coneural
Centre for Cognitive and Neural Studies, Cluj-Napoca

UNIVERSITATEA TEHNICĂ CLUJ-NAPOCA

FIAS
Frankfurt Institute for Advanced Studies
Frankfurt a.M. Germany

Brain Day

An introduction to neuroscience: Experiment, theory and modeling.
Cluj-Napoca, 19th January, 2005, 10:00 – 14:00.

Program:

- **Gordon Pipa**, *Frankfurt Institute for Advanced Studies (FIAS) & Max Planck Institute for Brain Research, Frankfurt, Germany.*

  Theory meets experiment : 'Evaluation of Joint-Spike Events of higher complexities in time series data from multi-electrode recordings.'

- **Andrei C. Miu**, *The Cognitive Neuroscience Program, Department of Psychology, Babeş-Bolyai University, Cluj-Napoca, Romania.*

  Behavioral Neuroscience and Brain Lession Studies.

- **Raul C. Mureşan**, *Coneural Cluj-Napoca, Frankfurt Institute for Advanced Studies (FIAS), Technical University Cluj-Napoca.*

  Computers challenging the brains. A losing battle?

The symposium is scheduled for the 19th of January 2005, at the Automation and Computer Science Faculty, the Technical University of Cluj-Napoca, G. Baritiu street 26-28. The lectures will be presented in amphitheatre no. 40, from 10:00 to 14:00.

* The official language is English.

Theory meets experiment : 'Evaluation of Joint-Spike Events of higher complexities in time series data from multielectrode recordings.'

Gordon Pipa
Frankfurt Institute for Advanced Studies
Max Planck Institute for Brain Research, Frankfurt a.M., Germany

The importance of synchronous and oscillatory neuronal firing for the coding of information by neuronal networks has been intensively discussed during recent years. To test this hypothesis we performed simultaneous recordings with up to 16 micro-electrodes in the prefrontal cortex of monkeys, while they were performing a delayed matching to sample task. The task is composed of three periods. During the sample presentation (500ms) the monkey is presented one out of 20 visual stimuli. During the delay period (3sec) the monkey has to memorize the stimulus and has to compare it to the one presented during the test period (more than 500ms). The monkey has to indicate a match or non-match condition by pressing one of two buttons. This allows us studying encoding, memory, recall/ rehearsal processes as well as motor preparation.

To study oscillatory activity we estimated the Power of the LFP signal. Phase-Locking was used to asses the Coupling between recorded sites in different frequency bands. And the Analysis of Joint-Spike events were performed to describe synchronous spiking activity. To assess variability and trends of the estimates Power, Phase Locking and Joint-Spike Events we used Bootstrapping and d-Jacknife techniques. Each Bootstrap estimation is based on 10 sub-samples of the full data set consisting of 75% of the trials. 6 of 10 are based on randomly selected trials, which allow estimating variability. The remaining 4 are used to consider variability given by systematic changes during the experiment and are consisting of data systematically lacking one quarter of the trials. Based on this variability estimation the statistical significance between different conditions had been assessed. Using this conservative statistical method only effects with are stable as well as reliable are assumed to be statistical significant.

Here we present that oscillatory activity and phase relations between different sites in the frequency band from 5 to 60 Hz as well as precise correlation of spike times (precision at least 5 ms) from different cites are strongly correlated to the monkey's behaviour and the encoded information. We show that the power of oscillatory activity in correct trials in the frequency band from 15 to 60 Hz is increased during the first 500 ms of delay and rehearsal period of the task, while the phase coupling is increased during encoding as well as in the two periods the power is increased, too. In contrast to this observation based on mass activity of a huge number of cells, activity of individual neurons shows significantly more interaction only during the encoding, test and motor preparation period.

We conclude that precisely synchronized spike discharges, oscillatory activity and phase locking between sites can be observed in memory-related activity of many prefrontal neurons and is modulated by the task. Results indicate that information is based on interactions of large neuronal populations, although task related mass activity does not have to be correlated with the firing of individual sites, indicating that neurons embedded in neuronal populations can still be very specific compared to the surrounding mass activity. Supported by the VW-Stiftung.

Behavioral neuroscience and brain lesion studies

Andrei C. Miu
The Cognitive Neuroscience Program, Department of Psychology, Babeş-Bolyai University, Cluj-Napoca, Romania

Behavior is the overt expression of the covert neural activity. The mechanisms underlying this relationship have been investigated at several levels of organization, that is, from genes to brain circuits, using anatomical, physiological and pharmacological, and behavioral paradigms. Although traditional neural and behavioral sciences have evolved as independent disciplines supported by encapsulated professional communities until the last decades of the twentyeth century, they have merged in the late 1970's into a multidisciplary domain known today as neuroscience, with the realization that the understanding of the behavioral brain is a challenge that needs an integration of efforts and approaches from several disciplines. Neuroscience framed the collaboration between those neurophysiologists who had developed methods to lesion the brain and those psychologists who had invented paradigms to observe and quantify the behavior of animals in experimental settings. Both disciplines have contributed equally to the new field because neither brain surgery, nor measuring behavior is a simple matter. It was to be realized later that neither one of these approaches could have evolved further without the other because one needed methods to study the loss of function promoted by the lesion, and the other needed a manipulation of the wet brain that could anchor behavior to the brain. Both neurophysiologists and psychologists have initially acknowledged that the functions of the brain can be localized in a particular brain structure or circuit. Although this thesis has often been absolutized, it has nonetheless proven useful. We will present some principles of sterotaxic surgery, that is, the means by which we produce controlled lesions of the brain, and complementary behavioral methods that allow us to study the resulting functional modifications.

Computers challenging the brains. A losing battle?

Raul C. Mureşan
Frankfurt Institute for Advanced Studies, Frankfurt a.M., Germany
Universitatea Tehnică Cluj-Napoca, Facultatea de Automatizări şi Calculatoare

What is going on inside our heads? Can we ever understand how we think, can we understand how we understand? It seems that brain research is the challenge of challenges, it is the will to understand who we are. As science advances, it became more and more clear that brain research is one of the most complex sciences, that the function of the brain could only be revealed by extensive interdisciplinary research, ranging from molecular biology to experimental procedures, computer science, advanced physics and chemistry.

It seems the complexity of brains surpasses any imagination as it is already acknowledged that not even the most advanced methods from theoretical sciences such as physics can provide tools for unraveling what brains do. So where do we go from here? Can computer science and theoretical neuroscience help us? The answer is yes, as a new field of research emerged in recent years: computational neuroscience.

We will discuss why computers as we know them today, are very different from brains and why artificial intelligence, in its present form is still so far away from the "real intelligence" of brains. Real world environments pose enormous difficulties to artificial systems while the brains are naturally developed to handle our daily universe. What are the principles underlying such capabilities of brains, and why "wetware" is much better than "hardware"?

Finally, we will describe some aspects of modeling, especially fundamental modeling. The process of modeling brains on computers seems to be more and more appealing since basic information theory could be applied also to brains. Surprising results show that brains behave like autonomous universes, that the complicated processes inside our heads can be related to chaos, self organization of systems and causality. It seems brains are behaving in a very un-intuitive special way and their complexity cannot be traced down only to computational or molecular mechanisms. The brains are neither computers, nor simple aggregates of biological matter. The brain is the most beautiful system of them all.