Dynamic Brain Forum (DBF)

Carmona (Seville, Spain)

September 3-6, 2012

Scientific and Social program

September 3

- Registration (at the hall of room ***Arcos*** of the hotel ***El Parador***) will run from 18:00 to 20:00.
- Reception ceremony and cocktail/buffet will start at 20:30 (at the ***patio Mudéjar*** of the hotel ***El Parador***).

September 4

(Scientific sessions will take place at the room *El Torreón* of the hotel *El Parador*)

- 9:00-11:00. Scientific Session 1. Discussant: Dr. Minoru Tsukada.
Speakers:
1. *Towards a computational psychiatry*. Dr. Péter Érdi, Hungarian Academy of Sciences, Budapest, Hungary.
2. *New technologies for delivering multifocal transcranial current stimulation*. Dr. Giulio Ruffini, Starlab, Barcelona, Spain.
3. *An essay on extracellular field contributions to a globally conscious brain*. Dr. Emmanuelle Tognoli, Florida Atlantic University, Boca Raton, Florida, USA.

- 11:00-11:30. Coffee break.

- 11:30-13:30. Scientific Session 2. Discussant: Dr. Walter Freeman.
Speakers:
1. *Neural systems with dynamic synapses: emerging phenomena and computational consequences*. Dr. Joaquín J. Torres, University of Granada, Granada, Spain.
2. *Information in the variability of neural responses*. Dr. Guglielmo Foffani, Hospital Nacional de Parapléjicos, Toledo, Spain.
3. *Etching syntactic rules into cortical latching dynamics*. Dr. Sahar Pirmoradian, SISSA, Trieste, Italy.

- 13:30-16:00. Lunch and rest time (at the **dining room** of the hotel ***El Parador***).

- 16:00-18:00. Scientific Session 3. Discussant: Dr. Barry Richmond.
Speakers:
1. *Reward inference by primate prefrontal and striatal neurons*. Dr. Masamichi Sakagami, Tamagawa University, Tokyo, Japan.
2. *Taking advantage of outcomes to make successful decisions*. Dr. Carlos Acuña, University of Santiago, Santiago de Compostela, Spain.
3. *The problem of causation in complex brain dynamics.* Dr. Hans Liljenstrom, Dept. of Energy and Technology, SLU, Uppsala, Sweden.

- 18:00-20:00. Poster session will take place at room ***Arcos*** of ***El Parador***. Coffee will be available during the session.

- 21:00-23:00. Dinner (at the ***El Molino de la Romera*** restaurant; located at 100 m from the hotel ***El Parador***).

- 23:00. Flamenco concert (at the ***El Molino de la Romera*** theater room).

September 5

(Scientific sessions will take place at the room *El Torreón* of the hotel *El Parador*)

- 9:00-11:00. Scientific Session 4. Discussant: Dr. Robert Kozma.
Speakers:
1. *The super-Turing computational capabilities of evolving recurrent neural networks involving only finitely many synaptic levels*. Dr. Jérémie Cabessa, Neuroheuristic Research Group, University of Lausanne, Lausanne, Switzerland.
2. *Brain functional connectivity: tools for the assessment of multivariate synchronization*. Dr. Francisco del Pozo, Center for Biomedical Technology (CTB), Madrid, Spain.
3. *The quest for general functional principles in brains and machines: the case of the excitation/inhibition ratio*. Dr. Alberto Ferrús, Instituto Cajal, CSIC, Madrid, Spain.

- 11:00-11:30. Coffee break.

- 11:30-13:30. Scientific Session 5. Discussant: Dr. Edgar Koerner.
Speakers:
1. *Synchronization of the brain oscillation within a brain and over brains for self-referential cognitive process*. Dr. Yoko Yamaguchi, RIKEN Brain Science Institute, Tokyo, Japan.
2. *Computational modeling of mental state dynamics for interactive play with child*. Dr. Tasaki Omori, Tamagawa University, Tokyo, Japan.
3. *Neural population representation hypothesis of visual flow and its illusory after effect in the brain: psychophysics, neurophysiology and computational approaches*. Dr. Hide-aki Saito, Faculty of Engineering, Tamagawa University, Tokyo, Japan.
4. *Mechanism of gain modulation in multimodal networks for spatial development*. Dr. Alexandre Pitti, Université de Cergy-Pontoise, Cergy-Pontoise, France.

- 13:30-16:00. Lunch and rest time (at the **dining room** of the hotel ***El Parador***).

- 16:00-17:30. Scientific Session 6. Discussant: Dr. Shigetoshi Nara.
Speakers:
1. *Spontaneous and evoked neural activities shaped through a sequential learning process*. Dr. Tomoki Kurikawa, Department of Basic Science, University of Tokyo, Tokyo, Japan.
2. *Learning and decisions as functional states of cortical circuits*. Dr. Agnès Gruart, Pablo de Olavide University, Seville, Spain.
3. *Convergent measures of abstract spatial coding in hippocampus*. Dr. Jan Lauwereyns, Kyushu University, Japan.

- 17:30-20:00. Poster session will take place at room ***Arcos*** of the hotel ***El Parador***. Coffee will be available during the session.

- 21:00-23:00. Closing Dinner (at the ***Salón Bermejo*** of the hotel ***El Parador***)

September 6

(Scientific sessions will take place at the room *El Torreón* of the *El Parador*)

- 9:00-11:00. Scientific Session 7. Discussant: Dr. Hiroshi Fujii.
Speakers:
1. *Ensemble coding for voluntary movements in rat primary and secondary motor cortices*. Dr. Yoshikazu Isomura, Brain Science Institute, Tamagawa University, Tokyo, Japan.
2. *Red nucleus neurons actively contribute to the acquisition of an associative learning task in behaving rabbits*. Dr. José M. Delgado-García, Pablo de Olavide University, Seville, Spain.
3. *Effect of emotion and personality on deviation from purely rational decision-making*. Dr. Alessandro E.P. Villa, Neuroheuristic Research Group, University of Lausanne, Lausanne, Switzerland.
4. *Chaotic itinerancy in dynamically coupled brains*. Dr. Ichiro Tsuda, Hokkaido University, Sapporo, Japan.

- 11:00-12:00. General Discussion and closing ceremony.

Financial support:

- El Colegio de América (Seville, Spain)
- Excmo. Ayuntamiento de Carmona (Seville, Spain)
- Global COE Program
- Grant-in Aid for Scientific Research on Innovative Areas
- Human Frontier Science Program
- Pablo de Olavide University, Seville (Spain)

Towards a computational psychiatry

Péter Érdi

Henry R. Luce Professor of Complex Systems Center for Complex System Studies, Kalamazoo College, Kalamazoo, MI and Wigner Research Centre for Physics, Hungarian Academy of Sciences, Budapest (Hungary)

Computational psychiatry (and neurology) seems to be an emerging field growing up from computational neuroscience. Psychiatric (and neurological) disorders are treated now by somewhat independent concepts, such as structural disconnectivities, pathological neural activities (arrhythmia), and reduced functional performance (e.g. aberrant computation). The lecture will review the main trends and offers some integrative strategies and give some hints towards a dynamical theory of schizophrenia.
The lecture discusses the following topics:
- Computational Psychiatry: Do We Need It?
- Functional Disconnectivities
- Patholophysiological Activities
- Pathological Brain Rhythms and Dynamical Neuropharmacology
- Aberrant Decision Making
- Systems-theoretical Approach to Schizophrenia

NOTES:

New technologies for delivering multifocal transcranial current stimulation

Ruffini, G.[1], Dunne, S.[1], Mitjà, G.[1], Farrés, E.[1], Ray, C.[1,6], Garcia, M.1, Soria-Frisch, A.[1], Mollfulleda, A.[1], Grau, C.[1,5], Pascual-Leone, A.[7,1], Miranda, P. C.[4,9], Salvador, R.[4], Mekonnen, A.[4], Molaee-Ardekani, B.[1,2], Wendling, F.[2], Merlet, I.[2], Márquez Ruiz, J.[8] and Delgado García, J.M.[8]

[1]Starlab Barcelona, Barcelona (Spain); [2]INSERM, U642, Rennes, F-35000 (France); [3]Université de Rennes 1, LTSI, F-35000 (France); [4]Inst. of Biophysics and Biomedical Eng., Faculty of Science, U. of Lisbon (Portugal); [5]Neurodynamics Laboratory, Psychiatry and Clinical Psychobiology Department, U. of Barcelona; [6]Department of Physics, Saint Mary's College - Moraga, CA (USA); [7]Berenson-Allen Center for Noninvasive Brain Stimulation, Beth Israel Deaconess Medical Center and Harvard Medical School; [8]Dpto. Fisiología, Anatomia y Biología Celular, División de Neurociencias, U. Pablo de Olavide, Sevilla (Spain); [9]Neuroelectrics Barcelona (Spain)

Transcranial current brain stimulation (tCS) is a family of related non-invasive brain stimulation techniques including direct current (tDCS), alternating current (tACS) and random noise current stimulation (tRNS). These techniques are based on the delivery of weak currents through the scalp (with electrode current intensity to area ratios of about 0.3-5 A/m2) at low frequencies (typically < 1 kHz) resulting in weak electric fields in the brain (with amplitudes of about 0.2-2 V/m). Advances in transcranial brain current stimulation (tCS) will play a key role in neuroscience research, diagnosis and clinical applications. HIVE (a FET Open EU project) is exploring a new generation of more powerful and controllable non-invasive brain stimulation technologies. Present tCS technologies suffer from poor focality and unknown spatial distribution of the generated electrical fields, making the effects of stimulation non-specific, hard to reproduce and interpret. To address this, the project has developed improved electric field and multi-scale neuron-field interaction models, and is currently carrying out experiments in humans and animals. Based on this work, we have developed a tCS multisite transcranial current stimulation device (MtCS) implementing online EEG feature extraction for visualization and control. This tCS device has novel characteristics: it is multichannel, portable and wireless; it uses EEG-like electrodes; it allows for the independent electrical current control of each electrode in terms of intensity, direction, frequency and phase. In particular, although it can be used as a coherent multichannel tDCS/tACS/tRNS system, arbitrary waveforms can also be input by the user. In addition, the system provides visualization of the generated electric fields and currents and it can capture and transmit EEG. EEG features extracted online can be used to tune stimulation parameters. These features include power spectra, connectivity maps and cortical and tomographic maps in different bands. The entire system is wirelessly controlled using a standard laptop and can stream data over the internet.

NOTES:

An essay on extracellular field contributions to a globally conscious brain

Emmanuelle Tognoli[1] and J. A. Scott Kelso[1,2]

[1]The Human Brain and Behavior Laboratory, Center for Complex Systems and Brain Sciences, Florida Atlantic University, Boca Raton, FL, USA; [2]Intelligent System Research Centre, University of Ulster, Derry (North Ireland)

Brain performance depends on the rapid exchange of information across neural ensembles that are dispersed spatially. It is well established that information is communicated proximally, chiefly by virtue of synaptic connections. However, this scheme of information exchange suffers delays of several tens of milliseconds for the communication of information between distant neural groups. Here we examine a theoretical proposal that brains also operate in the currency of spatial patterns of extracellular fields. On the extracellular side, dendrites are exposed to a local ionic environment that changes over time under the influence of proximal synaptic release and global activity-dependent fluctuations of extracellular fields. Fluctuations arising from local synapses have the largest magnitude and as such have received most experimental attention. Nonetheless low amplitude fluctuations of extracellular fields driven by the activity of distant neural population have the potentiality to convey information. We hypothesize that neurons could employ their tridimensional -spatially extended- dendritic arborescence to sample extracellular field gradients thereby facilitating quasi-instantaneous “awareness” of the global patterning of brain activity. If supported by empirical evidence, this hypothesis would have profound consequences for artificial neural networks and brain *in silico*: the spatial arrangement of neural populations is missing from most computational models of the brain. Our hypothesis would also bring fresh light to spatial morphosis occurring in the evolving and developing brain: putatively, directionally favorable arrangements of neural ensembles may explain idiosyncrasies in performance.

NOTES:

Neural systems with dynamic synapses: emerging phenomena and computational consequences

Joaquín J. Torres

Granada Neurophysics Group at Institute "Carlos I" for Theoretical and Computational Physics, University of Granada, E-18071, Granada (Spain)

I review here some of our recent results concerning the computational implications that *dynamic synapses,* characterized by activity-dependent synaptic processes such as synaptic depression and facilitation, have in the behavior of different neural systems. The first consequence is the appearance of dynamical memories which result from the destabilization of learned memory attractors. This has important consequences for dynamic information processing allowing the system to sequentially access the memories under changing stimuli. Although storage capacity of stable memories also decreases, our study has demonstrated the positive effect of synaptic facilitation to recover maximum storage capacity and to enlarge the capacity of the system for memory recall in noisy conditions. Moreover, the dynamical phase described above can be associated to the voltage transitions between *up* and *down* states observed in cortical areas in the brain. We studied the conditions in which the permanence times in the up state are power-law distributed, which is a sign for criticality, and concluded that the experimentally observed large variability of permanence times could be explained as the result of noisy dynamic synapses with large recovery times. Finally, we studied how short-term synaptic processes can transmit weak signals throughout more than one frequency range in noisy neural media by kind of *stochastic multiresonance.* This serves us to reinterpret recent experiments and to conclude that the observed behavior results of competition between (1) changes in the transmitted signals as neurons were varying their firing threshold, and (2) adaptive noise due to activity–dependent fluctuations in the synapses.

NOTES:

Information in the variability of neural responses

Guglielmo Foffani

Hospital Nacional de Parapléjicos, SESCAM, Toledo, Spain
School of Biomedical Engineering, Drexel University, Philadelphia PA (USA)

From the perspective of neural coding, the considerable trial-to-trial variability in the responses of neurons to sensory stimuli is puzzling. Trial-to-trial response variability is typically interpreted in terms of "noise" (i.e. it either represents intrinsic noise of the system or information unrelated to the stimuli). However, trial-to-trial response variability can be considerably different across stimuli, suggesting that it could also provide an important contribution to the information conveyed by the neural responses about the stimuli. To test this hypothesis, we addressed the problem of discriminating stimulus location from the spike-count responses of neurons recorded in the ventro-postero-medial nucleus of the thalamus (VPM) in anesthetized rats. Using a recently developed information theory approach, we verified that differences between stimuli in the trial-to-trial spike-count variability of the responses provided an important contribution to the overall information carried by the neurons. In addition, we found that the relatively reliable (sub-Poisson) firing regime of our VPM neurons was not only more informative, but also more redundant between neurons compared to a more variable (Poisson) firing regime with the same total number of spikes. The typical increase in trial-to-trial response variability from the periphery to the cortex could therefore serve as a strategy to reduce redundancy between neurons and promote efficient sparse coding distributed in large populations of neurons. Overall, our data suggest that the trial-to-trial response variability plays a critical role in establishing the tradeoff between total information and redundancy between neurons in population codes.

-A. Scaglione, K. A. Moxon, J. Aguilar, G. Foffani. Trial-to-trial variability in the responses of neurons carries information about stimulus location in the rat whisker thalamus. Proc Natl Acad Sci U S A 108:14956-14961 (2011).

NOTES:

Etching syntactic rules into cortical latching dynamics

Sahar Pirmoradian and Alessandro Treves

SISSA, Cognitive Neuroscience, LIMBO, Trieste (Italy)

We describe the elements of a project aimed at testing the ability of an associative network, modeling an extended network of many cortical areas, to acquire scaled-down syntactic rules. In the first stage we have developed an artificial language of intermediate complexity, BLISS, with about 150 words and some 20-30 production rules. This stage is now completed and published, with the characterization of several BLISS variants. In the second stage we have established an algorithm for generating distributed representations for the artificial language, in terms of the activation of a network of Potts units. This is a system which we have analyzed extensively, with Emilio Kropff and then Eleonora Russo, as a simplified model of cortical macrodynamics. The second stage is essentially completed, though parameters now have to be chosen depending on the findings of the last stage. This third and last stage involves utilizing the spontaneous latching dynamics exhibited by Potts networks, the word codes we have developed, and crucially hetero-associative weights favoring specific transitions, to generate, with a suitable associative training procedure, corpuses of sentences "uttered" by the network, and to assess their grammaticality under BLISS rules. This last stage has just started and it is most exciting, as the network has just begun to produce spontaneous sentences.

NOTES:

Reward inference by primate prefrontal and striatal neurons

Masamichi Sakagami[1], Hongwei Fan[1] and Xiaochuan Pan[1,2]

[1]Brain Science Institute, Tamagawa University, Machida, Tokyo 194-8610, Japan; [2]Institute for Cognitive Neurodynamics, East China University of Science and Technology, Shanghai 200237 (P.R. China)

The brain contains multiple yet distinct systems involved in reward prediction. To understand the nature of these processes, we recorded single-unit activity and local field potential (LFP) from the lateral prefrontal cortex (LPFC) and the striatum of monkeys performing a reward inference task using an asymmetric reward schedule. Prefrontal neurons inferred the reward value of a stimulus, even when the monkeys had not yet learned the stimulus-reward association directly. Striatal neurons, however, predicted the reward for the stimulus only after directly experiencing the stimulus-reward contingency. Our results suggest dissociable functions in their reward prediction, i.e., that the LPFC utilizes stimulus categorization or higher-order conditioning in a generative process of reward inference, whereas the striatum applies direct experiences of stimulus-reward associations in the guidance of behavior. Also we made correlation and causality analyses with the LFP data simultaneously recorded from the LPFC and striatum to clarify the information flaw between them. Interestingly, the information flaw from the LPFC to the striatum was larger in the trials where monkeys predicted smaller reward than in those with larger reward prediction. This may indicate the functional role on inhibitory control of LPFC over the striatal function on motivation or desire.

NOTES:

Taking advantage of outcomes to make successful decisions

Jose L. Pardo-Vazquez[1,3], Isabel Padrón [1,2], Ignacio Seoane[1], José Fernández-Rey[2] and Carlos Acuña[1,*]

[1]Departamento de Fisiología, Facultad de Medicina and [2]Departamento de Psicología Básica, Facultad de Psicología, Universidad de Santiago de Compostela, Spain. [3]Fundación Champalimaud, Lisboa (Portugal)

Outcomes of behavioral choices are important for behavioral adaptation. Electroencephalographic recordings identified a feedback related negativity (FRN), which appears 250-350 [ms] after the subject was informed that his decision has been erroneous. However, the sensitivity of this component to the outcomes on a trial-to-trial basis is unknown. Here we show that after FRN feedback related positivity (FRP) appears at 400-500 [ms]. These two components are coupled to decision performance in such a way that an external observer, looking only at the waves, can know if the subject has made a correct or an incorrect decision. Moreover, the FRP is more closely linked to the outcomes than the FRN. The difficulty of the decision affects in a different way the delay and amplitude of the FRN and FRP respectively, suggesting that they reflect different cognitive processes. The FRN could be related to an error detection system because it appears immediately after easy decisions and later on after difficult ones; this system could be responsible for fast error corrections. The FRP could reflect the difference between the expected and the current outcomes because its amplitude is greater for easy than for difficult decisions; this system would be useful for increasing confidence in future decisions.

NOTES:

The problem of causation in complex brain dynamics

Hans Liljenström

Div. Biometry & Systems Analysis, SLU, Uppsala, (Sweden) and Agora for Biosystems, Sigtuna, (Sweden)

The problem of causation is profound for any complex system consisting of several organizational levels, and for neural systems in particular. Mostly, upward causation is considered, where for example cortical neurodynamics and mental functions are supposed to be causally determined by the activity of neurons and ion channels. Downward causation, where the activity of higher levels has a causal effect on lower levels is less obvious and is more seldom considered. Equally difficult is the problem of causation in network structures, where neuronal networks may provide the most complex such structures known. Even when we know which types of cells are involved, with their excitatory and inhibitory connections, with their various types of neurotransmitters, and with afferent and efferent nerve bundles identified, we still have little understanding of the causal relationships between events and processes in such networks. In addition, the causal relationships in the perception-action cycle involved in interaction between an individual and its environment are not easily determined but are crucial for our understanding of such phenomena as consciousness, free will and social interaction. We have developed models of paleo- and neocortical structures in order to study their *mesoscopic* neurodynamics, as a link between *microscopic* neuronal and *macroscopic* mental events and processes. In this presentation, I will take these cortical network models and their results as an outset for discussion on the problem of causation in neural systems, with implications for neurocomputational modeling in general. I will present examples of both upward and downward causation, with a focus on cortical oscillations, chaos and noise, and will also discuss this in relation to cognitive function and dysfunction.

NOTES:

The super-Turing computational capabilities of evolving recurrent neural networks involving only finitely many synaptic levels

Jérémie Cabessa and Alessandro E.P. Villa

Neuroheuristic Research Group, University of Lausanne (Switzerland)

The computational power of recurrent neural networks is known to be intimately related to the nature of the synaptic weights of the neurons. In this context, various basic models of rational-weighted recurrent neural networks have been proven to be computationally equivalent to Turing machines, whereas real-weighted neural networks - so-called analog neural networks - have been proven to be capable of super-Turing computational capabilities. More recently, recurrent neural networks provided with rational but evolving synaptic weights have also been shown to be capable of super-Turing capabilities, equivalent to static analog neural networks. This result is important for it allows replacing the controversial analog assumption by natural evolving considerations towards the achievement of super-Turing computational capabilities of neural models. Here, we make a next step forwards concerning the computational power of more biologically oriented neural models by showing that evolving rational-weighted neural networks which involve only finitely many distinct synaptic levels are also capable of super-Turing computational capabilities, equivalent to those of analog neural networks.

NOTES:

Brain Functional Connectivity: Tools for the assessment of multivariate synchronization

Francisco del Pozo

Center for Biomedical Technology (CTB), Universidad Politécnica de Madrid (Spain)

The brain connectivity analysis from electromagnetic recordings (EEG / MEG) and fMRI, using techniques for the study of synchronization between experimental systems, configures a highly promising field in basic (cognitive studies) and clinical research (understanding pathophysiological mechanisms associated with various neurological diseases). A platform for the study of brain functional connectivity is presented that incorporates the most important recent advances in methodology for analysis of multivariate synchronization and dimensionality reduction and addresses several open questions in this field, such as the study of cross-frequency synchronization, the attenuation of the volume conduction effects by the use of multimodal approaches (simultaneous recording of MEG and EEG signals) and the use of magnetic resonance imaging to obtain anatomical and functional reconstruction of neuronal sources, more reliable than those obtained with standard algorithms, as well as the control of the effects of multiple comparisons by studying the spectral structure of the covariance matrix and the use of graph theory. The goal of this research is to significantly encourage the application of source reconstruction techniques, connectivity and clinical classification.

NOTES:

The quest for general functional principles in brains and machines: the case of the excitation/inhibition ratio

Alberto Ferrús

Instituto Cajal, CSIC, Madrid (Spain)

We have studied the olfactory perception in Drosophila under genetic conditions that increase or decrease the number of synapses in identified neurons of the olfactory pathway. The corresponding behavioral data show that the quality of perception (attractiveness or repulsiveness) of an odorant is effectively and coherently changed when the number of synapses is modified in specific neurons of the olfactory glomeruli. By contrast, the same genetic manipulations directed to other neurons of the pathway do not lead to changes in perception. Further, the phenomenon of long-term habituation is also affected by directed changes in synapses of key olfactory glomeruli neurons. Equivalent experiments in a different sensory modality, vision, also lead to changes in phototaxia. Most relevant, if the changes in the number of synapses are elicited at the same time in excitatory and inhibitory neurons, perception and habituation return to normal values in spite of the altered absolute number of synapses. These findings in Drosophila are being extended to rodents. So far, rats in which synaptogenesis has been increased in the hippocampal region show altered responses in hippocampus-dependent behavioral tests (freezing response) but not in other behaviors which are dependent on other brain structures. In an attempt to transfer these biological features to machines, an artificial nose is being tested in collaboration with the group of Dr. Pablo Varona in which the relative weight of ex/in signals can be controlled. The effects on odorant discrimination and sensitivity are currently under characterization.

NOTES:

Synchronization of the brain oscillation within a brain and over brains for self-referential cognitive process

Yoko Yamaguchi, Masahiro Kawasaki, Keiichi Kitajo, Yinjie Cheng, Ken-ichiro Iwasaki and Hideki Oka

RIKEN Brain Science Institute (Japan)

Emergence of EEG oscillations and their distant synchronization are well known to characterize various cognitive conditions either in animal or in human. It suggests the importance of synchronization in cognitive functions. However little is known whether how synchronization appears and how it contributes to cognitive functions. We have elucidated EEG oscillations in human experiments. We found that global networks are dynamically linked by theta phase synchronization according to task demands. Local activities are regulated by faster oscillations such as alpha and beta and further locked to theta by phase-phase coupling. We propose a working hypothesis that spatio-temporal hierarchical structure of synchronization enables parallel processing of internal constraint formation and rule-based sensory-motor processing as self-referential process. This hypothesis was applied to behavior and EEG in a human-human communication task. Our results in EEG shall be discussed in comparison with a computational model.

NOTES:

Computational modeling of mental state dynamics for interactive play with child

Takashi Omori

Tamagawa University (Japan)

An essential difference of a human-human interaction from a human-object interaction is a point that human has his/her intention, and works out on the other based on their plan. To understand the human-human and the human-agent interaction, we must understand the human mind dynamics that estimates others mental state and strategy, and decides his/her action affecting on other's mind process. In this paper, we report a series of studies to uncover the mental dynamics of human-human interaction and present the computational model of action decision based on an intention estimation of other. As the target of research, we constructed a robot that can play with a child. The robot has a mental model of interactive play, observes the mental state of the child, and produces a series of action that raises and keeps the internal state of child to enjoying state. A technical problem of this study was the evaluation of true mental state of the child. We asked well experienced nursery nurses to rate the degree of child's interest by observing a video image and analyzed the rating using the dynamics model of mental state change. The complex action dynamics of human-robot interaction was a result of the interaction between the robot action decision process and the natural mental state change of the child.

NOTES:

Neural Population Representation Hypothesis of Visual Flow and Its Illusory After Effect in the Brain: Psychophysics, Neurophysiology and Computational Approaches

Hide-aki Saito[1,2,3], Eiki Hida[1,2,3], Shun-ichi Amari[4], Hiroshi Ohno[5] and Naoki Hashimoto[1]

[1]Faculty of Engineering, Tamagawa University, Tokyo (Japan); [2]Tamagawa Center of Excellence Integrative Human Science Program, Tamagawa University; [3]Tamagawa University Research Institute, Brain Science Research Center; [4]RIKEN Brain Science Institute, Wako-shi, Saitama 351-0198 (Japan); [5]Faculty of Engineering, Kagoshima University, Kagoshima (Japan)

The neural representation of motion aftereffects (MAE) induced by various visual flows (translational, rotational, motion-in-depth, and translational transparent flows) was studied under the hypothesis that the imbalances in discharge activities would occur in favor in the direction opposite to the adapting stimulation in the monkey MST cells (cells in the medial superior temporal area) which can discriminate the mode (i.e., translational, rotational, or motion-in-depth) of the given flow. In single-unit recording experiments conducted on anaesthetized monkeys, we found that the rate of spontaneous discharge and the sensitivity to a test stimulus moving in the preferred direction decreased after receiving an adapting stimulation moving in the preferred direction, whereas they increased after receiving an adapting stimulation moving in the null direction. To consistently explain the bidirectional perception of a transparent visual flow and its unidirectional motion aftereffect by the same hypothesis, we need to assume the existence of two subtypes of MST D cells which show directionally selective responses to a translational flow: component cells and integration cells. Our physiological investigation revealed that the MST D cells could be divided into two types: one responded to a transparent flow by two peaks at the instances when the direction of one of the component flow matched the preferred direction of the cell, and the other responded by a single peak at the instance when the direction of the integrated motion matched the preferred direction. In psychophysical experiments on human subjects, we found evidence for the existence of component and integration representations in the human brain. To explain the different motion perceptions, i.e., two transparent flows during presentation of the flows and a single flow in the opposite direction to the integrated flows after stopping the flow stimuli, we suggest that the pattern-discrimination system can select the motion representation that is consistent with the perception of the pattern from two motion representations. We discuss the computational aspects related to the integration of component motion fields.

NOTES:

Mechanism of gain modulation in multimodal networks for spatial development

Alexandre Pitti, Philippe Gaussier and Matthias Quoy

Laboratoire ETIS, UMR CNRS 8051-Université de Cergy-Pontoise–ENSEA. Pontoise 95302 Cergy-Pontoise (France)

Perceiving objects in space is one of first tasks babies deal with during infancy. It is a rather difficult problem because infants have to learn first the different reference frames from their body (e.g., eye-centered, head-centered or hand-centered), encoded with multiple sensory modalities (vision, sound, tactile) in order to represent one object in space. This curse of dimensionality corresponds to the so-called binding problem across the modalities for which there is a still debate on its underlying neural mechanisms and its associated computational models. One important mechanism identified for multimodal integration is the so-called gain-field modulation mechanism, which has been observed in parietal and collicular neurons. This mechanism yokes the gain amplitude/activity of bi-modal neurons relative either to one or the other modality (touch and vision, sound and vision). As they encode a mutual information in a dynamical fashion, not sequential, they are argued to play an important role for the accurate and instantaneous coordinate transformation from one reference frame to the other (eye-hand, eye-ear), action execution and monitoring. In robotic experiments with a head-neck-eye device with ears, we exploit this mechanism for coordinate transformation across modalities and reference frames transposition, where embedded spiking neural networks learn visuo-, motor- and auditory integration in eye- and head-reference frames. After the learning stage, we observe similar features to biological parietal neurons to dynamically relocate objects in space during motion. In a second experiment with a physical simulation of a face with somatopic information, we model somatopic and retinotopic integration as it is observed in the superior colliculus for facial representation and coordinate mapping centered on the face. This work pursues some other investigations in which we modeled different aspects of spatial development with computer simulations and robots; we will investigate in future research how these neurons can serve for more complex spatial reference frames transformation, like during grasping and how they encode the peripersonal space or a dynamic body image.

NOTES:

Spontaneous and evoked neural activities shaped through a sequential learning process

Tomoki Kurikawa

Department of Basic Science, University of Tokyo, Tokyo (Japan)

In neural science, neural response activities to external stimuli are generally recorded in order to understand neural computation. In this scheme, spontaneous activity in the absence of an input is disregarded as a back ground noise. However, recent experimental studies have suggested that the spontaneous activity plays a role in information processing and this role is not unclear. In order to uncover the role, in our previous study, we proposed a novel memory view and introduced a neural network model in which network structure is given. We found that when a neural network responds to a memorized input significantly, the spontaneous activity wanders among the memorized patterns, which is like the behavior typically observed in the neural system. In this study, we introduce a model with a simple learning rule. By this rule, we can analyze the spontaneous and evoked (memorized) activities for larger class of network structures than the given structure in the previous model. As results, we found that two types of behaviors are shaped: One behavior shows a stationary activity both in the absence and presence of the learned input and does not respond to the input. The other behavior shows chaotic behavior wandering among the memorized patterns in the absence of the input and responds significantly to the input. Remarkably, the network structure for the latter is similar to that in the previous given model. It suggests that wandering spontaneous behavior is helpful to respond to external familiar stimuli.

NOTES:

Learning and decisions as functional states of cortical circuits

Agnès Gruart

Division of Neurosciences, Pablo de Olavide University, Seville (Spain)

The complexity of brain functions can only be approached by a multidisciplinary and complementary approach. The availability of genetically manipulated mammals (mostly mice) and of sophisticated electrophysiological techniques, susceptible of being applied in behaving animals during the acquisition of different learning paradigms, has largely facilitated this approach. Our group has studied for years the contribution of hippocampal, motor, premotor, and prefrontal circuits to different types of associative and non associative learning paradigms. For this, we have recorded activity-dependent changes in strength in cortical and subcortical synapses during the acquisition process. Until now, we have studied the contribution of many different neurotransmitters and related receptors in selected transgenic and knock-out animals, as well as using *in vivo* si-RNA injection procedures. The main output of our studies is that learning is the result of the activity of wide cortical and subcortical circuits activating particular functional properties of involved synaptic nodes. Collected data indicate that many synaptic sites within cortical circuits modulate their synaptic strength across the successive stages of the acquisition of new motor and cognitive abilities.

NOTES:

Convergent measures of abstract spatial coding in hippocampus

Jan Lauwereyns

Graduate School of Systems Life Sciences. Kyushu University (Japan)

The hippocampus is a crucial brain structure for spatial information processing in memory-guided tasks. Using a spatial alternation task with rats, various types of neural activity can be observed in hippocampal area CA1 that reflect an abstract level of coding. Particularly, during a one-second fixation period, when the rat is ready and waiting for a cue to pursue the task, the activities in hippocampal area CA1 show spatial biases that depend on the alternation sequence (where the rat came from and where it will go next). Such neural activity is independent of current spatial, sensory, and motor parameters. Instead, it appears to reflect a shift in information processing, from external processing, presumably driven by entorhinal cortical input, to internal processing, presumably driven by hippocampal area CA3. This shift can be observed in the timing of individual neuronal spikes relative to the theta oscillation as well as in the gamma power relative to the theta oscillation. Furthermore, from a comparison with error trials (due to premature fixation break) it appears that the gamma shift occurs only on correct trials. All of these measures converge toward a rich and consistent conceptual model of the dynamics of abstract spatial coding in rat hippocampus.

NOTES:

POSTERS

P1. Ensemble coding for voluntary movements in rat primary and secondary motor cortices

Yoshikazu Isomura

Brain Science Institute, Tamagawa University, Tokyo (Japan)

Motor cortex neurons are activated at a variety of timing during a voluntary movement. However, how excitatory (glutamatergic) and inhibitory (GABAergic) neurons in cortical layers of motor cortex participate in organizing the voluntary movement has been poorly understood. Here, we obtained juxtacellular recording and multiunit recording from the motor cortex of actively behaving rats, and demonstrated temporally and functionally distinct activations of excitatory pyramidal cells and inhibitory fast-spiking (FS) interneurons. Across the cortical layers, pyramidal cells were activated diversely for sequential motor phases (e.g., preparation, initiation, execution). In contrast, FS interneurons, including the basket cells, were recruited predominantly for the motor execution. Furthermore, our cross-correlation analysis of multiunit activity suggested that a class of pyramidal cells discharged synchronously with similar and different functional classes of neurons through direct or indirect synaptic connections. The spiking activity of most neurons was phase-locked to slow (40-60 Hz) and fast (80-100 Hz) gamma oscillations. In the next experiments, we improved training procedure of behavioral tasks, which made it possible that the rats rapidly learned to perform external- and internal-trigger movements. We recorded the neuronal activity in the primary (M1) and secondary (M2) motor cortices while the rats performed these motor behaviors. Unlike human and non-human primates, the M1 and M2 cortical neurons seemed to play a basically similar role in the expression of external- and internal-trigger movements. The two motor cortices may cooperate with each other to shape a motor command for voluntary movement.

1. Isomura Y et al., Nat Neurosci 12, 1586-93, 2009.
2. Kimura R et al., J Neurophysiol (in press)

NOTES:

P2. Red nucleus neurons actively contribute to the acquisition of an associative learning task in behaving rabbits

José M. Delgado-García, Renny Pacheco-Calderón, Alejandro Carretero-Guillén, and Agnès Gruart

Division of Neurosciences, Pablo de Olavide University, Seville-41013 (Spain)

The red nucleus (RN) is a midbrain premotor center that has been suggested as being involved in the acquisition and/or performance of classically conditioned nictitating membrane/eyelid responses. We recorded in rabbits the activity of RN and pararubral neurons during classical eyeblink conditioning using a delay paradigm. Neurons were identified by their antidromic activation from contralateral facial and accessory abducens nuclei and by their synaptic activation from the ipsilateral motor cortex and the contralateral cerebellar interpositus nucleus. For conditioning, we used a tone as a conditioned stimulus (CS) followed 250 ms later by a 100 ms air puff as an unconditioned stimulus (US) co-terminating with it. Conditioned responses (CRs) were determined from the evoked changes in the electromyographic (EMG) activity of the orbicularis oculi muscle. Recorded neurons were classified by their antidromic activation and by their changes in firing rate during the CS-US interval. Identified neurons increased their firing rates in relation to the successive conditioning sessions, but their discharge rates were related more to the EMG activity of the orbicularis oculi muscle than to the learning curves. Reversible inactivation of the interpositus nucleus with lidocaine during conditioning evoked a complete disappearance of both conditioned and unconditioned eyelid responses, and a progressive decrease in CR-related activity of RN neurons. In contrast, motor-cortex inactivation evoked a decrease in the acquisition process and an initial disfacilitation of neuronal firing (which was later recovered), together with the late appearance of CRs. Thus, RN neurons presented learning-dependent changes in activity following motor-cortex inactivation.

NOTES:

P3. Effect of emotion and personality on deviation from purely rational decision-making

Alessandro E.P. Villa, Marina Fiori, Sarah Mesrobian, Alessandra Lintas

Neuroheuristic Research Group, University of Lausanne (Switzerland)

Human decision-making has consistently demonstrated deviation from "pure" rationality. Emotions are a primary driver of human actions and the current study investigates how perceived emotions and personality traits may affect decision-making during the Ultimatum Game (UG). We manipulated emotions by showing images with emotional connotation while participants decided how to split money with a second player. Event-related potentials (ERPs) from scalp electrodes were recorded during the whole decision-making process. We observed significant differences in the activity of central and frontal areas when participants offered money with respect to when they accepted or rejected an offer. We found that participants were more likely to offer a higher amount of money when making their decision in association with negative emotions. Furthermore, participants were more likely to accept offers when making their decision in association with positive emotions. Honest, conscientious, and introverted participants were more likely to accept offers. Our results suggest that factors others than a rational strategy may predict economic decision-making in the UG.

NOTES:

P4. Chaotic itinerancy in dynamically coupled brains

Ichiro Tsuda

Research Institute for Electronic Science / Research Center for Integrative Mathematics, Hokkaido University, Sapporo (Japan)

Motivated by the studies on interacting brains through communication, we studied a typical dynamic behavior appearing in dynamically coupled systems. The coupling is important for yielding manifold geometric structure embedded in a set of trajectories, because the complexity of one dynamical system will be mutually renormalized in another system by the coupling terms. By this, a coupled system may provide a neuronal basis for communication. We investigated "chaotic itinerancy" as what giving a typical transition process in a coupled system. Chaotic itinerancy provides a new dynamical concept representing successive transitions in high-dimensional dynamical systems, in particular, in a coupled dynamical system. Each transition in chaotic itinerancy occurs between `quasi-attractors', where by a quasi-attractor we denote a subset of phase space, which absorbs most neighboring trajectories and yet drives another neighboring trajectories away. Chaotic itinerancy in neural systems means a dynamic trajectory in cortical state space, in which a reproducible sequence of states is yielded by repeated switching between ordered and disordered states in the activity of neural assemblies in cortex. One may associate the ordered states with memories represented by quasi-attractors, and the disordered states with transitions represented by chaos. We will show dynamic features of chaotic itinerancy in various levels of coupled systems. We will touch upon a role of chaotic itinerancy for some phase of communication.

The following URL includes some PDFs on our work on chaotic itinerancy: http://cls.es.hokudai.ac.jp/~tsuda/en/index.html

NOTES:

P5. Location dependency of information processing on dendrites in hippocampal granule cells

T. Aihara, H.Hayakawa and M.Tsukada

Brain Science Institute, Tamagawa University (Japan)

Recent study reported that two inputs with non-spatial (sensory; smell et al.) and spatial (place) information from the entorhinal cortex were delivered to lateral dendrites (LD) and medial dendrites (MD) in rat hippocampal granule cells, respectively. To investigate characteristics of LD and MD, electrical stimuli were applied to LD or MD at different frequencies and the field excitatory postsynaptic potentials (f-EPSP) were recorded at each side. As the result, f-EPSPs at LD and MD showed sustained and transient responses, respectively. Next, data fitting for our physiological experiment was performed using a dynamical synapse model (Tsodyks, 1998) so that suitable parameters of the model were fixed. In addition, Gaussian random inputs or regular inputs were applied to PD or DD in NEURON simulator with the fixed synapse dynamic synapse model. These results showed that inputs with non-spatial information to DD might increase the membrane potential so that might enhance a temporal-pattern discrimination of spatial (place) information to MD in hippocampal granule cell.

NOTES:

P6. Frontal cortex, hippocampus and striatum in behavioural control and simulation

J.P. Banquet, P. Gaussier, S. Hanoune, M. Quoy, F.Sargolini* and B. Poucet*

Laboratory ETIS, UMR CNRS 8051-Université de Cergy-Pontoise–ENSEA. Pontoise 95302 Cergy-Pontoise (France)
***Laboratory of Neurobiology and Cognition, CNRS, Université de Provence, Marseille, France**

Previous research on goal-oriented navigation in the rat has delineated two distinct systems, which may support two types of learning and performance: i) procedural learning leading to S-R habit-like response, likely implemented by dorsal striatum; ii) declarative learning and the acquisition of a 'cognitive' map leading to landmark navigation and more generally goal-oriented behaviour, depending on dorsal hippocampus. The global architecture of these two systems has not been taken into consideration so far. However, it is well known that the hippocampus and striatum establish direct connections with a large number of sensory-associative and motor-executive cortical areas, respectively. The nature of their interactions, cooperative versus competitive, is also a matter of debate, even though the hippocampal system and cognitive-controlled performance appears to be dominant during the initial stages of learning, whereas striatal system and habit behaviour take over after overtraining. More recent investigations have pointed out the involvement of dorsal striatum in spatial learning tasks classically requiring hippocampal integrity. The subdivision of the dorsal striatum into medial (DMS) and lateral (DLS) compartments (corresponding respectively to caudate and putamen in primates) could be a key to the solution of this paradox. Indeed, it has been shown that DMS lesions) impair performance on a place version of the water maze task, biasing the performance towards a cue strategy, and ii) render the animal insensitive to either outcome devaluation, or contingency degradation in a lever-press task. In contrast, DLS lesions do not produce these effects; in particular, the instrumental response remains sensitive to outcome devaluation after overtraining. These results support specific functions for i) a DMS-based circuit monitoring goal oriented behaviour through action-outcome association, and ii) a DLS-based circuit involved in the integration of sensori-motor representations leading to S-R associations and inflexible habit behaviour. Even though the anatomy of the brain (particularly of the prefrontal cortex and the striatal system) is more complex and elaborated in the primates, the above interpretation could lead to a model of several cortico-striatal parallel loops (limbic, cognitive, motor) with specific functions, but still with 'horizontal' interconnections capable to foster the transition from cognitive to procedural operation mode, as suggested in primates. In order to reconcile the early and more recent results, the hippocampus should be integrated in the DMS-based circuit, with the caveat that its function does not reduce to controlling behaviour, would it be cognitive, but has other important functions in declarative-episodic memory, in particular. The existence of plastic connections from CA1 and the subiculum of the ventral hippocampus to the medial prefrontal cortex are well documented, as well as the reciprocal more indirect connections from prefrontal cortex to hippocampus, through superficial layers of the entorhinal cortex, and midline thalamic nuclei such as nucleus reuniens, thus forming a loop. Yet, medial prefrontal cells do not have place fields akin to those of hippocampal place cells, when recorded in a simple foraging task. More recently, however, the existence of a functional link between hippocampus and medial prefrontal cortex was demonstrated by hippocampal and medial prefrontal cell recordings, in the rat performing a continuous place navigation task that taxes both spatial and temporal-sequential processing. In this task, the animal must i) reach a virtual landmark-defined goal area on the floor of the arena ii) stay there for 2 s to trigger the release of a food pellet iii) forage for the pellet that, although landing at a fixed place, can end up everywhere in the arena. This sequence is resumed once the rat has found the food pellet. In a series of experiments based on this protocol, results were collected, that defined the contours of a close functional integration between hippocampus and medial prefrontal cortex, more specifically in the spatio-temporal domain:

1-The continuous place navigation task singled out three areas of specific interest, in the arena, which were associated with increased activity of medial prefrontal cells, when the rat traversed them: -the virtual goal zone; -the pellet landing zone; -and the area close to the orienting landmark. The prefrontal ‘place’ fields were broad and noisy much as in some areas of the entorhinal cortex.

2-In addition to their classical principal fields (which can be observed everywhere in the recording arena), hippocampal place cells recorded during performance of the continuous place navigation task had a weaker secondary field, which was consistently observed across all place cells as the rats were waiting in the virtual goal zone.

3-This hippocampal activity observed as the animal was in the goal zone presented a temporal profile reminiscent of the activity of CA3 pyramidal cells during the interval between CS and US in conditioning paradigms. The activity increased, to eventually reach a maximum just prior to the end of the 2 s intervals, and thereafter decreased sharply. This discharge profile suggests a timing process of the interval between entering the goal-zone and getting out of it. A similar temporal profile was found in the activity of the medial prefrontal goal-cells, raising the question of the origin of this timing activity.

4- Ventral hippocampal lesions suppressed timing activity in medial prefrontal cortex, whereas inactivating the medial frontal cortex did not affect hippocampal timing activity. It was concluded that the hippocampus plays a primary role, not only in computing spatial information from allothetic and idiothetic sensory inputs, but also in computing temporal, and more generally, sequential information, at least when sensory and\or cognitive events are concerned. It cannot be excluded that specific timers operate in basal ganglia and/or cerebellum for motor events.

These results support the hypothesis that hippocampus-prefrontal connections are important in forwarding convergent spatial and temporal information to medial prefrontal cortex. This information would then be combined in the medial prefrontal cortex with valence information received from other structures like amygdala and orbitofrontal cortex, to eventually create a representation of goal locations. The goal-related activity of hippocampal cells would build up as a result of the progressive stabilization of medial prefrontal goal fields with increasing experience with the task, but would eventually become independent of prefrontal cortex integrity.

A detailed neural network model of the prefrontal and hippocampal subsystems, centered on the computation of spatio-temporal information (transitions between events), and featuring the hippocampal-prefrontal loop is sufficient to reproduce the different experimental results illustrating the temporal-spatial-motivational interactions performed by this loop, and their specific function in behavioural control. The experimental results demonstrate that the hippocampal-frontal loop is instrumental in controlling decision making and the temporal and spatial aspects of behaviour. The connections between medial prefrontal cortex and the dorsomedial and ventral striatum, as well as the connections between the CA1-subiculum and the ventral striatum suggest that the hippocampal system is set in parallel onto the frontal-striatal system, rather than in series. As a consequence, it could either participate in the control of behavioural processes, or function independently, according to circumstances. Indeed, the core function of the hippocampus consists to fast record and then rehearse episodic events and sequences; and, through hippocampo-cortical loops, to facilitate recollection of recent events.

1. Hirel, J., Gaussier, P., Quoy, M., Banquet, J.P., Save, E., Poucet, B. The hippocampo-cortical loop: Spatio-temporal learning and goal-oriented planning in navigation. (Submitted)
2. Hok, V., Lenck-Santini P. P., Roux, S. Save, E., Muller, R.U. and Poucet, B. (2007) Goal-related activity in hippocampal place cells. *J. Neurosci, 27*(3):472-482.

NOTES:

P7. Dynamic control of the cerebellar-interpositus/red nucleus-motoneuron network during motor learning

C. R. Caro-Martín*, R. Sánchez-Campusano, R. Pacheco-Calderón, A. Gruart, and J. M. Delgado-García

Division of Neurosciences, Pablo de Olavide University, 41013 Seville (Spain)

Understanding the role played by the cerebellar-interpositus/red nucleus-motoneuron network in the genesis and dynamic control of learned eyelid responses requires of a single experimental-analytical approach that allows us to integrate both neural motor commands emanating from those neural centers and eyelid kinematics. Here, we recorded the neural activity of facial, interpositus (IN), and red (RN) nuclei, and the electromyographic (EMG) activity of the orbicularis oculi (OO) muscle. Our aim here was to analyze in detail the firing activities of identified neurons at the involved nuclei, and selected kinetic (neurally generated motor commands) and kinematic (eyelid movements and EMG activity) parameters collected during classical eyeblink conditioning, using a delay paradigm. Experiments were carried out in three groups of animals, two groups of behaving cats and a third group of rabbits. In the first group of cats, the facial nucleus was systematically explored in the search for OO motoneurons antidromically activated from the electrode implanted in the zygomatic branch of the facial nerve. In the second group, two antagonistic types of posterior IN neurons (types A and B) were identified by their antidromic activations from the contralateral RN nucleus. To carry out a comparative study of the kinetic–kinematic relationships, we applied timing, correlation code and dispersion pattern analyses. We concluded that, in accordance with a dominant role of cerebellar circuits for the facilitation of flexor responses, type A neurons fire during active eyelid downward displacements ─ i.e., during the active contraction of the OO muscle. In contrast, type B neurons present a high tonic rate when the eyelids are wide open, and stop firing during any active downward displacement of the upper eyelid. In addition, we recorded in rabbits the activity of RN neurons which were identified by their antidromic activation from contralateral facial and accessory abducens nuclei and by their synaptic activation from the ipsilateral motor cortex and the contralateral IN nucleus. In this group of animals, a selective procedure of inactivation of the motor cortex or IN nucleus was also applied. Thus, the cause-effects correlates and the neural inactivation patterns allowed us to control the dynamic of the network across learning. Finally, we present a meta-analysis of the collected data revealing how facial, IN and RN neurons can change their activity during delayed eye-blink conditioning.

Supported by grants BFU2011-29089, P07-CVI-02487 to J.M.D.-G., and BFU2011-29286, P07-CVI-02686 to A.G., from Spain.

NOTES:

P8. Changes in synaptic strength at the hippocampal formation during the classical eyeblink conditioning in behaving rabbits

A. Carretero-Guillén[1], R. Pacheco-Calderón[1], R. Sánchez-Campusano[1], M. T. Hasan[2], J.M. Delgado-García[1] and A. Gruart[1]

[1]División de Neurociencias, Universidad Pablo de Olavide, Sevilla 41013 (Spain); [2]Max Planck Institute for Medical Research, Heidelberg (Germany); Charité – Universitätsmedizin, NeuroCure Cluster of Excellence, Berlin (Germany)

A high number of studies have been focused in the role of hippocampus in learning and memory, but the precise contribution of hippocampal circuits is still a matter of discussion. In this work we show data of recordings in the hippocampal formation during the acquisition of an associative task in conscious rabbits. We used four groups of rabbits, in one of them, we only applied an electrical stimulus to evoke the field excitatory post-synaptic potential (fEPSP) to see the putative effects of enviromental (i.e., context) influences on activity-dependent changes at the different hippocampal synapses and we called it the baseline group. In the second group we used the pseudoconditioning paradigm, in which the conditioned and unconditioned stimuli (CS, US) are not coupled, to check if uncoupled stimuli evoked the same synaptic changes than in the coupled presentation. Finally, in the third and fourth group we used a delay and trace paradigm respectively. The slope of evoked fEPSPs did not change across baseline sessions except for the CA3-CA1 synapse. Similar results were observed in the pseudoconditioning case. In contrast, an increase, or a decrease, tendency was observed in conditioning sessions depending on the synapse and on the paradigm used. These results show that a constant context do not evoke significant changes in strength at the hippocampal synapses, in contrast with changes evoked by relevant but uncoupled stimuli, and to those evoked because of the associative learning process. To understand the role of dentate gyrus in memory acquisition and retrieval processes, we are using recombinant adeno-associated viruses, which are equipped with doxycycline (Dox)-controlled genetic switches for reversible silencing of synaptic transmission. With this method, a single intraperitoneal injection of Dox induces synaptic silencing within two days and unsilencing after ten days. Preliminary results indicate the important role played by the dentate gyrus in the acquisition and retrieval processes.

NOTES:

P9. Activity-dependent changes in synaptic strength and molecules related with synaptic transmission, taking place in reward circuits during associative learning in mice

M.A. Gómez-Climent, M.T. Jurado-Parras, A. Gruart, J.M. Delgado-García

Division of Neurosciences, Pablo de Olavide University, 41013 Seville (Spain)

The nucleus accumbens (NAc) receives glutamatergic input from the medial prefrontal cortex (mPFC) and from the hippocampus (ventral subiculum, vSub). The vSub–NAc pathway is proposed to maintain responding on a learned task, whereas the mPFC–NAc pathway facilitates switching to novel response strategies. Since the phenomenon of plasticity has been related for a long time with learning and memory, we are studying the synaptic and structural plasticity of these synapses in the reward circuit during learning of a simple instrumental task and then switching the task. For this proposal, mice have to learn an operant learning in which a neutral action (poke with the nose a hole in the box´s wall) is associated with its consequence (reward). Once they have learn it, the hole is removed and a lever is introduced immediately afterward. From the first day of training, we record the EEG and synaptic activity of the mentioned synapses to see how learning and synaptic plasticity occurs simultaneously. The adaptive changes to the different tasks are also under analysis. Molecules related with synaptic transmission also are going to be analyzed with immunohistochemical techniques and image analysis. A complete picture of synaptic events taking place during learning and when a task is switched will be analyzed in the reward circuit.

NOTES:

P10. Hypobaric hypoxia affects cholinergic system in parallel with electrophysiological and behavioral indicators

R. Guerra-Narbona, J.C. López-Ramos and J.M. Delgado-García

Division of Neurosciences, Pablo de Olavide University, 41013 Seville (Spain)

The benefits of altitude acclimatization on memory and learning have been contrasted in rodents through immunohistochemistry techniques aimed to analyze the cholinergic system. Previous studies with cognitive and electrophysiological tests indicated that acclimatized mice (at simulated altitude of 5000 m) reached greater cognitive scores than acute hypobaric and control mice when submitted to tasks which, because their complexity, made expect submaximal results, once checked that it was no possible to establish these differences with conventional tasks. The simulated altitude acclimatization necessary to carry out the experiments was achieved in a hypobaric chamber designed with that end. For inmunohistochemistry studies, acclimatized and acute hypobaric mice were perfused at different times after submission to hypobaria, and its brains and those of naïve mice were analyzed to found changes in the expression of choline acetyltransferase (ChAT) and acetylcholinesterase (AChE) in septum, CA1 and piriform cortex. Results indicate a greater presence of ChAT in acclimated mice in all indicated areas, and a lower presence of this enzyme in acute hypobaric mice. The ratio ChAT/AChE was bigger in acclimated mice than in acute hypobaric animals. It may affect the final balance of cholinergic system and, therefore, the cognitive scores obtained in these mice.

NOTES:

P11. Experimental design for brain-machine interaction with alert behaving rats

S. Hernández-Gonzalez[1], C. Andreu-Sánchez[2], M.A. Martín-Pascual[2], A. Gruart[1], and J. M. Delgado-García[1]

[1]Division of Neurosciences, Pablo de Olavide University, Seville, Spain; [2]Neuro-Com Research Group, Universitat Autònoma de Barcelona, Barcelona (Spain)

The Skinner box provided with a lever — as device that automatically detects the occurrence of a behavioral response — has been classically used to study associative learning, using different conditioning paradigms. In our case, we propose to use, as operandum, a tablet computer method assembled inside an operant conditioning chamber that allows to program diferent experimental designs. Specifically, we will use a programmed schedule in which the rat had to perform a task of increased difficulty or to select between different operant choices, providing rewards of different strength. We have found this decision making situation is useful due to the variety of tests that can be applied. In a second experimental step we will tune up the use of multielectrode arrays to study the activity of neuronal populations (synaptic field potentials) and single neuron activities (unitary recordings) from the thalamo-cortical pathway from alert behaving rats. Stimulating and recording electrodes will be implanted in the mediodorsal thalamic nucleus (MDM) and the prelimbic cortex (PrL), respectively. This preliminary experimental design is aimed to determine the electrophysiological properties of MD – PrL pathway. Nevertheless, other cortical circuits will be studied as well. The main aim of this experimental approach is that, by using these tools, we will study how cortical pathways are involved in phenomena related to learning and memory processes.

NOTES:

P12. Visual scanning patterns during reading a picture book aloud by mothers in children with pervasive developmental disorder

N. Inoue-Nakamura[1], T. Sasaki[2] and K. Nakamura[3]

[1] Department of Elementary Education, Showa Women's University (Japan); [2] Kumon Educational Japan Co., Ltd, Japan; [3] Section of Cognitive Neuroscience, Primate Research Institute, Kyoto University (Japan)

In Japan, reading picture books aloud by mothers and fathers is one of the most important and frequent activities for the development of infants' literacy. However, infants and children could get additional information from the pictures. We examined visual scanning patterns of 2-year-old infants during their mothers read a picture book aloud in order to analyze where they did pay attention to in the picture book. All of the infants fixated far more frequently on faces and hands than feet and other areas. There is a notion that understanding of actions, such as pointing, gaze, and facial emotion, is the pivotal ability for infants to acquire the communication ability. Our data support such a notion. The ability to understand actions is the fundamental of nonverbal communication. Then, we examined visual scanning patterns of children with pervasive developmental disorder (PDD) during reading the same picture book by mothers and compared the patterns. In children with PDD, such an excessive concentration of fixation on faces and hands was not observed. Rather they paid attention to wider regions including feet and bodies. Such an unbiased scanning pattern is probably one of the behavioral features of children with PDD.

NOTES:

P13. Driving of cognitive processes by brain stimulation in mice

M. T. Jurado-Parras, J. Carponcy, A. Gruart and J. M. Delgado-García

Division of Neurosciences, Pablo de Olavide University, 41013 Seville (Spain)

The neural structures involved in ongoing appetitive and/or observational learning behaviors remain largely unknown. In order to determine the effects of electrical stimulation of the mPFC on a well-defined sequence of volitional behaviors, we trained mice in a Skinner box to press a lever to obtain a piece of food delivered from a nearby feeder, using a fixed (1:1) ratio schedule. We were then able to stimulate the mPFC at the precise moment of each lever press. We also stimulated the NAc in the same behavioral situation; it has been shown that the NAc is involved in neural circuits related to food intake and other aspects of feeding behaviors such as food selection according to their palatability. Because the hippocampus has been related with different types of associative (classical eyeblink conditioning) and non-associative (object recognition, spatial orientation) learning tasks, for comparative purposes we stimulated the dorsal hippocampus (pyramidal CA1 area) during the same set of ongoing behaviors. Mice improved their acquisition of a simple operant conditioning task by observational learning. Electrical stimulation of the observer's medial prefrontal cortex (mPFC) at a key moment of the demonstration (when the demonstrator presses a lever in order to obtain a reward) cancels out the benefits of observation. In contrast, electrical stimulation of the observer's nucleus accumbens (NAc) enhances observational learning. Ongoing cognitive processes in the demonstrator could also be driven by electrical stimulation of these two structures, preventing the proper execution of the ongoing instrumental task (mPFC) or stopping pellet intake (NAc).

Supported by grants from Spanish Ministry of Science and Innovation (BFU2008-0899, P07-CVI-02487 and BFU2008-03390, P07-CVI-02686), the Junta de Andalucía (Spain, BIO-122, CVI-02487 and PO7-CVI-02686) and the European Community´s Seventh Framework Program (FP7/2007-2013) under grant agreement no.201714 (DEVANX).

NOTES:

P14. Hippocampal mechanisms of learning and preference during brain stimulation reward

G. Vega-Flores, A. Gruart and J.M. Delgado-García

Division of Neurosciences, Pablo de Olavide University, 41013 Seville (Spain)

Brain stimulation reward (BSR) was described on the 50's of the past century in rodents. BSR is characterized by a stable level of self-stimulation execution and motivation. The medial septum (MS) has the capability of generating and maintaining BSR on operant conditioning using electrical self-stimulation. On the other hand, the hippocampus (Hip) is a structure related to the mechanisms underlying learning and memory. It has been described that hippocampal field excitatory post-synaptic potentials (fEPSPs) evoked at the CA3-CA1 synapse shows changes in strength related to the learning process. Also, MS and Hip are known as a source and upkeep of cerebral rhythms. The aim of this study was to describe Hip functional mechanisms of learning and motivation in a two-choice frequency reinforcement preference task (TCFPT) through BSR. Mice were implanted with stimulating (CA3) and recording (CA1) electrodes and the MS was implanted with stimulating electrodes. Train stimulation (20 pulses at 8, 20, or 100Hz) of the MS was used as reinforcement of BSR. Additionally, a single pulse was presented to Schaffer´s collaterals to evoke a fEPSP in CA1 40 ms after MS train. In addition, we evaluated power spectra (PS) in three different moving windows (2s length) around each reinforcement, two before reward and one after. The successive MS-BSR sessions evoked a progressive decrease in the amplitude of CA3-CA1 fEPSPs across the learning process from the acquisition until the highest performance day, while TCFPT data showed an increase in the PS for frequencies between 2-12Hz only for the preferred reward (100Hz) in the after-reward window. Here we describe two properties of septohippocampal projections on Hip activity, the first during the acquisition process (fEPSP results) where the Hip shows two different levels of susceptibility to septal inhibition related to the acquisition processes or to the execution of an already learned task, and the second related to motivation and preference.

NOTES:

P15. Neuropercolation models for cortical phase transitions and for efficient hardware platforms

Robert Kozma

Center for Large-Scale Integrated Optimization and Networks (CLION), University of Memphis, TN (USA)

Abstract: Among the wide range of modeling approaches to brain dynamics, random graph theory has unique advantages by describing cortical phase transitions as percolation processes. Random graph theory provides a rigorous mathematical formulation of the fundamental relationship between temporal dynamics of local random processes and the structure of the embedding large-scale graph. Our premise is that the repetitive sudden transitions observed in cortex are maintained by the percolation process in the brain as a large-scale random graph at the edge of criticality, which is self-organized in collective neural populations formed by synaptic activity. Our neuropercolation model addresses the complementary aspects of neocortex, manifesting complex information processing in microscopic networks of specialized spatial modules on the one hand, and developing macroscopic patterns evidencing that brains are holistic, multi-tasking organs, on the other hand.

In this talk we describe neuropercolation approach, which serves not only as a solid mathematical model of brain dynamics, but also an efficient computational platform to implement neurodynamics on neuromorphic hardware with 10^6 neurons and 10^10 synapses. We describe learning in neuropercolation through the formation of attractor landscapes. Adaptive neuropercolation models running on computational chips and embedded in an environment through sensors and actuators serve as prototype for intentional action-perception cycle in real life scenarios.

NOTES:

P16. Role of the rostral medial prefrontal cortex in the classical conditioning of eyelid responses in behaving rabbits

R. Leal-Campanario, J. M. Delgado-García, and A. Gruart

División de Neurociencias, Universidad Pablo de Olavide, Sevilla (Spain)

The rostral mPFC was identified by its afferent projections from the medial half of the thalamic medio-dorsal nuclear complex, and by the firing rate synchronization of mPFC neurons evoked by the stimulation of this thalamic nucleus. Classical conditioning consisted of a delay paradigm using a 370-ms tone as the conditioned stimulus (CS) and a 100-ms air puff directed to the left cornea as the unconditioned stimulus (US). During classical eyeblink conditioning sessions, the firing rate of recorded single unit activity of mPFC neurons increases during the CS-US intervals in simultaneity with the presence of CRs. Electrical train stimulation of the contralateral rostral mPFC produced inhibition of air puff-evoked blinks. The rostral mPFC stimulation at the CS-US interval for 10 successive conditioning sessions significantly reduced the generation of conditioned responses (CRs) compared with control animals. Interestingly, the percentage of CRs reached almost control values when train stimulation of the rostral mPFC was removed from the 5th conditioning session on. Rostral mPFC stimulation in well-conditioned animals decreased the percentage of CRs and modified the kinematics (latency, amplitude, and velocity) of evoked CRs. In contrast, lidocaine injections in the mPFC during the 2nd conditioning session increased the expected rate of CRs, and modify the kinematics of both reflex and CRs producing opposite effects to that evoked by mPFC stimulation. In summary, the rostral mPFC needs to activate in the right way to execute the acquired motor response in an appropriate and timed way.

NOTES:

P17. Deliberation or hurry: some implication from modeling temporal interaction between D1-like and D2-like receptors

Y. Li[1] and I. Tsuda[1,2]

[1]Research Center for Integrative Mathematics, Hokkaido University, Sapporo 060-0810 (Japan); [2]Research Institute for Electronic Science, Hokkaido University, Sapporo 060-0812 (Japan)

To survive in the surrounding circumstances, one has to keep making decisions so that he can adapt a variety of changes creatively. In a familiar environment, one can make a decision rapidly, but in a new, or changed environment, one could always prefer deliberation to hurry even though deliberation will be a slower process. Over decades, a number of experiments have suggested that dopamine could play a crucial role in decision-making process. However, the relation between dopamine and deliberation, namely, how dopamine affects the temporal process for deliberation, is still not clear. Interestingly, recent experimental evidence suggested that D1-like and D2-like receptors act the opposing effect with specific time and concentration dependence, which means that D1-like and D2-like receptors could dominate interactively the modulation effect in different time courses. In the present study, temporal interaction between D1-like and D2-like receptors is introduced into a decision-making neural network model. As a result, the duration period in which D2-like receptors predominate the modulation effect strongly affect the reaction period, as could correspond to a deliberative process. On the other hand, D1-like receptors efficiently improve the speed of decision-making, as could correspond to a rapid decision-making. Applying these effects to a simulated experiment in which a rat is foraging in a T-maze, we found that the rat shows, at the earlier laps, a longer residence at the choice point due to a higher novelty, but a fast turn after learning. This model brings us an important implication that temporal interaction between D1-like and D2-like receptors could deeply affect our decision-making process, deliberation or hurry.

NOTES:

P18. Decision making involve changes in the synaptic strength of the thalamic, hippocampal and amygdaline afferents to the medial prefrontal cortex

J.C. López-Ramos, R. Guerra-Narbona and J. M. Delgado-García

Neuroscience Division. University Pablo de Olavide. 41013 – Sevillle (Spain)

Decision making (and other cognitive functions) is assumed to take place at the medial prefrontal cortex. This cortical area is identified in rodents by its dense connectivity with the mediodorsal thalamus, and because its inputs from other sites, as hippocampus and amygdala. The aim of this study was to find a relation between the behavior of mice during the development of decision making tasks that involve penalties changes on the consequences of induced actions, and the strength of excitatory postsynaptic potentials fields (fEPSP) evoked in the prefrontal cortex from their thalamic, hipoacampal and amygdaline afferents. For that, mice were chronically implanted with stimulating electrodes in the mediodorsal thalamus, the hippocampal CA1 area, and in the basolateral amygdala, and with recording electrodes in the prelimbic-infralimbic area of the prefrontal cortex. Additional stimulating electrodes aimed to evoke negative reinforcements were implanted, for same tests, on the trigeminal nerve. Studies of passive avoidance, operant conditioning in Skinner box, and fear conditioning in an own designed chamber were carried out. In all of them, fEPSP evoked through stimulation of the three studied afferences to prefrontal cortex were recorded. Results showed a general decrease of the strength of these potentials when animals repressed their natural or learned behavior.

NOTES:

P19. Transcranial current stimulation (tCS) over somatosensory cortex modulates associative learning and induces tactile perception in behaving rabbits

J. Márquez-Ruiz[1], R. Leal-Campanario[1], R. Sánchez-Campusano[1], C. Ammann[1], B. Molaee-Ardekani[2,3], F. Wendling[2,3], G. Ruffini[4], P. C. Miranda[5], A. Gruart[1], and J. M. Delgado-García[1]

[1]Division of Neurosciences, Pablo de Olavide University, 41013-Seville (Spain); [2]INSERM, U642, Rennes, F-35000 (France),[3]Université de Rennes, 1, LTSI, F-35000,France[4]Starlab Barcelona SL, Teodor Roviralta, 45, 08022-Barcelona, (Spain)[5]Neuroelectrics, Teodor Roviralta, 45, 08022-Barcelona (Spain)

The transcranial current stimulation (tCS) is a non-invasive brain stimulation technique that has been successfully applied in both basic and clinical research. Nevertheless, little is known about tCS effects on cortical circuits and its implications in sensory perception processes. Rabbits were prepared for the chronic recording of local field potentials (LFP) in the somatosensory cortex (SS) in response to whisker and/or ventroposterior medial (VPM) thalamic nucleus stimulations in the presence of tCS. Animals were also prepared for classical eyeblink conditioning and simultaneous tCS. tDCS and tACS applied over the SS modulated cerebral cortical processes subsequent to the localized stimulation of the whisker pad or of the corresponding area of the VPM nucleus. The acquisition of a classical eyeblink conditioning was potentiated or depressed by the application of anodal or cathodal tDCS respectively. In addition, we noticed that tACS can successfully substitute for whisker CS during an associative learning task. Moreover pairs of pulses applied to the thalamic VPM nucleus suggested that tDCS modifies thalamocortical synapses at presynaptic sites. In conclusion, results reported here highlight the potential of this technique for modulating associative learning and demonstrate that peripheral whisker stimulation can be substituted by tACS as CS.

Supported by grants BFU2011-29089, P07-CVI-02487 to J.M.D.-G., and BFU2011-29286, P07-CVI-02686 to A.G., from Spain. In addition, this work was funded by the EU FP7 FET-Open HIVE (222079) project.

NOTES:

P20. Boosting the intelligibility of vocal communication via interindividual entrainment of neuronal oscillations

H. Mizuhara, S. Inoue, T. Sasaoka and M. Shikauchi

Graduate School of Informatics, Kyoto University (Japan)

Viewing the face of a speaker increases the intelligibility of vocal communication. The facial gestures and head movements coincide with the prosody, which is an important speech rhythm to represent the intonation, and are called ‘prosodic expression’. The frequency of the prosodic expression is same as the delta EEG oscillation. Furthermore, the syllable and phoneme, which are other crucial rhythms of speech, coincide with the neuronal rhythms in theta and gamma bands, respectively. The theta and gamma rhythms have been considered as temporal windows to encode the syllable and phoneme. This led us a hypothesis that the interplay of these multiple frequency oscillations could enhance the speech intelligibility; that is, the speaker’s prosodic expression could entrain the listener’s neuronal oscillation into a preferred phase for binding the oscillations for syllable and phoneme into a coherent whole. To elucidate our hypothesis, we recorded scalp EEG during a listening task. The results showed that the accuracy of speech perception enhanced when the speaker’s face was clearly presented to participants with an appropriate timing. The phase locking value of the delta EEG oscillations enhanced around the central electrodes. Thus, our results indicated that the intelligibility of the vocal communication is realized via phase resetting by the entrainment of speaker’s prosodic expression. This might ensure the interplay of multiple frequency oscillations for binding the syllable and phoneme.

NOTES:

P21. Working memory of rhythm information in the front-parieto-cerebellar motor system

K. Nakamura[1], N. Konoike[1,2], Y. Kotozaki[3], S. Miyachi[1], C. Makoto Miyauchi[3], Y. Yomogida[2,4], Y. Akimoto[3], K. Kuraoka[1], M. Sugiura[3] and R. Kawashima[3]

[1] Primate Research Institute, Kyoto University (Japan); [2] Japan Society for the Promotion of Science (Japan); [3] Institute of Development, Aging and Cancer (IDAC), Tohoku University (Japan); [4] Tamagawa University Brain Research Institute (Japan)

Rhythm is an essential element of human culture, particularly in language and music. To acquire language or music, we have to perceive the sensory inputs, organize them into structured sequences as rhythms, actively hold the rhythm information in mind, and use the information when we reproduce or mimic the same rhythm. To date, the neural substrates involved in the working memory of rhythm remain unclear. In addition, little is known about the processing of rhythm information from non-auditory inputs (visual or tactile). We measured brain activity by functional magnetic resonance imaging while healthy subjects memorized and reproduced auditory and visual rhythms. The inferior parietal lobule, inferior frontal gyrus, supplementary motor area, and cerebellum exhibited significant activations during both encoding and retrieving both auditory and visual rhythms. In addition, most of these areas exhibited significant activation also during the maintenance of rhythm information. All these brain areas are thought to be essential for motor control. When we listen to certain rhythm, we are often stimulated to move our body, which suggests a strong interaction between rhythm processing and body movement. Here, we propose that rhythm information may be represented as information about bodily movements in the supra-modal motor brain system.

NOTES:

P22. Gamma Activity that Predicts Error during Spatial Alternation in Rat Hippocampal CA1

H. Nishida[1], M. Takahashi[1,2], A. D. Redish[3] and J. Lauwereyns[1,2]

[1]Graduate School of Systems Life Sciences, Kyushu University (Japan); [2]Brain Science Institute, Tamagawa University, Japan; [3]Department of Neuroscience, University of Minnesota (USA)

The hippocampus is crucial for information processing in memory-guided tasks. Recent studies have indicated that the hippocampus plays an important role especially during a delay period. However, it remains unclear how this delay-specific hippocampal activity emerges and what kind of neural activity is necessary for successful memory-guided behavior. To investigate the underlying mechanisms, we trained rats to perform a spatial alternation task that included a 1-s fixation period. We analyzed the local field potential in hippocampal CA1 during erroneous fixation trials (EF trials; in which the rat failed to fixate for 1s). We found that high gamma activity increased around fixation onset, whereas low gamma activity increased around offset. Furthermore, the power ratio of high gamma relative to the entire gamma band decreased significantly prior to the fixation onset in erroneous trials with a short fixation time as compared to those with a long fixation time. Conversely, the power ratio of low gamma increased significantly with short fixation as compared to long fixation. Taken together, our results indicated that prior hippocampal activity during a delay is critical for appropriate behavioral control. The results are discussed in relation to the putative sources of the different types of oscillation (entorhinal cortex and CA3).

NOTES:

P23. A mathematical model of state-dependent phase resetting properties of alpha rhythm in the human brain

Kei-Ichi Ueda

Faculty of Science University of Toyama Yasumasa Nishiura, WPI-AIMR Tohoku University Yoko Yamaguchi, Neuroinformatics Japan Center, RIKEN Brain Science Institute Keiichi Kitajo, RIKEN, BSI-TOYOTA Collaboration Center; RIKEN Brain Science Institute; PRESTO, Japan Science and Technology Agency (JST) (Japan)

It is well known that human 10 Hz alpha oscillations observed by electroencephalogram (EEG) is enhanced when eyes are closed.
A previous experimental study using a manipulative approach by transcranial magnetic stimulation (TMS) has revealed more global propagation of phase resetting in the eyes-open condition than in the eyes-closed condition at the alpha band. The results indicate significant increase of directed information flow across the brain networks from the stimulated area to the rest of the brain when eyes are open, suggesting that the sensitivity to environmental changes and external stimuli is adaptively controlled by changing the power of alpha rhythm. The mathematical mechanism mediating the changes in the sensitivity, however, has not been well elucidated.
In this study, we propose a qualitative mathematical model describing the characteristic behavior of the EEG phase dynamics. It is numerically found that the propagation properties of the phase resetting qualitatively change depending on whether the group of oscillators at the stimulated area are synchronized or not. The results support the hypothesis that the power of the alpha oscillations controls the sensitivity to the external stimuli.

NOTES:

P24. Experimental approaches to mechanisms of human prospection and planning

J. Okuda

Department of Intelligent Systems, Faculty of Computer Science and Engineering, Kyoto Sangyo University (Japan)

Recently, cognitive and neural mechanisms underlying prospective abilities in humans have received a great deal of attention in a wide range of research areas. A growing body of experimental and theoretical studies has suggested that the human ability to construct ideas about possible future events (i.e., prospection) is closely related to the ability of storing and retrieving personal event information in the past (i.e., episodic memory). An influential idea about how the human prospection emerges is that information retrieved from past experiences might be re-combined and integrated into a coherent idea about what would happen at when and where in the future. Candidate brain regions supporting these processes have been identified mainly in medial regions of the cerebral hemispheres. Existing data, however, largely depend on brain activation experiments during which subjects orally express (or mentally imagine) possible future events in their personal lives. Therefore, the studies had a limitation in clarifying detailed mechanisms independent of subject-specific life background. In this presentation, I will introduce recent attempts to investigate brain mechanisms for constructing future plans from past experiences using materials and tasks unrelated to each subject's life history and knowledge. The results are also discussed in relation to formation of communication systems across humans.

NOTES:

P25. Temporal relationship between eye and hand movements during visuo-manual tracking task

Y. Sakaguchi and Y.Inoue

University of Electro-Communications, Graduate School of Information Systems, Chofu-shi, Tokyo (Japan)

When people try to track a moving visual target with a hand, the hand movement often shows discontinuous behavior even if the target moves continuously, suggesting the existence of some discrete control mechanism in our brain. As a possible mechanism explaining this phenomenon, we have proposed a control model that our brain divides a given motor task into discrete segments, executes feed-forward control within each segment, and plans/adjusts motor commands as a unit of segment. If our brain adopts such an intermittent control strategy, timings of eye movements must be closely related to those of discontinuous hand movements because visual information is essential for planning/adjustment of hand movements. In order to examine this point, we analyzed the temporal relationship between hand and eye movements during a visuo-manual tracking task. Generally, their relationship varied dynamically within a trial, but showed a tendency dependent on the target speed. When the target motion was rather slow (where the discontinuous hand behavior was clearly observed), especially, discontinuous eye movements (including saccades) were often observed in advance of discontinuities of hand movements. In addition, the nature of eye movements was apparently different between visuo-manual tracking and simple eye-tracking tasks. These results seem consistent with a view that the eye movement was controlled so as to capture essential visual information for determining the hand movement for each segment.

NOTES:

P26. Dynamic patterns of cortical activation and multisynaptic state functions during the acquisition of different learning paradigms

R. Sánchez-Campusano*, A. Carretero-Guillén, I. Fernández-Lamo, J.M. Delgado-García, and A. Gruart

Division of Neurosciences, Pablo de Olavide University, 41013 Seville (Spain)

The availability of genetic/pharmacological tools of animal modification, of standardized analytical methods, and of advanced electrophysiological techniques — susceptible of being applied in behaving animals during the acquisition of different learning paradigms — have largely facilitated the study of learning as a functional state of cerebral cortical circuits. The aim of this study was to revisit the hypothesis that each synapse in those cortical circuits contributes in a specific and precise way to the acquisition and storage of different types of associative learning tasks. In this study, we have recorded activity-dependent changes in synaptic strength in many different synapses at the hippocampal and prefrontal circuits during the acquisition and storage of associative learning tasks in alert behaving animals — mostly in mice, but also in rats and rabbits — during classical and instrumental conditioning paradigms. Furthermore, we have developed a dynamic approach of multisynaptic state functions to characterize the acquisition of new motor and/or cognitive skills. Here, a synaptic state function is analogous to a precise picture of a synaptic pathway while the behaving animal learns the task. Therefore, the different state functions of large cortical synaptic circuits during the very moment at which learning is taking place, could be specifically defined by 3D-arrays of synaptic sites, learning stages, and behaviors. The couplings among the different synaptic state functions were determined by means of weight functions that characterized the changes in synaptic strengths, the type (linear or nonlinear) of interdependences among state functions, as well as the timing and correlation relationships among them. The exhaustive analysis of the collected data indicates that many synaptic sites within cortical circuits modulate their synaptic strength across the successive stages of acquisition of associative learning tasks. The main output of this study is that learning is the result of the activity of wide cortical and subcortical circuits activating particular functional properties of involved synaptic nodes, and that we can quantify that activation pattern by means of state and weight functions. In this regard, we expect that a dynamic map of state functions relating the acquisition of new motor and cognitive abilities and the underlying synaptic plastic changes will be offered in the near future for different learning tasks.

Supported by grants BFU2011-29089, P07-CVI-02487 to J.M.D.-G., and BFU2011-29286, P07-CVI-02686 to A.G., from Spain.

NOTES:

P27. Predicting the Flow of Information by Gamma Oscillations in Hippocampus during Preparatory Waiting

M.Takahashi[1,2], H. Nishida[1], A. D. Redish[3] and J. Lauwereyns[1,2]

[1]Graduate School of Systems Life Sciences, Kyushu University, Fukuoka, Japan; [2]Brain Science Institute, Tamagawa University, Tokyo, Japan; [3]Department of Neuroscience, University of Minnesota, Minneapolis (USA)

Hippocampus is thought to play an important role in supporting behavior on the basis of memory, especially when the subject stays motionless and anticipates the next task event. The underlying neural mechanisms during such a preparatory period, however, remain poorly understood. Here, we show a novel dynamic shift of the information flow in hippocampus during the preparatory fixation period while the subject is fully alert. Four rats were trained on a delayed spatial alternation task using a sustained nose-poking paradigm. We recorded multi-unit activity and local field potentials (LFPs) in the dorsal CA1 pyramidal cell layer using a 14-tetrode hyperdrive assembly during task performance. Population analysis of the LFPs showed that the gamma-band activity shifted from high frequency (60 to 100 Hz) at the beginning of fixation, to low frequency (30 to 45 Hz) at the end of fixation. Fast gamma is thought to derive from extra-hippocampal regions (e.g., entorhinal cortex), whereas slow gamma originates from CA3-CA1 intra-hippocampal circuitry. Our data suggest that the delayed spatial alternation is supported via fast-gamma entorhinal input to the hippocampus. This would initiate the hippocampal computation when the fixation starts, and would then be converted to slow gamma activity for CA3-CA1 circuitry to convey the computation outputs as a function of the task context.

NOTES:

P28. Why People See Things That Are Not There? -A Neurodynamical Account with a Conceptual Model

H. Tsukada[1], H. Fujii[2], I. Tsuda[3,4] and K. Aihara[5]

[1] Department of Mathematics, Graduate School of Science Hokkaido University, Sapporo 060-0810 (Japan); [2] Department of Intelligent Systems, Kyoto Sangyo University, Kyoto 603-8555 (Japan); [3] Research Institute for Electronic Science, Hokkaido University, Sapporo 060-0812 (Japan); [4] Research Center for Integrative Mathematics (RCIM), Hokkaido University, Sapporo 060-0812 (Japan); [5] Institute of Industrial Science, The University of Tokyo, Tokyo 153-8505 (Japan)

DLB – the dementia with Lewy bodies is the second most prevalent disease (next to the Alzheimer's disease) with psychotic symptoms such as visual hallucinations, and fluctuating attention. (Perry and Perry, 1995). In fact, patients with DLB "see things that are not there" (Collerton et al., 2005). Images are generally vivid and colored, and continue for a few minutes (neither seconds nor hours). Images appear in contextually correct situations. Recently, data accumulate that cholinergic receptors are lost in e.g., prefrontal (PFC) and inferior temporal (IT) areas, and also in parietal cortex. It is also reported that the α7 subtype of nicotinic receptors (nAChRs) appears to be responsible. (Reid et al., 2000; Court et al., 2001). Our aim is to answer the question: how does the neurochemical event of cholinergic loss may cause the cognitive event of visual hallucinations? Our arguments should be based on neuroanatomical, neuropsychopharmacological and dynamical systems standpoints. Basic symptoms may come from malfunctions of both PFC and IT cortex, caused by loss of nAChRs. The two cortices are inevitably shutout from external information, forced to construct internal representation of objects at the fovea solely from internal contexts. We propose a conceptual model of dynamic interactions between PFC and IT leading to hallucinations.

NOTES:

P29. Neuronal energy flow in information coding and conjecture of the perceptual field

R.Wang and Z. Zhang

Institute for Cognitive Neurodynamics, School of Science, East China University of Science and Technology, Shanghai 200237 (China)

By re-examining the energy model for neuronal activities, we show the inadequacy in the current understanding of the energy consumption associated with the activity of a neuron. Specifically, we show computationally that a neuron first absorbs energy and then consumes energy during firing action, and this result cannot be produced from any current models of neurons or biological neural networks. Based on this finding, we provide an explanation for the observation that when neurons are excited in the brain, blood flow increases significantly while the incremental consumption of oxygen is very small. We can also explain why external stimulation and perceptual emergence are synchronized.

NOTES:

P30. Intermittent switching of information flow in coupled chaotic oscillators

Y. Yamaguti[1], I. Tsuda[1] and Y. Takahashi[2]

[1]Research Institute for Electronic Science, Hokkaido University, Kita-ku, Sapporo, Hokkaido 060-0812 (Japan); [2]Institute of Industrial Science, University of Tokyo, Komaba, Meguro-ku, Tokyo 153-8505 (Japan)

Each subregion of the neocortex carries out different types of information processings despite the similarity of anatomical structure. It is hypothesized that the heterogeneity observed in the connections between subregions contributes to the functional difference between higher and lower regions. In order to investigate the differentiation of behaviors induced by the heterogeneous coupling, we studied heterogeneously-coupled chaotic oscillators. By using information-theoretic measures, directions of information flows between two chaotic oscillators were investigated. The direction of information flow spontaneously switched in an intermittent manner, depending on the phase difference between two systems. Similar switching behavior was also observed in coupled maps with additive and multiplicative noises. In both models, the residence-time distributions obey a -3/2 power law, which suggests the presence of on-off intermittency.

-This work was supported by a Grant-in-Aid for Scientific Research on Innovative Areas “The study on the neural dynamics for understanding communication in terms of complex hetero systems (No.4103)” (21120002) of The Ministry of Education, Culture, Sports, Science, and Technology, Japan.

NOTES:

P31. Co-creation process of symbolic communication systems: Cognitive experiments and constructive studies

Takashi Hashimoto, Takeshi Konno, and Junya Morita

School of Knowledge Science, JAIST (Japan)

We study the co-creation process of symbolic communication systems, where people make a shared communication system through interaction from scratch, taking an integrative approach which includes cognitive experiment, constructive modeling, and brain measurement. As a basis of the integrative approach, we designed an experimental paradigm of a coordination game including symbolic message exchange. Analyzing the cognitive experiment, we found three stages in the formation of symbolic communication systems: building common ground (sub-symbolic pragmatics), sharing a symbol system (semantics and syntax), and forming a role division (pragmatics). Sharing semantics and syntax contributes to solve the game but is not enough to perfectly stable solution. Participants came to succeed stably by conveying and understanding dual meanings in symbolic messages, that is, referential and intentional. The pragmatic level is achieved by the role division and is grounded utilizing turn-taking, namely, the first sender sends his/her present place and the second sender does a destination both players can reach. As constructive modeling, we used ACT-R, a cognitive architecture designed for simulating and understanding human cognition, since it integrates sub-symbolic and symbolic learning mechanisms. From simulation analysis of the model, role-reversal imitation plays an important role in the formation of symbolic communication systems.

NOTES: