Proceeding

The Second Interdisciplinary Seminar on Brain and Cognition, Shiraz, Iran

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Abstract

Recent advances in brain and cognitive science studies have revolutionized concepts in neural dynamics, regulating mechanisms, coding systems and information processing networks which govern our function and behavior. Hidden aspects of neurological and psychiatric diseases are being understood and hopes for their treatment are emerging. As such, advancing neuroscience knowledge and its innovative applications should be fostered to empower both scientists and practitioners in serving the public by optimizing self-regulatory brain function. To reach the above, a key initiative has been "organizing interdisciplinary seminars on neuroscience" at SUMS. The second Interdisciplinary Seminar on Brain and Cognition (ISBC-2) was held on June 5, 2016 at SUMS. The conference, as the theme suggests, aimed to bring forward the interdisciplinary dialogue between neuroscience, cognitive and also computational approaches in study of Brain and Cognition. This paper is a brief report of the discussed topics in the four panels of ISBC-2, namely cognitive, systems, computational and clinical neuroscience.

From Cells to Society: The Central Role of Human Brain

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Recent global strategic initiatives on human brain have prompted policy makers to develop medium to long-term views and an analysis of future research developments with the aim of defining research agendas in neuroscience and cognitive science. With all ongoing efforts from Iranian neuroscientists, this has recently been the case in our community as well. As with all strategic activities, the Iranian Cognitive Science and Technologies Council and related authorities consider this topic timely to the advancement of science and of high-priority interest to the disciplines involved. In this respect the present communication highlights five key opportunities for advancing our understanding of the human brain including: 1- the development of integrated neuro-psychotherapeutic approaches to the treatment of psychiatric disorders; 2- the development of more valid disease models for research in to psychiatric disorders' 3- an improved understanding of the underlying mechanisms of the relationship between biology and environment; 3- more comparative and cross-disciplinary studies to explore how scientific concepts relating to the human brain are received and understood in different sociocultural context; and 5- research into the legal and ethical implications of recent developments in the brain sciences, including behavioral screening and manipulation, and emerging neurotechnologies.

Keywords: Cognitive Science; Clinical Neuroscience; Strategies; Neurotechnologies; Translational Neuroscience

Neural regeneration: combination of stem cells, signals and scaffolds

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Despite being introduced several treatment strategies for neurological disorders, the problem of low repairing capacity of central nervous system has been remained. In this regard, stem cell therapy can be helpful by supporting damaged tissue or replacing new cells. Stem cells have ability to self-renew and differentiate into multiple cell types, and hence can serve as a source for cell replacement of damaged neurons. Several sources can be considered for stem cell therapy including embryonic, fetal and adult stem cells. Recently, researchers have focused on induced pluripotent stem cells to alleviate some previous problems in stem cell isolation and transplantation strategies. In addition, tissue engineering can be helpful for creating a true 3-D environment. Combination therapy, using stem cells, scaffolds and signals, is a bright perspective in the field of neural regeneration.

Drug Addiction, Brain and Rehabilitation

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Addiction is a brain disease, which accompanies with brain structural and functional disorders. Based on Volkow model of drug addiction, four brain systems are involved in drug addiction, which are reward, motivation, memory and cognitive control systems. Reward system is the core of drug addictions. Attenuation of drugs rewarding effects could be useful for addiction treatment. In this way cognitive enhancement, especially the executive functions improvement, might be considered as an applied route. Motivational system is also another involved system in the field of addiction. Insula plays a fundamental role in appetitive and motivational processes underlying addiction. Disrupting of insular function can reduce addictive behaviors. This reduction could be achieved by deep brain stimulation (DBS), repetitive transcranial magnetic stimulation (TMS), transcranial direct current stimulation (TDCS) and also brain laser therapy. Memory systems are also important in addictive behaviors. Working memory is one of memory systems that contribute to and also compromised by substance abuse. Working memory can be improved with training. Recently, working memory training has been applied to substance abusers. It is also examined that how working memory exercises could be applied to the prevention of relapse. Programs that enhance working memory capacity may therefore be useful tools to assist in rehabilitation and relapse prevention. Cognitive control rehabilitation is also possible by different types of modulations such as contingency management cognitive reinterpretation of potential options and cognitive enhancement. It would be concluded that all involved systems in drug addiction could be enhanced by different neurocognitive rehabilitation techniques.

Keywords: Drug addiction, rehabilitation, reward, motivation, memory, cognitive control.

Advantages of functional MRI for Sensory Motor Brain Mapping in Patients with Brain Tumor

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Functional MRI and Diffusion Tensor Imaging was performed using a 1.5 Tesla MR scanner in 89 patients with brain tumors. The finger-tapping paradigm (active/passive) was used for sensorimotor mapping. Statistical analysis of the data was performed using the FSL (FMRIB, Oxford, UK) software. Activation maps were used to aid preoperative planning. Motor powers of the operated patients were assessed before and after the surgery. Activity of precentral and postcentral gyrus was seen in 93 percent of the patients. In 6 patients, fMRI was not of acceptable quality due to motion artifacts. Fifty-nine percent of the patients were candidate for tumor resection surgery. Among the patients who underwent surgery, 94.5 percent had no permanent changes in motor deficit. Motor power was increased in 4 patients while it was decreased in 1 patient. fMRI's efficacy in the preoperative mapping of motor areas is high. This technique shows that we can determine the risk factors of motor deficits in the patients after surgical resection of brain tumors.

Familiarity with cognitive neuroscience

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Cognitive neuroscience is the knowledge of investigating brain and its functions. This area is one field in cognitive sciences, which investigates the relationship between cognitive and mental

functions with brain and its activity. Goal of cognitive neuroscience is understanding the nature and structure of mental activities. Cognitive neuroscience has developed intensively, during last two decades. Cognitive neuroscience investigates the brain functions and their relationship with mental activities by using different techniques such as: Neuropsychology (Wechsler IQ Test, Wechsler Memory Test, BADS, Stroop Tasks, CANTAB Battery, etc.), Neuropharmacology (Animal Studies, Drug metabolites tracing), Electrophysiology (EEG, QEEG, ERP) and brain stimulation recording; and brain imaging techniques (fMRI, PET, MEG). Cognitive neuroscience also modulates brain activities by brain modulation techniques (neuro-feedback and neuro-cognitive training) and brain stimulation methods (RTMS, TDCS & low potent laser therapy). All these techniques will be mentioned separately in this communication.

Keywords: Cognitive neuroscience, brain activity, mental function, neuropsychology, neuropharmacology, electrophysiology, brain modulation, brain stimulation.

Cognitive Rehabilitation Therapy

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Luria provided the first comprehensive writing on this topic in Russia, The history of Cognitive Rehabilitation Therapy (CRT) dates back to World Wars stimulated further development of these methods of rehabilitation to meet the needs of soldiers who had brain injuries when they returned from combat zones. CRT is a complex collection of techniques designed to enhance perception, attention, comprehension, learning, reasoning, remembering, problem solving, and so forth in individuals who have impairments in these areas. Our approach to CRT assumes that therapy is most effective when it is focused on all relevant subsystems in a manner that improves cognitive performance. The relevant subsystems include all those assumed to be important in cognition-such as attention, perception, comprehension, learning, communication, problem solving, remembering and creative thinking-as well as other aspects of a person's life that affect cognition-such as emotions, nutrition, health, stress, and social functioning.

Critical Neuroscience: The context and implications of today's human brain research

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Critical neuroscience is an approach addressing contested issues surrounding the field of cognitive neuroscience from multiple viewpoints. The field engages neuroscientists in brain-based approaches to fields such as education, law, medicine, social policy, business and with the expansion of neuroscience more broadly. Critical neuroscience encourages collaborative approaches to careful assessments of the status quo, longer-term impacts, potentials and problems of cognitive neuroscience with in the laboratory and in the various areas of application. The project has been analyzing methods, technologies and theoretical paradigms reaching out to include practitioners from medicine, social policy, counseling and science journalism in order to better understand whether and how neuroscience could have value for such other domains. Many have begun to ask critical questions about neuroscience's increasing reach outside the lab and into the humanities as seen by the emergence of new hybrid fields such as neuro-aesthetics, neuro-theology or neuro-education.

Keywords: Critical neuroscience; Interdisciplinary; Cognitive; Implications

Face Recognition in Primates

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Social interactions are one of the most important aspects of behavior; especially in primates. These social interactions require a rich representation of faces and it is believed that the repertoire of face selective neurons, mostly found in temporal cortex, play the crucial role in representation of faces. However, our knowledge about how different aspects of face representation are achieved by various face sensitive neurons is still very rudimentary. Here, I present a review of the literature pertaining to face perception and recognition.

How decision is made in brain?

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Decision making is one of the most important questions in systems neuroscience, but neuroscience is not the only scientific field that is interested in decision making. Many fields from economics to social sciences are engaged in studying this topic. Neuroeconomics is an interdisciplinary research field that is emerged in last decade and studies the decision making and its underlying mechanisms in brain and in individual and social contexts. This communication focuses on some important approaches in neuroeconomics and the ongoing researches in this area.

Identifying the Subthalamic nucleus in Deep Brain Stimulation

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Electrical stimulation of Subthalamic nucleus (STN) is an effective therapy for alleviating Parkinson's symptoms, such as tremor, rigidity and bradykinesia. Extracellular recording using microelectrode is essential for the identification of STN and accurate implantation of deep brain stimulation leads. To do so, we first located the target areas using the stereotactic MRI scans. Then we used a multichannel microelectrode recording and stimulating technique to map and target the STN that we needed to reach. The STN was identified by visual inspection of the recorded signals during the surgery. It has been shown that power spectral density (PSD) of the recorded data can be used to accurately identify the STN. After the surgery, PSD was calculated over the 10 second recorded data in each depth. We compared PSD at high frequency band in each of the recording depth in order to identify boarders and length of the STN. The high frequency band PSD increased significantly as the electrode entered the STN and remained significantly above the level of the thalamus and decreased as the electrode was exited from the STN. PSD estimation method could accurately identify the boarders and length of the STN and its accuracy is comparable to visual inspection of the recorded signals by an expert.

Brain Computer Interface: From Dreams to Reality

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The first idea of Brain computer interface (BCI) was to design a machine to translate the brain thoughts. Although the idea seems marvelous, researchers found out that just a few imagination of body movements (e.g. left hand, right hand, foot, tongue) can lead to make specific changes to the EEG signals. They asked individuals to imagine certain mental tasks and simultaneously elicited discriminative features from the EEGs and then classify them by statistical classifiers. Nevertheless, BCI systems suffer from a variety of limitations that avoid them to be commercialized. In a pragmatic view, 40% of the whole world's population cannot use the current BCI prototypes because their brain produces a weak electrical activity during imagery movements such that these variations cannot be detected or distinguished. In addition, the performance of current BCIs is not still promising even for those 60% people. In order to enhance the performance BCIs, several approaches have been done such as BCI personalization, using evoked potentials (e.g. SSVEP), designing spatio-temporal frequency filters, and low frequency switch for asynchronous BCI. Moreover, other modalities such as MEG signals, fMRI are merged to the EEG signals to achieve a better accuracy.

Application of QEEG and ERP in research and clinical setting

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Quantitative electrophysiological assessments, using Quantitative Electroencephalography (QEEG) and event-related potential (ERP), provide the high temporal and low spatial information of networks processing which take place in the human brain. The data calculated in QEEG are used to create topographic color-coded maps that show electrical activity of the cerebral cortex. It provides several complex features that are missed in visual verification. Recent advances in computer and mathematic sciences and hence its application in neuroscience results in a wide approach to develop

normative database for brain activities. Using these databases one can distinguish the activities that are deviant from normal and the magnitude of deviation. In turn, could aid in the evaluation of a wide range of clinical disorders and research domains. ERP may be used in many different research programs, with goals that range from understanding how the brain implements the mind to making specific diagnoses in clinical settings. Some components of ERPs, together with suitable designs and manipulations of the experimental paradigm, can be very useful in evaluating information processes. Moreover, ERP measurements can reveal both specific neurophysiological correlates of poor performance and specific differences in covert neural processing in the absence of performance differences.

Statistical Physics Approach to Computational Neuroscience

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Statistical physics is the branch of physics which aims to derive macroscopic properties of systems given their microscopic details. For example, statistical physics provides a precise description of all properties of water given a detailed description of H2O and its interactions. One is of course forced to use statistical methods, once the number of molecules gets very large. Accordingly, one may then suspect that if one is given a detailed neuron characteristics and its possible synaptic interactions, methods of statistical physics should be able to provide a complete description of the collective properties of the brain. Although, this is not entirely true, it is not far from the truth either. One main complication is that brain exists in the state of non-equilibrium, where calculations become typically very difficult. In this talk I will discuss some general methods, physicists are using in order to model the brain, and some of the key properties they have mostly focused on. These include collective properties like oscillations, synchronization, and criticality. I will also discuss some of the key aspects of complex network theory and their relevance to neuroscience. I will finally discuss, some of our recent results where a simple three-state model of a neuron is studied to produce some of the above-mentioned properties. Our results are shown to be in very good agreement with direct experimental results on cortex.

Automatic classification of 6-month-old infants at familial risk for language-based learning disorder using a support vector machine

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This study assesses the ability of a novel, "automatic classification" approach to facilitate identification of infants at highest familial risk for language-learning disorders (LLD) and to provide converging assessments to enable earlier detection of developmental disorders that disrupt language acquisition. Network connectivity measures derived from 62-channel electroencephalogram (EEG) recording were used to identify selected features within two infant groups who differed on LLD risk: infants with a family history of LLD (FH+) and typically-developing infants without such a history (FH−). A support vector machine was deployed; global efficiency and global and local clustering coefficients were computed. A novel minimum spanning tree (MST) approach was also applied. Cross-validation was employed to assess the resultant classification. Infants were classified with about 80% accuracy into FH+ and FH− groups with 89% specificity and precision of 92%. Clustering patterns differed by risk group and MST network analysis suggests that FH+ infants' EEG complexity patterns were significantly different from FH− infants. The automatic classification techniques used here were shown to be both robust and reliable and should provide valuable information when applied to early identification of risk or clinical groups.

Odorant receptors of Drosophila are sensitive to the molecular volume of odorants

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Which properties of a molecule define its odor? This is a basic yet unanswered question regarding the olfactory system. The olfactory system of Drosophila has a repertoire of approximately 60 odorant receptors. Molecules bind to odorant receptors with different affinities and activate them with different efficacies, thus providing a combinatorial code that identifies odorants. We hypothesized that the binding affinity of an odorant-receptor pair is affected by their relative sizes. The

maximum affinity can be attained when the molecular volume of an odorant matches the volume of the binding pocket. The affinity drops to zero when the sizes are too different, thus obscuring the effects of other molecular properties. We developed a mathematical formulation of this hypothesis and verified it using Drosophila data. We also predicted the volume and structural flexibility of the binding site of each odorant receptor; these features significantly differ between odorant receptors. The differences in the volumes and structural flexibilities of different odorant receptor binding sites may explain the difference in the scents of similar molecules with different sizes.

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