GABA 1ST Scientific Workshop,

May 28-30, 2008, Tampere, Finland

ABSTRACTS OF PRESENTATIONS

Workpackage 1: Functional connectivity

Wednesday, May 28, 2008
10:30 – 11:00
Title: "Current status of WP1"
Speaker: Mario CHAVEZ
Institution: Centre National de la Recherche Scientifique (CNRS), Paris, France

Wednesday, May 28, 2008
11:00 – 11:30
Title: "Disentangling the modular structure of functional brainwebs"
Speaker: Miguel VALENCIA
Institution: Centre National de la Recherche Scientifique (CNRS), Paris, France
Abstract: Modular structure is ubiquitous among complex systems. Presumably shaped by evolutionary constraints, it underlies the function ally of most complex networks ranged from social to biological networks. Here we analyze the community (modular) structure of the human brain, one of the most challenging biological networks in nature. Specifically, we study the community structure of the functional brain networks extracted from functional magnetic resonance imaging (fMRI) signals. We unveil the modular structure of the human brain networks and show that communities present a spatial distribution that corresponds to anatomical structures with functional significance. The existence of brain communities leads us to study the roles of the modules' constituents. We classify these roles based on its pattern of inter– and intra–community connections, which enables us to obtain scale-specific representations of the network. We consider that the detected architecture constitutes the structural basis for the coexistence of functional segregation and functional integration, in terms of combining local and global levels of information process. We suggest that such a modular structure arises as a result of optimizing between structural and functional constraints, but also in order to achieve stability, robustness and adaption to changing environments.

Wednesday, May 28, 2008
12:00 – 12:30
Title: "Time-frequency small-world behavior in human brainwebs"
Speaker: Mario CHAVEZ
Institution: Centre National de la Recherche Scientifique (CNRS), Paris, France
Abstract: There is a growing interest in studying the role of connectivity patterns on brain functions. In recent years, functional brain networks were found to exhibit small-world properties during different brain states. Time-independent networks are currently recovered from long time periods of brain activity. Here we propose an approach, the event-related networks, which allows to characterize the dynamical evolution of functional brain networks on the time-frequency space. We illustrate this approach by characterizing connectivity patterns in magnetoencephalographic signals recorded during a visual stimulus paradigm. When compared with equivalent random and regular networks, results reveal that the functional connectivity varies in time and frequency during the processing of the stimulus, while maintaining a small-world structure. This approach may provide new insights into the connectivity of other complex, spatially extended, nonstationary systems.

Workpackage 2: "Abnormal synchronization"

Wednesday, May 28, 2008
12:30 – 12:45
Title: Current status of WP2
Speaker: José Luis CANTERO
Institution: Laboratory of Functional Neuroscience, Universidad Pablo de Olavide (UPO), Seville, Spain

Wednesday, May 28, 2008
12:45 – 13:30
Title: "Functional connectivity during encoding predicts subsequent memory"
Speaker: Mercedes ATIENZA
Institution: Laboratory of Functional Neuroscience, Universidad Pablo de Olavide (UPO), Seville, Spain
Abstract: Semantic knowledge enhances memory for knowledge about the world (semantic memory) and memory for episodes related to one's own experiences (episodic memory). However, the neural bases of semantic encoding that might predict subsequent retrieval of semantic and episodic information are poorly understood. To investigate this topic, we examined EEG oscillations during processing of famous faces that were preceded either by autobiographical cues or biographical cues from other celebrities. The former were designated as 'primed faces' and the latter as 'unprimed faces'.

We evaluated whether changes in functional coupling associated to encoding of primed and unprimed famous faces could predict behavioral benefits on the outcome of a later task either testing conceptual priming or spatial location of faces. For the assessment of intra- and interhemispheric functional connectivity, we used the Phase Lag Index (PLI), a measure of the asymmetry of the distribution of phase differences between two signals. Contrary to other synchronization measures, the PLI is much less affected by volume conduction and/or active reference electrodes. Results revealed that different patterns of functional connectivity correlated with performance under conditions of semantic and episodic retrieval. The parieto-occipital area of the right hemisphere became coupled with different structures of the two hemispheres within different frequency bands (high-theta, high-alpha and gamma) during encoding success of episodic retrieval between 500-900 ms after stimulus presentation. On the contrary, improved accuracy and speed during conceptual priming were associated to earlier long-distance interhemispheric patterns of theta phase coupling and decoupling at encoding. All together, these findings suggest that different global patterns of functional connectivity during semantic encoding determine the extent to which an item will be subsequently retrievable from the semantic and episodic memory systems.

Wednesday, May 28, 2008
15:00 – 15:30
Title: "Modeling synchronization loss in large-scale brain dynamics"
Speaker: Antoni PONS
Institution: Universitat Politècnica de Catalunya (UPC), Barcelona, Spain
Abstract: We study a neural mass model focusing our attention in the synchronization loss produced when connectivity in the brain is reduced. The neural mass model, presented recently by Sotero et al., is able to reproduce realistically the different rhythms observed in EEG experiments making feasible the comparison of the model results and experimental measurements. The connectivity parameters used in the model are related to the experimental reduction of local cortical thickness measured by MRI. Our aim is to connect quantitatively the EEG signal and the cortical thickness degradation observed in Alzheimer's patients. The preliminary comparison of experiments and model results is shown.

Wednesday, May 28, 2008
15:30 – 16:00
Title: "Measuring directional connectivity between EEG sources: application to early detection of Alzheimer's disease"
Speaker: Germán GÓMEZ-HERRERO
Institution: Tampereen Teknillinen Yliopisto (TTY), Tampere, Finland
Abstract: Directional connectivity in the brain has been typically computed between scalp electroencephalographic (EEG) signals, neglecting the fact that correlations between scalp measurements are partly caused by volume conduction through the brain tissues and the skull. Although recently proposed techniques are able to identify causality relationships between EEG sources rather than between recording sites, most of them need a priori assumptions about the cerebral regions

involved in the EEG generation. In this talk we present a novel methodology based on multivariate autoregressive (MVAR) modeling and Independent Component Analysis (ICA) able to determine the temporal activation of the EEG sources and their approximate intracerebral locations. The direction of synaptic flow between these EEG sources is then estimated using the directed transfer function (DTF), and the significance of directional strength evaluated with surrogated data. An extensive set of simulations showed the superior accuracy of this procedure with respect to several competing approaches. The validity of the novel approach was also evaluated with the analysis of the EEG alpha rhythm recorded from 20 volunteers under resting conditions, which revealed alpha generation mechanisms in agreement with previous findings in the literature. All together, these results confirm the validity of the proposed approach and suggest the potential of the obtained connectivity measures for early prediction of neurodegenerative disorders that damage functional connectivity in the brain. We explored this possibility by studying the integrity of thalamocortical circuits in patients with mild cognitive impairment (MCI). We found that synaptic flow underlying the lower alpha band (7.5-10 Hz) was abnormally facilitated in MCI patients as compared to healthy individuals. On the contrary, thalamocortical transmission for the upper alpha subdivision (10.1-12.5 Hz) was significantly decreased in MCI patients. These results indicate that functional damage of thalamocortical networks differentiates individuals at high risk of developing Alzheimer's disease from healthy aging.

Workpackage 3: "Connectivity topology"

Thursday, May 29, 2008
10:15 – 10:30
Title: "Current status of WP3"
Speaker: Gianni GIACOMELLI
Institution: Consiglio Nazionale delle Ricerche (CNR), Firenze, Italy

Thursday, May 29, 2008
10:30 – 11:15
Title: "Phase Synchronization in real data: application to epilepsy and memory formation"
Speaker: Anna POMYALOV
Institution: Weizmann Institute of Science, Rehovot, Israel
Abstract: I will discuss an application of phase synchronization techniques to different sets of neurophysiological data. I will address practical issues of an efficient choice of synchronization indexes for the particular data and will illustrate them on two different datasets: ECoG from epileptic patients and EEG in memory formation experiments. The main goal of the analysis of ECoG data was to localize the foci of epileptic seizures. We found that the focal areas statistically preserve an elevated degree of synchronization at all times. Moreover, these areas demonstrate a distinct increase in synchronization

shortly after the seizure onset. This signature may allow to distinguish between genuine focus and the areas that appear focal, but are actually driven by the real focus. If confirmed on a larger number of patients, these results may be useful to help improve the surgical treatment of epilepsy. Another project, that is conducted in collaboration with Seville group, is related to the study of memory formation with application to early diagnostics of the propensity to Alzheimer Disease. To identify the ``healthy'' memory formation patterns, at the present stage we have studied a group of young subjects. The main goal of the current experiment was to study the effect of ``priming''. We have reformulated a phase Lag Index for the EEG data, recorded in these experiments. The results suggest the presence of particular functional connectivity patterns corresponding to the encoding and retrieval of different kinds of memory.

Thursday, May 29, 2008
11:15 – 11:45
Title: "Precise firing sequences in coupled neural networks"
Speaker: Olga CHIBIROVA
Institution: Université Joseph Fourier (UJF), Grenoble, France.
Abstract: We simulated the activity of two hierarchically organized spiking neural networks characterized by an initial developmental phase featuring cell death (apoptosis driven by excessive firing rate), followed by spike timing dependent synaptic plasticity in presence of background noise. The upstream network received a spatiotemporally organized external input and the downstream network received an external input only from the upstream network. Precise firing sequences formed by recurrent patterns of spikes intervals above chance levels were observed in all recording conditions. These emerging firing patterns suggest the build-up of a connectivity, out of initially randomly connected networks, able to sustain temporal information processing. The downstream network, in particular when receiving a divergent connectivity from the output layer of the upstream network, was characterized by a larger impact of synaptic pruning that left less active cells. However, the relative frequency of precise firing sequences was larger in such downstream network and the dynamics of the patterns suggested the emergence of a hierarchically activity driven connectivity.

Workpackage 4: "Connectivity dynamics"

Thursday, May 29, 2008
12:00 – 12:15
Title: "Current status of WP4"
Speaker: Alessandro VILLA
Institution: Université Joseph Fourier (UJF), Grenoble, France.

Thursday, May 29, 2008

12:15 – 12:45

Title: "Relaying in the brain: a robust mechanism implementing zero time-lag long-distance synchronization of neuronal activity"

Speaker: Claudio MIRASSO

Institution: Universitat de les Illes Balears, Spain

Abstract: Multi-electrode recordings have unveiled observations of zero time-lag synchronization among remote cerebral cortical areas during the last 20 years. However, the transmission delays associated with axonal conduction among such distant regions can amount to several tens of milliseconds. It is still unclear which mechanism is giving rise to isochronous discharge of widely distributed neurons, despite of such latencies. Here we investigate the synchronization properties of a simple network motif densely embedded within the cortico-thalamic circuitry and found that, even in the presence of large axonal conduction delays, distant neuronal populations self-organize into lag-free oscillations. According to our results the relaying of cortical activity provided by the associative nuclei of the thalamus represents an ideal circuit to circumvent the phase-shifts and time-lags associated with transmission delays. This is in line with the recently proposed enhancement of large-scale cortical communication via these associative nuclei.

Thursday, May 29, 2008

12:45 – 13:15

Title: "Effect of feedback strength in coupled spiking neural networks"

Speaker: Javier IGLESIAS

Institution: Universitat Politècnica de Catalunya (UPC), Barcelona, Spain

Abstract: We simulated the coupling of two large spiking neural networks (104 units each) composed by 80% of excitatory units and 20% of inhibitory units, randomly connected by projections featuring spike-timing dependent plasticity, locality preference and synaptic pruning. Only the first network received a complex spatiotemporal stimulus and projected on the second network, in a setup akin to coupled semiconductor lasers. In a series of simulations, the strength of the feedback from the second network to the first was modified to evaluate the effect of the bidirectional coupling on the firing dynamics of the two networks. We observed that, unexpectedly, the number of neurons which activity is altered by the introduction of feedback increases in the second network more than in the first network, suggesting a qualitative change in the dynamics of the first network when feedback is increased.

Thursday, May 29, 2008

13:15 – 13:30

Title: "Data analysis web portal"

Speaker: Javier IGLESIAS

Institution: Universitat Politècnica de Catalunya (UPC), Barcelona, Spain

Thursday, May 29, 2008
14:30 – 15:00
Title: “Reconstruction of underlying nonlinear deterministic dynamics embedded in noisy spike train”
Speaker: Alessandro VILLA
Institution: Université Joseph Fourier (UJF), Grenoble, France.
Abstract: The time series formed by the exact times of occurrence of the neuronal spikes are referred to as "spike train". An experimentally recorded spike train includes observational noise that can include points that were not produced by the recorded neuron but due to some complex external noise process (*e.g.*, electrical artifacts, errors in the spike sorting procedure). Another type of noise corresponds to those spikes generated by the recorded neuron that were missed during the observation. This study presents a procedure aimed at denoising the spike trains in order to open the way to investigate the presence of underlying deterministic dynamics. The procedure is based on applying a method of detecting recurrent temporal patterns of spikes (Pattern Grouping Algorithm, PGA) which are used to form a reconstructed spike train. Three new indices are defined and the performance of the denoising effect of PGA is tested with several types of noise on time series generated by the attractors of the Zaslavskii and Ikeda mappings and the Chen's equation. The decrease in the ratio of spurious spikes improved the relative performance of the denoising procedure more than a decrease in the ratio of deleted spikes. This tendency was consistent in all three dynamical systems examined in this study. The results suggest that a strict criterion for the detection of spikes in experimental time series, thus reducing the number of spurious spikes, may raise the possibility to apply PGA to detect endogenous deterministic dynamics in the spike train otherwise masked by the observational noise.

Workpackage 5: “Signal integration”

Thursday, May 29, 2008
15:00 – 15:30
Title: “Current status of WP5”
Speaker: Wolf SINGER / Gordon PIPA
Institution: Max-Planck-Institut fürHirnforschung (MPIH), Frankfurt, Germany

Thursday, May 29, 2008
15:30 – 16:00
Title: "Unveiling causal relationships in simultaneous recordedneurophysiological data"
Speaker: Raúl VICENTE
Institution: Max-Planck-Institut für Hirnforschung (MPIH), Frankfurt, Germany

Abstract: The functional connectivity of the brain describes the network of statistically correlated activities of different brain areas. However, as it is well known correlation does not imply causality and most of synchronization measures are not able to distinguish context-dependent causal interactions among remote brain areas, i.e.to determine the so-called effective connectivity. This type of effective or causal brain networks is a fundamental step in unveiling the neural circuitry of brain areas and its directed interactions involved in the processing of information. In this talk I will present the use of the transfer entropy concept to establish the effective connectivity of healthy human brains under a simple Simon task from MEG measurements with a view to test the validity of this approach in neuroimaging techniques. The formalism of transfer entropy, based on information theory, has recently been proposed as a rigorous quantification of the information flow among several systems in interaction and it is the natural generalization of the well-known mutual information. In the experiment the subjects are presented with an "L" or "R" letter in either the left or the right side of a screen and instructed to press a left-side key in response to the "L" letter and the right-side key in response to the "R" letter, independently of the spatial location of the stimulus. The data were collected with a whole-head 275channels CTF-MEG scanner at a temporal resolution of 1.2 kHz. After appropriate preprocessing and artifact rejection of the MEG data, the transfer entropy between all possible pairs of channels was computed with a Kozachenko-Leonenko estimator while the statistical significance of the causal interactions was determined by a non-parametric permutation test. The flow of information revealed that different neuronal circuits (including long-range causal influences as interhemispheric temporal lobe interactions) are recruited for the four different experimental conditions ("L" letter on the left side, "R" letter on the right side, "L" letter on the right side, and "R" letter on the left side) during the processing of the visual stimulus and production of the appropriate motor response, in accordance to the physiologically expected predictions. The effective networks of Simon versus non-Simon effect conditions (the first two conditions versus the last two) are also compared and analyzed in basis to advance in the use of effective connectivity as a tool to better understand and classify different cognitive processes.

Friday, May 30, 2008
10:15 – 10:45
Title: “Contour integration in human and monkeys”
Speaker: Gordon PIPA
Institution: Max-Planck-Institut für Hirnforschung (MPIH), Frankfurt, Germany
Abstract: We present a new contour integration paradigm that we use to study synchronisation of neuronal activity in human subjects and behaving monkeys. We present the basic ideas and discuss crucial properties of the experimental paradigm. We also present first results obtained by psychophysics with 12 human subjects. In as second part of the talk we present the full chain of our multi level procedure for optimising stimuli for each recording session. As one part of this chain we present a very efficient and robust method for identifying receptive fields with a spline-based regression, that were developed as part of the EU-Project GABA.

Friday, May 30, 2008
10:45 – 11:15
Title: "Synchronizability of coupled logistic maps in the presence of communication delays: influence of the topology and the connectivity"
Speaker: Cristina MASOLLER
Institution: Universitat Politècnica de Catalunya (UPC), Barcelona, Spain
Abstract: We study the synchronizability of a network of coupled logistic maps, i.e., its propensity for synchronization, focusing on the roles of the connectivity, the topology, and the communication delay times. We consider five network topologies: scale-free, small-world, nearest-neighbor (with and without a central node), and a star-type topology. The delay times associated with the links are either heterogeneous or homogeneous. We study the influence of the connectivity of the network, measured in terms of the average number of links per node, and the coupling strength among the nodes. With weak connectivity and weak coupling the network displays an irregular oscillatory dynamics that is rather independent of the topology and the delay distribution. For large enough connectivity and coupling, the synchronization is mainly determined by the delays: when the delays are homogeneous the network exhibits collective synchronous oscillations; when the delays are heterogeneous, the network synchronizes in a steady-state. We analyze the effect of self-feedback links in each node, and show that they tend to enhance synchronizability when the delays are heterogenous and the connectivity is low.

Workpackage 6: "Generalisability"

Friday, May 30, 2008
11:30 – 11:40
Title: "Current status of WP6"
Speaker: Jordi GARCIA-OJALVO
Institution: Universitat Politècnica de Catalunya (UPC), Barcelona, Spain

Friday, May 30, 2008
11:40 – 12:05
Title: "Synchronization Properties of Network Motifs with Delayed Coupling"
Speaker: Ingo FISCHER
Institution: Heriot-Watt University, Edinburgh, UK
Abstract: We present studies of the synchronization properties of small networks of delay-coupled elements that can be considered general Network Motifs. Using the simplest examples of Kuramoto

phase oscillators we discuss the properties arising from the symmetries of different coupling geometries. We consider in particular unidirectionally coupled rings, bidirectionally coupled rings and open chains of oscillators, for which we analyze the existence and stability of in-phase and the out-of-phase solutions. In the unidirectional ring the delay mainly acts as inducer of multiple but similar branches of solutions (in-phase and out-of-phase). In the dynamics of bidirectionally-coupled rings the most symmetric solution is found to be more probable than other solutions due to the introduction of the coupling delay. Using lasers as oscillators we particularly study the dynamical behavior of N unidirectionally delay-coupled elements distributed along a ring configuration. We demonstrate that cascading nonlinear elements within a ring of fixed total propagation delay results in a simple scaling behavior of the correlation properties. In fact, the correlation properties of a ring with N elements can be deduced from the autocorrelation of the single delayed feedback system. Moreover, we find that by injecting the output of one of the elements of the ring into a unidirectionally coupled chain of identical lasers, we achieve complete synchronization between lasers of the chain and a ring with a coupling signal showing neither correlation nor mutual information with the synchronized dynamics.

Friday, May 30, 2008
12:05 – 12:30
Title: "Nonlinear response of a chaotic system as a tool for understanding collective behavior"
Speaker: Giovanni GIACOMELLI
Institution: Consiglio Nazionale delle Ricerche (CNR), Firenze, Italy
Abstract: The response of a nonlinear, chaotic dynamical system to an arbitrary modulation is analyzed both theoretically and experimentally in a regime where there is any type of (generalized) synchronization. In the experiment, a diode laser is optically injected and tuned in a chaotic regime and the pump current is modulated with a pulse generator with different shapes. We show that although the single response is chaotic and seemingly uncorrelated with the input signal, the average output is different from zero and synchronized with the input signal. A similar setup is analysed in the context of simple dynamical systems such as the Roessler model, and for the iteration of both tent and logistic maps. A theoretical framework for understanding such results is provided by the Frobenius-Perron operator formalism, which is explicitly implemented in the case of tent maps. The existence of a non-zero average output represents the key ingredient to understand the onset of collective phenomena in ensembles of chaotic systems.