ICCN 2019 Scientific Program

The 7th International Conference on Cognitive Neurodynamics 2019

Alghero, Italy
September 29 - October 2, 2019

How to get to ICCN 2019

ICCN 2019 is held in the Dipartimento di Architettura, Design e Urbanistica, Università degli Studi di Sassari, Alghero, Sardinia, Italy.
Address:
Bastioni Marco Polo 77, 07041 Alghero (SS), Italy

Directions

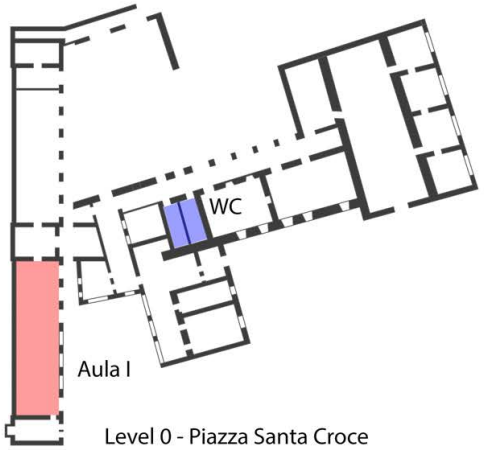
NOTE: The instructions below are just indicative! For any transportation option, make sure to double check the timetable a few weeks before your trip.

By air
- Landing in Alghero airport. The airport in Alghero offers mostly domestic destinations and some international destinations during the summer season. It is located around 10km from downtown.
- Landing in Olbia airport. The Olbia airport lies about 140km away from Alghero. It serves domestic and international destinations. The easiest way to get to ICCN 2019 from this airport is the direct coach service Olbia-Alghero (2.5 hours, 20 EUR).
- Landing in Elmas (Cagliari) airport. This is the main airport on the island, serving several international destinations. It lies further away from ICCN 2019, you should count around 5 hours travel time. You can reach Alghero by train, with a connection in Sassari. It is a good option if you plan to spend a few extra days before or after the conference to explore the beautiful island of Sardinia.

Another option is to rent a car at the airport and drive to Alghero. Most hotels in Alghero offer parking to their guests.

By ferry Many ferry services connect Northern Sardinia with the mainland. The main port is Porto Torres (around 40km from ICCN 2019), which is connected by ferry with Barcelona, Genoa, Civitavecchia, Marseille, Propriano.

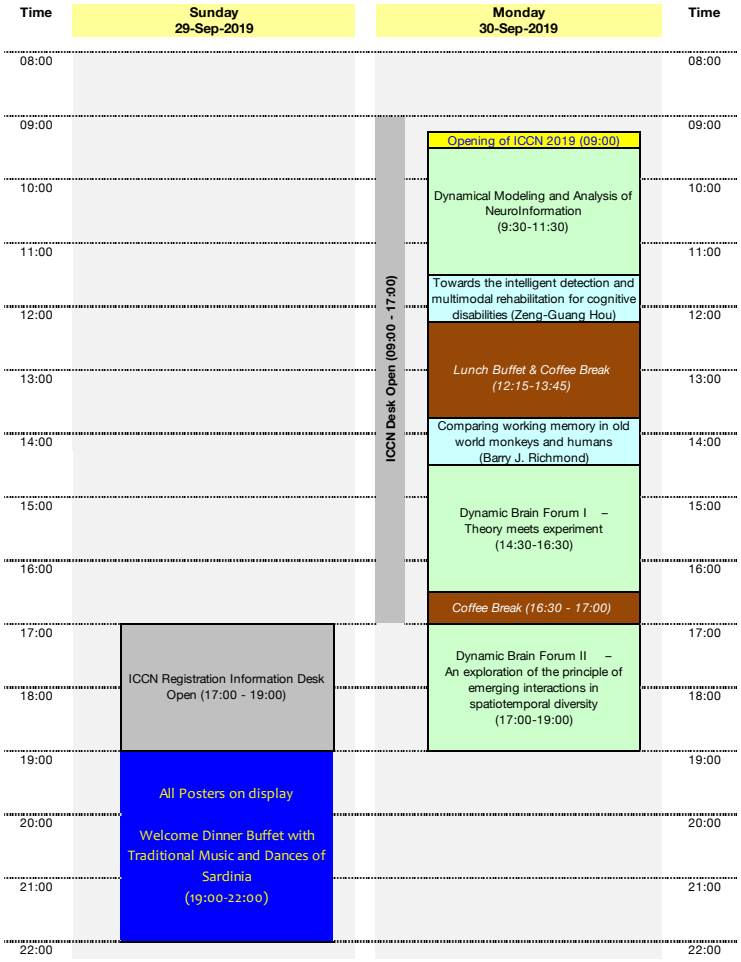
Conference venue floor plans



Level 0 - Piazza Santa Croce

Level 1 - Bastioni Marco Polo

Map of the conference venue and location of the building areas of interest of ICCN 2019


Time
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Monday
30-Sep-2019
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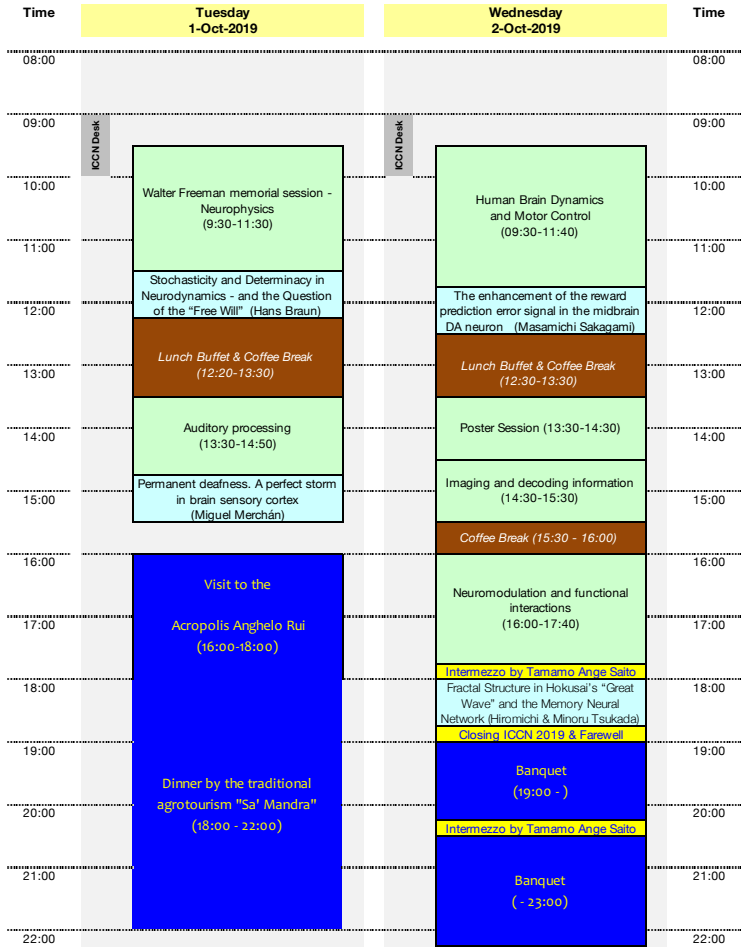
22:00
ICCN Desk Open (09:00 - 17:00)
Opening of ICCN 2019 (09:00)
Dynamical Modeling and Analysis of NeuroInformation (9:30-11:30)
Towards the intelligent detection and multimodal rehabilitation for cognitive disabilities (Zeng-Guang Hou)
Lunch Buffet & Coffee Break (12:15-13:45)
Comparing working memory in old world monkeys and humans (Barry J. Richmond)
Dynamic Brain Forum I – Theory meets experiment (14:30-16:30)
Coffee Break (16:30 - 17:00)
Dynamic Brain Forum II – An exploration of the principle of emerging interactions in spatiotemporal diversity (17:00-19:00)
ICCN Registration Information Desk Open (17:00 - 19:00)
All Posters on display
Welcome Dinner Buffet with Traditional Music and Dances of Sardinia (19:00-22:00)


Time
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ICCN Desk
ICCN Desk
Walter Freeman memorial session - Neurophysics (9:30-11:30)
Stochasticity and Determinacy in Neurodynamics - and the Question of the "Free Will" (Hans Braun)
Lunch Buffet & Coffee Break (12:20-13:30)
Auditory processing (13:30-14:50)
Permanent deafness. A perfect storm in brain sensory cortex (Miguel Merchán)
Visit to the
Acropolis Anghelo Rui (16:00-18:00)
Dinner by the traditional agrotourism "Sa' Mandra" (18:00 - 22:00)
Human Brain Dynamics and Motor Control (09:30-11:40)
The enhancement of the reward prediction error signal in the midbrain DA neuron (Masamichi Sakagami)
Lunch Buffet & Coffee Break (12:30-13:30)
Poster Session (13:30-14:30)
Imaging and decoding information (14:30-15:30)
Coffee Break (15:30 - 16:00)
Neuromodulation and functional interactions (16:00-17:40)
Intermezzo by Tamamo Ange Saito
Fractal Structure in Hokusai's "Great Wave" and the Memory Neural Network (Hiromichi & Minoru Tsukada)
Closing ICCN 2019 & Farewell
Banquet (19:00 -)
Intermezzo by Tamamo Ange Saito
Banquet (- 23:00)

Sunday, Sept.29, 2019 (Level 1 - Bastioni Marco Polo)
17:00-19:00
Registration and posters on display

19:00-22:00 (Level 0 - Piazza Santa Croce)
Welcome Dinner Buffet with Traditional Music and Dances of Sardinia

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Monday, Sept.30, 2019 (Level 1 - Aula VII)
09:15-09:30
Welcome address and opening of ICCN 2019

Monday, Sept.30, 2019 (Level 1 - Aula VII)
Dynamical Modeling and Analysis of NeuroInformation (Chair: Prof. Daqing Guo)

09:30-09:50
Yao Miao (Tokyo University of Agriculture and Technology)
Seizure Detection of Epileptic EEG Based on Multiple Phase-Amplitude Coupling Methods

09:50-10:10
Xiaochuan Pan (East China University of Science and Technology)
A cortical network model for visual attention

10:10-10.30
Yin Tian (Chongqing University of Posts and Telecommunications)
The Alpha Network Changes Elicited by Working Memory Training

10:30-10:50
Daqing Guo (University of Electronic Science and Technology of China)
Multiple control of absence seizures in the brain: a computational study

10:50-11:10
Zongmei Chen (East China University of Science and Technology)
Optimized Correlation-based Time Window Selection Algorithm for Motor Imagery based BCIs

11:10-11:30
Ying Yu (Beihang University)
Synchronization and beta oscillations in globus pallidus: Role of the striatum

Monday, Sept.30, 2019 (Level 1 - Aula VII)
Keynote Lecture 1 (Chair: Prof. Xiaochuan Pan)

11:30-12:15
Zeng-Guang Hou *(State Key Laboratory of Management and Control for Complex Systems Institute of Automation, The Chinese Academy of Sciences, Beijing, China)*
Towards the intelligent detection and multimodal rehabilitation for cognitive disabilities

12:15-13:45 (Level 0 - Aula I)
Lunch Buffet & Coffee Break

Monday, Sept.30, 2019 (Level 1 - Aula VII)
Keynote Lecture 2 (Chair: Prof. Minoru Tsukada)

13:45-14:30
Barry J. Richmond *(Section on Neural Coding and Computation, Laboratory of Neuropsychology, NIMH/NIH/DHHS, Bethesda, MD, USA)*
Comparing working memory in old world monkeys and humans

Monday, Sept.30, 2019 (Level 1 - Aula VII)
Dynamic Brain Forum I – Theory meets experiment (Chair: Yoshikazu Isomura)

14:30-14:55
Yoshikazu Isomura (Tokyo Medical and Dental University)
An exception to contralateral dominance of cerebral cortex – from abstract to concrete

14:55-15:20
Naoki Kogo (Radboud University)
Non-linear neural dynamics of mutual inhibition circuit in a real-life/computer model hybrid system

15:20-15:45
Hideaki Shimazaki (Kyoto University)
Neural interactions in visual cortex revealed by the state-space Ising model

15:45-16:10
Hiromichi Tsukada (Okinawa Institute of Science and Technology Graduate University)
Context-dependent learning and memory based on spatio-temporal learning rule

16:10-16:35
Shigetoshi Nara (Okayama University)
A time delayed effect in a recurrent neural network model and preliminary results of computer experiments

16:30-17:00 (Level 0 - Aula I)
Coffee Break

Monday, Sept.30, 2019 (Level 1 - Aula VII)
Dynamic Brain Forum II – An exploration of the principle of emerging interactions in spatiotemporal diversity
(Chair: Profs. Yutaka Yamaguti and Ichiro Tsuda)

17:00-17:20
Paul Rapp (Uniformed Services University of the Health Sciences, Bethesda MD, USA)
Quantifying information dynamics in CNS networks

17:20-17:40
Minoru Asada (Osaka University)
Pain nervous system as a key component to induce empathy, morality, and ethics

17:40-17:55
Yuji Kawai (Osaka University)
Complex and Structured Neurodynamics in Reservoir Computing

17:55-18:10
Tetsuya Takahashi (Kanazawa University)
The Emerging Field of E/MEG Analyses on Dynamical Neural Networks

18:10-18:25
Aoi Naito (University of Tokyo), Naoki Masuda (University of Bristol) and Tatsuya Kameda (University of Tokyo)
Social network and collective intelligence under non-stationary uncertain environment

18:25-18:40
Ikki Matsuda (Chubu University)
Evolution of Primate Multilevel Social Systems: Proboscis Monkey Society As Complex System

18:40-18:50
Ichiro Tsuda (Chubu University)
Mathematical modelling for functional differentiation

18:50-19:00
Discussion

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Tuesday, Oct.1, 2019 (Level 1 - Aula VII)
Walter Freeman memorial session - Neurophysics (Chair: Prof. Hans Liljenström)

09:30-09:50
James Wright (University of Auckland)
The Growth of Cognition and the Free Energy Principle

09:50-10:10
Paul Rapp (Uniformed Services University of the Health Sciences, Bethesda MD, USA)
Disrupted gamma synchrony after mild traumatic brain injury and its correlation with white matter abnormality

10:10-10.30
Alessandro E P Villa (University of Lausanne)
Initial topology in hierarchically organized evolvable neural networks determines the emergence of synfire chains

10:30-10:50
Xuying Xu (East China University of Science and Technology)
The spontaneous spiking in up and down oscillations and its energy feature

10:50-11:10
Roseli Wedemann (Universidade do Estado do Rio de Janeiro)
Nonlinear Fokker-Planck Approach to the Cohen-Grossberg Model

11:10-11:30
Hans Liljenström (Swedish University of Agricultural Sciences)
On the neurodynamics of intention, decision and free will

Tuesday, Oct.1, 2019 (Level 1 - Aula VII)
Keynote Lecture 3 (Chair: Barry J. Richmond)

11:35-12:20
Hans Braun *(Institute of Physiology, Philipps University of Marburg, Germany)*
Stochasticity and Determinacy in Neurodynamics - and the Question of the "Free Will"

12:20-13:30 (Level 0 - Aula I)
Lunch Buffet & Coffee Break

Tuesday, Oct.1, 2019 (Level 1 - Aula VII)
Auditory processing (Chair: Prof. Marisa Pedemonte)

13:30-13:50
Miguel Ángel Martín-Pascual (Instituto RTVE, Sant Cugat del Vallès (Spain)
Viewer's attention flow when watching audiovisual cuts

13:50-14:10
Isabella Silkis (Inst. Higher Nervous Activity & Neurophysiology, Russian Academy of Sciences)
A possible mechanism of learning-evoked reorganization of receptive fields in the primary auditory cortex

14:10-14:30
Marisa Pedemonte (CLAEH University, Uruguay)
Auditory processing during sleep: a clinical application in tinnitus

14:30-14:50
Celia Andreu-Sánchez (Universitat Autònoma de Barcelona)
Synchronization and Granger causality associated to audiovisual cuts

Tuesday, Oct.1, 2019 (Level 1 - Aula VII)
Keynote Lecture 4 (Chair: Prof. José-María Delgado-García)

14:50-15:35
Miguel Merchán *(Instituto de Neurociencias of Castilla y Leòn-INCyL, Universidad de Salamanca, Spain)*
Permanent deafness. A perfect storm in brain sensory cortex

The meeting point will be indicated at conference premise

16:00-18:00
Bus excursion and guided tour of the Acropolis Anghelo Rui

18:00-22:00
The bus excursion will stop for a
dinner by the traditional agrotourism "Sa' Mandra"

22:30
Return to Alghero downtown

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Wednesday, Oct.2, 2019 (Level 1 - Aula VII)
Human Brain Dynamics and Motor Control (Chair: Prof. Peiyang Li)

09:30-09:50
Alessandra Lintas (University of Lausanne)
ERPs in Controls and ADHD Patients During Dual n-Back Task

09:50-10:10
Peiyang Li (Chongqing University of Posts and Telecommunications)
Emotion analysis based on multi-class common spatial features of scalp EEG

10:10-10:30
Chuanzuo Yang (Beihang University)
Alterations of brain networks before and after surgery in temporal lobe epilepsy patients with hippocampal sclerosis

10:30-10:50
Feiyu Yin (East China University of Science and Technology)
PSO-Sub-ABLD based Parameter Optimization for motor imagery BCI

10:50-11:10
Xiuxin Wang (Chongqing University of Posts and Telecommunications)
Photoacoustic imaging of tibia fracture in rats

11:10-11:40
Zhipeng Liu (Chinese Academy of Medical Sciences & Peking Union Medical College)
Experimental study on transcranial electrical simulation based on magneto-acoustic effect

Wednesday, Oct.2, 2019 (Level 1 - Aula VII)
Keynote Lecture 5 (Chair: Dr. Alessandra Lintas)

11:40-12:25
Masamichi Sakagami *(Brain Science Institute, Tamagawa University, Machida, Japan)*
The enhancement of the reward prediction error signal in the midbrain dopamine neuron by the cost paid for the reward

12:30-13:30 (Level 0 - Aula I)
Light Lunch Buffet & Coffee Break

Wednesday, Oct.2, 2019 (Level 1 - Aula VII)
Poster Session

13:30-14:30
Qinyue Zheng (Huazhong University of Science and Technology) & Sihao Liu, Alessandro E.P. Villa, and Alessandra Lintas
Seizure Detection of Epileptic EEG Based on Multiple Phase-Amplitude Coupling Methods

13:30-14:30
Masashi Dotare (Yamaguchi University) & Yoshiyuki Asai, Sarah K. Mesrobian, Michel Bader, Alessandro E.P. Villa, and Alessandra Lintas
Training parameters with Dual N-Back task affect the outcome of the Attentional Network Task in ADHD patients

13:30-14:30
Manon Jaquerod (University of Lausanne) & Ramisha Knight, Alessandro E.P. Villa, and Alessandra Lintas
Event-Related Potentials and Fast Optical Imaging of Cortical Activity During An Auditory Oddball Task

13:30-14:30
Rossella Falcone (Section on Neural Coding and Computation, NIMH/NIH) & Mariko McDougall, David Weintraub, Tsuyoshi Setogawa, and Barry Richmond
Neural coding of reward value in richly modulated spike patterns in monkey ventrolateral prefrontal cortex

Wednesday, Oct.2, 2019 (Level 1 - Aula VII)
Imaging and decoding information (Chair: Dr. Simona Monaco)

14:30-14:50
Haixin Zhong (East China University of Science and Technology)
A CNN-inspired Model for Degradation Mechanism of Retina to V1

14:50-15:10
Simona Monaco (University of Trento)
Decoding real and imagined actions in the Early Visual Cortex

15:10-15:30
Pierre Bonzon (University of Lausanne)
Symbolic neural dynamics allow for reproducing optogenetics experiments

15:30-16:00 (Level 0 - Aula I)
Coffee Break

Wednesday, Oct.2, 2019 (Level 1 - Aula VII)
Neuromodulation and functional interactions (Chair: Prof. Woochang Lim)

16:00-16:20
Woochang Lim (Daegu National University of Education)
Equalization Effect in Interpopulation Spike-Timing-Dependent Plasticity in Neuronal Networks with Inhibitory and Excitatory Populations

16:20-16:40
Eriko Sugisaki (Tamagawa University)
Acetylcholine effects on STDP induced on spatial and non-spatial information in dentate gyrus

16:40-17:00
Yihong Wang (East China University of Science and Technology)
The maximum information principle of place cell activity

17:00-17:20
Takeshi Abe (Yamaguchi University)
Causal Interactions Among Cortical Regions During Sleep Based On fNIRS Recordings

17:20-17:40
Tao Zhang (Nankai University)
A new deep neural network inspired by directional mutual information between slow and fast neural information flow

17:40-18:00 (Level 1 - Aula VII)
Intermezzo by violinist Tamamo Ange Saito

Wednesday, Oct.2, 2019 (Level 1 - Aula VII)
Keynote Lecture 6 (Chair: Prof. Alessandro E.P. Villa)

18:00-18:45
Hiromichi Tsukada & Minoru Tsukada *(Brain Science Institute, Tamagawa University, Machida, Japan)*
Fractal Structure in Hokusai's "Great Wave" and the Memory Neural Network —Brain, Art and AI—

Wednesday, Oct.2, 2019 (Level 1 - Aula VII)
18:45-18:50
Farewell address and closing of ICCN 2019

19:00-23:00
Gala Dinner and Banquet
by Ristorante Quarte' Sayal Alghero

20:30
Intermezzo by violinist Tamamo Ange Saito

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Seizure Detection of Epileptic EEG Based on Multiple Phase-Amplitude Coupling Methods

Yao Miao, Toshihisa Tanaka, Shintaro Ito, and Jianting Cao

Abstract For epileptic electroencephalography (EEG) analysis, features extraction is crucial in seizure detection. In this paper, five methods for phase-amplitude coupling (PAC) were employed to analyze epileptic EEG to verify that PAC can be used as a biomarker to detect seizures. Specifically, five algorithms of evaluating PAC were used to compute PAC of seizure activity and seizure-free intervals at nine frequency band combinations. Then PAC of the EEG in a public dataset computed were classified by support vector machine (SVM), where the classification performance was assessed by calculating mean area under curve (AUC) based on receiver operating characteristic (ROC) with k-fold cross-validation (CV). Moreover, phase-amplitude comodulogram was applied to the same dataset to confirm intuitively classification accuracy. Results showed that the classification accuracy at band combination $\theta - \gamma$ was up to 0.96 and 0.99 for identifying seizure-free and seizure intervals both within epileptogenic zone, and for classifying seizure-free interval EEG not within epileptogenic zone and seizure EEG within epileptogenic zone separately. Classification results of five different PAC methods were similar to each other. Furthermore, it was shown that there existed significant coupling at band combination $\theta - \gamma$ for EEG of seizure activities by observing from the comodulograms, which were consistent with the classification results.

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Shintaro Ito
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Saitama Institute of Technology, 1690 Fusaiji, Fukaya-shi, Saitama, 369-0293, Japan, e-mail: cao@sit.ac.jp

A cortical network model for visual attention

Xiaochuan Pan, Tao Zhang, Xuying Xu, and Rubin Wang

Abstract It is known that visual attention increased firing rates of neurons, reduced their response variability and improved reliability of coding relevant stimuli. Despite of several decades of studies, mechanisms of visual attention still remains unclear. Recently some experiments reported that attention enhanced the synaptic efficacy between neurons mediated through NMDA and AMPA receptors. To understand how attention modulates neuronal activity at the synaptic level, we proposed a neural network consisting of three layers. The neurons were connected through excitatory AMPA and NMDA receptors, as well as inhibitory GABA receptors. The binding process of neurotransmitters with receptors is stochastic in the synapse, we hypothesize that attention could reduce the variation of the stochastic binding process and increase the fraction of bound receptors in the model. On the basis of this hypothesis, the model showed that attention increased firing rates of neurons and reduced their response variability. The attention-induced effects were stronger in higher regions compared to those in lower regions, and stronger for inhibitory neurons than for excitatory neurons. These results suggest that attention may modulate neuronal activity at the synaptic level.

Xiaochuan Pan · Tao Zhang · Xuying Xu · Rubin Wang
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The Alpha Network Changes Elicited by Working Memory Training

Yin Tian and Huiling Zhang

Abstract Previous studies have shown that different frequency oscillations were associated with cognitive processing such as working memory (WM). The current study combined EEG coherence and graph theory analysis to study the topological changes of WM brain network before and after training based on the whole region of the brain, and constructed difference statistical networks under alpha rhythms. The results showed that the subjects' WM networks after training had higher clustering coefficients and shorter optimal path lengths than the brain networks before training. Moreover, the alpha network revealed that long range fronto-parietal and fronto-occipital interactions during WM retention evolved in the alpha frequency range. The findings revealed that before and after WM training, the connections between neurons varied to complete the efficient transmission and processing of information, indicating the plasticity of neuron connections before and after WM training from the network level.

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Multiple control of absence seizures in the brain: a computational study

Daqing Guo

Abstract Absence epilepsy is the most typical generalized epilepsy. As the electrophysiological hallmark, the spike-wave discharges (SWDs) with frequency 2-4 Hz can be observed in the EEG recordings during seizures. Using computational models, we investigated the biophysical mechanisms for both internal and external regulations of absence seizures. We identified that increasing the strength of thalamic feedforward inhibition can significantly inhibit the seizure activities, and different types of inhibition (sending from thalamic reticular nucleus, i.e., TRN, to specific relay nuclei, i.e., SRN) play important but different roles in taming seizure dynamics. In particular, we found that strong GABAB inhibition tends to suppress SWDs, while GABAA inhibition mainly controls the dominate frequency of seizure dynamics. On the other hand, we also found that the BG might multiply control absence seizures via three inhibition pathways sending to thalamus and cerebral cortex. The SWD suppression induced by the inhibitory pathway projecting from the substantia nigra pars reticulate (SNr) to thalamic SRN is due to the GABAB weakening, while the SWD suppression induced by the SNr-TRN pathway is because of the collision in TRN. More interestingly, owing to the competition between these two pathways, we observed that the bidirectional control of absence seizures by the BG. Further investigations demonstrated that the GABAergic pallido-cotrical pathway might can also directly inhibit the typical 2-4 Hz SWDs generated in our model. These findings highlight the functional significance of thalamic feedforward inhibition (internal regulation) and basal ganglia (external regulation) in controlling and modulating absence seizures.

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Optimized Correlation-based Time Window Selection Algorithm for Motor Imagery based BCIs

Zongmei Chen, Cili Zuo, Hak-Keung Lam, Yangyang Miao, Xingyu Wang, and Jing Jin

Abstract For motor imagery (MI) based brain-computer interface (BCI) systems, the time latency and length of MI task vary between trials and subjects, due to the differences between subjects' reaction time and personal habits. Therefore, the starting and ending time point of each MI task can hardly be determined manually for different subjects. Fixed time window may contain task-irrelevant signals or does not contain sufficient task-related signals, which will lead to degraded the performance of MI-based BCI systems. To address this issue, an optimized correlation-based time window selection (OCTWS) algorithm is proposed for MI-based BCIs. The optimized starting point and length of MI task-relevant signals are determined simultaneously based on correlation analysis and performance evaluation. A public EEG dataset (BCI Competition IV Dataset I) is used to evaluate the proposed OCTWS method. Experimental results demonstrate that OCTWS helps improve the feature extraction and classification performance of MI.

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Hak-Keung Lam
Department of Informatics, King's College London, United Kingdom

Synchronization and beta oscillations in globus pallidus: Role of the striatum

Ying Yu, Kaijie Liang and Qingyun Wang

Abstract Striatum, the main entrance of cortical afferents to the basal ganglia, plays an important role in the Parkinson's disease, and it is often overlooked in the study of Parkinson's disease. In this paper, we add globus pallidus externus (GPe), globus pallidus internus (GPi) and subthalamic nucleus (STN) nuclei on the basis of the striatum-inhibiting microcirculation, and build a Striatum-GP-STN model. Numerical analysis results show that increasing the synaptic connections of medium spiny neurons (MSNs) to GPe and GPi neurons results in a pathological synchronization of GPe and GPi neurons, and the power spectral density indicates a significant increase in beta-band energy. This is likely to be a potential source of beta-band in the Parkinson's disease. The expansion of the Striatum-GP-STN model also provides new ideas for studying Parkinson's disease in the future.

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Towards the intelligent detection and multimodal rehabilitation for cognitive disabilities

Zengguang Hou

Abstract The aging of the population drives the rapid increase of cognitive disorders, which cause a heavy burden for families and nations. It is important to screen and interfere with cognitive disorders at the earlier stage, but we are short of affordable and effective approaches. In this talk, we will discuss our attempt in the design of the multi-mode detection and rehabilitation methods for cognitive disorders using computational intelligence algorithms, wearable devices, and rehabilitation robots.

Zengguang Hou
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Comparing working memory in old world monkeys and humans

Barry J. Richmond

Abstract There are two types of neural phenomena that have been called working memory. The first is a selective, attention demanding process. In this first process, until the attention is interrupted, the memory trace has high fidelity over time. The second is a non-selective, non-attention demanding process where all events seem to form a memory traces each decaying with time. The first process is generally thought of as true working memory in humans. We started out to study the substrates of these working memory types in monkeys. To our surprise (frustration?) we found that monkeys rely primarily on the second type of working memory even when put in situations where it seems most efficacious to use the first type. The monkeys make large numbers of false positive responses related to the time in the past when a visual stimulus was presented in a sequential string of visual distractors. By way of comparison, humans heavily favor the first type of working memory; they make almost no false positive responses when asked to remember a single index stimulus.

I will review our results and show how selective damage to different parts of the monkey brain thought important for supporting normal working memory function, prefrontal cortex, hippocampus, and different parts of lateral inferior temporal cortex, selectively interfere with different aspects of working memory.

For physiologists this raises a problem: how do we study mechanisms of working memory using monkeys if monkeys use different strategies to solve working memory tasks?

Barry J. Richmond
Chief Section on Neural Coding and Computation, NIMH/NIH Bldg 49, Rm 1B-80, Bethesda MD 20892 USA. e-mail: Barry.richmond@nih.gov

An exception to contralateral dominance of cerebral cortex: from abstract to concrete

Yoshikazu Isomura

Abstract The cerebral cortex usually governs contralateral body parts in sensation and movements. The rule of contralateral dominance of cerebral cortex is well established on the basis of a long history of human and animal experiments. We also confirmed the rule for the primary (M1) and secondary (M2) motor cortices controlling unilateral forelimb movements in behaving rats. However, we found that their posterior parietal cortex (PPC) neurons preferentially represent ipsilateral forelimb movements, in contrast to the contralateral preference of M1 and M2 neurons. Moreover, our optogenetic activation of PPC neurons evoked ipsilaterally biased forelimb movements. Even weak PPC activation affected their task performance of ipsilateral forelimb movements. I will talk about our interpretation on these paradoxical observations from the point of view of an evolutional difference between rodents and primates.

Yoshikazu Isomura
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Non-linear neural dynamics of mutual inhibition circuit in a real-life/computer model hybrid system

Naoki Kogo, Felix Kern, Thomas Nowotny, Raymond van Ee, Takeshi Aihara, and Richard van Wezel

Abstract To process ambiguous and noisy images, often experienced in our daily life, the neural system has to actively select and organize the input signals. For a percept to emerge it has been assumed that there are selection processes of competing neural pools. Theoretical research assumed a mutually inhibiting neural circuit underlying the competition and successfully modeled bi-stable perception that occurs in response to ambiguous images. We developed an experimental system to record two real life-pyramidal neurons (in vitro) connected by modeled mutual inhibition circuit (in silica). We show that simultaneous stimulations of the two pyramidal neurons in this hybrid system evoked bi-stable activity. Furthermore, the effect of adding noise and changing stimulus strength showed similar characteristics known from bi-stable perception, suggesting a fundamental role of the non-linear dynamics in perceptual organization.

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Dynamic neural interactions revealed by the state-space Ising model

Hideaki Shimazaki

Abstract Stimulus information and cognitive states of an animal are represented by correlated population activity of neurons. The maximum entropy method provides a principled way to describe the correlated population activity using much less parameters than the number of possible activity patterns. This method successfully explained stationary spiking activity of neural populations such as in vitro retinal ganglion cells. Modeling activity of cortical circuitries in vivo, however, has been challenging because both the spike-rates and interactions among neurons can change according to sensory stimulation, behavior, or an internal state of the brain. To capture the non-stationary interactions among neurons, we augmented the maximum entropy model (Ising model) using a state-space modeling framework, which we call the state-space Ising model. We will demonstrate that applications of the state-space Ising model to activity of cortical neurons reveal dynamic neural interactions, and how they contribute to sparseness and fluctuation of the population activity as well as stimulus coding.

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Context-Dependent Learning and Memory based on Spatio-Temporal Learning Rule

Hiromichi Tsukada and Minoru Tsukada

Abstract Hebbian learning rule (HEB) with recurrent connections has the ability to stabilize memory patterns, while spatio-temporal learning rule (STLR) has high ability to discriminate temporal difference of spatial input patterns in spatio-temporal context. These learning rules are confirmed to coexist in the brain by experimental study, however, how these learning rules interact each other in memory processing is still unclear. Here we constructed a recurrent neural network with two biological plausible learning rules (HEB and STLR), and evaluated how spatio-temporal context information is embedded in the memory by simulation. We found that spatio-temporal context patterns are embedded stably in the memory space as attractors with approximate balance of two learning rates, and clustered with temporal history. These findings contribute to the understanding of the fundamental neural mechanisms of spatio-temporal context learning in the brain.

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Time delayed effect can bring novel hierachical complex dynamics to neural network ?

Shigetoshi Nara

Abstract Complex dynamics could play an important role in advanced information processing and control in biological systems, particularly in neural(brain)-systems. Along this viewpoint, a recurrent neural network model with including time delayed effect is investigated by means of theoretical consideration and computer experiments as well. The proposed model not only works as the conventional associative memory but also enables us to embed a new kind of memory attractors which are unable to realize in the model without time delayed effect, for example chain ring like attractors or hierarchical structure of memory attractors. This is attributed to the fact that time delayed effect makes the available state space expand to larger dimensions than the given number of neurons and their states. These remarkable extensions of state space could generate emergent complex hierarchical dynamics in activity of neural system. In actual neural systems including brain, analogue property of real number is limited to finite resolution by biological restriction, so that infinite number of variables would be reduced considerably. Even if so, however, it may account for why human brain can show extraordinary memory-capacity comparing with speculated capacity from roughly estimated number of neurons concerning memorizing and recalling function.

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Quantifying Information Dynamics in CNS Networks

Paul E. Rapp, Christopher J. Cellucci, and David Darmon

Abstract We present a generically applicable four step process for quantifying information movement in complex networks.
(1) Construction of local entropy rate and specific entropy rate. Local entropy rate is a continuous, time-dependent measure that quantifies the information gained at time t on observing $x(t)$ given the recent past. There is a statistically responsible procedure for specifying "recent". Specific entropy rate is a related time-dependent locally determined measure that gives an estimate of uncertainty at time t.
(2) Construct specific transfer entropy. This is a time-dependent generalization of epoch-determined transfer entropy that gives a state- and time-resolved quantification of the predictive input of a candidate input system on a candidate output system.
(3) Construct a time-dependent network adjacency matrix. Specific transfer entropy can be used to populate the adjacency matrix characterizing a network. In the case of multichannel EEG/MEG recordings the nodes are electrodes, and specific transfer entropy quantifies information movement between electrodes. In this analysis the adjacency matrix is real, time-dependent and asymmetric. Any of a large number of measures commonly used to characterize an adjacency matrix can be used. The result $\Lambda(t)$ is a scalar function of time.
(4) Identify hierarchical transition chronometries in $\Lambda(t)$. The simple directive "find transitions in $\Lambda(t)$" is unacceptably naive. Dynamically meaningful transitions are time-scale dependent. In this analysis $\Lambda(t)$ is embedded and the structure of this embedded object is examined by quadrant scans of the corresponding recurrence diagram. A hierarchy of transitions can be identified by manipulating the embedding dimension.
We note that $\Lambda(t)$ can serve as the order parameter in phase transition experiments in which time is the tuning parameter.

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Pain nervous system as a key component to induce empathy, morality, and ethics

Minoru Asada

Abstract TBA

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Complex and Structured Neurodynamics in Reservoir Computing

Yuji Kawai

Abstract TBA

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The Emerging Field of E/MEG Analyses on Dynamical Neural Networks

Tetsuya Takahashi

Abstract TBA

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Social network and collective intelligence under non-stationary uncertain environment

Aoi Naito, Naoki Masuda, and Tatsuya Kameda

Abstract Collective intelligence in the highly-connected, uncertain world is a topic of major interests across various social and natural-science disciplines. Here we report results of a behavioral experiment with a total of 250 human participants and a computer simulation about emergence of collective intelligence in a non-stationary uncertain environment.

1. We define "collective intelligence" as an emergent property whereby social interaction yields group-level performance superior to individual-level performance on some objectively-definable dimension.
2. Here, we focus on collective performance in a non-stationary uncertain environment. Specifically, we are interested in how well a group of people can track temporal changes in environment, the issue common in social foraging by animals where resource-levels of several patches may change over time.
3. We implemented a two-armed bandit (2AB) task in a laboratory, where the expected rewards of the two options were changing over time. We then observed how a group of 10 people could track the changes through social interaction in a centralized or decentralized network. Participants could learn how their neighbors in the network had decided in a preceding round.
4. Results confirmed that participants in the social networks could track the environmental changes more precisely than when working alone. Yet, the overall effect of network structure was minimum. Participants generally elevated reliance on individual learning, which reduced the effects of network structure. A computer simulation, incorporating parameter values from the experiment, showed that this pattern would be robust across various social network structures. Implications of these findings for network and social sciences will be discussed.

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Evolution of Primate Multilevel Social Systems: Proboscis Monkey Society as Complex System

Ikki Matsuda, Ikuma Adachi, and Hiroki Koda

Abstract Great apes like chimpanzees often provide referential models to understand evolutional trajectories of human behaviour, cognition, morphology and social system as humans and chimpanzees shared a common ancestor only ~5-7 million years ago (Mya). However, there are other lesser known non-human primates which are phylogenetically far to humans, but sharing similar traits with humans in terms of social system, i.e., multilevel societies. Among primate social systems, the multilevel society, in which smaller levels of social organization aggregate into larger units, is one of the most complex, though its origins and function are still poorly understood. Proboscis monkeys (*Nasalis larvatus*), one of the rare primate species reported multilevel social system, belong to the odd-nosed colobines, and are a large, sexually dimorphic and primarily arboreal species. We will overview what/how multilevel society in proboscis monkeys and discuss proximate mechanisms maintaining and the selective factors underlying their social system. Investigation on primate multilevel social systems would not only provide insights into the evolutionary history of human social system but also possibility develop our understanding how brain encodes the spatial position of others in such a complex society.

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Mathematical modelling for functional differentiation

Ichiro Tsuda

Abstract One of the most striking characteristics of the developing brain is functional differentiation, while emerging interactions develop between networking differentiated areas. To clarify the neural mechanism of functional differentiation, we constructed a mathematical model of self-organization with constraints. By casting different constraints, we investigated the mathematical structures of functional differentiation and obtained the following specific behaviors. (1) We observed the genesis of a neuron-like unit in the developmental process of networking dynamical systems. (2) We observed the genesis of neuron-like units that respond specifically to visual and auditory stimuli, respectively. (3) We observed the genesis of functional modules from randomly uniform networks of oscillations, where the modular organization can be interpreted as the differentiation of a higher cognitive area and a lower motor area interacting with the body. In all cases, the appearance of chaos and chaotic itinerancy in the whole network system brings about the generation of functional elements via an acceleration of symmetry breaking.

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The Growth of Cognition and the Free Energy Principle

James Wright

Abstract A model for structure and function of the cerebral cortex at mesoscopic scale is presented in the context of Friston's Free Energy Principle and Perlovsky's Dynamic Logic. The foundation idea is that during embryogenesis neurons and synaptic connections are selected to form a connected ensemble maximising synchronous oscillation. The ensemble forms an ultra-small world, and the polysynaptic flux of action potentials between neurons approaches bidirectional symmetry with synchronous oscillation the equilibrium state. Analogies to thermodynamic internal energy, entropic energy, and free energy occur naturally. Under STDP and BCM rules, a heteroclinic network emerges, with stable and unstable fixed points of oscillation corresponding to activity in symmetrically connected, versus asymmetrically connected, sets of neurons. Wave properties correspond to experimental observations. Applied to populations of excitatory neurons of differing axonal length, bidirectional symmetry of polysynaptic flux constrains the possible anatomical configurations. Growth simulation outcomes produce columnar and non-columnar organizations and superficial patch connections. For visual cortex, orientation preference is realistically organized around singularities, with linear zones and saddle points, and varies with stimulus form and movement, also in accord with experiments. An antenatal scaffold of connections is created, upon which postnatal learning can establish ordered synaptic representations of moving stimuli, permitting their association and subsequent generation of motor sequences. Fast synaptic competition partitions equilibria, minimizing "the curse of dimensionality", while perturbations between imperfectly partitioned synchronous fields, under internal reinforcement, can enable the cortex to become a self-directed adaptive machine. The essence of Dynamic Logic is implicit in the matching of co-synchronous fields in multiple cortical areas, and as learning progresses free energy is minimized and entropy is bounded.

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Disrupted Gamma Synchrony after Mild Traumatic Brain Injury and Its Correlation with White Matter Abnormality

Paul E. Rapp

Abstract In the present study we examined synchronization of resting EEG signals and white matter integrity in military service members with a history of mTBI and demographically similar controls from the same military cohort. Applying WPLI, a newly developed neural synchronization measure we found reduced EEG phase synchrony at low-gamma frequency (25-40 Hz) across scalp regions in the mTBI group. The diffusion tensor imaging analysis measuring fractional anisotropy revealed degraded white matter integrity (lower FA value) of the right inferior cerebellar peduncle in the mTBI group. More importantly, we found that among mTBI cases, the reduced low-gamma synchrony and the degraded white matter integrity are positively correlated. These findings for the first time established a link between the impairments of structural connectivity and the impairments of neural functional connectivity in mTBI.

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Initial topology in hierarchically organized evolvable neural network determines the emergence of synfire chains

Paolo Masulli and Alessandro E.P. Villa

Abstract We investigate the effects of network topology on the dynamical activity of a hierarchically organized network of simulated spiking neurons. With a fixed basic two-by-two grid structure of processing modules each composed by almost 6000 leaky integrate-and-fire neurons and different connectivity schemes in-between these modules, we study how the activation and the biologically-inspired processes of plasticity on the network shape its topology using invariants based on algebro-topological constructions. By definition, a clique is a fully-connected directed subnetwork, that means there is one source and one sink in the subnetwork. We define 'k-clique hub cells' for a positive integer k any cell which is sink and source cell of at least k 3-cliques. We show that there is a statistically different distribution of in- and out-degrees between clique hubs and other cells. Furthermore, we show that by identifying 'clique hub cells' we can find synfire chains that are involved in spatio-temporal firing patterns. Hence, the results suggest a link exists between an initial topological structure characterized by sub-networks cliques and a functional connectivity emerging at a later stage as the outcome of synaptic plasticity mechanisms.

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The spontaneous spiking in up and down oscillations and its energy feature

Xuying Xu, Yihong Wang, and Rubin Wang

Abstract Periodic up and down transitions of membrane potentials are considered as a kind of significant spontaneous activities. Neural electrophysiology experiments have shown that membrane potentials make spontaneous transitions between two different levels called up and down states, which characterized by some features as follows in level of membrane potentials: bistability, directivity, spontaneity, synchronicity and spontaneous spikings. Here, we focus on the spontaneous spiking and its energy feature. We studied the influence of intrinsic characteristics and synaptic transmission on spontaneous spiking in up and down activities. The simulated results showed that fast sodium current was critical to the generation of spontaneous neural firing, while persistent sodium current was critical in spontaneous fluctuation without any stimulation or noise. With presence of noise, the role of persistent sodium current in subthreshold up and down transitions was partially replaced by oscillation of noise. And blocking excitatory synaptic transmission decreased neural firing and meanwhile revealed spontaneous firing, which agreed with experimental results. These results indicated that some neurons spiking spontaneously through intrinsic membrane mechanisms.

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Nonlinear Fokker-Planck Approach to the Cohen-Grossberg Model

Roseli S. Wedemann and Angel R. Plastino

Abstract Distributions maximizing the S_q power-law entropies are observed in the behavior of diverse types of complex systems, including some systems related to neuroscience. One known effective description of processes leading to these maximum entropy distributions is provided by nonlinear Fokker-Planck equations. In the present contribution, we explore a nonlinear Fokker-Planck equation associated with the Cohen-Grossberg model of neural network dynamics. We prove that the stationary distributions of this evolution equation have the S_q maximum entropy form. These distributions are q-exponentials, with an argument proportional to the energy (Liapunov) function of the Cohen-Grossberg network. The nonlinear Fokker-Planck equation investigated here also obeys an H-theorem, in terms of a free energy-like quantity that is a linear combination of the energy function and of an S_q entropy. These findings may help to understand the origin of the S_q maximum entropy distributions, which may be observed in brain dynamics.

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On the neurodynamics of intention, decision and free will

Hans Liljenström and Azadeh Hassannejad Nazir

Abstract What is the role of consciousness in volition and decision making? Are our actions fully determined by brain activity preceding our decisions to act, or can consciousness instead affect the brain activity leading to action? This has been much debated ever since the famous experiments by Benjamin Libet in the 1980s, where the current most common interpretation is that conscious free will is an illusion. Intentionality, which can be seen as a precursor to conscious (free) will, is central in Freeman neurodynamics of the action-perception cycle, where intention would precede our conscious decision to act. Consciousness may be seen as an emergent property of the neural activity of the brain, but in order for consciousness to play any role in our (choice of) actions, we must also consider downward causation in the nervous system. In addition, there may be circular causation in the action-perception cycle, and hence it is crucial to study causal pathways in the brain during volition. In this presentation, I will descibre a newly started project, where neuroscience, computational modeling and philosophy will be applied to elucidate the ancient enigma of free will. Computational modeling of brain parts involved in intention, decision, and action will complement experimental studies with EEG, MEG and fMRI to explore and map the causal relationships. Already, we have developed a neurocomputational model of the neurodynamics involved in decision making, involving both emotional and rational processes. In addition to individual experiential decision making, we also study the influence of the social and natural environment on human decisions. Our results so far confirm the notion that if decisions have to be made fast, emotional processes and aspects dominate, while rational processes are more time consuming and may result in a delayed decision. From some recent experiments in our consortium it appears that the readiness potential found in Libet's experiments with arbitrary choices are not found for more deliberate choices, where free will is more likely to come into play.

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Stochasticity versus Determinacy in Neurodynamics - and the Questions of the "Free Will"

Hans Albert Braun

Abstract "We don't do what we want, we want what we do." This is the logical consequence if one accepts that all our decisions are based on processes of our brain under deterministic natural laws. In recent years, this idea has received new nourishment through spectacular neurophysiological experiments demonstrating that the subjective experience of decision making is preceded by unconscious brain activity. In the following, these experiments and especially their conclusions will critically be examined and contrasted with other experiments that seriously question one of the foundations of the above assertion, the determinacy of neuronal information processing.

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Viewer's attention flow when watching audiovisual cuts

Miguel Ángel Martín-Pascual, Celia Andreu-Sánchez, José María Delgado-García, and Agnès Gruart

Abstract Audiovisual works have plenty of cuts, but viewers hardly notice them. Movie edition creates a discontinuity in audiovisual works. We analyze the effects of cuts on 36 subjects, using electroencephalography (EEG) techniques. Cuts result in an increase of attention in viewers by decreasing their eyeblink rate. They also cause a spread of potentials from the occipital area to the frontal area at around 200 ms after the cut, as the perception of the media content progresses to more-complex areas of process. Our results are coherent with previous studies on early discrimination of visual stimuli. The mentioned flow of potential happens differently depending on the style of edition in which cuts are inserted. Cuts in continuous narrative have a lower impact on the visual zone than do cuts in chaotic and fragmented narrative. However, the opposite is found in the prefrontal area, with a higher activity when continuous and lifelike narrative is being watched. These results can be applied for the management of attention when creating media content.

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A Possible Mechanism of Learning-Evoked Reorganization of Receptive Fields in the Primary Auditory Cortex: A Role of the Basal Ganglia, Prefrontal Cortex, Hippocampus, Acetylcholine and Dopamine

Isabella G. Silkis

Abstract A hypothetical mechanism is advanced that determines a role of acetylcholine and dopamine in the reorganization of receptive fields (RFs) in the primary auditory cortical area A1 evoked by learning with a pure tone with a frequency F. This mechanism is based on dopamine- and acetylcholine-dependent long-term changes in the efficacy of neural connections in the auditory and limbic cortico-basal ganglia-thalamocortical loops. Dopamine, released in response to the tone F and reinforcing signal acting at D1 receptors on striatonigral cells of the dorsal striatum promotes the induction of LTP in the efficacy of inputs from A1 neurons with preferred tuning frequency (PTF) equal or close to F. As a result, basal ganglia (BG) output more strongly disinhibits neurons in the MGB with the PTF close to F, thus promoting a rise in the activity of tonotopically connected MGB and A1 neurons. Simultaneously, LTD is induced at other corticostriatal inputs, leading to inhibition of MGB and A1 neurons with PTF different from F. Voluntary attention promotes RFs narrowing due to a rise in the prefrontal cortex activity and its excitatory input to A1, as well as by dopamine-dependent disinhibition of MGB neurons by the limbic part of the BG that includes the nucleus accumbens. Hippocampus is involved in auditory processing due to its connections with the cortex and projections to the nucleus accumbens. Acetylcholine released by the basal forebrain and pedunculopontine nucleus (that is also under inhibitory control from the BG) modulates RFs due to activity reorganization in the whole network. The complex effect of acetylcholine is determined by location of muscarinic and nicotinic receptors at both pyramidal cell and GABAergic interneurons. Therefore it depends on ACh concentration and strength of inhibition.

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Auditory processing during sleep: a clinical application in tinnitus

Marisa Pedemonte

Abstract It is known that changes in neuronal activity occur during the sleep-wake cycle along the entire auditory pathway, in the receptive field of cortical auditory neurons and in evoked responses. Subjective tinnitus is an anomalous auditory perception resulting from dysfunction of neuronal plasticity. A therapeutic strategy using acoustic stimulation with sound mimicking tinnitus during sleep was developed, resulting in decrease in the reported intensity of tinnitus and improvement in the patients' quality of life (Pedemonte et al., 2010; Drexler et al., 2016). We have studied the impact of sound stimulation on the power spectrum and the coherence of the electroencephalographic waves during sleep, starting to learn about the electrophysiological mechanisms that underlie the decrease in the intensity of the tinnitus (Pedemonte et al., 2014, 2019). Since each stage of sleep has different roles in the memory consolidation process, the impact on the intensity of tinnitus with acoustic stimulation at different stages of sleep was analyzed separately. All patients stimulated at stage N2 (stage with spindles) showed significant decrement in the tinnitus intensity the day after stimulation, while nobody stimulated at the stage N3 (slow wave sleep) showed changes in tinnitus intensity. No clear result was found if the stimulation was delivered during REM sleep. The results show that brain dynamics associated with N2 sleep stage is likely to be characterized by the possibility of establishing interactions with the auditory processing networks, thus resulting in a reduction of tinnitus intensity. These results are in agreement with other previous results showing more changes in power spectra and coherence in electroencephalographic waves in N2 sleep stage when there is sound stimulation.

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Synchronization and Granger causality associated to audiovisual cuts

Celia Andreu-Sánchez, Miguel Ángel Martín-Pascual, José María Delgado-García, and Agnès Gruart

Abstract We are not aware of the vast majority of the cuts when watching media content. However, they affect our perception. This research analyzes the effects of cuts in synchronization (Phase Locking Value, PLV) and Granger causality in 36 subjects, using electroencephalography (EEG) techniques. The PLV was studied as a phase synchronization index for the cut in theta, alpha, beta, and low gamma bands, before (from -500 ms to 0 ms) and after (from 0 ms to 500 ms) the cut. We found differences for the theta band in frontal, central, and occipital areas. We also evaluated the PLV depending on the style of edition in which cuts are inserted: the style of edition did not affect brain synchrony. Analyzing Granger causality differences for the 500 ms before the cut and 500 ms after the cut, we found Granger causality before the cut higher than after it. The style of edition seems not to affect causality either. This study proposes a new way to approach the study of media perception.

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Permanent deafness. A perfect storm in brain sensory cortex

Miguel A. Merchán

Abstract In order to build the perceptual scene, the brains of mammals have developed neural circuits, specialized in analysing and mixing different sources of sensory information. This ability requires a dynamic multimodal interchange of information along all stations of the sensory pathways from the brainstem to the cerebral cortex. When one sensory system fails, the brain cortex reorganizes its neural networks to preserve intermodal processing, what is known as cross-modal plasticity. In deafened ferrets, "de novo" emerging somatosensory responses have been shown by single unit recording in the auditory cortex (AC), undoubtedly demonstrating a multimodal sensory conversion in the brain cortex after sensory deprivation (Allman et al., 2009). Since receptive fields involve inhibitory GABA interactions such sensory conversion may reflect imbalanced cortical multimodal neurotransmission. Our results in a model of bilateral long-term deafness indicate that hearing deprivation induces an altered functional intermodal interaction which involves increased activation of the visual cortex (VC). Also, in humans, VC over-activation after permanent and long-term deafness has been demonstrated using visual evoked potentials (Neville et al., 1983). Over-activation of the VC in our model (Pernia et al., 2017) is generated by imbalanced horizontal interactions as indicated by restricted changes of immunocytochemical markers in layers 2/3. However, such imbalance does not equally affect both primary cortices. Because GABA interneurons specifically increase in primary AC, greater inhibition of cortical column microcircuits could be expected (fast spiking control). Our results also indicate that two homeostatic mechanisms actively work for a dynamic compensation of the out-of-balance bimodal relationship after deafness: 1) Increases in the expression and protein synthesis of AMPA receptors in the AC (which indicates an effort to compensate changes in its thalamic drivers' activation), and 2) The up-regulation of Arc/Arg3.1 shown by us in the VC which supports a reactive mechanism to compensate over-activation in the VC. In sum after prolonged deafness, cross-modal reorganization at long term induces the over-activation of neighbouring sensory cortices (in particular VC) as a result of a dynamic compensation of the horizontal feedbacks. A restricted stimulation with anodal currents (activation) in the AC may be able to rebalance cross-modal reaction, potentially improving cortical processing after cochlear implantation (Colmenárez-Raga et al., 2019). New strategies of directional restricted neuromodulation of sensory cortices by electric fields by using Deep Brain Stimulation via Temporally Interfering Electric Fields (Grossman et al., 2017) will be also discussed in this talk.

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ERPs in Controls and ADHD Patients During Dual n-Back Task

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Abstract Attention Deficit/Hyperactivity Disorder (ADHD) is a behavioral disorder of childhood and adolescence characterized by symptoms that include impulsiveness, inattention, hyperactivity, impaired decision making and primary deficits of executive functions. In a vast proportion of the diagnosed adolescents, the clinical symptoms may persist into adulthood and ADHD patients are characterized by Working Memory (WM) impairment. In the present study we analyze brain dynamics by EEG recordings during the dual *n*-back task in a population of young adults with ADHD and healthy controls. The WM capacity and attention span are tested by *n*-back task, and divided attention is tested by running the task in the visual and auditory modalities concurrently. We analyzed the event-related potentials (ERPs) triggered by the onset of the audio-visual stimuli. In ADHD the amplitude of N200 wave component was only slightly reduced and the peak latency was unaffected. The amplitude of P300 peak was reduced in ADHD with respect to controls at all sites along the midline. The latency of P300 peak in ADHD was reduced at Fz and Cz. In particular at Fz the latency of ADHD was reduced after a response that required matching the visual cue 1 or 2 trials back in time. These results support the hypothesis that the P300 component, associated with a cognitive workload, peaked earlier in the ADHD than in controls and it may be used to follow the outcome of cognitive training.

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Emotion analysis based on multi-class common spatial features of scalp EEG

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Abstract Emotion analysis has earned much attention in affection computing and clinics. Specially, major results from EEG based emotional recognition converge to a consistent conclusion that power distribution difference of EEG signals holds close relation with different emotional states, which can be served as discriminative features for emotional recognition. Previous studies mainly utilize power spectra density (PSD) to analyze different emotion states. However, PSD is hard to capture the discriminant features that represent the activation difference between different emotional states effciently. In essence, the discern of emotion states based on power spectra is due to the difference existing in the spatial power spectra distribution on scalp for different emotion states. Therefore, the methods which can integrate energy distribution information may further improve the recognition accuracy. Comparing with traditional power spectral analysis, common spatial pattern is capable of assigning higher weights to the channels holding powerful discriminant information between different emotional states. Motivated by the above merits of CSP, we designed a hierarchical structure (one to one, one to many, etc.) based on CSP so as to extract features capable of representing the discriminative information between different emotional states from scalp EEG.

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Alterations of brain networks before and after surgery in temporal lobe epilepsy patients with hippocampal sclerosis

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Abstract Patients with temporal lobe epilepsy (TLE) are often potential candidates for surgery. Characterizing brain networks before and after surgery can be benificial for understanding the mechanism of seizure termination and future treatment. In this paper, Electroencephalograph (EEG) recordings in the inter-ictal stage before and after surgery (IIB and IIA, respectively) and ictal stage before surgery (IB) were collected from 15 TLE patients with hippocampal sclerosis. Permutation Disalignment Index (PDI) was used to reveal the alterations of brain networks. Results suggested that the brain network in the IB had higher mean strength or lower entropy than that in the IIB, while the network in the IIA was reversed. Furthermore, the network in the IB was more regular, and the post-operative network was further away from that. This may provide potential application in the prediction of surgical outcomes.

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PSO-Sub-ABLD based parameter optimization for motor-imagery BCI

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Abstract Common spatial pattern (CSP) is one of effective feature extraction algorithms, which is widely applied to motor imagery (MI)-based Brain Computer Interface (BCI). However, its performance is susceptible to artifacts and noise. Therefore, some researchers proposed Sub-Alpha-Beta Log-Det Divergences (Sub-ABLD) algorithm to improve the performance of BCI systems. The performance of Sub-ABLD algorithm depends on the values of hyperparameters α, β and η. In this study, a strategy named PSO-Sub-ABLD was proposed to select three hyperparameters with particle swarm optimization (PSO). Two public BCI competition datasets were used to validate the effectiveness of the proposed strategy. The results show that compared with CSP and Sub-ABLD with default hyperparameters, PSO-Sub-ABLD method gains better classification accuracy.

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Photoacoustic imaging of tibia fracture in rats

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Abstract Microwave-induced Photoacoustic tomography (TAT) is an emerging non-invasive imaging technology. This study opens a new direction for TAT to image the rat tibia fracture. The TAT system we used consists of a pulsed microwave source, a focusing transducer, a step rotation system, a data acquisition device and a data reconstruction system. In this work, we investigate the feasibility of TAT for detecting tibia fracture in a rat model. Both in vitro and in vivo TAT imaging experiments were conducted. The results obtained indicate that the TAT can clearly reveal the structural characteristics of the hind limbs and the differences between normal and post-fracture tibia. This study demonstrates that TAT may have the potential to be a new imaging tool for basic research and clinical diagnosis of bone diseases.

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Experimental study on transcranial electrical simulation based on magneto-acoustic effect

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Abstract As an important neuromodulation tool, transcranial electrical stimulations have been widely applied in the cognitive sciences and the treatment of neurologic and psychiatric diseases. In this paper, a novel non-invasive transcranial electrical stimulation with high-resolution - transcranial magneto-acoustic stimulation (TMAS) method has been firstly performed experimentally and firstly used in living mice. It can obtain the spatial resolution of 2 millimeter in the cortex and even the deep brain regions. The induced electrical field of TMAS has been simulated and measured using a test sample. Then, an animal experimental system has been built and the healthy as well as Parkinson's disease (PD) mice have been simulated by TMAS in vivo. To investigate the effect of the TUS at the same time of the TMAS in operation, a TUS-group has been added in the experiments and compared with that of TMAS-group. The results evaluate the high-resolution ability and the safety of TMAS, and show that both the TMAS and TUS have improved the active learning ability and memory ability of the healthy mice and the PD mice. Meanwhile, the improvement performance of TMAS-group is superior to the TUS-group. Based on the in vivo TMAS studies, we propose the view that the TMAS is a dual-mode stimulation combined by the electric field of magneto-acoustic effect and the mechanical force of TUS. It provides an explanation of the mechanism of TMAS. This research also suggest that future US stimulation in MRI-guided studies should require careful consideration about the induced magneto-acoustic E-field caused by the static magnetic field of MRI.

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The enhancement of the reward prediction error signal in the midbrain dopamine neuron by the cost paid for the reward

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Abstract The midbrain dopamine (DA) neuron plays a key role in reward processing and codes signals associated with the reward prediction error (RPE) to update the value of options. Here, we examined whether these RPE signals are modulated by the cost paid to obtain the reward. After focussing a fixation point, two macaque monkeys were required to make a saccade to a condition cue, then a target appeared. In the high cost condition, long fixation to the target was required. In the low-cost condition, only a short fixation was required. After fixation on the target, the subjects made a saccade to the reward cue. Choice trials between condition cues and between reward cues were inserted randomly to test if the subjects showed a preference. Free reward and free air-puff trials were inserted randomly to determine whether each DA neuron was of a salience or motivation subtype. A cue signaling a costly action to be performed triggered less response in DA neurons with respect to a cue signaling a less costly action, but DA neuron responses to cues predicting reward and to the delivery of rewards were found to be enhanced after the monkey had performed a costly action compared to a less costly action. These findings suggest that DA neurons incorporate the cost of performing an action into the prediction error signal, and that RPEs are enhanced following the performance of a costly action. This finding suggested that monkeys would be faster to learn stimulus-reward associations after performing a costly action compared to a less costly action. A subsequent behavioral experiment confirmed this hypothesis. Information about action cost is processed in the DA reward system in a manner that amplifies the DA RPE signal, thereby producing more rapid learning under situations of high cost.

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Unsupervised analysis of EEG signals reveals common personality traits during an iterated Ultimatum Game

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Abstract Decision making is considered the most essential phase in volitional act and in the "Theory of the Consumer" it is assumed that rational individuals maximize the consumption of real goods given a limited availability of nominal goods (money). The Ultimatum Game (UG) is a two-player game, in which Player_1 (P1) has a certain sum of money at his disposal and offers a share to Player_2 (P2). If P2 accepts the proposal, the share is done accordingly, but in case of rejection both players end up with nothing. If players were selfish income-maximizers P2 should accept any amount and P1 should offer small amounts Experimental results show that most humans do not behave like that. What happens in the brain while the game is ongoing? Decisions must be the result of a sort of calculation of costs and benefits that a human is capable to perform rather quickly. The working hypothesis is that the dynamics of the interactions within the brain network underpin decision making and its investigation can be achieved by recordings brain signals. We study the correlation between unsupervised machine learning analysis of Event-Related Potentials recorded during the whole decision-making process (N=50 participants) with personality traits measured by the HEXACO questionnaire and with the Brief Mood Introspection Scale. Unsupervised feature extraction of ERPS found two very robust clusters of participants: (i) associated with Emotionality, characteristic of people showing a greedy behavior; (ii) associated with Honesty and Agreeableness, for people expressing willingness-to-share. This approach is likely to open the way to new studies of the neural basis of where and how a "decision" is taken in the brain.

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Training parameters with Dual N-Back task affect the outcome of the Attentional Network Task in ADHD patients

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Abstract Patients affected by Attention Deficit/Hyperactivity Disorder (ADHD) are characterized by impaired executive functioning and/or attentional deficits. Our study is aimed to determine whether the outcomes measured by the attentional network task (ANT), i.e. the reaction times (RT) to specific target and cueing conditions and alerting, orienting, and conflict effects, are affected by cognitive training with a Dual N-Back task. We considered three groups of young adult participants: ADHD patients without medication, ADHD with medication (MADHD) and age/education-matched controls (CTL). Working memory training began the day after the pretest. Participants were asked to perform 20 trainings composed of 20 blocks during an entire month. They were told that they would have to practice the Dual N-Back task for about 30 minutes per day during the week and to rest for two-day in the weekend. Each experimental group was randomly assigned into two conditions, the first with a progressive level (PL) of difficulty training, while the second was blocked at the level 1 during the whole training phase (baseline training). We observed that PL training was beneficial with reduced RTs in all groups and reduced conflict effects. MADHD showed a positive effect already with baseline training, whereas ADHD showed no significant reduction of neither RTs nor conflict effect after baseline training. No group showed any effect of training on alerting and orienting effects.

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Event-Related Potentials and Fast Optical Imaging of Cortical Activity During An Auditory Oddball Task

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Abstract Event-related potentials (ERP) have been repeatedly used to study the spatiotemporal dynamics of the attentional response in the well-known oddball paradigm. We combined electroencephalography (EEG) with frequency-domain near-infrared spectroscopy (fNIRS) of the frontal cortex to measure neuronal activity with a high spatial and temporal resolution. The aim of this study was to determine the precise chronology of event-related optical signals (EROS) and their consistency with ERPs. In agreement with previous studies, the oddball condition produced larger waveforms for rare (1500 Hz pure tone) with respect to frequent stimuli (1000 Hz), with N1, P2, N2, P3a and P3b components. At a latency corresponding to the mismatch negativity/N2 wave component, EROS showed the organization of a complex activity in a functional network of frontal areas, with rare tones activating the left premotor dorsal cortex and the left inferior frontal cortex and decreasing the activity of the right superior frontal gyrus. Rare tones elicited also a strong N500 (N400-like) wave component that EROS contributed to localize at the level of the right medial frontal gyrus by EROS. The simultaneous recording of fNIRS and EEG measurements with high temporal accuracy over the human prefrontal cortex supports the potential for this approach to unravel the functional cortical network involved in cognitive processing.

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Neural coding of reward value in richly modulated spike patterns in monkey ventrolateral prefrontal cortex

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Abstract Monkeys with lesions of the lateral prefrontal cortex lose the ability to integrate the reward value information across multiple domains. We recorded neuronal responses from the area 9/46 of ventrolateral prefrontal cortex (vlPFC) of two monkeys while they were performing a task in which in each trial was offered a reward. The reward value, signaled through its association with a visual cue, was constructed by combining one of 3 reward sizes (2, 4 or 6 drops of water) with one of 3 discounting delays (1, 5 or 10s after the choice). The monkeys accepted or refused the offer by releasing the bar after the appearance of the go signal. They were increasingly likely to accept offers as the reward became larger and the delay became shorter. We observed that the reward values were well described by a simple reinforcement learning model for the discounted value of the rewards. In the period soon after the visual cue was presented to the animal, 68% (118/173) of the neurons modulated their firing rate according to the reward size and/or delay. We asked whether vlPFC neurons modulated their activity according to the value that the animal assigned to each offer. The estimated discounted values from the reinforcement model from the behavior were used to correlate with the mean firing rate for each offer, for each neuron. We found that 35% (41/118) of the neurons increased or reduced their firing rate linearly in relation to the discounted value measured from the behavior. The other neurons clearly showed modulation according to both reward size and delay, very few neurons were sensitive to only one factor. Some vlPFCneurons had a strong pulse after value cue appeared, others showed a strong pause, and still others showed three phase responses (small pulse followed by a pause followed by a strong pulse). Despite these striking patterns of responses, principal component analysis showed that the value-related information was encoded in the spike count. This analysis showed, however, that the period with the strong value related coding was restricted to a window that began and ended during cue's presence before the imperative target (a small yellow or purple spot) appeared.

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A CNN-Inspired Model for Degradation Mechanism of Retina to V1

Haixin Zhong and Rubin Wang

Abstract The visual system is under heated investigation in the field of neuroscience and computer vision (CV). In alignment with the implementation of some large brain projects across the world such as those in China, Europe, the United States and Japan, the intersection of visual system in these two fields has been promoted. Therefore, as the most important source of human perception towards the objective world, research on mechanism of the visual information processing bears great significance for exploring biological vision and developing CV. However, there is a scarcity of soundly established and widely accepted theory that can be used to explain this mechanism. Specifically, what remains unknown is the degradation mechanism of visual information data during the topological mapping between retina and V1. Hence, in view of the characteristics of convolutional neural network (CNN), this paper draws on the concept of convolution algorithm to propose an edge detection model based on retina to V1 (EDMRV1), which is built on the pathway of photoreceptors-ganglion cells-LGN-V1 in the functional channel of image features detection. The results not only match the neurobiological experimental data, but they show that the image edge features of visual information are detected by the convolution algorithm according to the function of synaptic plasticity, when visual signals are hierarchically processed from low-level to high-level in visual cortex. Findings are expected to lay a solid foundation for revealing the mechanism of the visual information processing in future research. In CV, applying the model to the scenes of illumination with different brightness has a better performance on the edge features detection than that in the traditional algorithms, providing an intelligent basis for breakthroughs in CV. This research also opens up opportunities for the integration of CV and neuroscience.

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Decoding real and imagined actions in the Early Visual Cortex

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Abstract Patients with motor impairments learn to use brain-computer interfaces with training that consists of imagining what they want the effect or to do. Neurologically intact individuals use motor imagery to improve performance of acquired skills and acquisition of new ones. We explored whether areas implicated in hand actions and imagery tasks, including the Early Visual Cortex (EVC), have a shared representation for planning and imagining hand movements. In a slow event-related fMRI paradigm, participants (N=16) performed or imagined performing actions with the right dominant hand towards a centrally located object composed of a small shape attached on a large shape. The actions consisted of grasping the large shape, grasping the small shape, or reaching to the center of the object while fixating a point above the object. Each trial started with an auditory cue instructing participants about the task (Imagery, Movement) and the action (Grasp large, Grasp small, Reach-to-touch) to be performed at the end of the trial. A 10-s delay was followed by a go cue to perform or imagine performing the action (Go phase). Importantly, for both Imagery and Movement only the object, but not the hand, was visible to the participants. We used standard retinotopic mapping procedures to localize the retinotopic location of the object in the visual cortex. Using multi-voxel pattern analysis, we decoded action type in the planning phase of Movement tasks as well as in the Go phase of Imagery tasks in the anterior intraparietal sulcus (aIPS) and in EVC. We found cross-decoding between planning and imagery in aIPS, but not in EVC. Our results suggest a shared representation for planning and imagining specific hand movements in aIPS but not in low-level visual areas, such as the EVC. Therefore, planning and imagining actions have overlapping but not identical neural substrates.

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Symbolic neural dynamics allow for reproducing optogenetics experiments

Pierre Bonzon

Abstract Symbolic neural dynamics abstracting the functionalities of synaptic plasticity has been used to define the basic mechanisms of an associative memory. This formalism is extended here to represent memory engrams at a meso-scale level in order to reproduce animal behaviors derived from actual experiments. It is illustrated through the simulations of optogenetic manipulations leading to the reversible retrograde amnesia and false memories of contextual fear conditioning. These results support the hypothesis that separate processes are involved in long term memory i.e., the retention of specific patterns of connectivity between engram cells required for the storage of information, on one hand, and the synaptic strengthening needed for its consolidation and retrieval, on the other. Defined by a logic program, this simulation platform could be used to design and predict the results of finer grains experiments involving inhibitory/excitatory loops formed between various brain regions.

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Equalization Effect in Interpopulation Spike-Timing-Dependent Plasticity in Neuronal Networks with Inhibitory and Excitatory Populations

Sang-Yoon Kim and Woochang Lim

Abstract We consider clustered small-world networks with inhibitory (I) and excitatory (E) populations. This I-E neuronal network has adaptive dynamic I to E and E to I interpopulation synaptic strengths, governed by interpopulation spike-timing-dependent plasticity (STDP). In previous works without STDPs, fast sparsely synchronized rhythms, related to diverse cognitive functions, were found to appear in a wide range of noise intensity D for static synaptic strengths. Here, by varying D, we investigate the effect of interpopulation STDPs on fast sparsely synchronized rhythms that emerge in the I- and the E-populations. Depending on values of D, long-term potentiation and long-term depression for population-averaged values of saturated interpopulation synaptic strengths are found to occur, and they make effects on the degree of fast sparse synchronization. In a broad region of intermediate D, the degree of good synchronization (with higher synchronization degree) becomes decreased, while in a region of large D, the degree of bad synchronization (with lower synchronization degree) gets increased. Consequently, in each I- or E-population, the synchronization degree becomes nearly the same in a wide range of D. We note that this kind of equalization effect in interpopulation synaptic plasticity is in contrast to the Matthew (bipolarization) effect in intrapopulation (I to I and E to E) synaptic plasticity where good (bad) synchronization gets better (worse).

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Acetylcholine effects on STDP induced on spatial and non-spatial information in dentate gyrus

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Abstract Spatial and non-spatial information, coming from medial perforant path (MPP) and lateral perforant path (LPP) respectively, is considered to be integrated on granule cell in dentate gyrus (DG) to play an important role in learning and memory. At both connected sites on dendrite, the phenomenon of learning and memory of spike-timing dependent plasticity (STDP) is known to be induced. Meanwhile, acetylcholine (ACh) is released from cholinergic terminals in DG when attentional processes are paid. And there are reports that ACh enhanced STDP in CA1 area. In order to investigate the ACh effects on STDP and its mechanism in DG, STDP-inducing protocol was applied to measure STDP on MPP or LPP in the presence of eserine, furthermore, the changes in baseline amplitude during the STDP protocol were investigated. As the results, STDPs at both sites were enhanced if ACh receptors were activated, then clarified that the baseline amplitude was one of the factors for the enhancement on MPP. These findings suggest that spatial and non-spatial information are strengthened in learning and memory if attentional processes are paid, but the underlain mechanisms are different.

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The maximum information principle of place cell activity

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Abstract Spatial cognitive function provides information about the surrounding environment to the animal, which is crucial for the animal?s survival. However, the formation of place codes in different dimensional spaces cannot be uniformly explained. In this paper, a constrained optimization model based on information theory is constructed to explain why the unique activity pattern of place cell occurs in different dimensional spaces across species. The question is proposed as, using limited amount of neural energy, how to arrange the spike locations (to form place field) in the available environment to obtain the most efficient spatial information representation? Variational techniques are applied to solve this conditional functional extremum problem and the results suggest that the place field will comply with a certain centralized distribution (normally is Gaussian form) automatically to convey the largest amount spatial information per spike, under the constraint of limited neural energy. The animal?s natural habitat property and locomotion experience statistics also affected the spatial codes. These findings not only reconcile the argument of whether the spatial codes of place cell are isotropic in different dimensional spaces, but also provide an insight about the maximum information principle of the place cell activity.

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Causal Interactions Among Cortical Regions During Sleep Based On fNIRS Recordings

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Abstract Functional connectivity between cerebral cortical regions during natural sleep has attracted a keen interest from both cognitive and clinical neuroscientists because of its importance in understanding the default mode network of human brain. Multiple recordings of functional near-infrared spectroscopy (fNIRS) in several sleep phases make it possible for us to detect potential differences of directional interactions between cortical areas from healthy subjects and patients with ADHD or sleep disorders. Namely, we propose a computational method to estimate time-domain Granger causality among fNIRS time series using a Kolmogorov-Smirnov test based on F-statistics. In order to validate indication of directional interactions, we also apply convergent cross mapping to the time series as an alternative approach to causality based on state space reconstruction of dynamical systems. Comparing the averaged heatmaps of significant causal pairs of regions, we show not only that the map of directional interactions varies for each sleep phase, e.g. REM, of the same subject, but also that there is a different level of disruption in the map across a range of patients. These observations suggest an unexplored source for non-invasive classification benchmark of the above cognitive disorders.

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A new deep neural network inspired by directional mutual information between slow and fast neural information flow

Tao Zhang, Sitong Wang, and Zhuo Yang

Abstract Artificial neural networks are initially inspired by neuronal structures and connections, given that the neural connection is changed during a learning process. Yet, it is hard to directly validate that an adaptive structure truly works within complicated animal brains. Sufficient evidences have been given in the level of cells about the adaptive structure of synaptic plasticity. In the present study, it was found that the connective pattern of neurons was significantly altered for the period of a learning process in the level of neuronal groups. By inferring the coupling direction between slow neural information flow and fast one, a novel artificial neural network structure with a multi-layer architecture has been proposed, accordingly. The structure is constructed on the basis of the experimental electrophysiological data and accordant with the principle of maximum entropy. The potential efficiency may lead to an inspiration for the future architecture of artificial neural network.

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Fractal Structure in Hokusai's "Great Wave" and the Memory Neural Network

Minoru Tsukada and Hiromichi Tsukada

Abstract Google used 10 million natural images as input information and performed self-organized learning with a huge neural network with 10 billion synapses, and neurons with a receptive field resembling a cat's image appeared in the upper layer. Hokusai drew "Great Wave" by using his memory with a fractal structure. Which do you think is "beautiful": "Google's cat picture" and Hokusai's "Great Wave"? I think Hokusai's one is beautiful. Because it is based on stunning information compression. The proposed network in this paper is composed of a one-layer artificial neural network with feedforward and feedback connections. In the feedforward connections, the spatiotemporal learning rule (STLR) (Tsukada et al., 1994, 1996) has high ability in pattern separation and in the recurrent connections, Hebbian learning rule (HEB) in pattern completion. The interaction between the two rules plays an important role to self-organize the context-dependent attractor in the memory network. The context-dependent attractors depend on the balance between STLR and HEB. The structure is an important factor of memory networks to hierarchically embed a sequence of events.

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