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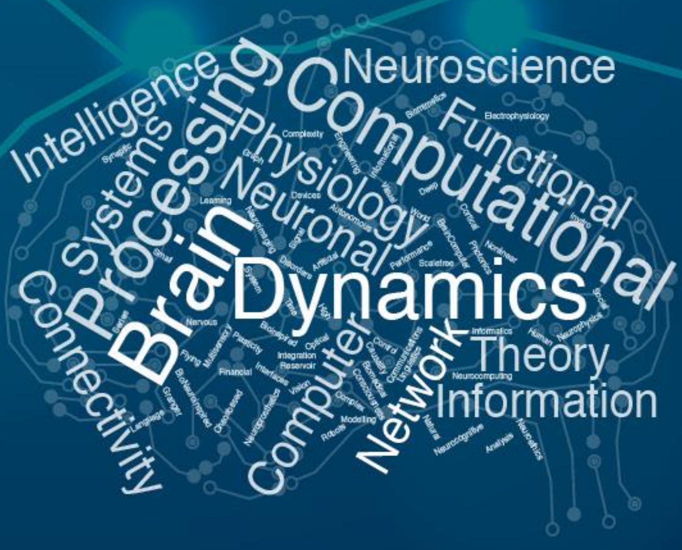
Poster Abstracts



Contents

Exploratory Strategies of *Drosophila melanogaster* in Adaptation to Darkness

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Like most animals, *Drosophila melanogaster* depends on visual cues in their environment to carry out goal-directed behaviors, such as locomotion, navigation, and courtship. To optimize optic flow and thus, maximize 3D information gained from the environment during locomotion, they develop a stereotyped, almost universal locomotor strategy called the saccadic strategy. This strategy separates rotational movements from translational ones, resulting in a pattern that consists of long stretches of translational movements interspersed with short and fast rotations for reorientation[1]. We were then interested to find out how their locomotor strategy would change if we remove visual cues from their environment. A previous study has found that flies that have been reared in complete darkness since 1954 (dark-flies)[2] showed longer phases of rotations and reduced phases of translations. They also perform drifts called the Tōhoku drift, which increases the area covered by their mechanosensory organs[3]. This finding indicates a shift of strategy from an optic flow-optimizing strategy to a mechanosensation-optimizing one. Continuing with this finding, I modeled and simulated the wt- and dark-flies' locomotor strategies *in-silico* to find out if the dark-adapted locomotor strategy would actually outperform the saccadic strategy when and exploring and foraging in darkness. I found that the virtual dark-flies were indeed able to find significantly more food than the virtual wt-flies. Therefore, I could show with my results that the dark-adapted strategy is more efficient in foraging in darkness than the saccadic strategy.

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Keywords: vision-guided behaviors, locomotor strategies, computational modeling, computational neuroethology

Haploinsufficiency of Tsc2 expression leads to network hyperexcitation via a GABAB-dependent pathway

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The mammalian target of rapamycin (mTOR) pathway is a key player for correct neuronal network development. Tuberous sclerosis complex 2 (Tsc2) down-regulation induces mTOR hyper-activation, which results in intellectual disability, social deficits and epilepsy. Using acute slices from Tsc2$^{+/-}$ and wildtype (WT) mice we studied developmental alterations of synaptic transmission and network balance during the first postnatal month in the medial prefrontal cortex.

Miniature excitatory and inhibitory postsynaptic currents (mEPSCs/mIPSCs) were recorded in layer II/III pyramidal neurons. While between postnatal days (p) p10-12 no difference appeared between WT and Tsc2$^{+/-}$ animals, at p15-19 the latter displayed a potentiation of glutamatergic transmission. At p25-30 the inhibitory system could compensate this unbalance, but Tsc2$^{+/-}$ neurons displayed reduced GABAB receptors (GABABRs)-mediated tonic inhibition at a cellular level.

Local field potential recordings in brain slices revealed no differences in response to Kainate application at p15-19, but inreased activity in p25-30 Tsc2$^{+/-}$ slices only. GABABRs blockade abolished the difference. This suggests a reduced GABABRs-mediated stabilization of network activity in heterozigous animals. Furthermore GABABRs blockade could affect frequency of epileptic-like discharges in WT but not in Tsc2$^{+/-}$ slices.

We conclude that the first event deviating from normal development in Tsc2$^{+/-}$ animals happens after eye opening, and results in potentiation of phasic glutamatergic transmission, which however does not destabilize the network and is compensated by p25-30. At this age Tsc2$^{+/-}$ neurons display decreased tonic GABAB-mediated inhibition. Even if phasic GABAergic transmission compensates phasic glutamatergic potentiation, tonic GABABR-mediated inhibition is decreased, likely due to reduced functional GABABRs. The increased intrinsic excitability is sufficient to imbalance the network.

Is Vibration a Suitable Feedback Form for Application of P300-based Brain Computer Interface in Neurorehabilitation?

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In our previous research it was shown that vibration of human fingers can decrease motor cortex excitability. However, there are some evidence of positive long-latency effects of vibrotactile stimulation on motor cortex excitability [1]. The main purpose of this research is to find out whether or not vibration could be used as a feedback form in P300-based Brain Computer Interface (BCI-P300) paradigm in the context of a neurorehabilitational technique. To answer the question posed, motor evoked potentials (MEPs) were initiated by transcranial magnetic stimulation (TMS), and the MEP amplitudes while perceiving the vibrotactile feedback and while being at rest were matched.

It was 19 health volunteers included to the research. During the experiment a volunteer intended to flex a finger of a phantom anthropomorphic hand by means of attention concentration on a finger chosen. Blinks of LEDs placed on each finger were used as visual stimuli in BCI-P300 paradigm. Thereby, a finger chosen by a volunteer was detected. While using the interface a volunteer perceived vibration of own finger corresponding to the chosen phantom finger. Further, the phantom hand was excluded from a volunteer's field of view. In this mode, a volunteer perceived vibration of a random own finger. Every vibration act was accompanied by TMS starting off in 1.6 seconds after vibration set in. MEP amplitudes were matched by Wilcoxon test.

It was confirmed that vibration has inhibitory effects (1.6 seconds-latency) on motor cortex excitability as a MEP amplitude decreases while a volunteer perceives vibration. However, when vibration was used as a feedback form, MEP amplitudes increased. The mechanisms of motor cortex inhibition by sensory stimuli are still not completely understood. Though the modulation is associated with intercortical sensorimotor connection circuit [2]. Positive effects of vibration as a feedback form made us conclude that feedback-associated information affects motor cortex by neural pathways which are different from ones used while perceiving random finger vibration.

Summing up, it can be assumed that vibration can be used as a feedback form in neurorehabilitational BCI-P300 paradigm in spite of negative effects of feedback-free vibration on motor cortex excitability.

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Keywords: vibration, excitability, neurorehabilitation, BCI-P300.

EEG Connectivity Measures in Prognostication of Postanoxic Coma Patients

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Early prognostication in postanoxic comatose patients remains a challenge. In this work, we investigate EEG functional connectivity (FC) measures as a contributor to prediction of outcome in these patients, as well as their additional value when combined with other predictive variables. For that purpose, machine learning classification models were trained with 3 sets of parameters calculated at 12, 24 and 48 hours after cardiac arrest (CA): FC metrics, a validated set of conventional qEEG measures[1], and a combination of both; these models were then evaluated to see if they could predict whether a patient was going to present a good (CPC[2] 1-2) or a bad (CPC 3-5) outcome. We included 594 patients, with 46% presenting good outcome. A sensitivity of 50.8% (48-52% CI) in predicting poor outcome was achieved by the best FC-based classifier at 12 h after CA, while the best conventional qEEG-based model presented a sensitivity of 32.6% (28-37% CI) using data from 12 and 48 h after CA. The best combined model achieved a 69.3% (64-74% CI) with the 12 and 48 h dataset. All sensitivities for poor outcome prediction are at 100% specificity (98-100% CI). Thus, FC parameters derived from EEG contribute to outcome prediction of postanoxic coma by themselves and are complementary to a validated model of classic EEG parameters, showing better performance than methods currently used in clinical practice and newly proposed.

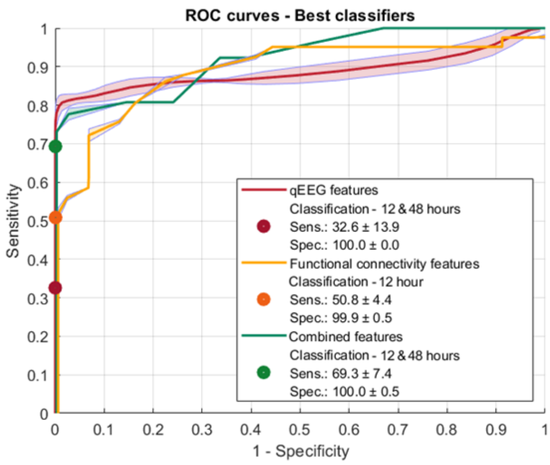

Figure 1. ROC curve mean and SD from the best classifiers trained in this study. The circular

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Keywords: Postanoxic coma, ICU, Machine Learning, Functional Connectivity

Functional imaging of the honeybee's visual system: Neural correlates of visual sensing

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The honeybee is an excellent animal model for the study of visual perception, learning, and memory. Extensive behavioural studies have shown that honeybees perceive, learn, and memorize colours, shapes, and patterns when these visual cues are paired with a sucrose reward. To precisely navigate for kilometres with respect to the hive, they sense light polarization, the geomagnetic field, and memorize cognitive maps.
In the last decade, conceptual and technical advances improved significantly our comprehension of visual processing in bees, but the neuronal mechanisms which underlie visual processing at a population level are still poorly understood.
The development of a reliable platform for synchronized light stimulation and *in vivo* functional imaging of the honeybee's visual system using two-photon microscopy will allow addressing new questions regarding neuronal coding of visual information:
Focusing on the early stage of visual processing we will characterize by functional imaging the visual neuropils, Lamina, Lobula, Medulla, and the Anterior Optic Tubercle;
Combining visual and olfactory stimulation, we will investigate the neural processing which integrates the information coming from the different neuronal pathways.
One of the most interesting questions that could be answered about the visual system of insects concerns magnetic reception, as there is more and more evidence of light-dependent magneto-sensitivity in various invertebrate species. Initial behavioural experiments will allow us to develop a protocol for magnetic stimulation on harnessed bees, opening the opportunity to study neural correlates of magnetoreception along the visual pathway.

Keywords: Vision¸ Two-photon Microscopy, Magnetoreception, Honeybee, Navigation

Power Spectral Analysis of EEG Activity During Resting State Task. Analysis of Differential Dynamic Features for Patients With Dementia

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In the present, implementing early diagnoses of dementias is a very relevant challenge. This could become a critical point for society and health system given the increase in people with advanced ages. In this sense, it is important to find differences in the brain activity of patients with dementia who could have the potential to develop an early diagnosis of these pathologies. Here, we analyze temporal series of time-frequency power of EEG signals for a resting state task for two groups of patients suffering an early stage of dementia disease (Frontotemporal dementia and Alzheimer disease) and a control group of healthy subjects. First, we compare the mean power spectral looking for data-driven specific topographic differences between groups. Then, we focuses over dynamics aspects of the temporal series from power-bands for each sensor. In the context of dynamics systems, we calculated temporal power variability, the lifetime of bursts of activity, information measures (Lempel-Ziv complexity) and spatio-temporal clusters behavior obtaining in this way complementary information to the mean power based measures. The results shows distinctive power dynamics patterns for each group of patients respect to control group. These differences are complementary and no restricted to topography of mean power differences found previously. We tested these measures in a supervised classification analysis (using a support vector machine algorithm) obtaining high values of accuracy detecting patients of each group. It is concluded that an analysis that focuses on the fine temporal detail of the oscillatory activity of the EEG (using methodologies related to dynamics systems) may be relevant to improve and complement actually measures to develop potential biomarkers for early dementia diagnosis.

Keywords: EEG, Dynamics Systems, Dementia, Resting State, Time Frequency

Correlated Structural Networks of Grey and White Matter Changes in Schizophrenia

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Background: Schizophrenia is a brain disorder characterized by diffuse, diverse, and wide-spread changes throughout the grey matter volume (GM) and white matter structure (FA) when compared to healthy controls. While each of these image modalities has been thoroughly investigated individually, using the multimodal fusion method parallel independent component analysis (pICA) affords the opportunity to explore the correlations between the changes in GM and FA. pICA is a data-driven method that emphasizes the maximal independence of the components while analyzing the pattern of interactions between the two data sets.

Method: The images were acquired from 73 subjects with schizophrenia (SZ) and 82 healthy controls (HC). There were 12 components investigated from each feature (FA and GM). The loading coefficients from the images were used to calculate the correlation values sample-wide, identifying the pairs of features that were significantly correlated and had significant differences between HC and SZ.

Results: There were 3 components with significant group differences. The first pair (r=0.6115, p=2.87x10^-17) showed significant differences between SZ and HC, (HC>SZ, FA component, t=3.21, p=0.0016 and GM component, t=3.63, p=0.00039). The second pair (r= 0.5904, p=6.18 x 10^-16), had group differences for the FA component (HC>SZ, t=2.99, p=0.0032) and for the GM component (HC>SZ, t=2.67, p=0.0082). The third component pair (r=0.4626, p=1.36 x 10^-9), the FA component (HC>SZ, t=3.5, p=0.00053) and the GM component showed (HC>SZ, t=2.92, p=0.0041).

Conclusions: This multimodal analysis highlighted networked areas of correlated grey matter density and white matter integrity that differ between healthy controls and subjects with schizophrenia, allowing insight into disease-related changes not found with unimodal analysis alone. These areas include, but weren't limited to: the right and left thalamus, lateral occipital cortex, middle temporal gyrus, precuneus cortex, postcentral gyrus, cingulate gyrus/cingulum, lingual gyrus, and brain stem.

Keywords: Multimodal Imaging, Fusion Imaging, Grey Matter Density, Fractional Anisotropy, Schizophrenia

Investigating the Neural Predictors of Flow Using fMRI

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Flow, popularly referred as *being in the zone*, can be described as a state of optimal performance. The subjective experience corresponding to this state has been well characterized using 9 psychological constructs, such as concentration, transformation of time or sense of control, as measured through a self-report questionnaire called the Flow State Scale (Jackson & Marsh, 1996). However, little is known of the neural correlates of flow. Only a handful of brain imaging studies have investigated the neural correlates of flow and all have done so by contrasting two different task conditions, making it unclear whether the observed differences in activity are truly flow-related rather than task-related.

To remedy this, we take here a different approach based on the method presented in Rosenberg *et al.* (2016), where sustained attention-related networks were defined using resting state connectivity and performance on a sustained attention task administered at a different time. Similarly, we identify flow-related neural markers using resting state connectivity and a measure of flow collected at a different time. Importantly, this approach avoids any possible confounds from task-related differences since the behavioural and connectivity data are not acquired simultaneously.

We have already validated our ability to measure the propensity to enter flow by contrasting flow questionnaire responses after playing a video game at an optimal level of challenge versus at an over-challenging level. As in Rosenberg *et al.* (2016), we ask whether individual flow states can be predicted from patterns of resting state connectivity. We predict these patterns will reveal a rather unique network highlighting the combined contribution of attention-related, emotion-related and reward-related networks to the experience of Flow. Preliminary results have highlighted a resting state network whose activity is negatively correlated with flow proneness, and as shown in figure 1, stronger connectivity in this network is predictive of flow proneness.

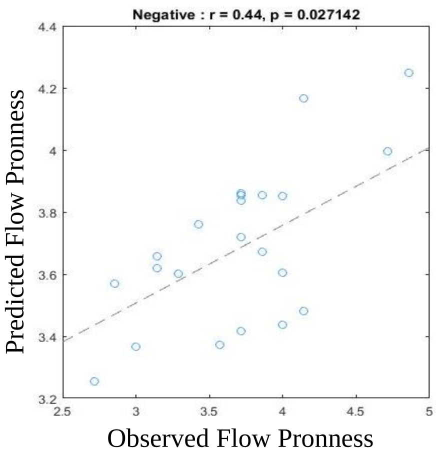

Figure 2, Plot of observed flow proneness against the predicted value form the connectivity strength resting neural network.

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Keywords : Flow, Attention, fMRI, Video Games

Brains On Board

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"Small" brains – such as those of insects like honeybees- have been observed to enable sophisticated cognitive behaviours, while at the same time being accessible from an experimental point of view. Bee's remarkable behaviours comprise different types of learning, including -but not limited to- reinforcement, trace, reversal and contextual learning. The experimental accessibility of the bee brain allows researchers to gain insight into the neural basis of these accomplishments, also advancing our understanding of cognition in other animals e.g. vertebrates.

In the "Brains on Board" project, researchers from three universities (Sussex, Sheffield, Queen Mary) are collaborating in order to uncover the hidden workings of insect brains.

This poster gives an overview over the project and its achievements that so far range from highly efficient computational methods, like the GPU-optimized "GeNN" framework, to models of relevant areas in the insect brain (e.g. of the visual system), to the development of sophisticated radar techniques for tracking bees and "on board" model implementations on flying robots.

Keywords: Insect-Inspired, Brains, Modelling

Cognitive Enhancement by means of network-targeted Cortico-Cortical Associative Brain Stimulation

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Fluid intelligence (g*f*) represents the ability to cope with novel scenarios irrespective of previously acquired knowledge. Given its impact in everyday living, its correlation with academic and professional success, as well as its contribution to resiliency against pathological conditions, improving g*f* has become a crucial topic for contemporary neuroscience. Here we applied a novel Non-Invasive Brain Stimulation (NIBS) technique based on Hebbian plasticity principles by means of double-coil Transcranial Magnetic Stimulation (TMS), called cortico-cortical paired associative stimulation (cc-PAS). Concurrent stimulation of two g*f*-related brain regions was delivered to induce a plastic rearrangement of inter-regional connectivity, possibly leading to a transient modification of individual g*f* levels. Thirty healthy individuals carried out a baseline visit comprehensive of a full cognitive assessment and structural/functional magnetic resonance imaging (fMRI) acquisition. In each of the following TMS visits, participants solved four parallel versions of a validated gf task (Sandia matrices), before and after neuronavigated cc-PAS. Stimulation was applied to a left-lateralized fronto-parietal network based on task-fMRI meta-analysis maps and individual functional connectivity (FC) fMRI data.
Overall, 2 experimental conditions were carried out, where the inter-stimulus interval (ISI) was set as equal to plus10ms (P→F) or as equal to minus10ms (F→P) respectively; as well as three control conditions: (i) a non-associative TMS condition, with ISI=0ms (Simultaneous-TMS); (ii) stimulation over one single gf region (Prefrontal-TMS) (iii) repeated g*f* assessment following the same experimental design but with no TMS (NoStim).
Cc-PAS enhanced accuracy at g*f* tasks related to Logical and Relational reasoning in a direction dependent manner. Specifically, as for logical trials, a significant increase in accuracy (10.10%) was found for P→F compared to the other control conditions. Conversely, the analysis of relational trials revealed a significantly higher accuracy (6.97%) after F→P condition. Moreover, the regression analysis based on resting-state FC identified a cluster of regions whose positive correlation with the g*f* network was correlated with the behavioural changes observed after P→F and F→P cc-PAS. Specifically, FC profile of the left MFG predicted changes in performance at both Logical and Relational trials (ΔACC Logical reasoning P→F $p< .05$; $R2= 48\%$; ΔACC Relational reasoning F→P $p< .05$; $R2= 45\%$), while FC of left parietal targets only predicted enhancement for Relational reasoning (ΔACC Relational reasoning F→P $p< .05$; $R2= 43\%$). The present results constitute an original evidence of cc-PAS effects on higherorder cognition in healthy individuals. Even though the complete understanding of the neurophysiological substrates of cc-PAS requires more in-depth electrophysiological investigations, the specificity of the present results suggests the possibility of modulating specific inter-regional brain dynamics in a timing-dependent manner. Data also strengthen the pivotal role of the left fronto-parietal network in g*f*-related processing, promoting cc-PAS as a tool to causally validate the importance of specific cortical networks into explaining variability in g*f*.

Analysis of Connectivity and Signal Dynamics in the Honeybee Antennal Lobe Networks.

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Antennal lobes are the first structures where the olfactory stimuli, recorded from olfactory receptor neurons, are encoded into a sequence of spike trains which are then relayed toward the mushroom bodies which represent the higher brain area where the environmental stimuli are integrated and an output response is generated. The coding mechanism of the antennal lobes is based on a series of computing units called glomeruli, which are connected to each other in a way they influence their activity. Thanks to the Calcium-imaging technique and by mean of a Two-photon microscope, we were able to extract signals from a subset of glomeruli when bees were exposed to different odour stimuli. Here we investigate the mechanism of interaction of the glomeruli, by processing the signal obtained from several glomeruli in response to different odorants. We focus on connectivity patterns for different stimuli.

Furthermore, we investigate the possibility to use machine learning algorithms in order to perform an odour prediction based on the pattern of glomeruli responses.

Keywords: honeybee, glomeruli, connectivity, machine learning

Validation and performance of effective network inference using multivariate transfer entropy with IDTxl

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IDTxl is a new open source toolbox for effective network inference from multivariate time series using information theory, available from Github at http://github.com/pwollstadt/IDTxl. The primary application area for IDTxl is the analysis of brain imaging data (import tools for common neuroscience formats, e.g. FieldTrip, are included); however, the toolkit is generic to analysing multivariate time-series data from any discipline and complex system.

For each target node in a network, IDTxl employs a greedy iterative algorithm to find the set of parent nodes and delays which maximise the multivariate transfer entropy. Rigorous statistical controls (based on comparison to null distributions from time series surrogates) are used to gate parent selection and to provide automatic stopping conditions for the inference.

We validated the IDTxl Python toolkit on different effective network inference tasks, using synthetic datasets where the underlying connectivity and the dynamics are known. We tested random networks of increasing size (10 to 100 nodes) and for an increasing number of time-series observations (100 to 10000 samples). We evaluated the effective network inference against the underlying structural networks in terms of precision, recall, and specificity in the classification of links. In the absence of hidden nodes, we expected the effective network to reflect the structural network. Given the generality of the toolkit, we chose two dynamical models of broad applicability: a vector autoregressive (VAR) process and a coupled logistic maps (CLM) process; both are widely used in computational neuroscience, macroeconomics, population dynamics, and chaotic systems research. We used a linear Gaussian estimator (i.e.Granger causality) for transfer entropy measurements in the VAR process and a nonlinear model-free estimator (Kraskov-Stoegbauer-Grassberger) for the CLM process.

Our results showed that, for both types of dynamics, the performance of the inference increased with the number of samples and decreased with the size of the network, as expected. For a smaller number of samples, the recall was the most affected performance measure, while the precision and specificity were always close to maximal. For our choice of parameters, 10000 samples were enough to achieve nearly perfect network inference (>95% according to all performance measures) in both the VAR and CLM processes, regardless of the size of the network. Decreasing the threshold for statistical significance in accepting a link lead to higher precision and lower recall, as expected. Since we imposed a single coupling delay between each pair of processes (chosen at random between 1 and 5 discrete time steps), we further validated the performance of the algorithm in identifying the correct delays. Once again, 10000 samples were enough to achieve nearly optimal performance, regardless of the size of the network.

We emphasise the significant improvement in network size and number of samples analysed in this study, with 100 nodes / 10000 samples being an order of magnitude larger than what has been previously demonstrated, bringing larger neural experiments into scope. Nonetheless, analysing large networks with 10000 samples and using the model-free estimators is computationally demanding; therefore, we exploited the compatibility of IDTxl with parallel and GPU computing on high-performance clusters.

The Effect of Verbalization on the Completeness of Imagery Representations of Abstract and Concrete Concepts

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Intelligence is based on one's conceptual framework. This framework is a hierarchy of various cognitive structures represented by imagery and verbal components of the cognitive system [1]. Although there are many studies, which reveal the connection between verbal and imagery components of thinking and cognitive functions, the extent to which verbal and imagery cognitive systems are related to one another remains unknown [2].

The purpose of this study (n = 61, 41 females, aged 18 – 25, mean age – 20 y.o.) was to reveal the role that verbal structures play in actualization of imagery representations of abstract and concrete concepts. We used "Pictograms" (modified version) as a main research tool. We predicted that a) quality of the written verbalization of the concept correlates with quality of its imagery representation; b) abstract and concrete concepts differ in the completeness of actualization of the main features of imagery and verbal components of the concept.

We revealed a correlation between the scores for completeness of imagery representations and the scores for written verbalizations of the concepts ($p < 0{,}01$; $r = 0{,}516$). Both types of representations of abstract concepts appeared to be of a higher quality than those of concrete ones ($p < 0{,}01$).

The results suggest that a highly developed conceptual system provides the full functioning of both image and verbal systems for constructing mental representations of concepts [1]. In addition, it appears that understanding the meaning of concrete concepts is associated with their frequent actualization in everyday context, which requires considerable cognitive effort to find the abstract meaning of concrete concepts.

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Keywords: verbal representations, imagery representations, abstract concepts, concrete concepts

Exploring the Role of Directionality in Shaping Transition Dynamics in the Brain Using Basin Stability.

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Understanding structure-function relationships in the brain remains an important challenge in neuroscience. However, whilst structural brain networks are intrinsically directed, due to the prevalence of chemical synapses in the cortex, most studies in network neuroscience represent the brain as an undirected network [1]. Here, we explore the role that directionality plays in shaping transition dynamics of functional brain states. Using a system of Hopfield neural elements with heterogeneous structural connectivity given by the Macaque cortical network, we investigate the effect of removing directionality of connections on brain capacity, which we quantify via its ability to store attractor states. In addition to determining large numbers of fixed-point attractor sets, we deploy the recently developed basin stability technique in order to assess the global stability of such brain states as well as their robustness to non-small perturbations. By comparison with standard network models with the same coarse statistics, we find that directionality effects not only the number of fixed-point attractors but also the likelihood that neural systems remain in their most ‘desirable’ states. These findings suggest that directionality plays an important role in shaping transition routes between different brain networks states.

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Keywords: Neural networks, Dynamical systems, Computational neuroscience, Directionality, Basin stability

Structural Connectivity in Deafness: a Network-Based analysis.

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Deafness is usually accompanied by functional brain alterations that may be thought as an alteration to connectome scaffolding. The general goal of this study was to investigate brain structural network organization in early deaf subjects (ED) as result of cross-modal plasticity mechanisms. A total of 44 subjects participated in this study: 14 ED, 15 age and gender matched hearing controls (HC), and 15 age and gender matched hearing signers (HS). Full-brain diffusion-weighted images and T1 anatomical images were acquired with 4T Bruker Medspec MRI scanner. Data were corrected for eddy currents and head motion followed by bias field correction and global intensity normalization. Probabilistic spherical deconvolution was adopted to estimate fibre orientation distributions (FODs), which were used for generating whole brain Anatomically-Constrained tractograms. A template of 638 similarly-sized regions[1], was adopted for anatomical parcellation in each subject. Three connectomes were derived for each subject based on the following white matter edge metrics between each pair of parcellation nodes: sum of weighted tracks, mean length and mean fractional anisotropy (FA) of interconnecting tracks. Then Network-Based Statistics[2] and Graph Analysis were performed.
Network-based comparisons across groups showed significant reductions in ED relative to both HC and HS for mean FA ($p\text{-value}_{HC\text{-}ED}$ =0.003; $p\text{-value}_{HS\text{-}ED}$<0.001), mean length of interconnecting tracts ($p\text{-value}_{HC\text{-}ED}$ =0.002; $p\text{-value}_{HS\text{-}ED}$=0.003) and number of streamlines ($p\text{-value}_{HC\text{-}ED}$ =0.001; $p\text{-value}_{HS\text{-}ED}$=0.001). Network global efficiency was significantly reduced in ED compared to HC in both mean tract length ($t\text{-value}_{ED\text{-}HC}$ =-2.45 $p\text{-value}_{ED\text{-}HC}$ = 0.02) and number of streamlines ($t\text{-value}_{ED\text{-}HC}$ = -2.11 $p\text{-value}_{ED\text{-}HC}$ = 0.04) connectomes. No statistically significant differences were detected, either at network level or in graph metrics, between HC and HS. To the best of our knowledge, we identify for the first time white matter structural connectivity alterations in auditory sensory deprivation, using both network-level characteristics and graph indices.

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Keywords: structural connectivity, deafness, connectomics, graph analysis.

Time Resolved Intrinsic Community Assembly

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The field of resting state fMRI research aim at uncovering the intrinsic functional organization of the brain through the understanding of the properties of spontaneous coordinated fluctuations of the BOLD (Blood Oxygen Level Dependent) signal. We propose a novel method for analyzing the time resolved evolution of integration and segregation of resting state networks. **Method** Data consisted of 10 min rs-fMRI (TR=2s) from 27 children with low head motion. The BOLD-signal was decomposed into its three first intrinsic mode functions(IMFs) that were then used to explore potential differences in organizational principles in the frequency domain. Instantaneous phase synchrony analysis (IPSA)[1] was applied to find the phase difference matrix at each timepoint as well as the leading eigenvector. The latter was mapped onto the community structure revealed by the Louvain algorithm. The second IMF was used for deriving the most probable 8-node assemblies followed by clustering. The phase relationship between the sub-cluster nodes were evaluated as a function of time. **Results & Contributions** Assemblies where grouped into 33 clusters that to a large extent replicated known static RSNs. Based on pairwise tendencies to either integrate (assemble together simultaneously in phase in the same community) or segregate (assemble simultaneously in different communities and hence in relative anti phase to the other cluster) a meta structure was revealed dividing the clusters into four distinct groups. Cluster assemblies were relatively abrupt while disintegration was gradual with greater time lag between clusters from different meta-clusters. State evolution was gradual and continuous in contrast to the more commonly reported switching between discrete states[2]. Mean duration of assembly was ~8 s (IMF2). The three IMFs showed self-similarity in pairwise topological patterns and in relative frequency of assembly contradicting the common assumption that the first IMF mostly represents noise[3].

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Keywords: Resting state fMRI, time-resolved, state, integration, segregation

Effective connectivity of large scale resting state networks as well as of individual network nodes can differentiate patients with schizophrenia from controls; a spectral DCM application on resting state fMRI data

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We applied spectral dynamic causal modelling (spDCM; Friston et al., 2014) to analyze the effective connectivity differences between (a) large scale resting state networks of 25 patients with schizophrenia and 31 healthy controls, and (b) individual network nodes (i.e. DMN, SN and DAN, plus left and right hippocampus) from the same data set. Constrained ICA using the GIFT toolbox (Rachakonda et al., 2007) was first performed to obtain 14 resting state networks (Shirer et al., 2012). At the network level, patients showed increased connectivity e.g. from the sensorimotor network to the DAN, higher visual network, and the auditory network, but decreased connectivity from the sensorimotor network to the posterior SN. At the node level, patients showed increased connectivity from the left hippocampus to the dorsal anterior cingulate cortex, right anterior insula, left frontal eye fields and right inferior parietal sulcus, as well as increased connectivity from the right hippocampus to the left and right anterior insula, right frontal eye fields and right inferior parietal sulcus. Taken together, these results support effective connectivity as a valuable approach in differentiating resting state connectivity patterns between patients with schizophrenia and controls, potentially using these differences as diagnostic biomarkers.

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Keywords: spectral Dynamic Causal Modelling, resting state fMRI, schizophrenia, hippocampus

Prediction Of Mean Firing Rate Shift Induced By Externally Applied Oscillations In A Spiking Network Model

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One presumable role of neural oscillations is stabilization or destabilization of neural codes, which promotes retention of the encoded information [1]. We hypothesize that such function could stem from the ability of oscillations to differentially affect neural populations that actively retain information and those that stay in the background state [3]. To explore this mechanism, we considered a bistable excitatory-inhibitory network of leaky-integrate-and-fire (LIF) neurons with external sinusoidal forcing. The two steady states differ by their average firing rates and correspond to the active retention and to the background, respectively. We wanted to understand how periodic beta-band input affects time-averaged firing rates in both states. In order to address this question, we developed a method for semi-numerical prediction of the oscillation-induced average firing rate shifts. We found parameters, for which the oscillatory input produced an increase in the average firing rate of the excitatory population in the active memory state, but not in the background state. Our predictions were confirmed by spiking network simulations. Given the obtained results, we suggest that our method would be useful for further investigation of oscillatory control working memory or decision-making models.

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Keywords: computational neuroscience, spiking networks, working memory, oscillations

Investigating the Impact of Genetic Background on Brain Dynamic Functional Connectivity Through Machine Learning: A Twins Study

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Functional magnetic resonance imaging (fMRI) is a popular approach for understanding the functional connectivity of human brain. Recently, dynamic functional connectivity has been used to analyze connectivity variations on resting state fMRI. Here, we use task based fMRI (using the Poffenberger Paradigm) data collected in mono- and dizygotic twin pairs [1]. The task is to examine if the two groups of twins can be discriminated by using the dynamic connectivity, so to prove that genetic background has an effect on functional connectivity. To this aim, we have explored the dynamic connectivity patterns of task-relevant and task-orthogonal sub-networks using graph Laplacian representation [2] in combination with a metric defined on the space of covariance matrices to compute the similarity between twins' dynamics in the mental state. Linear SVMs with an unsupervised feature selection (Laplacian Score) [3] were then used to discriminate the two classes of twins. In this work, we addressed a discrimination task on classes of twins (monozygotic versus dizygotic) with the help of machine learning algorithms applied to the pairwise variability of dynamic functional networks.

In our approach we have used as features the time-series of distances between dynamic networks. Specifically, each pair of twins was represented by a sequence of differences between the dynamic connectomes. Linear SVMs have been then used to discriminate the two groups. To reduce the dimensionality of data we have also used the Laplacian Score [20] to perform an unsupervised feature selection. The results suggest that using a proper metric based on graph Laplacians of DFC matrices is valuable method to study the variability of brain regions' activations. The results of our study demonstrate that genetic influences on brain network profiles can be detected using the dynamic functional connectivity. In MZ twin pairs, the task-relevant visuomotor networks are more similar than they are in DZ twin pairs and this genetic difference is very useful to be used as a feature to classify a pair of twins either MZ or DZ. On the other hand, when considering only the task-orthogonal non-visuomotor network or whole network, they don't play significant role in terms of classification. These findings imply that Zygocity modulates the connectivity of task-relevant networks which can be used to distinguish the two groups.

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Keywords-Dynamic functional connectivity, SVM, feature selection, Connectomes, task-based fMRI, graph Laplacian

Towards an all-optical system to investigate insect brain connectivity

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We present our first results in building an all-optical setup to perform two-photon calcium imaging on optogenetically activated neurons: the goal is to add optogenetics to our experimental two-photon imaging platform and apply this technique to different models, starting with cell cultures, testing a genetically modified zebrafish line, to arrive performing experiments with transgenic fruit fly *Drosophila melanogaster* and subsequently with honeybee *Apis mellifera* at the level of the primary olfactory processing brain centers, the antennal lobes.

Insect brains are an important model in neurobiology, thanks to their small sizes, tight structures, but rich performances. We use two-photon calcium imaging to study morphology and functions of the insect olfactory system in order to investigate various aspects of information coding [1][2]. Optogenetically activating specific nodes of the antennal lobes will allow modulating neuronal activity with high selectivity and precision both in the temporal and spatial domain, permitting a further investigation of stimuli elaboration process.
The key point of our setup is an all-optical approach, consisting in a light induced neuronal activation and a two-photon imaging record of the neuronal activity; for this porpouse a 473 nm activation laser is overlapped with the infrared imaging beam. Using this approach it is possible to study the connectivity on a larger scale with respect to other setups like the electrophysiological ones, and at the same time more precisely with respect to the ones using unspecific light activations.

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Keywords: calcium imaging, optogenetics, two photon, olfactory system, insect brain