Letter to Editor:

Operationalizing Cognitive Science and Technologies' Research and Development; the "Brain and Cognition Study Group (BCSG)" Initiative from Shiraz, Iran

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A B S T R A C T

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. Although the two comprehensive mega-projects on brain mapping are in place in the United States and Europe; the proportion of science contributed by the developing countries should not be downsized. With the granted supports from the Cognitive Sciences and Technologies Council (CSTC), Iran can take its role in research on brain and cognition further. The idea of research and development in Cognitive Sciences and Technologies (CST) is being disseminated across the country by CSTC. Towards this goal, the first Shiraz interdisciplinary meeting on CST was held on 9 January 2014 in Namazi hospital, Shiraz. CST research priorities, infrastructure development, education and promotion were among the main topics discussed during this interactive meeting. The steering committee of the first CST meeting in Shiraz decided to frame future research works within the "Brain and Cognition Study Group-Shiraz" (BCSG-Shiraz). The study group comprises scientific leaders from various allied disciplines including neuroscience, neurosurgery, neurology, psychiatry, psychology, radiology, physiology, bioengineering, biophysics, applied physics and telecommunication. As the headquarter for CST in the southern Iran, BCSG-Shiraz is determined to advocate "brain and cognition" awareness, education and research in close collaboration with CSTC. Together with CSTC, Shiraz Neuroscience Research center (SNRC) will take the initiative to cross boundaries in interdisciplinary works and multi-centric research projects within the study group.

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1. Introduction

Science is on the verge of a seemingly endless journey to understand brain and cognition. The mysterious aspects of complex brain functions which resemble our consciousness, attention, feelings, thoughts, perception, memory, learning capacity and executive functions in health and disease conditions have opened an intriguing chapter in neuroscience.

Cognitive sciences and technologies encompass innovative and dynamic knowledge and techniques to understand and intervene brain and cognitive processes (Yarkoni, Poldrack et al. 2010). The novel advances in converging fields such as bio-, nano- and information technologies improve our quality of life and the use of brain-machine interface may give rise to optimal mind and mental faculties in human (Gordijn 2006, Thomas, Dyson et al. 2013). Moreover, a true image of brain and cognition is essential when medical science struggles to overcome the miseries caused by brain damage, neurological diseases and neuropsychiatric disorders (Mazziotta 2001).

There has been an extensive research and investment on brain and cognitive sciences in the developed world over the past few decades inasmuch as 1990s was called the brain decade (Mattei 2013). During the past 5 years such efforts gained momentum and mega-projects on brain mapping were commenced in the United States and Europe (Quaglio, Karapiperis et al. 2013, Underwood 2013, Sze, Wintermark et al. 2014). The most comprehensive project known as Brain Research through Advancing Innovative Neurotechnologies (BRAIN) uses brain mapping to unlock critical mysteries of brain function (Tsien, Li et al. 2013, Weiss 2013). This is being done partly through identification and characterization of brain component cells and circuits, defining details on synaptic connections as well as in vivo dynamic activity of neurons and the algorithms governing complex processing in one neural circuit or a number of interacting pathways in the whole brain. Such huge data is compiled to test the neuronal significance in various cognitive and non-cognitive functions (Ng, Bernard et al. 2009, Akil, Martone et al. 2011, Berman and Cerf 2013).

Among all these investments and acquisition of competition in brain and cognitive science research in developed countries, there should still be a true space left for the resource-limited and developing nations to pursue the same. Recently, there seems to be an evolving confidence in developing nations not only to improve previous works which often took place in developed countries, but also to create unsurpassed knowledge on their own (Kao 2009, Ashrafi, Mohammadhassanzadeh et al. 2012).

We now seem to have taken essential steps to attend such competition at regional and international levels. Our country has started to pioneer brain and cognitive science studies in the region following the establishment of the Cognitive Science and Technologies Council (CSTC) as a governmental infrastructure supporting scientific and technological efforts in this field across Iran. (http://www.cogc.ir/)

In a quick survey on the articles published in the field of cognitive neuroscience for instance (1996-2012), Iran is ranked 2nd in the Middle East (52 documents, 468 citations, 192 self-citations, 12.17 citations per document and the H index of 14) showing that our intentions are being translated to concrete actions (http://www.scimagojr.com/countryrank, retrieved on 1 February 2014).

The presence of scientists in the field of brain and cognitive science, well-established academies, improving infrastructures, supports from the authorities and above all, our goodwill would continue to offer hope as we move.

Given the multidisciplinary nature of cognitive sciences and technologies (CST), scientists and scholars from a diverse field of expertise are expected to enter this quest. Being a new field of especially in Iran, we should try our best to spread the idea and introduce research and practical opportunities of CST across the country. CSTC has conducted introductory meetings in different provinces including Tehran, Mashhad, Isfahan and Shiraz and would continue holding such events.

The first Shiraz interdisciplinary meeting on CST was held on 9 January 2014 in Namazi hospital, Shiraz Iran. This meeting was conducted by CST council in close collaboration with Shiraz Neuroscience Research Center. Around 100 participants (students, researcher and faculty members from CST related disciplines) and 17 speakers put together insights and reviewed the available scientific data trying to translate workable ideas into practical opportunities in brain and cognitive science in Shiraz. CST research priorities, education and promotion and infrastructure development were the main topics discussed during the event. According to the steering committee, our future research in CST will be framed within the "Brain and Cognition Study Group-Shiraz" (BC-SG-Shiraz). Together with other neuroscience research

groups, Shiraz Neuroscience Research center (SNRC) will bridge the gaps for interdisciplinary collaborations between experts in multi-centric research projects within BCSG-Shiraz (see http://snrc.sums.ac.ir/en/about_us/introduction.html for strategies).

The current report outlines the main discussed and agreed upon topics during the first interdisciplinary meeting on CST in Shiraz.

2. The Vision, Philosophy and Goals behind "BCSG-Shiraz" Initiative

A number of renowned local experts in the field of brain and cognitive sciences came together to discuss current status, opportunities and practical strategies to foster basic, applied and clinical research and practice on brain and cognitive studies in Fars province. Experts from Shiraz University of Medical Sciences (SUMS), Shiraz University and Shiraz University of Technology (SUT), departments of neuroscience, neurosurgery, neurology, psychiatry, psychology, radiology, physiology, bioengineering, biophysics, applied physics and telecommunication met up to form the BCSG-Shiraz.

The idea of studying how the brain cells and complex neural circuits put together reality and thoughts for us has gaind much attention. This has prompted the development of novel technologies and helped researchers to study brain and cognition in a more comprehensive way.

Together with the developed world's efforts in brain research, the resource-limited countries need to develop practically feasible strategies and tactics of their own to evaluate challenges and opportunities in the field and arrive at their scientific visions.

With the view of the available infrastructure and supports provided by CSTC in Iran, the BCSG-Shiraz has planned to be one the mostly engaged headquarters for CST research across the country.

In order to speed up collaborative research, the areas of expertise, strengths and shortcomings in each department need to be defined. The introductory discussions led by the experts from various departments during the meeting made this visible and future meetings are expected to make it clearer.

While our focus is not to depend on technology per se, the use of tools is essential to obtain insights on how the brain functions in health and disease conditions. During this meeting and follow up discussions, the available and potentially required technologies in biochemistry, structural and molecular neurobiology, electrophysiology and neural recording, neural modeling and computation, translational neuroscience, cognitive studies and clinical neuroscience were identified. Potential request for support and proposed research plans are being consolidated by BCSG-Shiraz to be consulted with CSTC.

BCSG-Shiraz has tried to line up a clear vision toward its goals. Crossing the links between the experimental insights and theory, biological findings and engineered products, technological advances and research/clinical implications, non-human findings and translational application are the integral parts of our vision. Our mission comprises: a) establishing a platforms for the exchange of ideas and research data within the study group making accessibility and central maintenance possible, b) building the base for interdisciplinary research on CST within the province, c) trying to map neural function in time and space from a multidisciplinary perspective, knowing that cognition is a product of an integrated work of molecules, cells, and circuits in distinct parts of the brain with functions within milliseconds, minutes, hours to days and some extending to our lifetime, d) validating and introducing technologies within the study group (ranging from cellular-molecular techniques, structural study methods, neuroimaging, neurointerventional techniques and tools to functional neurosurgery, clinical tools and technologies, etc), and e) closely following ethical issues in brain and cognition research with full observation of neuroethis in data privacy, critical neural science implications in law, politics, education, commerce, etc.

The current top priorities for research within BCSG-Shiraz (in alphabetical order) include but not restricted to: 1-applications of neurostimulation in neurological and psychiatric disease conditions, 2- application of brain-computer interface (BCI), 3- cognitive neuropsychology, 4-complex systems approach to neural networks, 5- functional neurosurgery and psychosurgery research, 6-learning and memory, 7- neurodegeneration and neuroprotection, 8- neurodevelopmental- and attention-deficit/hyperactivity disorders, 9-neuroimaging and 10-sleep neuroscience.

3. Awareness Campaigns, Education and Research on brain and Cognition; Why Now?

The remarkable advances and discoveries in the field of brain and cognitive sciences have offered novel insights into neural circuits and their dynamics, coding systems and information processing networks which regulate our behavior.

Referring to literature, one may find quite an extensive array of theoretical and practical evidence derived from CST research (Baronchelli, Ferrer-i-Cancho et al. 2013, Clark 2013, Plummer, Eskes et al. 2013, Sandamirskaya 2013, Brooks and Ragir 2014). Meanwhile, the main challenge is to find best ways to integrate such extensively trialed experimental approaches and scale them to the level of circuits and systems (Butler 2013, Kubilius 2013, Jennings and Stuber 2014). With the advent and partial availability of neuroscience study techniques in Iran and Shiraz academic institutions, now is the time to pursue a continued progress. The BCSG-Shiraz not only plans to operationalize research projects but also to support public awareness and education in neuroscience. BCSG-Shiraz is determined to design activities during the annual Brain Awareness Week (BAW) (McNerney, Chang et al. 2009) in order to aware the society about the progress and benefits of brain research.

4. The Deliverables of the BCSG-Shiraz Initiative; Scientific Review and High Priority Research Areas

4.1. Neuroscience Program, the School of advanced Medical Sciences and Technologies, SUMS

Neuroscience deals with anatomy, behavioral functions, biochemistry, development, evolution, genetics, pharmacology, and physiology of nervous systems as well as biologically inspired robotics and prosthetics, computational modeling, and mechanisms of neurological and psychiatric diseases (Butler 2013). Thus, a formal training program, particularly at PhD level, needs to at least partly address all the above fields. This calls for a multidisciplinary faculty and a broad-based scope. Shiraz University of Medical Sciences is among the few universities in Iran to offer formal PhD program in neuroscience.

The department of neuroscience within the school of advanced medical sciences and technology, SUMS, has integrated faculties from the various departments to consolidate strengths in research and education in neuroscience. Conducting basic and clinical research and providing a standard training to the next generation of neuroscientists is what the department pursues.

Over the full course of neuroscience PhD program at SUMS (51 theoretical and research credits), a wide range of themes including cellular and molecular neuroscience (the ultra-structural basis of neurodegenerative and neuro-developmental disorders), cognitive neuroscience, developmental neuroscience, systems neurosci-

ence, neurobiology of diseases and translational/clinical neuroscience will be addressed. The currently available research facilities such as neural stem cells setup, neuronal and astrocyte cell culturing, molecular biology, electron microscopy, histology and stereology, behavioral and imaging techniques are expected to make well-experienced trainees.

The collaborating/allied research institutes with the neuroscience PhD program at SUMS include Shiraz Neuroscience Research Center (SNRC) and the Research Center for Psychiatry and Behavioral Sciences (RCPBS). A number of research facilities and laboratories with full-established setups for neural stem cells, embryonic and adults' stem cells, proteomics, gene therapy, immunotherapy, tissue engineering, cancer research, recombinant antibodies, recombinant proteins, nanotechnology and biotechnology labs within SUMS have signed memorandum of understanding with the neuroscience program for mutual supports and joint projects.

One of the main long-term goals of the department is to translate laboratory bench data into clinical applications to help patients with devastating neurological and psychiatric diseases. All faculty members of the program are now a part of BCSG-Shiraz. (http://novinu.sums.ac.ir/department/nerves/)

4.2. Functional Neurosurgery and Psychosurgery Setup

Some incapacitating mood and mental disorders may occasionally be treated with psychosurgery also referred to as neurosurgery for mental disorders (NMD). This may become indicated when the psychiatric disorder is severe and all other treatments have failed. Brain mapping and functional neurosurgery have also been implicated in decreasing damages to eloquent brain areas upon surgery and improving the outcome (Heeramun-Aubeeluck and Lu 2013). When pathologies are in the close proximity of functional cortices or neural tracts, the use of functional neurosurgery techniques may be seen as the only standard approach (Bauer, Martin et al. 2014).

NMD is increasingly applied in treating refractory and medication-resistant major depression and obsessive compulsive disorder (OCD) (Greenberg, Price et al. 2003, Bear, Fitzgerald et al. 2010). Nevertheless, in case a resistant patient has failed to respond to all previously tried medications or electroconvulsive therapy (ECT), it is possible that further physical treatments such as surgery and deep brain stimulations (DBS) are similarly inappropriate (Greenberg, Price et al. 2003).

Some psychiatric disorders make the patients absolutely inappropriate candidates for psychosurgery. These conditions include personality disorders, uncomplicated schizophrenia, and anorexia nervosa (Shah, Pesiridou et al. 2008). After all, NMD is not deemed appropriate for patients with a chance to respond to other treatment modalities and is generally not performed in patients below the age of 20. Many patients who undergo NMD still need to receive continued medical therapy even if the procedure is considered quite successful. Since the procedure cannot be reversed, case selection should be meticulous and surgical planning needs to be well-established before the operation (Greenberg, Price et al. 2003). Ablative procedures and DBS are the two main approaches in NMD (Eljamel 2008).

OCD is characterized by obsessions (recurring thoughts and sensations which typically cause or aggravate anxiety) and compulsions (reactions and rituals such as washing, checking, etc. to reduce anxiety level). Comprehensive studies in OCD using brain mapping and neuroimaging (functional MRI and positron emission tomography) have proposed the frontal lobe (prefrontal and orbitofrontal cortices as well as anterior cingulated gyrus) and paralimbic circuits (mainly the corticostriato-pallidothalamocortical or CSPTC circuit) as the main sites of pathology (Heeramun-Aubeeluck and Lu 2013).

Therapeutic approaches for OCD include pharmacological and non-pharmacological therapies and ultimately, surgery. Behavior therapy through exposure and/or response preventive therapy may abate symptoms alone or in combination with medications (Romanelli, Wu et al. 2014, Van Ameringen, Simpson et al. 2014). However, when specific cases fail to respond to all previous measures, surgery may become indicated. When ablative procedures are the preferred option; cingulotomy, capsulatomy and subcaudate tractotomy may be performed. Limbic leucotomy is a procedure characterized by simultaneous cingulotomy and stereotactic subcaudate tractotomy (SST) (Greenberg, Price et al. 2003, Heeramun-Aubeeluck and Lu 2013).

More recent findings in neuroimaging have indicated that structural changes in limbic and autonomic corticostriatopallidothalamocortical (CSPTC) circuits may play a central role in the pathogenesis of this disease. Therefore, targeting the CSPTC circuit foci using DBS may provide therapeutic benefits in some cases. DBS is being used for number of movement disorders and other neuropsychiatric conditions (Greenberg, Rauch et al. 2010). The department of neurosurgery at SUMS together with SNRC is currently establishing a setup for brain mapping, functional neurosurgery and NMD. (http://snrc.sums.ac.ir/en/about_us/introduction.html)

4.3. Applications of Neurostimulation in Epilepsy and other Neurological Disease Conditions

Cumulating evidence has supported the beneficial effects of neurostimulation in some medically intractable neurological disorders including epilepsy, chronic pain, headache disorders and a number of refractory movement disorders namely Parkinson's disease, tremor and dystonia (Gross and Lozano 2000, Stuart and Winfree 2009, Dafer 2010, Magis, Jensen et al. 2012, Asconape 2013). Moreover; depression, obsessive-compulsive disorder and Tourette syndrome have also received beneficial therapeutic effects following neurostimulation. Stimulation of the anterior nuclei of the thalamus (DBS), vagaus nerve stimulation (VNS) and more recently, responsive neurostimulation (RNS) are the three so far modalities supported by class I clinical evidence(Asconape 2013). Meanwhile, there are converging evidence supporting the safety and efficacy of non-invasive neurostimulation techniques including the transcranial magnetic stimulation (TMS) in treating neuropsychiatric and cognitive disorders namely depression, Alzheimer's disease and schizophrenia (Keshtkar, Ghanizadeh et al. 2011, Devi, Voss et al. 2014, Schulz, Berger et al. 2014)

When medical treatment for epilepsy (antiepileptic medications) fail to result in seizure remission (20-30% of patients turn to be cases of medically refractory epilepsy), epilepsy surgery may become warranted in selected cases (Wu and Sharan 2013). However, following resection, patients may possibly be left with neurological deficits. To avoid this, brain stimulation is considered as an alternative therapy for cases with intractable focal epilepsy. While many symptomatic and idiopathic generalized epilepsy cases fail to respond to ablative epilepsy surgery, neurostimulation can practically be applied to eloquent brain areas, and to multiple seizure foci with minimal concern for neurological deficits. Other than epilepsy, neurostimulation in implicated in some other neurological or psychiatric conditions such as Parkinson 's Disease (PD), chronic pain and headache (Dafer 2010, Carmona-Torre, Martinez-Urbistondo et al. 2013, Reese, Knudsen et al. 2013).

PD is a chronic debilitating neurodegenerative disorder afflicting 1 % of the population over 60 years old. There remains a significant disease burden and cost for medical therapy, nursing homes and social care as the disease progresses and despite optimal medical therapy, there is still a remarkable morbidity and disability left over in PD (Keller 2013).

DBS is often offered to advanced PD cases with no predictable response to medications, namely dopamine agonists. Applying DBS is shown to help such patients with reducing tremor, improving hypokinesias, stabilizing medication fluctuations and reducing or halting dyskinesias. The appropriate administration of DBS is shown to control levodopa fluctuating responses and dyskinesias which are hardly improved following medication adjustments (Ngoga, Mitchell et al. 2014).

Neurostimulation has also demonstrated efficacy in treating pain pathologies which seem resistant to conventional medical management or surgery (Stuart and Winfree 2009, Magis, Jensen et al. 2012). Studies have supported favorable outcome in pain management following spinal cord stimulation (SCS), peripheral nerve stimulation (PNS) and DBS (Stuart and Winfree 2009). Some spectacular approaches such as applying hypothalamic DBS, occipital nerve stimulation, sphenopalatine ganglion stimulation and SCS are suggested as potential neuromodulation therapies for refractory primary headaches (Hashemi, Nami et al. 2012, Magis, Jensen et al. 2012).

Evaluating the clinical perspectives of refractory epilepsy, movement disorders and pain-related pathologies, as well as investigating the practical implication of neurostimulation techniques are among the research priorities within SNRC. Members of the BCSG-Shiraz would design clinical trials and fundamental research projects on this.

(http://med.sums.ac.ir/departments/clinical_sciences/norology/research-activities/index.html)

4.4. Applications of Brain-Computer Interface

The idea of brain computer interface (BCI) was first presented by Gert Pfurtscheller and Jonathan R. Wolpaw from the BCI Lab in Graz University of Technology, Austria, and the BCI research and development Project, New York, USA (Mak, McFarland et al. 2012, Tangermann, Muller et al. 2012). The advent of BCI soon started to offer help to paralyzed, spinal cord injury and amyotrophic lateral sclerosis (ALS) patients (Muller-Putz, Pokorny et al. 2013, Liu, Li et al. 2014). BCI has partly enabled such patients to communicate with their environment using their EEG signals upon imagery movements (Pires, Nunes et al. 2011, Muller-Putz, Pokorny et al. 2013). This communication which is mediated by biosignals and brain waves in particular, can lead to the control external devices such as robotic arms, cursor or wheelchair movement (Fabiani, McFarland et al. 2004, Mohamed, Marwala et al. 2011, Li, Pan et al. 2013).

BCI systems are developed into different ways including self-paced and cue-based. In the self-paced BCI systems, subject arbitrarily imagines a mental task while in the cue-based systems the starting time of imagination is announced by the system to the subject. Although self-paced systems are realistic systems but real time detection of different imaginations involves with a high false positive rate (Boostani, Graimann et al. 2007, Eliseyev, Faber et al. 2011). In general, the self-paced systems first detect the imagination event and then translate the imagined information into a motion output. To obtain high-quality brain signals, neurosurgeons may implant an electrode array in the cerebral cortex where such electrodes are wired to a BCI system (Hill, Lal et al. 2006, Charvet, Foerster et al. 2012). The accuracy of BCI systems controlled by ECoG is near optimal (Charvet, Foerster et al. 2012). Nevertheless, this invasive method is not pleasant on the patients' side and they prefer noninvasive methods like EEGs (Leamy, Kocijan et al. 2014). Neuro-feedback can be a typical example of the more accessible applications of BCI. Over the past years, neuro-feedback has turned to the most famous application of BCI in Itan. As a BCI modality, neuro-feedback is used to improve symptoms in attention-deficit /hyperactivity disorder (ADD and ADHD), post-traumatic stress disorder (PTSD), bipolar mood disorder (BMD) and depression. It has also been considered as a neuro-enhancement technique for healthy individuals involved in highly attended tasks (Lee, Kim et al. 2010).

The BCI process involves transforming brain signals in electroencephalography (EEG) into machine-assisted outputs when the subject is carrying out a task (Alvarez-Meza, Velasquez-Martinez et al. 2013). BCI is implicated in cognitive tasks (for instance in lie detection), arithmetic tasks, auditory tasks (via auditory evoked potentials extraction) and visual tasks (via visual evoked potentials extraction) (Daly, Cheng et al. 2009, Molina and Mihajlovic 2010, Hsu 2011).

Upon signal acquisition from neural activities and while a cognitive or non-cognitive task is being implemented, critical EEG features such as band power, complexity measures (entropy-based), fractal dimensions, Hjorth Parameters, wavelet family features, non-negative tensor factorizations, common spatial pattern (CSP) and Kernel CSP define the quality of the potential output (Hsu 2011). The inter-individual variation in such parameters is diverse and normalization of such outputs in computational neuroscience is time-consuming and labor-intensive (McFarland, Sarnacki et al. 2011).

Some cutting edge issues in BCI include 1- personalization by designed kernel for each subject, 2-fusion of EEG and magnetoencephalography (MEG) signals to modify the spatial resolution and 3- fusion of EEG and functional magnetic resonance imaging (fMRI) to optimize the spatial resolution upon BCI paradigms (Weiskopf, Mathiak et al. 2004, Mellinger, Schalk et al. 2007). As a part of BCSG-Shiraz, the biomedical engineering group at the school of electrical and computer engineering of Shiraz University will render research designs, classifiers and feature selection algorithms in our BCI-related projects. (http://www.shirazu.ac.ir/en/index.php?page_id=1965)

4.5. Learning and Memory

As critical attributes of cognitive functions, learning and memory constitute a part of our self-awareness and consciousness (Goverover and Chiaravalloti 2014). One of the most challenging aspects of neurobiology is to understand various anatomical, biophysical, and molecular processes involved in learning and memory (Reber 2013). Cognitive neuroscience has begun to understand which newly defined neural circuits critically involve in learning and under what neuro-biochemical and neurophysiological mechanisms our brain selectively encodes, consolidates and retrieves the data (Callinan, Theiler et al. 2013). The short-term memory and related learning depend on how the neural cells are connected and cross-talk at synaptic and neural transmitter level. Whereas, the long-term memory mainly depends on the production of new proteins and expression of particular genes at mRNA level (Abel and Klann 2013, Johnson, Marro et al. 2013). The potential changes in properties of membrane channels and neural excitability are still among evolving areas of research in molecular and cellular neuroscience of learning and memory (Abel and Klann 2013).

The BCRG-Shiraz would cover some central topics to study neural mechanisms which underlie learning and memory both in animal models and human subjects. To do so, an array of human and non-human studies will continue to be conducted using neurochemical, electrophysiology, imaging and clinical evaluations in memory function. Investigation of physiological variables in some biological functions such as sleep and dreaming with respect to memory processing will also be amongst BCSG-Shiraz prospective projects.

We would be particularly interested to investigate the neurophysiological and pathological variables which contribute to age-related memory loss, as well as pronounced emotional memory (such as what observed in PTSD and upon craving in addiction) (Koob 2009, Schweizer and Dalgleish 2011). The plausible mechanisms underlying neural plasticity, learning difficulty, implicit and explicit memory in visual and auditory category learning are also intriguing themes to address in our study group. Above all, we are trying to utilize the current setup to study potential ways of preventing or ameliorating age-related cognitive decline.

4.6. Effects of Electromagnetic Radiation on Cognitive Functions

One of the other areas of interest in BCSG-Shiraz is the study of the possible detrimental effects of ionizing and non-ionizing radiation in microwave frequency range on brain health and cognitive functions. Over the past years, the 'Ionizing and Non-ionizing Radiation Protection Research Center' at SUMS has focused on studying the health effects of exposure of laboratory animals and humans to some common and/or occupational sources of electromagnetic fields such as mobile phones (Mortazavi, Rouintan et al. 2012, Mortazavi 2013, Mortazavi, Mosleh-Shirazi et al. 2013, Mortazavi, Taeb et al. 2013). While radar equipments deal with high-power radio-frequency waves by producing high-voltage and high frequency alternating electrical current, some people are routinely exposed to the pulsed high- frequency electromagnetic fields. Critical job holders in navigation, aviation, national defense, and weather forecasting are shown to be at increased risk (Mortazavi, Taeb et al. 2013). However, with the popular use of mobile phones and MRI (Mortazavi, Mahbudi et al. 2011), the possible hazards of the electromagnetic radiation is not limited to the above groups. Recent investigations on the health concerns following occupational exposure to radiofrequency radiation has not only supported the induction of toxic effects at cellular level (Deng, Zhang et al. 2013) but also suggested adverse effect of such exposures on short-term memory and reaction time as exemplary domains of cognitive functions (Foroozandeh, Derakhshan-Barjoei et al. 2013, Mortazavi, Taeb et al. 2013). Findings have also indicated that the visual reaction time (VRT) of university students is significantly affected by a 10 min exposure to electromagnetic fields emitted by a mobile phone (Mortazavi, Rouintan et al. 2012). Furthermore, it has been shown that occupational exposures to microwave radar radiations may decrease reaction time in radar workers (Mortazavi, Taeb et al. 2013). BCSG-Shiraz would pursue continued research on further possible effects of electromagnetic radiation on brain and cognitive functions (http://crrs.sums.ac.ir/en/index.html).

4.7. Complex Systems Approach to Neural Networks

Brain exists in a state of a delicate balance between competing tendencies such as excitatory vs. inhibitory, random firing vs. complete synchronization, purely local activity vs. collective large activities and integration vs. segregation (Hilgetag and Hutt 2013). From the physical point of view, systems in between two phases exhibit critical behaviors (Beggs and Timme 2012). For instance, the brain can process a wide range of light intensities. As such, a desert at night (black) and a desert at noon (light) are orders of magnitude apart. This indicates that systems at a critical point show a wide variability. The brain criticality and variability are integral features when we pursue research in neural connectivity and take a complex system approach in such studies (Hilgetag and Hutt 2013).

A wide range of brain functions including variability, adoptability, fluctuations, self-organization, meta-stability, functional connectivity, and emergent properties can all be understood through approaching the brain as a dynamical system which operates at a critical state. Non-equilibrium critical states are of great interest to physicists specializing in statistical and complex systems (Kitzbichler, Smith et al. 2009, Tagliazucchi, Balenzuela et al. 2012). This is a typical example where physics contributes to neuroscience studies. (http://shirazu.ac.ir/en/index.php?page_id=234)

4.8. Neuroimaging

Multichannel electroencephalography (EEG), magnetoencephalography (MEG), near-infrared spectroscopic imaging (NIRSI), transcranial magnetic stimulation (TMS) , structural MRI, magnetic resonance angiography/venography (MRA/ MRV), perfusion-/diffusion-weighted imaging (PWI/DWI), diffusion tensor imaging (DTI), magnetic resonance spectroscopy (MRS), single photon emission computed tomography (SPECT) , positron emission tomography (PET) as well as PET-CT, PET-MRI , functional magnetic resonance imaging (fMRI) are among the most common neuroimaging protocols and techniques applied in neuroscience research and brain mapping in particular (Busatto 2013, Lee, Lee et al. 2013, Weyandt, Swentosky et al. 2013, Barquero, Davis et al. 2014).

MEG has been used to study cognitive processes such as vision, audition, and language processing in fetuses and newborns (Chen 2001, He and Liu 2008). In research, MEG's primary use is the measurement of time courses of neural activity. MEG accurately pinpoints

sources in primary auditory, somatosensory, and motor areas detecting and localizing pathological activity in patients with epilepsy, and in localizing eloquent cortex for surgical planning in patients with brain tumors or intractable epilepsy. This method is also used for the classification of patients with multiple sclerosis, Alzheimer's disease, schizophrenia, Sjögren's syndrome, chronic alcoholism, and facial pain (Savoy 2001, Kelley and Johnson 2007, Hernandez-Gonzalez, Bringas-Vega et al. 2011). Other imaging modalities mentioned above have various spatial and temporal resolutions making them appropriate method for distinct studies. DTI is an imaging method used to visualize major white matter tracts (Weyandt, Swentosky et al. 2013).

In our setting, we are using fluoroscopy, digital subtraction angiography (DSA), ultrasound, multi-detector CT scan, conventional MRI, DWI, MRA/MRV, MRS (single voxel), SPECT and dense array EEG. Our neuroimaging setup is required to be soon equipped with fMRI, DTI, multi-voxel MRS, PET-CT SCAN / PET-MRI and TMS. (http://namazi.sums.ac.ir/wards/para/radiology/)

4.9. Attention-Deficit/Hyperactivity Disorder

Current research is providing more insights on what causes ADHD (Ghanizadeh 2011, Ghanizadeh 2013, Ghanizadeh 2013, Ghanizadeh, Freeman et al. 2013). Some genes which regulate the dynamics of dopamine and norepinephrine neurotransmitters are shown to be implicated in the pathophysiology of ADHD (Sharma and Couture 2014). Furthermore, studies have suggested reduced levels of catecholamine neurotransmitters in some cases (Slopien, Dmitrzak-Weglarz et al. 2006). Since the function of prefrontal cortex and its neural circuits, which play an important role in cognitive control, is partly dependent to optimal cathecolamine stimulation, the reduced level of these neurotransmitters are expected to result in weakened regulation of attention and behavior in ADHD (Slopien, Dmitrzak-Weglarz et al. 2006, Fusar-Poli, Rubia et al. 2012).

Some altered brain activities in ADHD are shown to be resulted from deficiency in the circuits connecting the cortex, striatum, and cerebellum, particularly in the right hemisphere (Sharma and Couture 2014). ADHD cases often show notable cognitive deficits especially in executive functioning such as planning and motor control. They may also show serious compromise in their visual-spatial processing capacity. This specific deficiency may contribute to their academic weakness and difficulty with geometry, reading maps and spatial relations (Don-

nelly 2006, Taanila, Ebeling et al. 2014). Research of neurodevelopmental disorders such as ADHD, autism, Asperger's syndrome is gaining momentum. Field experts at the Research Center for Psychiatry and Behavior Sciences, SUMS, have joined the BCSG-Shiraz for prospective interdisciplinary research projects in this area. (http://prc.sums.ac.ir/fa/index.html)

5. Concluding Remarks

Some core competencies of Shiraz University of Medical Sciences (SUMS) including well-established research and technological infrastructures make it an appropriate platform for applied research in interdisciplinary domains. With over 55 registered research centers and a reference laboratory, SUMS has acquired the first rank for the number of ISI papers and the second rank for the number of ISI paper per faculty member among the medical universities in Iran. Experts from various allied disciplines in the study of brain and cognition in Shiraz have come together to utilize potential opportunities for shared projects. Delegates from SUMS, Shiraz University and Shiraz University of Technology (SUT) are coalesced to establish BCSG-Shiraz. This initiative received endorsement from the Iranian Cognitive Science and Technologies Council (CSTC) and is expected to receive supports to flourish.

The role of Shiraz Neuroscience Research Center (SNRC) appears to be of pivotal value here. SNRC consistently pursues to attract potential talents in the field of neuroscience at local, national and regional levels. The center also tries to put into operation high-technology treatment and diagnostic services in neuroscience and continues to appeal operational and financial supports to facilitate prospective research within BCSG-Shiraz. Some other SNRC-advocated scientific activities to cater the study group's aims include publishing public-awareness brain science materials as well as academic books and journals in various aspects of basic, translational and clinical neurosciences.

As the headquarter for cognitive science and technologies in southern Iran, BCSG-Shiraz has decided to implement projects on brain and cognition awareness, education and research in close collaboration with CSTC.

Some research areas including neuro-stimulation, brain-computer interface, cognitive neuropsychology, complex systems approach to neural networks, functional neurosurgery and psychosurgery, learning and memory, neurodegeneration and neuroprotection, neuro-developmental- and attention-deficit/hyperactivity disor-

ders, neuroimaging and sleep neuroscience are considered priorities for BCSG-Shiraz's prospective strategic planning.

The steering committee of BCSG-Shiraz (coordinated by SNRC) will hold interval meetings to consolidate plans and strategies for interdisciplinary research on brain and cognition. To benefit continued support from CSTC, BCSG-Shiraz would duly intimate the council with the interim/progress reports of planned, ongoing and concluded projects.

6. Declarations

6.1. Competing Interests

The present report outlines the communications and experts' opinions during the meeting held on 9 January 2014, Shiraz, Iran. Authors declare no competing interest upon data review, talk delivery during the meeting, interactive discussions and preparation of the present report.

6.2. Funding

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6.3. Guarantor

MTN

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6.5. Contributorship

All authors equally contributed to literature review. MTN drafted the manuscript. All authors contributed to critical reversion of the manuscript for important intellectual content. MTN and SS provided administrative and technical material support. All authors read and approved the final manuscript. Authors are sorted alphabetically since all made almost equal contributions to this publication.

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