain imaging reveals impaired representations as well as altered connectivity in adults with dyscalculia

Two hypotheses have been proposed about the etiology of neurodevelopmental disorders: representation impairments versus disrupted access to representations. We implemented a multi-method brain imaging approach to directly compare the representation vs. access hypotheses in dyscalculia, a highly prevalent but understudied neurodevelopmental disorder. We combined several magnetic resonance imaging methods, including multivariate analyses, functional and structural connectivity, and voxel-based morphometry analysis, in a sample of 24 adults with dyscalculia and 24 carefully matched controls. Results showed a clear deficit in the non-symbolic magnitude representations in parietal, temporal, and frontal regions in dyscalculia. We also observed hyper-connectivity in visual brain regions and increased grey matter volume in the default mode network in adults with dyscalculia. Hence, dyscalculia is related to a combination of diverse neural markers which are altogether distributed across a substantial portion of cerebral cortex, supporting a multifactorial model of this neurodevelopmental disorder.

P03 – Caglar Cakan (BCCN Berlin, Technical University Berlin, Germany)

Simulating large-scale human brain networks with a mean-field model of EIF neurons: exploring resting state FC and stimulation with electric fields

The use of whole-brain networks for understanding the dynamics of the interaction between brain regions has experienced a rise in popularity in the last few years. Here, we calibrate a whole-brain network model to human resting state data, and use it to explore the effects of weak electric fields on the network dynamics.

The structural connectivity of the brain network is extracted from parcellated brain scans using an atlas with 68 regions (Desikan et al., 2006) and DTI tractography of long-range axons to estimate coupling strengths and delays between regions averaged over 48 individuals (Ritter et al. 2013, Schirner et al. 2015). The mean activity of each brain region is described by a mean-field population model of EIF neurons (Ladenbauer, 2015). After fitting local parameters such as recurrent coupling strengths and delays and the global parameters coupling strength, axonal signal transmission speed and external noise intensity, our model can produce simulated BOLD functional connectivity (FC) with high Pearson correlation (mean .55, max/min .78/.25) to the empirical 20 minute resting state BOLD FC of these individuals. A local model with a limit cycle at gamma frequencies and a bistability with a low and a high-activity fixed point was found to produce good fits.

A range of global parameters can produce good grand average FC fits. However, the FC in the resting state is not stationary. To capture the brain's dynamical properties in the resting state, the FC fit is complemented by a fit of the FCD matrix (Hansen et al, 2015). We show that the simulated FCD matrix is well comparable to empirical data (Kolmogorov distance around 0.1) on several timescales. Clustering of the power spectra of the local nodes shows that nodes of the brain graph can be divided into two sets with dominant alpha and gamma frequencies respectively and that contralateral regions end up in the same cluster.

Lastly, we present results of modeling the effect of external tACS-like brain stimulation on the global network activity. By modifying the dynamics of a subset of nodes, the global dynamics of the brain network can be shaped. We stimulate the bilateral entorhinal cortices, the main interface of the cortex to Hippocampus. We show that on the global network level, transitions from a DOWN state to an UP state tend to lock on the onset of oscillatory stimulation and relate these results to experimental findings in the rat brain conducted in Ref. (Battaglia et al, 2004).

P04 – Jose Luis Perez Velazquez (University of Toronto and The Hospital for Sick Children, Canada)

Towards a statistical mechanics of brain coordination dynamics: maximization of number of connections is associated with conscious awareness

Great attention in current neuroscience research concentrates on the understanding of how the coordinated activity of functionally connected brain cell ensembles determines, or is associated with, cognition and pathological states. The common notions used in these studies are centered on the determination of magnitudes of indices of correlated activity such as synchrony and the derivation of connectivity and other similar measures. In order to make sense of all these extremely abundant data that are being generated, the search for organising principles of brain function is today more crucial than ever. We sought to identify global features of brain organization that are optimal for sensory processing and that may guide the emergence of conscious awareness. Our results provide a (very simple) answer to the question of what the magnitudes of synchrony indices represent in terms of the structure of brain activity.

We have followed the classic approach in physics when it comes to understanding collective behaviours of systems composed of a myriad of units: the assessment of the number of possible configurations, or microstates, that the system can adopt. In our study we focus on the collective level of description and assume that coordinated patterns of brain activity evolve due to interactions at the mesoscopic level. Thus we use several types of brain recordings (magnetoencephalography, scalp and intracerebral electroencephalography) in conscious and unconscious states —sleep stages and seizures— in order to evaluate the number of “connections” between brain areas and the associated entropy and complexity. We present evidence that conscious states result from higher entropy and complexity in the number of configurations of pairwise connections. The number of pairwise channel combinations is near the maximum of all possible configurations when the individual is processing sensory inputs in a normal manner (e.g. with open eyes). Our interpretation is that a greater number of configurations of interactions allows the brain to optimally process sensory information, fostering the necessary variability in brain activity needed to integrate and segregate sensorimotor patterns associated with conscious awareness. Therefore, the information content is larger in the network associated to conscious states, suggesting that consciousness could be the result of an optimization of information processing. These findings encapsulate three main theories of cognition and help to guide in a more formal sense inquiry into how consciousness arises from the organization of matter.

P05 – Josephine Cruzat (Center for Brain and Cognition, Universitat Pompeu Fabra, Barcelona, Spain)

The dynamics of human cognition: increasing global integration coupled with decreasing segregation found using intracortical EEG

Cognitive processing requires the ability to flexibly adjust and integrate information across large brain networks. However, still more information is needed on how brain networks dynamically reorganize to allow such broad communication across many different brain regions in order to integrate the necessary information. Here, we use intracranial EEG to record neural activity data from depth electrodes stereotactically implanted in 12 epileptic patients while they performed a picture-naming task. The iEEG electrodes covered broad regions of the brain including cortical as well subcortical regions, so that we were able to assess the global changes at the level of a broad extended network.
This allowed us to investigate the network properties of the brain underlying cognitive processing using our operationally defined concepts of segregation and integration as global network measures of brain function. Across all patients, we found significant increases in integration and decreases in segregation during cognitive processing ($p<0.05$), especially in the gamma band (50-90 Hz). Accordingly, we also found significantly higher level of global synchronization and functional connectivity during the execution of the cognitive task, again particularly in the gamma band. Furthermore, we demonstrate that these modulations in the level of communication across the network were not caused by changes in the level of the underlying oscillations as reflected by the corresponding power spectra.

P06 – Elena Solesio-Jofre (Research group on brain, affect and cognition, Department of Psychology, Universidad Autónoma de Madrid, Spain; Motor Control Laboratory, Movement Control and Neuroplasticity Research Group, Catholic University of Leuven, Belgium)

Motor learning modulates resting state functional connectivity within a single training session as a function of age

Motor performance generally deteriorates with age. Notably, the extent to which motor skills can be learnt or regained in normal aging and the underlying neural mechanisms remain unclear. Recent work in young adults has demonstrated that training of a motor task can modulate resting state functional connectivity, with important behavioural implications. In the early phase of learning, considerable improvement in performance is typically achieved whereas in the later phase of learning, performance shows a plateau effect and the training-induced performance gains become more subtle. Here, we investigated whether and how inter- and intra- hemispheric resting state functional connectivity was modulated within and between motor learning sessions, and also to test its behavioural relevance as a function of age. To this end, resting state fMRI scans occurred twice: before and after 5 training sessions, distributed across 2 weeks. During the training period, young and older individuals learned a set of complex bimanual tracking task variants. Both young and older adults were capable of reaching considerable performance gains due to our training protocol. However, older adults showed poorer motor performance than young adults, but larger training-induced improvement relative to baseline. Learning effects achieved within the scan sessions modulated resting state functional connectivity in both age groups. Specifically, we observed increases in inter- and intra-hemispheric functional connectivity in young adults, and decreases in their older counterparts. Conversely, motor training between scan sessions did not modulate resting state functional connectivity as a function of age. Remarkably, increases in inter-hemispheric functional connectivity correlated with training-induced motor improvement. Our findings confirm that motor learning is still robust in older adults. Moreover, they suggest that task learning within a single session shapes the pattern of spontaneous activity at rest differentially in young and older individuals and confirm the behavioural relevance of rs-FC changes.

P07 – Nicholas Jarman (Catholic University of Leuven, Belgium)

Universal model of small-world network emergence

Small-world network structure universally emerges in adaptive self-organizing systems. Small-world structure, we propose, is a global attractor of network evolution, driven only by its current connectivity structure and a random factor representing the influence of arbitrary activity on the network structure. We illustrate this principle by presenting an adaptively rewiring network, in which the nonrandom rewiring component is determined by the exponential heat kernel, as a representation of the current network connectivity structure. Adaptive rewiring universally leads to high levels of small-world structure in the evolving networks. In addition, network evolution can be tuned to bias toward either shorter path lengths and produce modularity, or toward longer path lengths and produce a centralized structure. The model evolution may therefore be considered as a basic mechanism for the emergence of a family of small world networks, including both modular and centralized ones.

P08 – Ramon Guevara Erra (Universite Paris Descartes, France)

The epileptic thalamocortical network is a macroscopic self-sustained oscillator: Experimental evidence and models

The rhythmic activity observed in the nervous system, in particular in epilepsies and Parkinson's disease, has been often hypothesized to originate from a macroscopic self-sustained neural oscillator. However, this assumption has not been tested experimentally. Here we support this viewpoint with in vivo experiments in a rodent model of absence seizures, by demonstrating frequency locking to external periodic stimuli and finding the characteristic Arnold tongue. We also develop a simple Kuramoto-type model of coupled oscillators for the thalamocortical network, based on experimentally obtained phase response curves. These results have important consequences for developing methods for the control of brain activity, such as seizure cancellation.

P09 – Vincent Wens (ULB Neuroscience Institute & ULB-Erasme hospital, Belgium)
Synchronous intra and cross-networks interactions of the default-mode network

Recent studies of resting-state networks (RSNs) focused on the fast fluctuations in functional connectivity (FC) and identified multiple short-lived resting-state FC (rsFC) patterns involving interactions both within and across RSNs (Hutchison et al., 2013). However, little is known about how connections covary temporally to generate these transient patterns. Here, we explore this question using magnetoencephalography (MEG) by mapping brain couplings that fluctuate in synchrony. We focus on both intra and cross-RSNs interactions of the default-mode network (DMN) in view of its dynamical centrality (de Pasquale et al., 2012).
Time-dependent rsFC was derived using sliding-window (length: 10 s; de Pasquale et al., 2010) alpha-band source envelope correlation (see Wens et al., 2015 for details on FC estimation) from MEG recordings of 78 right-handed adults at rest (5 min, eyes open). We concatenated spatially the rsFC maps from 4 DMN seeds (mesial prefrontal and posterior cingulate cortices and left and right temporo-parietal junctions) and applied a group-level temporal independent component (IC) analysis to reveal DMN-based rsFC covariations. Each IC represented a dynamical mode of synchronous coupling fluctuations.
We identified four types of covariation patterns involving either (i) intra-DMN couplings only, (ii) cross-RSNs couplings only between the DMN and other RSNs (sensorimotor, visual, auditory, language, or fronto-parietal attentional), (iii) mixed intra-DMN and cross DMN-RSN couplings, and (iv) all brain couplings. Several dynamical modes of FC synchrony (both within and across RSNs) matched known RSNs or sub-networks (O'Neill et al., 2015) and involved temporal anticorrelations. These results may unify previous findings on dynamic MEG-based rsFC (de Pasquale et al., 2012; O'Neill et al., 2015) and shed new light on the formation of transient sub-networks and cross-RSNs integration.

P10 – Wako Yoshida (ATR, CiNet, Cambridge University, UK)
Brain connectomics and chronic pain

Clinical and translational research into chronic pain is limited significantly by the lack of a replicable biomarker. In the brain, the difficulty arises from the multiple parallel changes that are thought to represent the chronic pain state, and have yielded the emerging view of chronic pain as a 'network disorder'. With the development of graph theoretic techniques, as well as machine learning based classifiers, it may now be possible to develop a brain network based biomarker for chronic pain. We conducted a multi-site resting-state fMRI imaging experiment to examine brain networks in chronic back pain patients and healthy controls. Sparse multinomial logistic regression yields a biomarker with a diagnostic accuracy above chance level significantly, and graph theoretic analysis reveals that the chronic pain state is strongly associated with network hub disruption, defined according to nodal clustering coefficient. These results provide evidence of characteristic global brain network differences in chronic back pain. They also illustrate the potential for an accurate functional biomarker of chronic pain, and would offer an opportunity to create translatable biomarkers for animal studies, using similar methodologies.

P11 – Hannes Almgren (Department of Data Analysis, Faculty of Psychology and Educational Sciences, Ghent University, Belgium)

Stability and Variability of Effective Connectivity in Resting State Networks

During rest, the brain shows several patterns of synchronous activity called resting state networks (RSNs; Biswal et al., 1995; Damoiseaux et al., 2006). Recently, researchers have found specific patterns of causal relations within and between RSNs (e.g., Liao et al., 2010; Sharaev et al., 2016). In the present research we aimed to investigate the longitudinal stability and variability of these effective connections within RSNs. Therefore, a longitudinal fMRI dataset containing data of a highly sampled individual (Laumann et al., 2015), including 104 resting state fMRI sessions, was analyzed. The research focused mainly of three topics: (1) stability of effective connectivity within RSNs, (2) relations between effective connectivity and psychological, behavioral and physiological measures, and (3) change in effective connectivity across task sessions. Eight RSNs were chosen for our analyses: occipital and lateral visual, auditory, sensorimotor, left and right frontoparietal, default mode, and executive control network. Effective connectivity for each possible within-network connection was inferred using spectral dynamic causal modeling (spDCM; Friston et al., 2014). Results revealed that stability of effective connections depended on the number of ROIs in a network. Networks including two ROIs showed considerable stability (SD = 0.023-0.053), while networks consisting of more than two ROIs showed more variability (SD = 0.10-0.23), which is probably related to more complex estimation processes for DCM. Effective connections of the default mode network were not found to be significantly related to amount or quality of sleep (all p-values > 0.05). Finally, a decrease in bidirectional connectivity was observed between two ROIs (ACC and right MFG) of the executive control network across longitudinal working memory task performance.

P12 – David Alexander (Brain and Cognition Research Unit, Catholic University of Leuven, Belgium)

Large scale cortical integration measured via motion of brain signals: task-related trajectories in cortical waves

Globally coherent patterns of phase are analyzed at single-trial level. Episodes of globally coherent activity occur in the delta, theta, alpha and beta bands in data from EEG, MEG and ECoG. The relevant signal has the form of large-scale waves, which propagate with a range of velocities. The mean speed of the waves at each frequency band was proportional to temporal frequency, giving a range of speeds in the MEG of 0.06 to 4.0 m/s, over the temporal frequencies of delta to beta. The wave peaks moved over the entire measurement array; this makes them an ideal candidate mechanism for global integration of cortical activity.
We illustrate the task-related nature of the wave trajectories with data from experimental tasks including hand movements and visual perception (dot lattices and Vernier). The direction of motion was more predictable during task-relevant intervals, showing the functional relevance of the waves. The waves show systematic variation in velocity and direction, locked to the timing of task components. These episodes of wave activity are related, via their latency, temporal frequency and task-dependency, to known event-related potential events such as the P2 and P3.

P13 – Frederik Van de Steen (Department of Data Analysis, Faculty of Psychology and Educational Sciences, Ghent University, Belgium)

Critical comments on EEG sensor space dynamical connectivity analysis

Many different analysis techniques have been developed and applied to EEG recordings that allow one to investigate how different brain areas interact. One particular class of methods, based on the linear parametric representation of multiple interacting time series, is widely used to study causal connectivity in the brain. However, the results obtained by these methods should be interpreted with great care. The goal of this paper is to show, both theoretically and using simulations, that results obtained by applying causal connectivity measures on the sensor (scalp) time series do not allow interpretation in terms of interacting brain sources. This is because 1) the channel locations cannot be seen as an approximation of a source's anatomical location and 2) spurious connectivity can occur between sensors. Although many measures of causal connectivity derived from EEG sensor time series are affected by the latter, here we will focus on the well-known time domain index of Granger causality (GC) and on the frequency domain directed transfer function (DTF). Using the state-space framework and designing two simulation studies we show that mixing effects caused by volume conduction can lead to spurious connections, detected either by time domain GC or by DTF. Therefore, GC/DTF causal connectivity measures should be computed at the source level, or derived within analysis frameworks that model the effects of volume conduction. Since mixing effects can also occur in the source space, it is advised to combine source space analysis with connectivity measures that are robust to mixing.

P14 – Javier Rasero Daparte (Istituto Nazionale di Fisica Nucleare, Sezione di Bari, Italy)

Consensus clustering approach to group brain connectivity matrices

In the supervised analysis of human connectome data, subjects are usually grouped by high-level clinical categories (e.g., patients and controls). However, the population of healthy subjects (as well as those of patients) is typically highly heterogeneous: clustering algorithms find natural groupings in the data, and therefore constitute a suitable technique for disentangling the heterogeneity that is inherent to many diseases and to the cohort of controls. Such an unsupervised classification may also be seen as a preprocessing stage, so that the subsequent supervised analysis might exploit the knowledge of the structure of data. We propose here a new method, rooted on the consensus clustering paradigm developed in Complex Networks theory, where the connectivity pattern of each brain region is analyzed by a standard clustering algorithm and a consensus matrix is built by merging the partitions obtained in correspondence of each brain region. The unsupervised strategy we propose here to group subjects, without using phenotypic measures, consists of (i) definition, for each node, of a distance matrix for the set of subjects (ii) clustering the distance matrix for each node, by k-medoids method (iii) build the consensus network from the corresponding partitions and (iv) extract groups of subjects by finding the communities of the consensus network thus obtained. By analyzing publicly available data-sets, as well as a simulated toy system, we demonstrate that the proposed approach allows to robustly identify groups of subjects with similar connectomes, thus providing a partition of subjects beyond the measured labels associated to them.

P15 –Katharina Glomb (Center for Brain and Cognition, Universitat Pompeu Fabra, Barcelona, Spain)

Temporal dynamics of human resting state fMRI

It is well known that the pattern of pairwise correlations of BOLD signals is preserved during rest. These correlations are more generally referred to as functional connectivity (FC) because they are thought to reflect functional integration between brain regions. Recently, it has been established that FC is not static, but that it changes over time, however, the dynamics that determine these changes remain elusive. In this study, we use a sliding windows approach to track global fluctuations in FC and BOLD variance. We find that both go hand in hand, suggesting that one cannot be interpreted without taking the other into account. Additionally, we analyze activation time courses of resting state networks (RSNs) obtained via tensor factorization, a method which makes very few assumptions about the underlying structure of the data. RSN time courses exhibit a large amount of co-activation which varies with global fluctuations in FC and BOLD. We find that many properties of the observed fluctuations in FC and BOLD, including their ranges and their correlations amongst each other, are predicted by the presence of long-term correlations. However, we also encounter interesting characteristics that are not explained in this way. In particular, we find that fluctuations in the BOLD signal and fluctuations of FC exhibit a non-linear relationship which suggests that the brain transitions between states of high synchronization and states of low synchronization in a non-trivial manner.

P16 – Mariam Kostandyan (Department of Experimental Psychology, Ghent University, Belgium)

Neural mechanisms of global / specific proactive and reactive cognitive control in a rewarded Stroop task: A simultaneous EEG-fMRI study

Motivation is known for its potential to bias cognitive control, typically yielding superior task performance in rewarded trials (e.g., Padmala & Pessoa, 2011). Reward influence on cognitive control can manifest itself via proactive or reactive mechanisms of control (Braver, 2012). Typical experimental paradigms to study the influence of reward on cognitive control mechanisms are 1) monetary incentive delay paradigm (MID) where reward information is cue-locked and 2) stimulus-reward association task (SRA) where reward information is stimulus-locked (and often overlaps with the task). Neuroimaging results of studies using SRA paradigms suggested that reward could enhance reactive control (e.g., Boehler, Schevernels, Hopf, Stoppel, & Krebs, 2014), whereas the neuroimaging results of MID tasks found shifts from reactive to proactive control in reward context (e.g., Jimura, Locke, & Braver, 2010). Yet, direct comparisons between these different reward manipulations are lacking. Moreover, possible reactive-control enhancements need to be further distinguished from alternative processes, e.g. specific feature-level preparation. To investigate these questions, a Stroop color naming task with four different block types was used: SRA (reward and congruency factors), MID (reward and congruency factors), Cued-SRA (reward and congruency factors, C-SRA; cues were reward irrelevant and reflected preparatory attentional set), and neutral (congruency factor) block. We conducted a simultaneous EEG-fMRI study with a mixed event-related / block design, which allowed us to discriminate between sustained and transient preparatory effects on task performance. Behaviorally, main effects of reward and congruency for all blocks were observed. This was paralleled by dissociations in sustained and transient neural activity in areas related to motivation and cognitive control.

P17 – Marco Marino (Catholic University of Leuven, Belgium)
Detecting high-density EEG electrodes from anatomical MR images

Electroencephalography (EEG) studies require precise source localization. Spatial localization of EEG electrodes affects neural sources imaging and forward model generation (Khosla et al. 1999, Wang and Gotman 2001). With classical approaches (Koessler et al 2007), EEG coordinates are detected in sensor space and registered to anatomical magnetic resonance (MR) images, allowing analysis in source space. Direct detection on MR images prevents potential digitization and co-registration errors, and can therefore ensure more accurate neural source estimation. In this study, we propose an automated method for the detection and labeling of EEG electrodes from anatomical MR images for high-density EEG (hdEEG) montages.
Anatomical MR images were processed to create an electrode-enhanced image in individual space. Image processing included intensity non-uniformity correction, background noise and glasses artifact removal. Next, we defined a search volume around the head where electrode positions were detected in 3D Cartesian coordinates system. Electrodes were identified as local maxima in the search volume and registered to the MNI (Montreal Neurological Institute) standard space using an affine transformation. This allowed the matching of the detected points with the specific EEG montage template, as well as their labeling. Matching and labeling were performed by using the Coherent Point Drift (CPD) method (Myronenko and Song 2010).
No electrode was wrongly labeled in any case. Our automated method showed distances on average smaller than 4 mm for all the subjects (Figure 1, Figure 2).
Our method provides objective and repeatable measurements of EEG electrodes coordinates. Also, it minimizes further sources of errors such as electrodes position digitization and projection, since the detection is performed directly on the MR image (Figure 3). It showed good accuracy and suitability for hdEEG systems, which would provide better source localization, and therefore contribute to the use of hdEEG as an accurate brain-imaging tool.

P18 – Almudena Serrano Barroso (Department of Experimental Psychology, Faculty of Psychology, University of Seville, Spain)
Development of clinical applications for a new perspective on ADHD children

Attention-Deficit Hyperactivity Disorder (ADHD) is a prevalent and debilitating disorder diagnosed on the basis of persistent and developmentally-inappropriate levels of overactivity, inattention and impulsivity. Impulsive behavior is a core DSM-5 diagnostic feature of ADHD that is associated with several pejorative outcomes. Experimental procedures in which signals are related to rewards and the way in which the subjects respond to them could be key in the study of the disorders of impulse control.

Individuals make choices and prioritize goals using complex processes in which they attach value to the rewards they receive in relation to the previous stimuli. Recent studies have shown that autoshaping in rats and its application in human models could help to identify biological markers of impulsivity and define specific endophenotypes. The development of endophenotypes is more adequate for the effective application of pharmacological and behavioral treatments than traditional classification of mental diseases based on diagnosis scales. With this aim, our research analyzed the possible implications of attention factors using BCI technology, a direct communication pathway between brain signals and an external device. For this experiment we used a wireless EEG biosensor that digitizes and amplifies raw analog brain signals in order to identify biological markers of impulsivity. This research was supported by PSI2015-65500-P grant (MINECO, FEDER, UE).

P19 – Luca Faes (Bruno Kessler Foundation, Trento, Italy)

Multiscale information-theoretic analysis of coupled stochastic processes: Theory and application to brain-heart interactions

Complex physiological systems like the brain and the cardiovascular system coordinate their activity through regulatory mechanisms operating across multiple temporal scales. Accordingly, scaling techniques are needed to fully elucidate the dynamics of these systems in different states and conditions. The present study extends the framework of information dynamics, which provides entropy-based measures of information storage (self entropy, SE) and information transfer (transfer entropy, TE) in coupled dynamical systems, to the analysis of multiscale processes. Working in the context of linear multivariate stochastic processes, we first show that the multiscale formulation of a vector autoregressive (VAR) process introduces a moving average (MA) component, and provide a state space (SS) representation of the corresponding VARMA process. Then, we exploit the SS model parameters to compute analytical measures of SE and TE as a function of the time scale. The framework is tested on simulated unidirectionally and bidirectionally coupled VAR processes, showing that rescaling allows to elicit meaningful patterns of information storage and transfer that are not fully disclosed at one single scale, but may also evidence potentially misleading behaviors. Further, we apply the framework to the analysis of brain-heart physiological networks during sleep, considering the time series of heart rate and EEG delta power variability measured in healthy subjects across different wake and sleep states. We find peculiar patterns of brain-heart information dynamics distinctive of well-defined physiological states, such as the prevalence of cardiac information storage during wake and REM, and of from brain-to-heart information transfer during light sleep and deep sleep.

P20 – Roma Siugzdaite (Department of Experimental Psychology, Ghent University, Belgium)

Congruency investigation of language lateralization between task and resting state fMRI in humans with situs inversus totalis

The total reversal of internal organs is a congenital condition called situs inversus totalis (SIT). Though with the exception of the reversed frontal and occipital petalia observed using anatomical MRI techniques, the left hemisphere dominance for language in SIT was still found similar to controls. The objective of this study was to investigate functional brain asymmetries of language network in SIT subjects in a bigger sample. 15 SIT (4 left handed) and 15 matched controls underwent the scanning session performed on 3T Siemens scanner. Structural T1-weighted image was acquired for each participant using MPRAGE sequence (176 slices, TR=2250ms, TE=4.17ma). For resting state fMRI images were acquired using echo planar imaging (EPI) gradient-echo sequence 484s long (220 volumes, TR=2s, TE=24, 42 interleaved slices per volume). FMRI images were preprocessed in SPM12 using standard preprocesing pipeline: slice-timing, realignment, coregistration with the corresponding structural MR images, normalization into standard MNI space and smoothing using a 6-mm FWHM Gaussian kernel. We finished preprocessing with detrending, filtering and regression of three parameters (motion and noise from the white matter and CSF). To individuate resting state networks of interest we performed independent component analysis using GIFT toolbox. From twenty five independent resting state networks only Language network was selected for further analysis. Group comparison was performed using two-sampe t-test and laterality index with iterative thresholding was calculated to find language dominant hemisphere. We found that language network was not reversed in SIT group, though asymmetries were more consistent with left-handedness of subjects. We found that for the speech production left language lateralization was observed in 13 from 15 controls and 11 from 15 SITs, clearly showing left hemisphere dominance for language. On group level the Language network measured during resting state was not reversed in the SIT group. On a single subject level lateralization of the connectivity patterns in Broca's area in the LN showed 47 percent corresponding to the task data. In this study we investigated congruency between word generation task and Language network in rs-fMRI and their hemispheric preferences. Both groups in the task and in Language network during the rest showed similar activation patterns, but only during the task we found small significant differences. Though as a group SIT did not show functional asymmetry in the Language network. Even though there is no consistency between subjects inside the group, further research needed to understand sources of variability in the group of SIT.

P21 – Roma Siugzdaite (Department of Experimental Psychology, Ghent University, Belgium)
Lesion to hippocampus changes resting state functional connectivity in rat brain reflecting structural damage

Temporal lobe epilepsy (TLE) is associated with pathologic changes in hippocampal physiology and morphology. Resting state functional connectivity (rsFC) is known to reflect structural connectivity, but also allows to explore interactions between remote regions. We will try to disambiguate the effect of the epileptogenic lesion from a normal surgery. The purpose of this study is to trace changes in rsFC using BOLD-fMRI after inducing a unilateral left hippocampal lesion in rats. Male Sprague Dawley rats (n=20, 250-275 g) were anesthetized, followed by continuous s.c. infusion medetomidine and were inserted into the MR scanner (7T Bruker Pharmascan, Ettlingen, Germany). Anatomical (voxel size 0.156 x 0.156 x 0.156 mm3) and fMRI (voxel size 0.375 x 0.375 x 1.1 mm3) data were acquired. Afterwards, kainic acid (0,4 µg/0,1 µl) was injected into the right hippocampus under isoflurane anesthesia (5% induction, 2% sustenance). Four days and 3 months after the injection the animals were scanned again using the protocol described above. Twenty-four ROIs were segmented in each rat using anatomical MRI: cingulate, retrosplenial, prefrontal, sensorimotor, auditory visual cortexes, striatum, septum, hippocampus, thalamus, hypothalamus, colliculus and amygdala/enthorinal/piriform (AEP) cortex bilaterally. Mean time series were extracted from realigned, detrended and filtered (bandpass, 0.01~0.1HZ) rs-fMRI data in the ROIs before and after the lesion was induced. Functional connectivity was compared in each of these rats in pre- and two post-lesion scans. The rsFC analysis showed generally reduced functional connectivity between different areas, ipsilateral but also contralateral to the lesion. Functional connectivity density revealed voxel-wise reorganization in rat brain where less connected voxels disappear 4 days post-lesion and a number of more densely connected voxels decreases 3 months post-lesion. We conclude that functional connectivity measures in resting state fMRI are a valuable tool to map brain dynamics and its reliability when we act on some specific nodes via targeted lesions.

P22 – Valentina Ticcinelli (Lancaster University, UK)
Characterizing coupling functions in networks of oscillators

How to characterize and reconstruct networks from data is a challenge which pervades all of science. Numerous methods have been introduced for detecting the existence of causal connections in networks, most of which focus on pairwise interactions. Here, we present a new method, based on dynamical Bayesian inference, which is capable of detecting the e ffective phase connectivity within networks of time-evolving coupled oscillators subject to noise. It can reconstruct not only pairwise, but also joint conductivities and conductivities of higher degree, including triplets and quadruplets of interacting oscillators. Moreover, one can infer details of the coupling functions from which, in turn, the existence of causal links can be determined as well as the underlying functional mechanisms. We will illustrate the characteristics and potential of the method by application to a numerically-generated network of phase oscillators, with time-dependent coupling parameters, and subject to noise. By the mean of an algorithm based on two-dimensional correlation, we are able to integrate the information carried by the form of the coupling functions, using a polar representation. The procedure makes use of numerically-generated banks of comparison functions. As examples, results derived from real data will be shown, comparing the coupling functions computed between EEG brain waves for the situations with eyes-open or eyes-closed.

P23 – Anton Tokariev (University of Helsinki and BABA Center, Finland)

Effects of premature birth on functional networks in neonates

The few months around human birth comprise a developmentally critical period when the main neuronal pathways grow, setting framework for the large-scale neuronal network activity. In this work, we studied the effects of premature birth on the functional networks measured by scalp EEG.

We recorded 19-channel scalp EEG at term age from healthy full-term neonates (FT, n = 67) and preterm born babies (PT, n = 46). Five minute epochs of EEG were analyzed during two different vigilance states, active and quiet sleep. The data was band-pass filtered into 12 logarithmically equal frequency bands (Fc = 0.4, 0.7, 1, 1.4, 2, 2.8, 4, 5.7, 8, 11.3, 12, 22.6 Hz; cut-off frequencies [0.85…1.15] · Fc). We used realistic neonatal head model (Tokariev et al., 2015) and Dynamic Statistical Parametric Mapping (Dale et al., 2000) to reconstruct 8000 cortical sources that were collapsed into 64 parcels. We assessed functional connectivity as phase-phase (PPC; debiased phase lag index (Vinck et al., 2011)) and amplitude-amplitude (AAC) interactions between parcel activities. For AAC, we computed Pearson correlation coefficients between orthogonalized amplitude envelopes. Source simulations were used to define edges with reliable connectivity estimates. We compared levels of mean connectivity strength between FT and PT for inter-regional connectivity (pairwise relations between frontal, central, occipital, and temporal). Consistent networks were derived at group level for each group, both vigilance states, and frequency.

Spatial patterns of functional networks were highly dependent on vigilance state and oscillation frequency in both infant groups. The mean levels of PPC were higher for PT at low frequencies (0.4-0.7 Hz), mainly in frontal and central regions. PPC was stronger in FT at midrange (1.4-5.7 Hz) and high frequencies (16-22.6 Hz), mostly in the temporal region. Mean levels of AAC were higher in PT mostly at low (0.4-1 Hz) and high (11.3-22.6 Hz) frequencies in connections related to frontal or central regions. AAC at midrange (2.8-8 Hz) was higher in FT in the connections involving temporal and occipital regions.

Our results suggest that prematurity affects early functional networks. Interestingly, frequency bands and regions showing stronger connectivity in the preterm babies were those that are known to exhibit strong endogenous activity in the neonate. The observed effects are likely due to a developmental delay in the PT infants, caused by the developmentally suboptimal environment after premature birth.

P24 – Marco Ganzetti (Catholic University of Leuven, Belgium)

Defining algorithm parameters for intensity inhomogeneity correction of structural MR images in SPM

Intensity non-uniformity (INU) in magnetic resonance (MR) images is a major issue when conducting analyses of brain structural properties (Belaroussi, 2006). An imprecise INU correction may lead to qualitative and quantitative misinterpretations. The majority of INU-correction methods available in the neuroimaging community have performance largely dependent on the specific parameter settings used (Zheng, 2009). In this study, we addressed the question of how to define input parameters for a specific INU correction algorithm.

We assessed to what extent and how indirect metrics, essentially based on statistical properties, can support the characterization of optimal parameters using the algorithm implemented in SPM8 (Ashburner & Friston, 2005). As for the metrics, we evaluated the coefficient of variation for the white matter (CVWM=σWM/μWM), the coefficient of variation for the gray matter (CVGM=σGM/μGM), and the coefficient of joint variation (CJV= σWM+σGM/|μWM-μGM|). σ and μ indicate the standard deviation and the mean intensity of a tissue class, respectively. Investigations were conducted on simulated T1-w images with INU fields at different magnitude and with different noise level. In this regard, we generated two realistic INU fields characterized by different spatial profiles. The role of spatial smoothing on the metrics performance was also evaluated for different noise levels. The quantitative assessment of metrics performance was conducted in terms of voxel-wise distance (Weiskopf, 2011) between the simulated INU field and the estimated one. Afterwards, based on the superior CJV performance, we developed a data-driven approach for the parameter selection in real MR data. To this end, we implemented an enhanced procedure for the definition of white and grey matter masks, based on which the CJV was calculated. Eventually, as a validation, we used T1-w images selected from three publicly available datasets, acquired at different magnetic field strength: 1.5 T (IXI database of the Imperial College London), 3 T (KIRBY21 database of the Kirby Research Center for Functional Brain Imaging in Baltimore) and 7T (NITRC neuroimaging data repository).

Our analyses revealed that the optimal input parameters chosen based on the CJV generally provide lower absolute distances, and therefore more accurate results than input parameters chosen based on CVWM and CVGM. Moreover, metrics performance showed to be mostly dependent on the noise level. For a light smoothing level (FWHM=1 mm), we observed a marked improvement of CJV based parameter selection whereas no clear changes of CVWM and CVGM values were found. Notably, an excessive smoothing

(FWHM>2 mm) led to less accurate INU reconstructions. This was evident in terms of CVWM and CVGM, and less pronounced when CJV was used. Finally, the analysis of CJV values on real MR data showed the CJV to be sensitive to INU properties, since the maximum of the CJV values across the whole set of input parameters was different across MR images.
Our findings suggest that it is possible to tailor the parameter configuration of the INU correction algorithm based on the characteristics of the MR image to be processed, leading to a substantial improvement compared to the default parameter configuration. We identified the CJV as the most accurate metric, as long as the noise level in the INU-corrected image was controlled by means of a light extent of spatial smoothing. Since considerable progresses are being made on the development of high-field MR scanners (Umutlu, 2014) the problem of INU correction is becoming a priority in the neuroimaging community (Uwano, 2014; Van De Moortele, 2005). The data-driven approach we propose may contribute to address this problem by optimizing the performances of any given INU correction algorithm.

P25 – Tianlu Wang (Catholic University of Leuven, Belgium)
Feasibility study on neurofeedback training to down-regulate the SN/VTA

The difficulty for people to make healthy eating choices in today's society of abundance can lead to obesity and associated health issues in the long run. These eating patterns are influenced by the brain regions substantia nigra and ventral tegmental area (SN/VTA), the regions in the midbrain involved in attributing incentive salience to appetizing food stimuli. We hypothesize that tuning down the SN/VTA activity is a way to decrease the intrinsic motivation towards food and help people make more sensible eating choices. In this study, we developed a real-time fMRI neurofeedback protocol that trains participants to down-regulate their dopaminergic midbrain activity in response to appetizing food stimuli. We explored the effect of the new protocol in a feasibility study with five participants. The results showed successful down-regulation in three of the five participants. We furthermore examined effects of different feedback designs, and obtained useful opinions from the participants through a series of questionnaires. The practical experience gained through the study and the questionnaire results from the participants allow us to make suggestions to improve future neurofeedback training designs for the down-regulation of SN/VTA activity in response to appetizing food.

P26 – Svitlana Popovych (Department of Animal Physiology, University of Cologne, Germany)

Phase locking analysis reveals neurophysiological markers of movement execution in young and old subjects

Motor actions are generated by complex interactions of various brain regions. The same brain regions can build various functional networks depending on the action. Identifying the neural signals that encode an action's component (selection, preparation, execution) remains a difficult task. In the current study, EEG data were recorded continuously from 18 young (22-35 years, 10 female) and 24 old (60-79 years, 12 female) right-handed healthy subjects as they performed a simple motor task. The task required participants to execute a left or right index finger tapping triggered by a visual cue or by an uncued voluntary choice. We found that voluntary and visually triggered movements exhibit significant phase locking in the delta-theta frequency band (2-7 Hz) around movement onset both in young and old subjects. However, we found significant differences in accuracy rate and mean beta-amplitude between the two groups of subjects. The inter-regional phase-locking analysis using the phase-locking value (PLV) as indicator revealed a significant change in low-frequency bands (2-7 Hz) around movement onset in the voluntary conditions for both age groups. However the derived phase-locking networks are significantly different between them. We hypothesize that older subjects establish additional interhemispheric connections to compensate for the loss of connectivity in M1-SMA. Thus phase locking in the delta-theta frequency band is therefore an electrophysiological marker of execution of movement, no matter how it has been initiated. We suggest that this intra- and inter-regional synchrony helps the simultaneously active pathways of distinct cortical networks that initiate voluntary and stimulus-triggered movements, converge to a common motor output and activate the appropriate muscles to perform the movement. This mechanism may thus be regarded as a prototype for organizing more complex motor activities.

P27 – Marcelo Armendariz (Catholic University of Leuven, Belgium)

Integration of depth cues in the primate visual cortex

To reconstruct the third dimension from flat retinal images, the brain exploits a range of monocular and binocular depth cues. However, the neural mechanisms underlying cue integration is still poorly understood. Traditionally, this process has been broadly conceived in modular terms, with the independent processing of individual cues followed by a combination stage in which the influence of each cue reflects the reliability with which it is encoded. Computational and recent imaging studies in humans suggested the existence of a fusion mechanism that combines the information of different depth cues (Ban et al. 2012; Murphy et al. 2013). In particular, the latter studies showed, rather unexpectedly based on previous monkey research, that area V3B/KO may house neurons coding for a fusion mechanism of different depth cues. To investigate cue integration in monkeys using exactly the same paradigm as in Ban et al. (2012), we performed an equivalent fMRI study. Specifically, we showed monkeys a set of stimuli representing near or far depth planes defined by motion parallax, binocular disparity and the combination of both in either a congruent (i.e. the two cues signal the same depth planes) or incongruent fashion (i.e. the two cues signal different depth planes). We used a linear support vector machine to classify between near and far patterns in retinotopically defined regions of interest (ROI) of visual cortex. To quantify differences in prediction accuracies across conditions and to assess fusion, we conducted three test for cue integration: integration index, congruent vs incongruent cues and transfer index (similar to Ban et al. 2012). We found that fMRI responses are more discriminable when the two cues signal depth concurrently, and that depth information provided by one cue might be diagnostic of depth indicated by the other. We revealed that monkey area MT shows fMRI signals consistent with a fusion mechanism of independent depth cues. In fact, these results may reconcile the human imaging data with previous monkey electrophysiological studies implicating area MT in depth perception based on motion and binocular disparity signals (Nadler et al. 2008; Nadler et al. 2013; DeAngelis et al. 1998). In general, our findings together with those obtained in humans provide evidence for a fusion mechanism for depth perception in the dorsal stream of primates. The fusion of depth cues, however, appears to be computed in different areas in humans (V3B/KO) and monkeys (MT). Therefore it is tempting to speculate that human V3B/KO may have been part of the MT cluster in an ancestor of monkeys and humans which has drifted in a caudo-dorsal direction during human evolution.

P28 – Jessica Samogin (Catholic University of Leuven, Belgium)

Effects of an audiovisual training on visual discrimination tasks: ERP and source localization analysis

Neurons in several brain regions (both cortical and subcortical) show multisensory integrative capabilities, exhibiting enhanced responses when two stimuli of different modalities (e.g. an auditory and a visual stimulus) are presented in spatial and temporal coincidence. This capability can be exploited to rehabilitate single sensory deficits through multisensory training, which promotes the strengthening of synapses along brain circuits including multisensory regions. The Superior Colliculus (SC), a subcortical region in the midbrain, is widely recognized as a primary site of integration of spatio-temporally coincident audiovisual (AV) stimuli. In addition to SC, dorsal posterior parietal (DPP) cortices constitute a site of convergence of audiovisual information. Moreover, both the SC and DPP cortices are part of the retino-collicular-dorsal pathway, functionally involved in motion signal processing. Aim of the present study is to investigate whether an audiovisual training – consisting of repetitive AV stimulation in spatial coincidence – is able to specifically activate the SC and DPP region, possibly reinforcing the synaptic connections along the retino-collicular-dorsal pathway. To this aim, 64-channel electroencephalographic data were recorded from 30 healthy subjects, during the execution of two lateralized visual tasks: a motion discrimination task mainly involving the collicuo-dorsal pathway, and an orientation discrimination task mainly involving the striate and ventral extrastriate cortex. Both tasks were performed before and after 2 hours of an AV training, during which participants were asked to detect and perform a saccade toward the presented AV stimulus; the training involved a single hemifield (trained hemifield). Half of the participants ('experimental group') underwent a training with AV stimuli in spatial coincidence; the remaining half ('control group') underwent a training with AV stimuli in spatial disparity. For each subject and each task, the ERP evoked by the visual stimulus was computed at each electrode and the statistical analysis was limited to the ERP over the electrodes (FC1, FC2, Fz, Cz) showing maximal N100 component (negative peak in the post-stimulus window 140-180ms). Participants in the experimental group showed a post-training enhancement of the N100 component only in the motion discrimination task for stimuli ipsilateral to the trained hemifield. Participants in the control group showed no effects in either task. In order to identify possible differences at cortical level underlying this ERP effects, we reconstructed the activity in 84 cortical Region Of Interest (ROI) corresponding to the Brodmann Areas (BA), taking advantage of the software sLORETA. Statistical analyses revealed a significant post-training enhancement of activity only in structures belonging to BA7 (an area in the DPP region) in the time interval 140-180 ms, specifically for the motion discrimination task in the experimental group. Overall, results suggest that: i) the N100 enhancement observed on the scalp can reflect an higher activation in area BA7 in the DPP region; ii) the latter may be the consequence of plastic reinforcement of synapses along the colliculo-dorsal pathway promoted by the AV training. These results may be relevant in the perspective of rehabilitation of patients with visual field defects.

P29 – Wouter De Baene (Cognitive Neuropsychology, Tilburg University, The Netherlands)

A comparison of the functional network topology of low-grade and high-grade glioma patients

In Europe, between 8.5 and 14 per 100,000 persons per year are diagnosed with a primary brain tumour (Gigineishvili et al., 2014). The most common type of primary brain tumours are gliomas, which are classified based on their malignancy. Compared to high-grade gliomas (HGG; WHO-grade III-IV), low-grade gliomas (LGG; WHO-grade I-II) are less malignant and tend to grow less aggressively with lower degrees of cell infiltration and proliferation. This slower tumour growth might lead to greater neuroplasticity potential in LGG patients (Esposito et al., 2012), which can result in compensation by remote areas within the ipsi-lesional and contra-lesional hemisphere (Duffau, 2006). The majority of glioma patients suffers from cognitive deficits (Gehring et al., 2008). These deficits are more profound in patients with high- versus low-grade tumours (Noll et al., 2015) and manifest themselves across multiple domains (e.g. memory, attention, information processing, executive functioning; Gehring et al., 2012). This wide spread across cognitive domains suggests a global impairment of the underlying networks induced by the brain tumour (Martino et al., 2011). How changes in network connectivity due to brain damage relate to behaviour is, however, relatively unknown. The goal of this study was to explore the differences in functional network topology between LGG and HGG patients and its link with cognitive performance (more specifically executive functioning). We expected differences in the functional network topology between LGG and HGG patient groups both within the ipsi-lesional and contra-lesional hemisphere.

Whole-brain resting state fMRI data (3T Philips Achieva with PRESTO pulse sequence) were acquired in 123 glioma patients (65 LGG, 58 HGG patients) prior to resective brain surgery. After preprocessing, the rs-FMRI data for each subject was parcellated using the AAL atlas to construct a 90 node graph (whole brain) and two 45 node graphs (one for each hemisphere). The connectivity matrices for each subject were formed by the z-transformed correlation coefficients between each pair of ROIs. Next, topological metrics were calculated on graphs thresholded at different levels of sparsities (from 10% to 35%). For each graph, an averaged scalar for each metric independent of a single threshold selection was calculated (Achard et al., 2006). The following network measures were computed: (1) global connection strength, which provides information of the total degree of connectivity, (2) global efficiency, which reflects the integration of network-wide communication, (3) local efficiency, which represents the potential for local information transfer, and (4) modularity, which reflects the degree to which a network can be decomposed into internally correlated subnetworks. Permutation tests were performed to compare these metrics between LGG and HGG patients. A subsample of 78 patients (49 LGG, 29 HGG patients) were also neuropsychologically tested prior to brain surgery using the CNS Vital Signs test battery. The Shifting Attention Test (SAT) was used as a measure of executive functioning (Gualtieri & Johnson, 2006). Linear mixed-effects models were used to describe the relationship between the different graph metrics and executive functioning.

In the total sample of 123 glioma patients, for all three graphs (whole brain, ipsi-lesional and contra-lesional hemisphere), global connection strength, global efficiency, local efficiency and modularity did not differ between the LGG and HGG group. In the sample of 78 patients, lower executive functioning was observed in HGG patients compared to LGG patients ($p < .01$; $M = 83.48$, $SEM = 4.84$ for HGG vs $M = 98.33$, $SEM = 2.23$ for LGG). Executive functioning was only related to the local efficiency of the contra-lesional hemisphere ($p < .05$): higher local efficiency was linked with worse executive functioning.

Our results show that, despite the difference in tumour growth speed between LGG and HGG patients, differences in the functional network topology of the whole brain and of the ipsi-lesional and contra-lesional hemisphere cannot be detected between these groups. Furthermore, our results suggest that executive functioning is related to the local efficiency of the contra-lesional hemisphere: Better executive functioning of the patients is related to smaller potential for local information transfer.

P30 – Stefan Fuertinger (Icahn School of Medicine at Mount Sinai New York, US)
On the feasibility of epileptic seizure forecasting using intracranial high frequency connectomics

According to the WHO annual report 2015, epilepsy affects more than 50 million people of all ages and ethnicities worldwide. About one third of patients develop intractable epilepsy, which does not respond to pharmacological treatment and for some, resection of the epileptogenic brain region remains the only treatment option. Management of patients with intractable epilepsy is challenging due, in part, to poorly understood pathophysiological mechanisms underlying the electrographic signature of epileptic seizures. To this end, high frequency oscillations (HFOs) of cortical networks have been suggested as potential markers of epileptogenic areas. However, despite their significance in ictogenesis, the detailed functional role of HFOs in the development and propagation of seizures remains largely unknown.
In a recently published study, we assessed HFO dynamics underlying epileptogenic activity by constructing functional networks based on pairwise inter-electrode normalized mutual information coefficients for temporally successive one-second segments of iEEG data. The temporal evolution of inter-ictal network communities was characterized by a remarkably stable structure, while seizure periods exhibited highly irregular network architecture shaped by a distinct pre-ictal increase in the number of nodal communities, followed by a sudden ictal drop and a rebound post-ictally. These findings provided first evidence that epileptic seizures can be characterized by a breakdown of the community structure in dynamic HFO networks, shown by the appearance of small unstable communities in the pre-ictal phase.
Based on these results, we designed a preliminary algorithm to forecast seizure events using the relative change in partition distances of temporally successive HFO networks. While network partitions were stable interictally, community dynamics started to show critical (> 8%) changes in partition distances up to 50 s prior to seizure onset. Topographic network organization reliably identified pre-ictal activation patterns regardless of markedly different electrographic readings. Specifically, a sudden breakdown of the community architecture in HFO networks always preceded the electrographic seizure onset suggesting that measures of topographic network organization can be used to detect epileptic seizures prior to their clinical onset.

P31 – Quanying Liu (ETH Zurich, Switzerland)
Frequency-dependent connectivity analysis using high-density EEG

The existence of resting-state networks (RSNs) in the human brain has been largely documented by functional magnetic resonance imaging (fMRI) (Fox & Raichle 2007, Gillebert & Mantini 2013) and magneto-encephalography (MEG) studies (Brookes et al 2011, Hipp et al 2012). However, the neuronal mechanisms underlying RSNs, especially in which frequency range the spatially isolated regions in RSNs communicate with each other, are still unclear. High-density EEG (hdEEG) has high temporal resolution and relative good spatial resolution, offering a unique window into the characterization of brain functional interactions in the frequency domain. Our study has two goals: 1) to detect the spatial pattern of RSNs with a seed-based approach using hdEEG and 2) to investigate the frequency-dependent functional connectivity in these EEG-RSNs, and particularly in the default mode network (DMN).

We collected 5-minute resting state hdEEG (256 channels) signals, electrode positions and a T1-weighted anatomy magnetic resonance image in 19 subjects (age 28±5.9 years, 14 females). To estimate the frequency-dependent connectivity in a single subject, we used four main processing steps: 1) Data preprocessing, to attenuate noise and artifacts that are mixed in the data (Liu et al 2015); 2) Volume conduction model creation and source reconstruction, to estimate the distribution of active brain sources that most likely generates the potentials measured over the hdEEG sensors (Liu et al 2016); 3) Pair-wise correlation analysis in frequency domain, to calculate the spectrum of all the dipoles while eliminating the effects of signal leakage (Hipp et al 2012); 4) Frequency-dependent connectivity analysis, to generate the correlation map in specific frequency band for each subject in individual space. Finally, group-level connectivity maps were generated by means of a random-effect analysis (Smith & Nichols 2009), using a voxel-wise non-parametric permutation test (RANDOMISE in FSL).

We applied our methodology to 4 pairs of bilateral seeds, belonging to the auditory (AN), dorsal somatosensory (DSN), dorsal attention (DAN) and visual networks (VN), respectively. The inter-hemispheric connectivity in these four networks showed different profiles, with significant values in the following ranges: 39-53Hz for AN, 18-24Hz for DSN, 9-22Hz for DAN, 10-13Hz for VN. We also generated frequency-dependent connectivity maps from hdEEG in these selected bands, and we found a large degree of resemblance with the ones obtained using fMRI using the same seeds. We also calculated connectivity maps for the 4 main nodes of DMN: MPFC, PCC, LANG and RANG. Only when we examined the connectivity in the alpha band we found correspondence with the fMRI connectivity results. In particular, long-range connections in the DMN were strongest in alpha band, whereas connectivity in the gamma band was rather local. By using the dice similarity between connectivity maps obtained by hdEEG and fMRI we quantitatively confirmed that the main carrier of DMN connectivity was in the alpha band.

Our findings are in line with and extend previous evidence from resting-state MEG (Brookes et al 2011, Hipp et al 2012) and simultaneous EEG-fMRI (Mantini et al 2007), suggesting that large-scale network connectivity in the human brain depends on the frequency of neuronal oscillations. Importantly, our results showed that long-range connectivity in DMN is mainly related to alpha rhythm, whereas short-range connectivity is more weighted toward the gamma rhythm. We suggest that our methodology for frequency-dependent connectivity analysis may contribute to the further development of hdEEG as a potential tool for functional connectivity research as well as for clinical applications.

P32 – Quanying Liu (ETH Zurich, Switzerland)
High-density electroencephalography permits the detection of resting state networks

The existence of resting state networks (RSNs) in the human brain has been largely documented by functional magnetic resonance imaging (fMRI) and magneto-encephalography (MEG) studies (Fox & Raichle, 2007; Gillebert & Mantini, 2013; Brookes et al., 2011; de Pasquale et al., 2010; Hipp et al., 2012; de Pasquale et al., 2012). However, no research group has been able to map brain networks using EEG recordings so far. In this study, we demonstrate that high-density EEG (hdEEG) can be used to detect RSNs.
We collected 5-minute resting state hdEEG (256 channels) signals, electrode positions and T1-weighted structural MRI in 19 subjects (age 28±5.9 years, 14 females). We developed a dedicated processing pipeline, which included 4 main processing steps: 1) ICA-based EEG artifact reduction (Mantini et al., 2008); 2) creation of 12-tissue realistic head model using a 12-layer finite element method (FEM) to estimate how electrical signals transmit from each brain source to the sensors (Hallez et al., 2007); 3) reconstruction of brain activity by the eLORETA method (Pascual-Marqui et al., 2011); 4) temporal ICA on downsampled (1Hz) power time series of voxels. After estimating the component maps in individual space, we warped them to MNI space, and selected the EEG RSNs by matching them with fMRI-RSN templates. Finally, group-level RSN maps were generated by means of a random-effect analysis (Smith & Nichols, 2009), using a voxel-wise non-parametric permutation test (RANDOMISE in FSL).
We identified 14 RSNs (group-level: $N=19$, $p<0.001$, TFCE corrected) from hdEEG data. These 14 RSNs are: default mode network (DMN), dorsal attention network (DAN), ventral attention network (VAN), right frontoparietal network (rFN), left frontoparietal network (lFN), language network, opercular network (CON), auditory network(AN), ventral somatomotor network (VSN), dorsal somatomotor network (DSN), visual foveal network (VFN), visual peripheral network (VPN), medial prefrontal network (MPN) and lateral prefrontal network (LPN). Furthermore, to test the robustness of the pipeline, we split the continuous 5-minute hdEEG into 2 pieces of 2.5-minute signals (segment 1 and segment 2).
We developed a complete analysis pipeline to detect RSNs spatial maps using hdEEG recordings. Our work suggests that hdEEG can be used as an alternative to MEG to investigate the electrophysiological basis of functional networks.

P33 – Hanni Kiiski (Trinity College Institute of Neuroscience, Dublin, Ireland)
Visual P3 event-related potential activations predict cognitive efficiency after 12-months in multiple sclerosis patients and controls

Cognitive impairment affects ~65% of multiple sclerosis (MS) patients. Objective measures of cognitive functioning, such as cognitive electrophysiology, would be of great value in clinical practice. Our goal was to examine whether P3 event-related potential (ERP) activations would predict cognitive efficiency, and processing speed, in MS patients and controls. Seventy-eight (35 MS patients, 43 healthy age-matched controls) completed visual and auditory two-stimulus oddball and three-stimulus oddball tasks, and the adapted Minimal Assessment of Cognitive Function in Multiple Sclerosis battery (MACFIMS, Benedict et al., 2002), at Month 0 and Month 12. Data were recorded from a 128-scalp channel electroencephalography array. Machine learning approach was applied to predict composite scores of 1) cognitive efficiency and 2) processing speed at baseline and 12 months later with P3 ERP activations. Our findings show that brain activations recorded during visual two-stimulus P3 task predict cognitive efficiency performance 12 months later (a cross-validated r of .45). In addition, visual P3 ERP activations predicted cognitive efficiency and processing speed at baseline. We conclude that brain activations measured during P3 tasks of visual modality may have utility as objective measures of cognitive efficiency and processing speed.

P34 – Caroline Malherbe (Department of Computational Neuroscience and Clinic and Polyclinic of Neurology, Head and Neuro Center, University Medical Center - Eppendorf, Hamburg, Germany)

Spatial neglect in patients with left hemisphere stroke: a causal functional contribution analysis based on game theory

Stroke patients often display spatial neglect, an inability to report or respond to relevant stimuli in the contralesional space. Though this syndrome is considered to result from dysfunction of the large-scale attention network (Umarova, 2011), it is still disputed, damage of what grey and white matter regions leads to neglect (Malhotra, 2015). To address this question, we used an inference approach based on game theory, the Multi-perturbation Shapley value Analysis (MSA) (Keinan, 2004), which is a robust and exact multivariate mathematic method for inferring functional contributions from multi-lesion patterns.

Lesion patterns of 128 left hemisphere acute stroke patients (age: 63±14 years; lesion size: 23,7±29,6 ml) were investigated in relation to 2 behavioral neglect scores: the line bisection test, and the Center of Cancellation (Rorden, 2012) of Bells Test (CoC), assessed 5±2 days post-stroke. Patients with negative test score (corresponds to contralesional neglect) and positive test score (neglect to ipsilesional space) were analyzed separately, as representing distinct neuropsychological phenomena. We defined 9 regions of interest (ROI): superior (STG) and middle temporal gyrus (MTG), inferior parietal lobe (IPL), inferior frontal gyrus (IFG), arcuate (AF), superior longitudinal (SLF) and inferior occipitofrontal (IOF) fasciculi, basal ganglia (BG), and the rest of the brain (ROB). For each region and patient we considered relative lesion size (in %) of each region. To quantify causal contributions of the regions, we used an objective value characterizing the contributions of ROIs across all possible lesion configurations, the Shapley value (Keinan, 2004). The approach requires a complete set of performance scores for all combinations of intact or lesioned regions, i.e., $2^9=512$ scores for 9 ROIs. We obtain this full dataset through support vector machine

(SVM) prediction (Chang, 2011). To choose the best kernel (linear or Gaussian) and penalty parameter C for a dataset, we consider the accuracy of a leave-one-out prediction across the 128 patients dataset. To the predicted full dataset of lesion configurations and behavioral scores, We applied the game theoretical approach to the predicted full dataset of lesion configurations and behavioral scores. In a system composed of $N=\{1,...,9\}$ ROIs performing a task, we define a coalition S, where $S \subseteq N$, and a performance score $v(S)$, which is a real number representing the performance measured for the perturbation configuration in which all the elements in S are intact and the rest perturbed. The marginal importance of ROI i to a coalition S, with $i \notin S$, is represented as: $\Delta i(S)=v(S\cup\{i\})-v(S)$. Then, the Shapley value of each player $i\in N$ is defined by the following equation, where $\Re$ is the set of all n! orderings of N and Si(R) is the set of players preceding i in the ordering R: $\gamma i(N,v)=1/n! \sum R\in\Re\Delta i(Si(R))$.
Contralesional neglect (negative CoC of Bells Test) was associated mainly with damage to left STG, AF and SLF (linear kernel, 71% accuracy); whereas ipsilesional neglect (positive CoC of Bells Test) was related to lesion of IPL (linear kernel, 60% accuracy). Contralesional neglect (negative values of line bisection test) was associated mainly with SLF damage (Gaussian kernel, 85% accuracy); whereas ipsilesional neglect (positive values of line bisection test) was related to IPL lesion (linear kernel, 91% accuracy).
This work focused on spatial neglect resulting from left hemisphere stroke lesions and demonstrated the contribution of different anatomical structures to distinct aspects of spatial attention deficits, potentially explaining contradictions in lesion anatomy of neglect. Whereas the contribution of the left STG to the occurrence of neglect to the right hemispace (negative values of Bells test) is in line with previous findings (Suchan, 2011), here we demonstrated the relevance of left dorsal fronto-parietal connections damage to the severity of the contralesional spatial bias, emphasizing the importance of disconnection in neglect. For the first time, the relevance of the left IPL for spatial processing in the left hemispace is shown, for both functional scores, line bisection and Bells test. As a perspective, the functional interactions of the ROIs should be explored to highlight overlapping and synergistic interactions in human attentional function.

P35 – Chie Nakatani (Catholic University of Leuven, Belgium)
EEG phase-amplitude coupling increased after rTMS

The EEG signal has multiple frequency bands, which emerge as a result of interactions among different neural populations. Couplings between these bands, in particular Phase-Amplitude Coupling (PAC) between slow and fast bands, are observed within and across brain regions. PAC is believed to have a crucial role in processing and transfer of information in the brain. Accordingly, PAC has received considerable attention recently. A neuro computational model of PAC indicates two pey parameters. One is connectivity between pyramidal and fast inhibitory interneurons. PAC will increase as the connectivity between increases. The other is the input noise level to the system. As the noise level increases, the fast oscillaltion emerge, stabilize, and saturate. PAC will increase, and decrease, accordingly (Chehelcheraghi, et al., 2016). We tested the model prediction using repetitive Trans-cranial Magnetic Stimulation (rTMS) technique. Two seconds of 10Hz rTMS was applied to intraparietal sulcus, temporal-parietal junction, and lateral occipital complex of healthy human volunteers. The stimulation was hypothesized to increase the connectivity via forced simultaneous firing of the neurons, and/or noise to the stimulation loci. Post-rTMS period of EEG was analyzed. PAC was estimated in six band pairs, delta-beta, delta-gamma, theta-beta, theta-gamma, alpha-beta, and alpha-gamma. In all band pairs and stimulation loci, PAC increased after the TMS. The model prediction was, therefore, supported.

P36 – Marinho Lopes (University of Exeter, UK)

Synchronization in the random-field Kuramoto model on complex networks

The Kuramoto model has been the paradigmatic model to study synchronization phenomena in a multitude of fields including neuroscience. This model describes the dynamics of interacting phase oscillators. Depending on how strong the coupling between oscillators is, they either oscillate independently from each other or oscillate synchronously with a certain frequency. It has been demonstrated that the transition from an incoherent asynchronous state to a coherent synchronous state depends on the network structure that connects the oscillators, and their specific type of interaction. Here we study how network structure impacts on the properties of the phase transition, and in addition we consider the presence of random fields disturbing the oscillators. We demonstrate that the network topology and the random-field heterogeneity have a strong impact both on the critical coupling at which the transition takes place and on the kind of synchronization phase transition, which can be of first-, second- or infinite-order (Lopes et al., 2016). These results may be relevant to understand how network structure and disorder affect the emergence of synchrony in real systems such as cortical oscillations or the circadian clock in the brain (Liu et al., 1997; Breakspear et al., 2010; Lu et al., 2016).

P37 – Mique Saes (VU University medical center, Amsterdam, The Netherlands)

EEG based parameters in chronic stroke patients are related to motor recovery

Prediction of motor recovery post stroke has been a focus for several years. Electroencephalography (EEG) based parameters such as the Brain Symmetry Index (BSI) and Delta Alpha Ratio (DAR) may improve prediction of motor recovery post stroke. The first aim of the present study was to investigate whether the BSI and DAR differ between chronic stroke patients and healthy individuals. The second aim was to investigate whether these EEG parameters are related to motor recovery of the upper paretic limb.

64-channel EEG data was acquired from 21 chronic stroke patients (>6months post stroke, initial upper limb paresis) and 9 healthy age-matched controls. Asymmetry in brain activity was investigated by calculating the BSI. Differences in relative spectral power were investigated by calculating the DAR. Motor recovery of the upper limb was measured using the Fugl-Meyer Assessment for the upper extremity (FMA) which is assumed to reflect most closely behavioural restitution.

A Mann-Whitney U-test revealed that the BSI was significantly higher in chronic stroke patients (Mdn=0.174, IQR=0.069) compared to healthy controls (Mdn=0.118, IQR=0.035), U=21, z=-3.33, r=0.61, $p<0.001$. Regarding the DAR, there was no significant difference between chronic stroke patients (Mdn=2.12, IQR=1.66) and healthy controls (Mdn=1.07, IQR= 1.86), U=72, z=1.02, r=0.19, p=0.326. A linear regression showed that the FMA is significantly related to the BSI ($F(1,19)=7.248$, p=0.014, R2=0.276). FMA is not related to the DAR ($F(1,19)=1.759$, p=0.200, R2=0.085).

It is concluded that chronic stroke patients show more asymmetry in brain activity compared to healthy controls. The BSI is also negatively associated with motor control of the upper paretic limb. The BSI and DAR are both suggested to be investigated in a longitudinal study with repeated measurements in which dynamics in brain activation are associated with functional prognosis early post stroke.

P38 – Valentina Pasquale (Istituto Italiano di Tecnologia, Genova, Italy)

Desynchronization of network dynamics induced by in vivo intra-cortical micro-stimulation

Enhancing functional motor recovery after localized brain injury is a widely recognized priority in healthcare as disorders of the nervous system causing motor impairment, such as stroke, are among the most common causes of adult-onset disability. Recently, techniques using intra-cortical brain stimulation (ICMS) have been employed to promote post-injury neuroplasticity for the restoration of motor function. In particular, activity-dependent stimulation (ADS) has been demonstrated to increase motor recovery following cortical injury in experiments on in vivo rodents. The aim of the present work is to develop a set of analytical measures to better quantify the effects of intra-cortical ADS (with respect to open-loop random stimulation) on the electrophysiological activity of cortical networks in the healthy brain of anesthetized rats. Spontaneous activity within layer V of rat pre-motor cortex (rostral forelimb area, RFA) was extracellularly recorded using a 16-contact microelectrode and analyzed following treatment of ADS driven by RFA activity or Gaussian-distributed (i.e., random) stimulation approximating the ADS frequency. Two areas within S1 (forelimb or barrel field, FL or BF) were chosen alternately for stimulation to assess the efficacy of the stimulation on different cortical locations. We quantified first-order statistics of sorted neurons, such as mean firing rate and inter-spike interval distribution, and we also estimated functional connectivity changes within RFA by using cross-correlation-related measures, as well as the coupling of each recorded neuron to the population activity. All stimulation protocols induced changes in the subsequently recorded activity of RFA. All performed analyses consistently suggest that ICMS, especially when delivered to BF area, induces an increase of de-correlated activity in RFA. ADS resulted to be more effective than random stimulation, further strengthening the idea that ADS can be used to modulate cortical state and connectivity, and is a potentially powerful tool to steer neuroplasticity after injury. Our analytical tools allow to critically investigate the neurophysiological effects of ADS, as well as providing a foundation for assessing the optimal stimulation parameters for treating brain injury.

P39 – Giulia Liberati (Université Catholique de Louvain, Belgium)

Direct intracerebral recordings from the human insula to investigate salience and intensity coding of nociceptive and non-nociceptive stimuli

The human insula, especially its posterior portion, is considered to play a fundamental role in pain perception. Using intracerebral electroencephalographic recordings (iEEG), we recently showed that both nociceptive thermal stimuli and non-nociceptive vibrotactile, auditory and visual stimuli elicit consistent local field potentials (LFPs) in the posterior and anterior insula, with matching spatial distributions. (Liberati et al. 2016, PLoS Biol). Therefore, insular LFPs reflect activity unrelated to nociception, and cannot be considered as a signature for the perception of pain. We hypothesized that LFPs elicited in the insula by nociceptive and non-nociceptive stimuli could reflect multimodal activities related to the re-orientation of attention towards salient stimuli. To this end, we assessed whether the magnitude of insular LFPs elicited by thermonociceptive, vibrotactile, and auditory stimuli could be modulated by stimulus salience, independently of the intensity of perception.

Using depth electrodes implanted in the left anterior and posterior insula of four female patients (age: 23-28) suffering from focal epilepsy, iEEG was recorded in a total of 31 insular sites. To investigate the relationship between insular LFPs, intensity of perception, and salience, we used a paradigm based on stimulus repetition, to reduce stimulus salience independently of stimulus intensity (Iannetti et al. 2008, J Neurophysiol). Participants received stimuli from three sensory modalities (nociceptive, vibrotactile, auditory) in a randomized blocked design. In each block, trains of three stimuli of identical intensity (S1-S2-S3, ‘triplets’) were delivered at a constant inter-stimulus interval (ISI) of 1 s (40 ms duration per stimulus). Two different intensities, ‘high’ and ‘low’, were used for each modality, in a randomized order. At the end of each ‘triplet’, participants rated the intensity of each stimulus on a numerical scale ranging from 0 to 10.

For all modalities, all four participants rated the ‘high’ intensity stimuli as more intense than the ‘low’ intensity stimuli. In contrast, intensity ratings were not affected by stimulus repetition: similar ratings were provided for each of the three stimuli belonging to a given triplet. A linear mixed model (LMM) analysis performed on the average peak-to-peak amplitude of the LFPs elicited by each triplet using ‘modality’ (nociceptive, vibrotactile, auditory), ‘stimulus intensity’ (high, low), and ‘stimulus repetition’ (S1, S2, S3) as fixed factors, and ‘subject’ as a contextual variable, showed a main effect of ‘stimulus repetition’ ($F= 36.82$, $p<.001$): the LFPs elicited by the first stimulus of the triplets (S1) were significantly greater in amplitude than the amplitudes of the LFPs elicited by the second (S2) and third (S3) stimuli ($p<.001$). Furthermore, there was a main effect of stimulus ‘intensity’ ($F=17.26$, $p<.001$): the LFPs elicited by high intensity stimuli were larger than the LFPs elicited by low intensity stimuli ($p<.001$). Finally, there was a main effect of ‘modality’ ($F=29.34$; $p<.001$): nociceptive LFPs were, on average, smaller than auditory LFPs and larger than vibrotactile LFPs.

In all participants, and for all three types of sensory stimuli (nociceptive, vibrotactile, auditory), stimulus repetition at a short and constant 1-s ISI had no effect on the intensity of perception. In contrast, the reduction of stimulus salience induced by stimulus repetition was associated with a significant decrease of LFP amplitude. Although obtained from a limited number of subjects, these results suggest that the LFPs elicited in the human insula by transient nociceptive and non-nociceptive stimuli reflect multimodal activity involved in detecting, orienting attention towards, and/or reacting to the occurrence of salient sensory events, regardless of the sensory modality through which these events are conveyed, and independently of perceived intensity.

P40 – Jasmine Tan (Goldsmiths, University of London, UK)

Neural correlates of flow state in musicians

Flow refers to an altered state of consciousness occurring during intense engagement in an activity during which people typically experience feelings of intense pleasure and happiness, usually while performing at their peak. Though the experience of flow state is commonly reported by musicians, it has only recently become the subject of empirical research. It is considered a very desirable state to be in and may play a part in why musicians spend so much time engaging in musical practice and performance. This project is an exploratory study on the neural correlates of flow state as experienced by musicians. Musicians self-induced flow by playing pieces that reliably put them into flow state, usually because they particularly enjoy the music and they are extremely familiar with performing it. They also brought in music that did not induce flow state for them as a control. Their EEG signals were recorded during their performance and after to measure the after-effects of flow. Power analyses found increased upper alpha (10 – 12 Hz) and increased beta (13 – 30 Hz) in frontal areas in the post-performance time after experiencing flow compared to not experiencing flow. This seems to offer some support to Dietrich’s theory of flow as transient hypofrontality. Phase slope index (PSI) was calculated to measure directed connectivity between electrode regions. High connectivity in theta band in the right frontal area was found in flow but absent in non-flow. However, only those highly disposed to experience flow showed this pattern of activity. This suggests that this region may be important in flow experience. Overall, our results show that the subjective emotional experience while performing music has neural correlates and suggest that there is much to be studied and understood about the effects of flow state on musical performance.

P41 – Mohit Adhikari (University Pompeu Fabra, Barcelona, Spain)

Decreased integration and information capacity in stroke measured by whole brain models of resting state activity.

While several studies have shown that focal lesions affect the communication between structurally normal regions of the brain, and that these changes may correlate with behavioral deficits, their impact on brain's information processing capacity is currently unknown. Here we test the hypothesis that focal lesions decrease the brain's information processing capacity, of which changes in functional connectivity may be a measurable correlate. To measure processing capacity, we turned to whole brain computational modeling to estimate the integration and segregation of information in brain networks. First, we measured functional connectivity (FC) between different brain areas with resting state fMRI (R-fMRI) in healthy subjects (n=26), and subjects who had suffered a cortical stroke (n=36). We then employed a whole-brain network model which coupled average excitatory activities of local regions via anatomical connectivity. Model parameters were optimized in each healthy or stroke participant to maximize correlation between model and empirical FC, so that the model's effective connectivity was a veridical representation of healthy or lesioned brain networks. Subsequently, we calculated two model based measures: integration, a graph theoretical measure obtained from FC that measures the connectedness of brain networks, and information capacity, an information theoretical measure that cannot be obtained empirically, representative of the segregative ability of brain networks to encode distinct stimuli. We found that both measures were decreased in stroke patients, as compared to healthy controls, particularly at the level of resting-state networks (RSNs). Furthermore, we found that these measures, especially information capacity, correlate with measures of behavioral impairment and the segregation of RSNs empirically measured. This study shows that focal lesions affect the brain's ability to represent stimuli and task states, and that information capacity measured through whole brain models is a theory-driven measure of processing capacity that could be used as a biomarker of injury for outcome prediction or target for rehabilitation intervention.

P42 – Stefano Buccelli (Department of Neuroscience and Brain Technologies, Istituto Italiano di Tecnologia, Genova, Italy)

Restoring communication between damaged neuronal networks

Neural stimulators and implantable systems represent one of the most promising technologies to reduce neurological impairments. The realization of a prosthesis prototype capable to restore the communication between damaged in vitro neuronal circuitries was the objective of the European FET project BRAIN BOW (www.brainbowproject.eu). Here we present the results obtained in that framework.

The biological element used in this study is constituted by dissociated cortical rat neurons plated over a 60-channel Micro-Electrode Array (MEA) device. We used engineered neuronal networks constituted by two isolated modules linked through long-range axonal connections. At a mature developmental stage (from 21 Days In Vitro on), these networks were able to exhibit synchronized activity events involving both modules Presenting authord Network Bursts (NB). During experiments we performed a focused laser ablation to cut the connections between modules to mimic a traumatic brain injury. A neuromorphic board based on Field Programmable Gate Array (i.e. the actual 'prosthesis') was specifically designed to perform real-time event detection (e.g. spike detection, NB detection etc.) and trigger consequent electrical stimulation to one or more electrodes in a closed-loop fashion. From now on, with the term "bridging" we mean real-time NB detection on one module of the network which results in a stimulus delivered to the other module.

In our experiments, a low-frequency regular stimulation (0.2 Hz) was delivered to an electrode belonging to one of the two modules and the response propagated to both modules. After a focal lesion, the two modules resulted both anatomically and functionally disconnected, since the response to stimulation resulted confined only to the module hosting the stimulation electrode. We then performed two kinds of 'reconnection' strategies: i) unidirectional bridging; ii) bidirectional bridging. In case of protocol (i), a low frequency regular stimulation (0.2 Hz) was delivered to the first module and a bridging from the first to the second module was performed. This experiment allowed us to evaluate the recovery of the system by investigating the propagation of the electrophysiological activity from one module to the other after lesion. The post-stimulus time histogram upon regular stimulation confirmed that the directed communication from the stimulated module to the other one was restored. The aim of protocol (ii) was to offer an artificial communication channel between the disconnected modules without imposing any preferred direction (i.e. from one module to the other and vice-versa). The cross correlation between the activity of the two modules confirmed the partial restoration of the communication between the disconnected modules.

The preliminary results of this work demonstrate that our neuromorphic board is able to put in uni- and bidirectional communication two previously connected and then disconnected neuronal networks. The developed communication protocol can be seen as an interesting starting point towards the development of a stand-alone neuroprosthetic device able to restore communication between disconnected brain regions.

P43 – Helmut Schmidt (Centre de Recerca Matematica, Bellaterra, Barcelona, Spain)
Macroscopic response of quadratic integrate-and-fire neurons to external oscillatory forcing

We use a neural mass model to study the macroscopic response of neuronal systems to external oscillatory forcing. The neural mass model represents the low-dimensional behavior of quadratic integrate-and-fire neurons in the thermodynamic limit. The structure of this model permits the use of Fourier decomposition to study the effect of periodic external forcing (both sinusoidal and non-sinusoidal) on the resulting dynamics beyond linear analysis. The nonlinear response exhibits both chaotic and non-chaotic behavior, which is organized by saddle-node bifurcations and period-doubling bifurcations. If the system is bi-stable, i.e. there exists a stable state with high firing rate and a stable state with low firing rate, these bifurcations lead to the switching between active and inactive states. Especially for non-sinusoidal ("burst-like") oscillations the minimum amplitude necessary to cause this switching strongly depends on the frequency. This has consequences for memory and information processing, where it is necessary to gate, sustain and clear neuronal responses to external stimuli. Our findings reveal highly nontrivial nonlinear resonance properties of neuronal circuits, which indicate that the optimal frequency for inter-areal communication depends on the "burstiness" of the relevant signals.

P44 – Timothy West (Wellcome Trust Centre for Neuroimaging, UCL, London, UK)
Parkinsonian synchronization dynamics in the cortical-sub-cortical network: Models and metrics

We investigate the changes in synchronization within the Cortico-Subcortical network that occur in Parkinson's disease (PD). Using neurophysiological data from both humans, as well as rodent models of PD, we aimed to make a broad assessment of neural synchrony with and without dopamine depletion. We used: stationary measures of statistical dependency between signals; metrics that aim to correct for spurious correlations arising from volume conductance; directed or causational analyses; and finally, nonlinear measures aiming to assess the presence of long tailed correlation structure within the phase interactions between two signals. Using this broad toolbox we ask questions pertaining to how synchronization is organized in the brain and how the impairment seen in PD relates to its disruption. Working from these findings and others, we are beginning to construct models of the cortico-basal ganglia circuit in order to determine the underlying dynamical system that ties anatomical, functional and effective connectivity into one holistic view. From these models we aim to characterize the stability of coupled dynamical systems in order to gain a better mechanistic understanding of the origins and impairment of pathological oscillations in PD.

P45 – Daniel Fraiman (Universidad de San Andrés, Argentina)
Statistics of brain networks

The study of random graphs and networks had an explosive development in the last couple of decades. Meanwhile, techniques for the statistical analysis of these networks were less developed. In this work we focus on brain networks and study some statistical problems in a nonparametric framework. We address the following questions: Given one or more samples of brain networks, How to calculate a representative brain network? How to define a notion of variability for networks? How to identify a network outlier? How to test if the groups of networks have the same probability law? How to perform classification? Answers to these questions provide an important step in the development of potential neuroimaging-based tools for diagnosis. Finally, we show an application to electroencephalographic data to test whether variability in functional brain networks implicated in Tango observation can discriminate between groups differing in their level of expertise. We found that experts and beginners significantly differed in the functional organization of task-relevant networks. Specifically, networks in expert Tango dancers exhibited less variability and a more robust functional architecture.

P46 – **Pallabi Sengupta** (Universitat Pompeu Fabra, Barcelona, Spain)
Local changes in the binary functional connectivity after artificial language exposure

Statistical Learning (SL) is the implicit process of using statistical attributes to learn about consistencies in our surrounding environment. SL plays a role in language learning, allowing for the segmentation and acquisition of words by calculating the transitional probabilities of the occurrence of speech sounds next to each other. To investigate the local changes caused by SL in the resting state brain, we developed a novel method inspired by the genome-wide association (GWA) technique. RS-fMRI was acquired in a group of 38 participants before and after listening to either an artificial language or a random audio stream, and FC matrices were calculated and binarized to convert the z-transformed Pearson's correlation values into presence or absence of the functional link. This equipped us to detect changes in link frequencies as a result of the experimental condition. We tested for all possible unique functional links across the whole brain and detected a significant decrease in the link-frequency for the functional link between the Right Posterior Cingulum and Left Superior Parietal Lobule after the subjects performed statistical learning.

P47 – Rikkert Hindriks (Computational Neuroscience Group, Universitat Pompeu Fabra, Barcelona, Spain)
Is cortical alpha-band activity organized in propagating waves? An MEG source imaging study

Alpha-band (7-13 Hz) oscillations emerge from the resting human brain and comprise a set of rhythms that cover large parts of the cortex, including visual, auditory, motor and frontal regions. They are thought to provide functional inhibition of task-irrelevant regions by flexible and periodic modulation of cortical excitability. Their large-scale organization is not well understood, however, and is surrounded by controversies. Two of these open questions are if resting-state alpha oscillations are organized in propagating waves or in functional networks and if such (hypothetical) waves are mediated by intra-cortical or cortico-cortical fiber systems. We address these questions by using a large data-set of 95 healthy human participants (Human Connectome Project (HCP)) each of which underwent three eyes-open resting-state magnetoencephalographic (MEG) recording sessions and whose cortical surfaces have been registered using state-of-the-art multi-modal registration methods developed by the HCP. We projected the sensor data to the cortical surface models using a recently developed imaging method designed to reduce surface bias in the source reconstructions. Our preliminary findings are that there is no evidence for propagating waves mediated by cortico-cortical fibers. Instead, on the macroscopic scale (several centimeters), alpha-band activity seems to be generated by distributed sources, while on the mesoscopic scale (several millimeters), there are some indications for (intra-cortically mediated) traveling waves.

P48 – Ehsan Darestani Farahani (Research Group Experimental ORL, Department of Neurosciences, Catholic University of Leuven, Belgium)
Source analysis of auditory steady-state responses based on independent components

Several electrophysiological studies have investigated neural generators of auditory steady-state responses (ASSRs). The low signal-to-noise ratio (SNR) of these auditory evoked responses as well as the activity of deep sources complicate ASSR source analysis. Most of the prior ASSR localization studies, whether they used dipole source analysis or distributed source analysis, averaged the recorded ASSR across subjects to achieve a higher SNR. Consequently, they have a bias toward return the largest source of the ASSR instead of all sources (large as well as small ones). Another limitation of prior ASSR studies, particularly MEG studies, concerns the difficulty of detecting deep and also radially oriented sources. The aim of the current study is the spatio-temporal reconstruction of ASSR sources with no prior assumptions about their number and location. In order to reconstruct ASSR sources, we applied independent component analysis (adaptive mixture ICA) with subsequent equivalent dipole modeling to single-subject EEG data (young adults, 20-30 years of age).

These data were based on white noise stimuli, amplitude modulated at 4, 20, 40, or 80 Hz. The independent components that exhibited a significant ASSR were clustered among all participants by means of a probabilistic clustering method based on a Gaussian mixture model. Our results suggest that a widely distributed network of ASSR sources, located in cortical as well as subcortical regions, is active in response to different stimuli. For the four modulation frequencies, the identified dipole clusters were located in the similar locations around the left and right auditory cortex and the brainstem. The phase and SNR of the reconstructed sources were consistent with the ASSR literature. In conclusion, the present study shows that the ICA source analysis approach successfully deals with both low SNRs and deep sources.

P49 – Marcello Giannini (Laboratory for Perceptual Dynamics, Brain & Cognition Research Unit, Catholic University of Leuven, Belgium)

Large-scale phase gradient in eye fixation-related EEG activity

Human EEG shows large-scale spatiotemporal dynamics during free viewing behavior. We investigated the role of such dynamics in the lambda activity. Lambda activity is a brain response over the occipital areas, about 100 ms after fixation onset as observed by simultaneous recordings of EEG and eye movement. The activity is thought to reflect the shift of the retinal image in visual cortex. Previous studies analyzed lambda activity by averaging across trials, thereby suppressing spatiotemporal phase patterns. We applied methods which allowed us to detect these patterns at the single trial level. By linear regression we built a wave model as a phase gradient that varies smoothly over the scalp. The model explained on average more than 57% of the variance in the observed phase in the theta EEG frequency band. The moment of the highest fit was the one preceding the peak of the lambda wave. The results indicate emergence of a large-scale travelling wave starting after the fixation onset and fading in about 100 ms afterwards. This wave may have a role in the integration of visual information across cortical areas.

P50 – Federico Raimondo (Applied Artificial Intelligence Lab, Department of Computer Sciences, University of Buenos Aires, Argentina)

Probing consciousness with heart-brain interactions in severely brain-injured patients

It is known that the brain monitors and regulates visceral organs, such as the heart (Park & Tallon-Baudry, 2014). However, the relationship between this regulation and consciousness levels has not been fully explored. We tested whether potential phase resets of the heart cycle, while the subjects where stimulated with a validated auditory paradigm that tests two levels (local/short or global/long) of regularities (Bekinschtein et al., 2009; Sitt et al., 2014) can be used as an index to characterize cognitive function in patients with disorders-of-

consciousness.
A cohort of 91 conscious subjects (healthy controls, in minimally conscious state-MCS) and 70 unconscious patients (in vegetative state/unresponsive wakefulness syndrome-VS/UWS) were tested with the local-global paradigm (Bekinschtein et al., 2009). Patients' consciousness level was assessed with the Coma Recovery Scale-Revised (Giacino et al. 2004) (CRS-R). Since no direct EEG measure was available in the recordings, Independent Component Analysis was used to extract the embedded ECG signal from the recorded EEG. In order to validate this ECG extraction method, simultaneous EEG and ECG recordings were acquired from an independent group of 12 healthy subjects. The overall heart rate (HR), and heart rate variability (HRV) in very low frequency (0–0.04 Hz), low frequency (0.04–0.15Hz) and high frequency (0.15–0.4 Hz) were computed from the extracted ECG. To address the question how conscious processing of auditory regularities affects the ongoing cardiac activity, two intervals locked to the stimulus onset were defined: the PRE interval (the interval between the preceding R peak and the stimulus), and the POST interval (the interval between the stimulus and the following R peak). Analysis encompassed both parametric and Bayesian inferential statistics.
The ECG extraction method was validated by computing the time difference between the direct and the ICA-extracted ECG R peaks; the Bayesian ANOVA showed no interaction between the type of auditory stimuli (deviant or standard trials) and the time difference (BF01=521.017). A positive correlation between CRS-R scores and heart rate (r=0.31, p=0.008) as well as heart rate variability in high frequency (r=0.33, p=0.006) was identified only for the VS/UWS group. Between the MCS and VS/UWS groups, we found no evidence for an attention-driven effect in the local auditory violations, neither at PRE (BF10=0.18) nor at POST interval (BF10=0.19). However, there was strong evidence for this effect in the global auditory violations only at POST interval (BF10=34.15; PRE interval BF10=0.24). A post-hoc t-test showed that this effect was due to shortened RR intervals immediately after the offset of the 5th sound only for the MCS patients.
Violations of global regularities, which cause a long-lasting brainscale P3 response in conscious individuals, induces a top-down effect on cardiac activity. Violations of local regularities, which cause a transient and local response confined to auditory cortical areas independent from the consciousness level, did not induce this effect. Our results suggest a link between conscious attention and the neural counterpart of cardiac monitoring, consistent with previous theoretical frameworks (Park & Tallon-Baudry, 2014). Our results open a new window for the clinical exploration of states-of-consciousness using brain-body interactions.

P51 – Enrico Amico (Purdue University, US)
connICA for reconstructing individual connectomes

Connectivity Independent Component Analysis (connICA) is a novel data-driven methodology, which implements Independent Component Analysis (ICA) for the extraction of robust independent functional connectivity (FC) patterns from a set of individual functional connectomes, without imposing any a priori data stratification into groups (Amico et al., 2016). The application of ICA directly onto the human connectome domain has revealed huge potentials for the analysis of human brain neuroimaging data (see Amico et al., 2016 for an example on human brain data at different levels of consciousness).
In this study we explore the use of connICA for improving the estimation of individual functional connectomes from a group-level perspective. That is, once extracted the main FC independent components (or FC-traits), we go back to the individual subjects space by reconstructing each individual FC based on the FC-traits and individual weights as found by connICA. This provides a refined individual FC, that accounts for group-level FC patterns.
We here test the connICA refining procedure on a test-retest group of 13 healthy volunteers. The following properties were evaluated:

- Some individual FC will change more than others after connICA reconstruction
- Group average FC matrices will be similar before and after the connICA reconstruction
- Intraclass correlation (ICC) will be higher after connICA reconstruction
- FCs will be, overall, more similar (i.e., reduced Frobenius norm) between visits of the same subjects
- Resting state networks will be more prominent after connICA reconstruction (as measured by Newman's Q modularity fitness)

We show that connICA reconstruction indeed satisfies all the aforementioned properties. Finally, we discuss the future directions of this promising methodology.

P52 – Caroline Garcia Forlim (University Medical Center Hamburg-Eppendorf, Germany)
Dysconnected cerebrum-cerebelum network in schizophrenia: a network-based statistic approach

Schizophrenia is a complex disease characterized by delusions, hallucination, lack of motivation, reduced emotional expression among others. It has been suggested that schizophrenia is related to disrupted brain connectivity. Graph theoretical studies have found abnormal structural and functional in multiple brain networks supporting the theory of dysconnectivity syndrome (Hadley et al., 2016) and suggesting wide-range of connectivity disturbances (van den Heuvel and Fornito, 2014). Nevertheless, there is no consensus regarding localized mechanisms and their associated symptoms. The cerebellum, an often overlooked region, might play a key role in schizophrenia. It has been suggested that a misconnection between cerebellum and cortex can lead to a misinterpretation of the information arriving from the cortex, resulting in, for example, experiences of delusion and auditory hallucinations (Andreasen and Pierson, 2008). Here, we calculated the functional connectivity (FC) matrix from resting state fMRI in patients with schizophrenia and controls and applied a network-based statistic method, a new nonparametric cluster statistic, to look for differences in the subnetwork brain wiring. We also correlated FC and graph measures from the subnetwork to clinical symptom scores. We found a single dysconnected subnetwork comprising the following cerebrum-cerebellum regions mainly comprising brain regions related to visual processing and the cerebellum. More precisely: inferior and superior occipital, lingual, cuneus, cerebellum X and Vermis. The density of the connections was higher in the right hemisphere. The schizophrenia patients presented higher FC than the control participants. We also found that FC of this subnetwork is correlated with the inability to experience pleasure (anhedonia) which fits well to the notion that the vermis is considered the “limbic cerebellum” based on its connections to limbic structures in the brain (Heath et al., 1979). These findings reinforce the role of cerebellum in schizophrenia and it is consistent with structural imaging studies that showed alteration in this region (Okugawa et al. 2005).

P53 – Vicente Pallarés (Universitat Pompeu Fabra, Barcelona, Spain)
Individual versus day-to-day variability in fMRI resting-state measurements

Research on the human connectome has described and characterized the anatomical architecture of the brain, also called structural connectivity (SC). Many studies have focused on linking the brain structure to function, as measured by neuroimaging, such as in fMRI, MEG and EEG. These techniques provide insight into the statistical dependence between different brain regions, which is referred to as functional connectivity (FC). FC is usually quantified by the pairwise correlation between the neuroimaging measurements of brain areas; here we use the AAL116 parcellation for which 116 regions of interest (ROIs) are defined. The observed FC pattern is a consequence of interactions between the neuronal populations of the ROIs, which has been coined as 'effective connectivity' (EC). Via the neuronal dynamics, EC links SC to FC, bridging the gap between the anatomical substrate and the brain functional response. EC depends on many dynamical mechanisms (neurotransmitters, excitability, etc.); in our work, we estimate it for a dynamical model of the whole brain based on an iterative optimization such that the model FC reproduces the empirical FC. The experimental data correspond to resting-state fMRI acquired from 6 subjects for 50 sessions, as well as 50 subjects scanned during a single session. This unique dataset allows for the analysis of the variability of resting-state fMRI from an intra- and inter-subject perspective: we thus compare – at the ROI level – the variability of FC to that of EC, which provides a mechanistic explanation for the generation of FC. Our EC estimation procedure relies on spatiotemporal FC, Presenting authorly the covariances between fMRI time series with and without time shift; it captures information about the fMRI dynamics, beyond “spatial” correlations between ROIs. In particular, we analyze the time constant of the fMRI signals both at the local (ROI) and global (whole-brain) levels, demonstrating session-to- session joint variability in specific subnetworks. Recent studies have also demonstrated the capability of FC to discriminate between different subjects, playing the role of a functional connectome fingerprint. Here we quantitatively compare the discriminability of FC and EC, the latter capturing the dynamical interactions of the brain.

P54 – David Pascucci (University of Fribourg, Switzerland)
Directed interactions from parietal cortex orchestrate the selective processing of visual stimuli

We investigated how dynamic, directed interactions among cortical areas orchestrate task-specific processing of visual stimuli. We recorded separate fMRI and high-density EEG while participants saw oriented gratings under two task conditions. In the “attended” condition participants discriminated the orientation of the grating, in the “ignored” condition participants detected a color change in the fixation spot. Fourteen active nodes in occipital, parietal and frontal areas were identified with fMRI and used to derive time-series of EEG source activity. Multivariate Granger causality analysis revealed stronger stimulus-evoked driving in the gamma band from V1 to lateral occipital cortex and from occipital to fronto-parietal areas in the “attended” condition. In the “ignored” condition, however, driving was increased in the alpha and beta band. This increase was characterized by both ongoing and evoked (after ~ 200 ms) influences from parietal regions (bilateral superi or parietal lobule) to widespread areas. Taken together, our findings support the role of gamma activity in the bottom-up propagation of attended information and show how top-down influence from parietal cortex in the alpha and beta band can rapidly inhibit further processing of irrelevant stimuli.

P55 – Fadila Hadj-Bouziane (Lyon Neuroscience Research Center - ImpAct Team, France)
Boosting norepinephrine transmission alters the dynamics of global and local brain functional connectivity

The locus cœruleus (LC) is the principal source of norepinephrine (NE) in the brain and this neuromodulatory system is known to influence cognitive processes. Yet, to date, the exact mechanisms by which it exerts its effects remain poorly understood. Current theoretical models postulate that the LC-NE system adjusts the neural gain (Aston-Jones & Cohen 2005) or acts as a ‘‘network reset’’ signal (Bouret and Sara, 2005) to allow an optimal reconfiguration of brain activity. To investigate this issue, we manipulated the level of NE and examined the ensuing changes in brain functional connectivity patterns at rest.

We scanned three monkeys in the dark with a contrast agent (MION) at 1.5 T (400TRs, TR=2s, voxel size=2x2x3mm). We compared the changes on whole-brain connectivity patterns induced by intramuscular injections of either saline or a NE-reuptake inhibitor (atomoxetine, ATX: 0.5 mg/kg). Specifically, we investigated the effects of ATX on: 1/ the functional connectivity within and between resting-state networks identified using Independent Component Analysis (ICA); 2/ the functional connectivity of the LC region using a seed-based approach, and 3/ both global and local brain topology using graph theory.
We found that boosting NE transmission induces large-scale reorganizations of brain networks at rest. It modulated the functional connectivity pattern of a brainstem network including the LC region and interactions between associative and sensory–motor networks as well as within sensory–motor networks. Among the observed changes, those involving the fronto-parietal attention network exhibited a unique pattern of uncoupling with sensory–motor networks and correlation switching from negative to positive with the brainstem network that included the LC nucleus. In addition, boosting NE transmission altered the global and local brain topology, shifting its functional architecture toward a stronger local efficiency, suggesting an improvement of the neural gain (Eldar et al. 2013).
Our results provide empirical evidence for current theoretical models of the LC-NE system. The co-occurrence of a large-scale brain networks reconfiguration and increase of the neural gain induced by a boost in NE transmission underlines a central feature of this neuromodulatory system on the brain functional connectivity patterns. These mechanisms could provide the brain with complex yet contextually specific palettes of brain states, allowing us to interact optimally with our environment.

P56 – Daria La Rocca (CEA/NeuroSpin, INRIA Parietal team, France)
Correlates of perceptual learning in MEG functional connectivity analysis

Functional connectivity (FC) analysis methods have provided important insights into brain plasticity associated with learning [Lewis et al. 2009]. In the proposed work FC has been employed to study the dynamics of interactions between cortical regions in a perceptual learning paradigm (Zilber et al., 2014). In magneto-encephalography (MEG), FC is usually assessed in terms of phase synchronization between distant signals associated with different regions. FC patterns based on phase-lag index have been obtained from source reconstructed MEG data, and analyzed in order to infer the correlates of efficient perceptual learning. The analyzed dataset is composed of 36 subjects belonging to three different groups trained to a visual discrimination task: V group performed purely visual training V, AV group performed multi-sensory (Auditory and Visual with congruent information delivered by both modalities) training to measure the impact of supramodal processing, and AVn (Acoustic white noise superimposed on relevant visual stimuli) group served as control. Task-related FC patterns have been first extracted regardless the training group, considering all subjects together in a pre-training (PRE) block where the same experimental conditions were delivered to all participants. In order to assess the significance of the extracted profiles, PRE and resting state (REST) FC patterns have been statistically compared (permutation t-test). Different frequency bands of interest (from Theta to upper Gamma) have been separately investigated to improve our understanding of the underlying mechanisms. Furthermore, a comparison between PRE and post-training (POST) FC patterns has been performed, considering for the POST block the three groups separately. Overall, our results show task-specific FC patterns common to the three groups mainly in the Alpha (8-14 Hz, both hemispheres) and Beta (15-30 Hz, right hemisphere) bands, and some FC patterns specific to the multi-sensory AV training in the Beta (left hemisphere) and low Gamma (30-45 Hz, left hemisphere) bands. The former patterns include Alpha desynchronization within the visual cortex and between visual and temporal regions during the PRE block. The amount of desynchronization between such regions significantly decreases in the POST block, likely due to a reduced attention demand and related neural resources engaged for processing visual information after training. Still common to the three groups, we observed Beta couplings during the PRE and POST blocks within the right frontal lobe (motor, PMC, FEF, vlPFC), and between frontal regions and IPS. These patterns are consistent with the expected Alpha task-related desynchronization (decreasing with training) in the visual cortex, and with the Beta activation in the frontal lobe for the button-press task execution. Common to AV and Avn groups, we found significant POST-specific couplings between left vlPFC and auditory (AUD) cortex in the Alpha band, and between left visual motion area MT and AUD in the low Gamma band, suggesting the involvement of the auditory cortex in the visual discrimination task after the multi-sensory training blocks. Specific to the AV group we found, in the POST block, modulations of the PRE FC patterns in the Alpha and Beta bands, and new task-related connections in the Beta and low Gamma bands arising after training. Modulations include further desynchronization of right MT-V4 from PRE to POST blocks (also negatively correlated to task difficulty in the POST block) in the Alpha band, and strengthening of right vlPFC-IPS and MT-IPS connections from PRE to POST in the Beta band. POST-specific couplings in AV, which represent the main difference with respect to PRE FC patterns, include the synchronization between left FEF, visual motion area MT, vlPFC and multisensory cortex mSTS in the Beta band, and between left MT and vLPFC (also positively correlated to task difficulty) in the low Gamma band. The areas involved in the patterns specific to the AV group are known to be implicated in the processing of multisensory information (mSTS, vlPFC), the accumulation of sensory evidence (visual motion area MT) and the subsequent decision making (FEF, vlPFC and IPS). Overall, these FC patterns support the hypothesis of an optimized visual perceptual learning in the AV group reflected in the related PRE-POST plasticity.

P57 – Konstantina Kalogianni (Department of Biomechanical Engineering, Delft University of Technology, Delft, The Netherlands)

Can we define EEG's spatial resolution?

The accuracy of EEG-based source localization depends on the choice of the inverse method, the accuracy of the forward method employed, but also on the configuration of the true sources (location and orientation), the temporal distance of their activity, and on the structure and level of the noise in the recordings. When sources in proximity are active with a small time-delay, for example the underlying sources of somatosensory evoked potentials, the spatial resolution of EEG source reconstruction is unknown. The term 'spatial resolution' refers to our ability to separate nearby sources from the analysis of multi-channel EEG data. As of today, a generally accepted quantification of this ability does not exist. The goal of this study was to define EEG's spatial resolution and examining factors that may affect it. In EEG experiments the true sources are unknown, and a strict validation of the methodology is impossible. Hence, we employed numerical simulations in which two dipole sources changed in time with waveforms resembling somatosensory evoked potentials with peaks at 'expected' moments (N20, P50, P100). Source signals were projected to the scalp (forward modeling). Inter-dipole distances were varied and Gaussian white or realistic (spatially and temporally correlated) EEG noise was added to the simulated scalp recordings. We used a range of signal-to-noise ratios (SNRs) and repeated simulations 200 times per condition for statistical evaluation. Prior to inverse modeling pre-whitening was applied in both the simulated data and the computed lead-field. We explored three algorithms for source reconstruction: a least squares method (two dipole fit), a scanning method (sc-MUSIC), and a distributed method (sc-eLORETA). We assessed the accuracy of source localization via the distance between the true (simulated) point sources and the reconstructed ones. To quantify the resulting spatial resolution of EEG, we introduced the separability of sources, i.e. the distance between two estimated dipolar sources, divided by standard deviation of the estimated dipole position. Finally, we defined the spatial resolution as the minimum distance between the true sources needed to achieve a separability of one. Our simulations revealed separability of two sources in the presence of realistic noise with SNR up to 3 if they are 11 mm or further apart. In the presence of realistic noise, this spatial resolution could only be obtained after spatial pre-whitening as preprocessing step, irrespective the inverse method used. Although dipole fit showed better ability to seperate sources in proximity in our paradigm, the performance of sc-MUSIC indicates proper localization of proximate sources, even when the number of underlying dipoles is unknown. We conclude that the separability of two sources is a proper definition of spatial resolution. The best spatial resolution is obtained through pre-whitening of the EEG signal when using a dipole fit or sc-MUSIC method.

P58 – Marc Bennett (Trinity College Dublin, Ireland)
Neuro-endophenotypes of intense and overgeneralized threat processing in adolescents

Anxiety is not just characterized by intense fear in response threat-relevant stimuli, such as angry facial expressions. Quality-of-life is hampered when fear becomes widespread and triggered by range of innocuous cues. Here, we use the IMAGEN consortium dataset to investigate neural pathways underlying both heightened and over-generalized threat processing of social cues in adolescents. Participants (N = 2,055) completed a facial recognition task wherein a neutral facial expression either turned angry or remained natural. Penalized regression with internal cross-validation is being used to (a) identify regions of interest associated with the processing of both intense (i.e. angry faces) and overgeneralized (i.e. neutral faces) threat processing and (b) determine whether these regions are distinctive in adolescents at-risk of social anxiety (N= 80), relative to matched controls (N = 80). In addition, we will establish whether these pathways are specific to social anxiety by also including a group of adolescents at risk of non-social, generalized anxiety (N = 132). This poster will outline both our early findings and next steps. Overall, this study has the potential to elucidate neuro-endophenoytpes of threat processing that specifically relate to social and non-social anxiety symptomology.

P59 – Malbor Asllani (NaXys, Namur, France)
A non invasive method for brain desynchronization in neurological diseases

Many coordination phenomena are based on a synchronisation process, whose global behaviour emerges from the interactions among the individual parts. Often in Nature, such self-organising mechanism allows the system to behave as a whole and thus grounding its very first existence, or expected functioning, on such process. There are however cases where synchronisation acts against the stability of the system; for instance, it has been observed, that certain psychomotor symptoms, e.g. tremors, are results of an abnormal synchronisation phenomenon in the activity of the responsible neuronal zones, whose outcome is the onset of diseases such as epilepsy or Parkinson. In the latter case, for example, the activity of the neurons in the basal ganglia naturally synchronise in absence of sufficient dopamine neurotransmitters causing the emergence of abnormal psychomotor symptoms. In this work we propose an innovative and non invasive control method to tackle the synchronisation process present in neurological diseases inspired by the Hamiltonian control theory, by adding a small control term to the system we are able to impede the onset of the synchronisation. We present our results on the paradigmatic Kuramoto model but with the intention of applying it to the deep brain stimulation (DBS) technique for controlling the symptoms.

P60 – Adria Tauste Campo (Hospital del Mar Medical research Centre, UPF, Barcelona, Spain)
Time-dependent alterations of network dynamics before epileptic seizures

Epileptic seizures are known to follow specific changes in brain dynamics. While some algorithms can nowadays robustly detect these changes, a clear understanding of the mechanism by which these alterations occur and generate seizures is still lacking. Here, we provide evidence that such changes are initiated by an alteration of physiological network state dynamics. Specifically, our analysis of long intracranial EEG recordings from a group of 10 patients identifies a critical phase of a few hours in which time-dependent network states become less variable and is followed by a global functional connectivity reduction before seizure onset. This critical phase is characterized by an increased presence of high-connected network states and is shown to particularly constraint the activity of the epileptogenic zone in patients with validated good post-operative outcome. Our approach characterizes pre-seizure networks dynamics as a cascade of two sequential events providing new insights into seizure prediction and control.

P61 – Katherine Baquero (Movere group, Cyclotron Research Center, University of Liege, Belgium)
Mean and variance of dynamic functional connectivity in Parkinson's disease

Patients with Parkinson's disease (PD) present movement disturbances such as bradykinesia, akinesia and hypokinesia. The pathological hallmark of PD is a progressive loss of dopaminergic neurons in the upper brainstem that normally modulate the activity in regions of motor circuits (Rodriguez-Oroz, 2009). Functional magnetic resonance imaging (fMRI) studies have shown altered connectivity in the motor network in patients with PD (Wu, 2012; Michely, 2015). However, little is known about how this connectivity fluctuates over time and how this differs in patients with PD. In this work, we performed the standard sliding-window approach of Dynamic Functional Connectivity, to quantify how the connectivity fluctuates over time [4] in control subjects and PD patients.
40 PD patients "on" medication (25 males, age 66.5(8.6) years, mean disease duration 5.2(3.5) years, H&Y scale 1.5(0.6)) and 42 healthy controls (23 males, age 65.1(8.3) years) matched for age, gender and levels of education. Resting-state BOLD fMRI data were acquired using a short TR on a 3T MRI scanner (voxel size 3.4x3.4x5.0 mm; matrix size 64x64x20, TR = 1.3 s; 350 scans). fMRI data preprocessing with SPM12 included: inhomogeneity field correction, head motion correction, coregistration into structural MRI, spatial normalization with Dartel and smoothing with 6mm FWHM. Data was linearly detrended and bandpass filtered (0.01 – 0.1Hz); time series of white matter, cerebrospinal fluid, six affine motion parameters and outliers found with ART were regressed out with CONN15, and the mean of BOLD fMRI time series was extracted for predefined regions of

interest (ROIs) of the motor network (Bilateral Primary Motor Cortex, Bilateral Premotor cortex, Central Supplementary Motor Area, Bilateral Putamen, Bilateral Thalamus, Central Brainstem and Bilateral Cerebellum; the Bilateral Prefrontal Cortex was included as a baseline). Static functional connectivity was detected considering the full scanning time, while the dynamic connectivity was assessed by using a window of 40 TR (52 seconds), moving in steps of 1 TR, which is within the range proposed in the literature (Hutchison, 2013). The static and dynamic connectivity were measured with Pearson correlation followed by a normalization with Fisher's r to z transform. The mean and variance of the dynamic connectivity matrices per ROI-ROI connection were measured per subject (Thompson, 2015). In order to have group results for the static and dynamic connectivity, the average of static connectivity and mean and variance of dynamic connectivity matrices were compared among control subjects and PD patients. Standard statistical t-tests were used to compare the static and dynamic connectivity among groups with $p<0.05$ uncorrected.

The results of static connectivity and the mean of the dynamic connectivity showed a high degree of similarity. In the group of control subjects, there was a clear connectivity between the entire motor cortex and subcortical regions (such as putamen and thalamus). However, this connectivity was disrupted in PD patients. Instead, in patients, stronger connectivity was found within the motor cortex, which itself was disconnected from the putamen and thalamus. The variance in dynamic connectivity may illustrate fluctuations of the connectivity over time. In the group of control subjects, a particularly high connectivity variance was found within the motor cortex. In PD patients, a similar pattern was observed. However, the variance of connectivity within the putamen and thalamus, as well as their connectivity with the other ROIs, was lower than in control subjects.

These novel results indicate the potential importance of the mean and variance as descriptors of dynamic functional connectivity. The mean of the dynamic functional connectivity was similar to the static connectivity, showing that what we call "static connectivity" may be interpreted as the mean of the fluctuations in connectivity. The variance of connectivity describes how much this connectivity is moving from its mean, i.e., how the connectivity fluctuates over time. In this work, we showed that the connectivity of the motor network is disrupted in PD patients, as compared to control subjects. In PD patients, we observed a hyperconnectivity within the motor cortex, while its connectivity with subcortical regions was disrupted. Control subjects presented a higher variance of connectivity within the motor cortex, while the putamen and thalamus showed less variance in connectivity in PD patients. In conclusion, these results show that there is a lower mean and variance of connectivity between the cortical and subcortical regions in PD patients.

P62 – Etienne Hugues (Grenoble Institute of Neuroscience, Grenoble, France)

The quest for understanding brain dynamics at rest: comparing large scale rate models with multiple neuroimaging markers

As of today, the resting -or spontaneous- state of the brain is maybe the best experimentally described brain state. Through the use of neuroimaging data, mainly fMRI and MEG, the last two decades have witnessed a considerable improvement of our knowledge of its spatiotemporal organization. In the last decade, together with the availability of the structural connectome, and from the hypothesis that dynamics is an emergent state shaped by this sole connectome, a number of large scale models, obtaining global neural activity from the choice of a local dynamical model, have been proposed to give a theoretical understanding of brain dynamics at rest. However, using the sole BOLD fMRI functional connectivity (FC) to find the best working point of each model, as it is usually done, it was recently found that many models exhibit a similar agreement with this data (Messé et al., 2014; Messé et al., 2015). Beyond emphasizing the importance of the structure, the fact that different and incompatible local dynamics are found equally acceptable is not improving our understanding of this unique dynamical state. Therefore, before using these models for applications as is usually done, it is necessary to improve their comparison with respect to data.

In this study, to better assess the qualities and shortcomings of a given model, we propose to broaden the comparison to multiple neuroimaging markers. When combining evidence from complementary modalities like fMRI and MEG, a number of markers of rest dynamics can be obtained: beyond BOLD fMRI (Fox and Raichle, 2007), FC is also found in MEG data (Brookes et al., 2011); at short timescales, BOLD FC is dynamic, which can be well described using a point process (Tagliazucchi et al., 2012); in MEG recordings, alpha oscillations exhibit long-range temporal correlations (Linkenkaer-Hansen et al., 2001) and, at shorter timescales, the whole signal exhibits avalanches whose size is distributed according to a power law (Shriki et al., 2013; Zhigalov et al., 2015). At this stage of our understanding, beyond the mathematical details of a model, it is more important to judge the dynamical scenario that this model represents. As a model example, we will consider here an excitatory and inhibitory population rate model with fast and slow (NMDA) synapses, a generalization of a previously proposed model fitting the BOLD FC (Deco et al., 2014). As this model can also exhibit alpha oscillations (Hugues et al., 2013), it is an interesting candidate for the test against the previously cited markers.

In a future study, we propose to enlarge the scope of this study to all the dynamical scenario which have been proposed. For the structure and the activity dynamics, we will also use the high quality data of many subjects from the Human Connectome Project. Overall, by rejecting and selecting dynamical scenarios -and models- and by eventually inferring new ones, we hope to foster the theoretical understanding of rest, a necessary step to address on a firm basis related questions like sleep, tasks, electrical or magnetic stimulation, brain diseases, and so on.

P63 – Laura O'Halloran (Trinity College Institute of Neuroscience and the Irish Research Council, Ireland)

The use of neuroimaging data in identifying factors involved in substance use initiation and misuse in young adulthood: Insights from neuroimaging

Dysfunction in brain regions underlying impulse control, reward processing and executive function has been associated previously with substance misuse (e.g. alcohol, cannabis and nicotine) in adolescents and young adults. However, identifying pre-existing neurobiological risk factors, as distinct from changes arising from early substance-use, is difficult. Here, we outline how neuroimaging data can identify the neural predictors of substance-use initiation and misuse by using prospective longitudinal studies to follow initially substance-naive individuals over time and by neuroimaging adolescents with inherited risk factors for alcohol misuse.

A comprehensive narrative of the literature regarding neuroimaging studies published between 2010 and 2016 focusing on predictors of substance (alcohol, cannabis and nicotine) use initiation and misuse in adolescents and young adulthood.

Prospective, longitudinal neuroimaging studies have identified pre-existing differences between adolescents who remained substance-naive and those who transitioned subsequently to substance use. Both functional and structural grey matter differences were observed in temporal and frontal regions, including reduced brain activity in the superior frontal gyrus and temporal lobe, and thinner temporal cortices of future alcohol users. Interactions between brain function and genetic predispositions have been identified, including significant association found between the Ras protein-specific guanine nucleotide releasing factor 2 (RASGRF2) gene and reward-related striatal functioning.

Neuroimaging predictors of substance use have shown modest utility to date. Future research should use out-of-sample performance as a quantitative measure of a predictor's utility. Neuroimaging data should be combined across multiple modalities, including structural information such as volumetrics and cortical thickness in conjunction with white-matter tractography. A number of relevant neurocognitive systems should be assayed; particularly, inhibitory control, reward processing and executive functioning. Combining a rich magnetic resonance imaging data set could permit the generation of neuroimaging risk scores, which could potentially yield targeted interventions.

P64 – Hannelore Aerts (Department of Data-Analysis, Faculty of Psychology and Educational Sciences, Ghent University, Belgium)

Modeling brain activity in brain tumor patients and healthy controls: a proof-of-concept study

Recent advances in noninvasive neuroimaging technology have allowed the creation of comprehensive whole-brain maps of the structural and functional connections of the human cerebrum, the so-called *connectome* (Hagmann 2005; Sporns, Tononi, and Kötter 2005). This has enabled the construction and validation of computational models of brain activity, allowing the investigation of the intricate relation between structure and function (Honey et al. 2009). In addition, dynamical models may be used as unique predictive tools to investigate the impact of structural connectivity damage on brain dynamics, by virtually lesioning the structural connectome. In this proof-of-concept study, we investigate for the first time the feasibility to simulate brain activity based on a brain tumor patient's pre-operative structural connectome. Applying an appropriate computational model, we simulate brain activity, and compare simulated and empirical brain dynamics to evaluate model performance. The same procedure is carried out using a healthy structural connectome, after which model performance between both subjects is compared.

A 60-year old female patient with a meningioma tumor and her 64-year old male partner were included in this study. From both participants, three types of MRI scan were acquired on the day before the patient's surgery: a multi-shell HARDI DWI, a resting-state fMRI, and an MPRAGE T1-weighted structural MRI. Data were preprocessed and converted to a structural and functional connectivity matrix using the pipeline of Schirner et al. (2015), and subsequently uploaded into The Virtual Brain (Sanz Leon et al. 2013). In order to simulate brain dynamics, we followed the approach outlined by Falcon et al. (2015). In particular, the Stefenscu-Jirsa 3D model (Stefanescu and Jirsa 2008) was used, a low-dimensional neural population model that focuses on local field potentials and is able to capture the most important network dynamics. A subject-specific parameter space exploration was conducted to obtain optimal parameter values for two global parameters (long-range coupling and conduction velocity) and three local parameters (K_{11}: excitatory on excitatory; K_{12}: excitatory on inhibitory; and K_{21}: inhibitory on excitatory) of the model. BOLD responses then were simulated using the chosen parameter values. In the last step, model performance was evaluated by comparing empirical and simulated BOLD time series amplitudes, connectivity strength, and graph metrics derived from both connectivity matrices.

For the brain tumor patient, the following parameter values were used: long-range coupling of 0.75, conduction velocity of 90mm/ms, K_{12}=0.01, K_{21}=0.01, and K_{11}=1. Similar optimal values were obtained for the healthy control participant: long-range coupling of 0.70, conduction velocity of 50mm/ms, K_{12}=0.08, K_{21}=0.10, and K_{11}=1. Comparison between empirical and simulated brain dynamics in terms of time series amplitudes, functional connectivity strength, and graph metrics showed good correspondence in both participants (Figure 1).

Results from this proof-of-concept study show that it is feasible to simulate biologically plausible neural activity based on a brain tumor patient's structural connectome. Although the correlation between empirical and simulated functional connectivity was somewhat smaller in the brain tumor patient compared to the healthy control, the correspondence between modeled and empirical time series amplitudes and whole-brain topological properties were similar in the brain tumor patient and healthy control.

Figure 1. Comparison between simulated and empirical brain dynamics in terms of time series amplitudes, connectivity strength, and graph metrics, for a brain tumor patient and healthy control.

Amplitudes BOLD time series			
Patient simulated	Min: -4.17	Patient empirical	Min: -3.28
	Max: 4.11		Max: 5.49
	Mean (of absolute values): 0.80		Mean (of absolute values): 0.81
Control simulated	Min: -4.16	Control empirical	Min: -4.01
	Max: 3.95		Max: 4.32
	Mean (of absolute values): 0.80		Mean (of absolute values): 0.79
Connectivity strength correlation			
Patient	$r = 0.26$ ($p < 0.001$)		
Control	$r = 0.34$ ($p < 0.001$)		
Graph metrics			
Patient simulated	$\lambda = 1.15$	Patient empirical	$\lambda = 1.35$
	$\gamma = 1.00$		$\gamma = 1.16$
	$\sigma = 0.87$		$\sigma = 0.86$
Control simulated	$\lambda = 1.23$	Control empirical	$\lambda = 1.16$
	$\gamma = 1.01$		$\gamma = 1.02$
	$\sigma = 0.82$		$\sigma = 0.88$

λ = normalized characteristic path length, γ = normalized clustering coefficient, σ = small-worldness index

P65 – Daniele Marinazzo (Department of Data-Analysis, Faculty of Psychology and Educational Sciences, Ghent University, Belgium)

Retrieving the hemodynamic response function in resting state fMRI: methodology and applications

Retrieving the hemodynamic response function (HRF) in fMRI data is important for several reasons. Apart from its use as a physiological biomarker, HRF can act as a confounder in connectivity studies. In task-based fMRI is relatively straightforward to retrieve the HRF since its onset time is known. This is not the case for resting state acquisitions. We present a procedure to retrieve the hemodynamic response function from resting state (RS) fMRI data. The fundamentals of the procedure are further validated by a simulation and with ASL data. We then present the modifications to the shape of the HRF at rest when opening and closing the eyes using a simultaneous EEG-fMRI dataset. Finally, the modulation of this RS-HRF with propofol anesthesia is presented.

The procedure starts from the assumption that resting-state brain dynamics can be driven by spontaneous events, which are retrieved by setting a threshold on the normalized BOLD signal. A linear time invariant (LTI) system is used to model the relationship between spontaneous neural events and the BOLD response. Once the events have been collected, a GLM is fitted using the delay between event and BOLD peak as a free parameter. The HRF is retrieved both with the canonical model with derivatives (canon2dd) or as a Finite Impulse Response (FIR). Simulated HRFs are used as the ground truth for simulations. We employ a public dataset to explore the relationship between baseline CBF and HRF. We investigate the

electrophysiological basis of the HRF and its coupling to electrical brain activity with simultaneously recorded EEG and fMRI data acquired at 7T.
Starting from lower but still realistic SNR values, the fit between simulated and retrieved HRF is stable and accurate. A correlation analysis across voxels in each subnetworks showed a striking spatial overlap between CBF and HRF response height (PSC, baseline). Less differences are observed in other HRF parameters, probably due to the sampling rate. A positive correlation between BOLD and canonical HRF convolved alpha power was observed in the thalamus, and a negative one in the Occipital Lobe. We observe opposite patterns of HRF shapes between the thalamus and occipital cortex under the two conditions, consistent with the correlation and anti-correlation between the alpha power spectrum and BOLD signal in thalamic and occipital cortex.
The feasibility and effectiveness of an algorithm aimed to retrieve the HRF at rest is overall confirmed by simulation data, and evidence from vascular flow and electrophysiology. Additionally, functional modifications to the HRF shape are consistent with evidence previously reported using different methodologies.

P66 – Elena Patricia Núñez Castellar (Department of Data-Analysis, Faculty of Psychology and Educational Sciences, Ghent University, Belgium; Department of Communication Sciences, imec-MICT, Ghent University, Belgium)
Functional connectivity of executive attentional networks during flow: Spectral Granger Causality analysis

The present research aims to assess whether by means of a secondary attentional task and EEG recordings, changes in the activity of two separate orienting networks and two separate executive attentional networks can be mapped during the subjective experience of flow - focused motivation leading to a feeling of spontaneous joy. Participants were requested to respond as fast as possible to a secondary task while playing a game on a primary screen. Since during Flow subjects are deeply immersed in the game, we hypothesize that changes on the functional connectivity of the attentional networks might reflect the process of attentional maintenance. In a first stage, two executive attentional networks were investigated. The cingulo-opercular (CO) system, which is involved in tonic alertness and the frontoparietal (FP) network thought to be related to task switching and initiation of within trials adjustments. The interaction between the ACC activity and these attentional networks was investigated. Data of eighteen participants were collected. Brainwaves were recorded with 31 active electrodes. Granger Causality analysis was applied to the source reconstructed time series for each node. The Granger causality index (GCI) was calculated for every driver-target sources using multivariate autoregressive modeling in two windows of interest: 0 to 250ms and 250ms to 500ms. Permutation based tests revealed significant GCI differences for all driver-target pairs between the two time windows for the CO network. Increased out flow of information from aPFC to dACC driven by significant changes in power in beta and theta bands were found in the CO network. In a second stage we investigated the evolution of changes in power in these bands for this driver-target pair during the 8 minutes of recordings when comparing the three conditions.

P67 – Marcel Falkiewicz (Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany)

Spatial modes of functional connectivity - interpretations and applications

Spatial modes of functional connectivity are able to capture relationships between well-established brain networks. Modes have usually been used either as inputs for either blind source separation techniques (e.g. ICA), or spectral clustering algorithms (e.g. NCut) to discover discrete, spatially independent locations in the brain which can be later used as nodes in graph-theoretical analyses. Here we investigate the interpretability and utility of spatial modes derived with nonlinear dimensionality reduction technique called diffusion map embedding. We derive modes from the dense connectome built on the basis of resting state data from 820 subjects participating in the Human Connectome Project. First few modes describe relationships between large-scale cortical networks. We spatially regressed the obtained spatial modes on task time series, which produces a time course for each mode. We demonstrate that standard deviations of the modes over time are related to average functional connectivity between the opposite poles of each mode. Furthermore, few averaged mode time courses can be used to achieve very high accuracy in predicting task conditions in new subjects, as well as behavioral performance in working memory task. These results support the utility and interpretability of spatial modes for functional connectivity.

P68 – Lia Talozzi (Functional MR Unit, Policlinico S. Orsola-Malpighi, Bologna and Department of Biomedical and Neuromotor Sciences, University of Bologna, Italy)

The arcuate fasciculus: hemispheric asymmetries and gray matter projections evaluation with along-tract and shape DWI based tractography methods

The arcuate fasciculus (AF) is a white matter (WM) tract of the fronto-parietal-temporal network. Post-mortem and MRI studies established that the AF mainly connects the frontal Broca's area for language production, and the temporal Wernicke's area for its comprehension (Dick et al. 2012). In this study we compared three different AF tractography methods. We focused on quantitative regional tract analysis using an along-tract statistics to describe AF asymmetries between brain hemispheres, regional diffusion properties, geometry, curvature and tract orientation.
29 healthy subjects (F/M= 14/15, age= 38±18, mean±sd, years) underwent a standardized brain MRI protocol (1.5T GE scanner), including T1-weighted volumetric and DW imaging

(TR=10 s, b=900 s/mm2, 7 volumes with null b-value, 64 diffusion gradient directions , voxel=1.25x1.25x3 mm3). Tractography was performed using three different algorithms: deterministic fiber-tracking with a spherical deconvolution (SD) diffusion model (Touriner et al. 2012), probabilistic fiber-tracking with the ball and sticks model (Beherns et al. 2003), and probabilistic fiber-tracking with the SD model (Touriner et al. 2012). Tractography ROIs were drawn in the MNI space, localizing the seed in the WM underlying the angular gyrus (Giorgio et al. 2010) and targets in the frontal and temporal lobe grey matter (GM), according to the Harvard-Oxford probabilistic atlas, thresholded at 25%. AF connectivity distributions were thresholded at 10% with respect to the maximum of connectivity. Along-tract statistics were restricted to the portion of the tract before its branches towards GM terminations. The AF was divided in fifteen segments by parameterizing the monotonic increase along the longest geodesic distance. For this purpose, we evaluated the second eigenvector of the Laplacian matrix, calculated on the thresholded tract mesh surface. For each segment diffusion parameters and centroid coordinates (x,y,z) were evaluated. A non-parametric paired test, the Wilcoxon signed-rank, was used for left-right comparisons, with a significant level set at $p < 0.05$ and corrected by the FDR (False Discovery Rate) method for multiple comparisons.

We were able to track the AF on both the hemispheres in all subjects with all the three tractography methods, obtaining different results. In particular, the AF tract volume increased if we used probabilistic rather than the deterministic tractography. Comparing tract volume in each hemisphere, with deterministic tractography it was greater on the left throughout the whole tract, whereas with probabilistic tractography the tract volume was greater on the left mostly in the temporal portion. Concerning diffusion parameters, FA values were lower on the left with respect to right: with the ball and stick model this behavior was localized in the fronto-parietal junction, whereas with probabilistic SD tractography the difference was found in most of the AF segments. On the contrary, the deterministic algorithm measured a lower FA on the right only in one segment of the temporo-parietal portion. Concerning the centroid coordinates, in the right hemisphere the AF had a greater curvature in the temporal lobe with respect to the left hemisphere; this different curvature was measured with all the tractography methods. In the frontal tract portion of the AF, on the other hand, segment centroids were more inferiorly located on the left; this difference was only found by the probabilistic methods.

Usually the AF identification is suboptimal, especially with deterministic method, likely due to the presence of crossing fibers, which are more present in the right hemisphere (Chen et al. 2015). In our study we were able to perform AF tractography with all the three tractography methods in all subjects and in both the hemispheres, in agreement with post mortem fiber dissection studies. The apparent AF volume changed with the tractography methods, according to their abilities to resolve crossing fibers. The hemispheric differences in the diffusion parameters and tract spatial localization can be explained on the basis of tract GM terminations. Group variability maps show several cortical terminations in the temporal lobe: the superior temporal gyrus (STG) BA 22, the middle temporal gyrus (MTG) BA 21, the fusiform gyrus BA 37, the inferior temporal gyrus (ITG) BA 20. Only probabilistic algorithms found that the AF is more connected to the STG on the left compared to the right hemisphere. This asymmetry in STG projections could explain both the different AF curvature across the hemispheres and the lower FA at left. Moreover, in the frontal portion of the left hemispheric tract only the probabilistic algorithms found an AF lateral branch towards the ventral premotor cortex BA 6, posteriorly to the inferior frontal gyrus (IFG) BA 44-45 cortical termination. This could explain the more inferior localization of the frontal AF segment centroids on the left hemisphere. These results are in agreement with other probabilistic tractography studies (Rilling et al. 2008) that extend the classical Broca's and Wercnicke's areas to others GM terminations and that also consider right hemisphere AF connectivity. To our knowledge, this is the first study that quantitatively mapped the geometry of the AF tract and compared different algorithms with an along-tract statistics. This tractography approach could be integrated with the fMRI technique, since, especially the probabilistic tractography allows the evaluation of GM terminations and hemispheric differences. Moreover, both DWI and fMRI techniques can be combined for pre-surgical or rehabilitation planning in patients with language dysfunction.

P69 – Joydeep Bhattacharya (Department of Psychology, Goldsmiths, University of London, London, United Kingdom)

Investigating the role of dynamic connectivity in cognitive development of young children

Recent evidence from neuroimaging studies of dynamic connectivity suggests that the reconfiguration of brain networks across time influences the cognitive capacity of individuals where well-functioning brains have been reported to exhibit a greater degree of reconfiguration. In the present study, we investigated the role of dynamic connectivity in cognitive processing of young children. Resting state MEG data were recorded from 88 children, 3-4 years old, while they were watching cartoon. Their performance on Kaufman Assessment Battery for Children (K-ABC) were also evaluated separately. We estimated the dynamic connectivity in eight frequency bands from the MEG data using imaginary coherence in conjunction with a sliding window approach. We quantified the dynamic connectivity using edge-variability, a simple first derivative based measure. Edges showing high values of edge-variability influence the temporal evolution of the network's modular structure and in turn, the reconfiguration of the network between successive time instants. The children were divided into 3 classes - Low, Medium, and High - based on their K-ABC scores. We employed a machine learning framework, including feature selection and classification, to identify the connections whose edge-variability differentiated the three classes. The laterality index of edge-variability features yielded a classification performance around 60% which is reasonably higher than the chance level accuracy of 33.33%. Additional analysis of selected features revealed that the high-scoring children exhibited a greater degree of left lateralization of edge-variability in the lower theta band as compared to the low-scoring participants. We also evaluated the classification performance using static connectivity features to assess the relative sensitivity of the edge-variability features. It was found that the edge-variability features (laterality index) yielded relatively better results than the static connectivity features which yielded classification accuracy around 55%; highlighting the sensitivity of the K-ABC scores to the network dynamics. Further, for the static connectivity features, it was found that the high scoring participants were characterized by dominantly low connectivity in the lower theta band; this is consistent with the neural efficiency hypothesis of intelligence which suggests that well-functioning brains are better at suppressing irrelevant connections while enhancing task-relevant connectivity. Altogether these results demonstrate a novel insight into the role of brain networks and its temporal dynamics at an early stage of development.

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