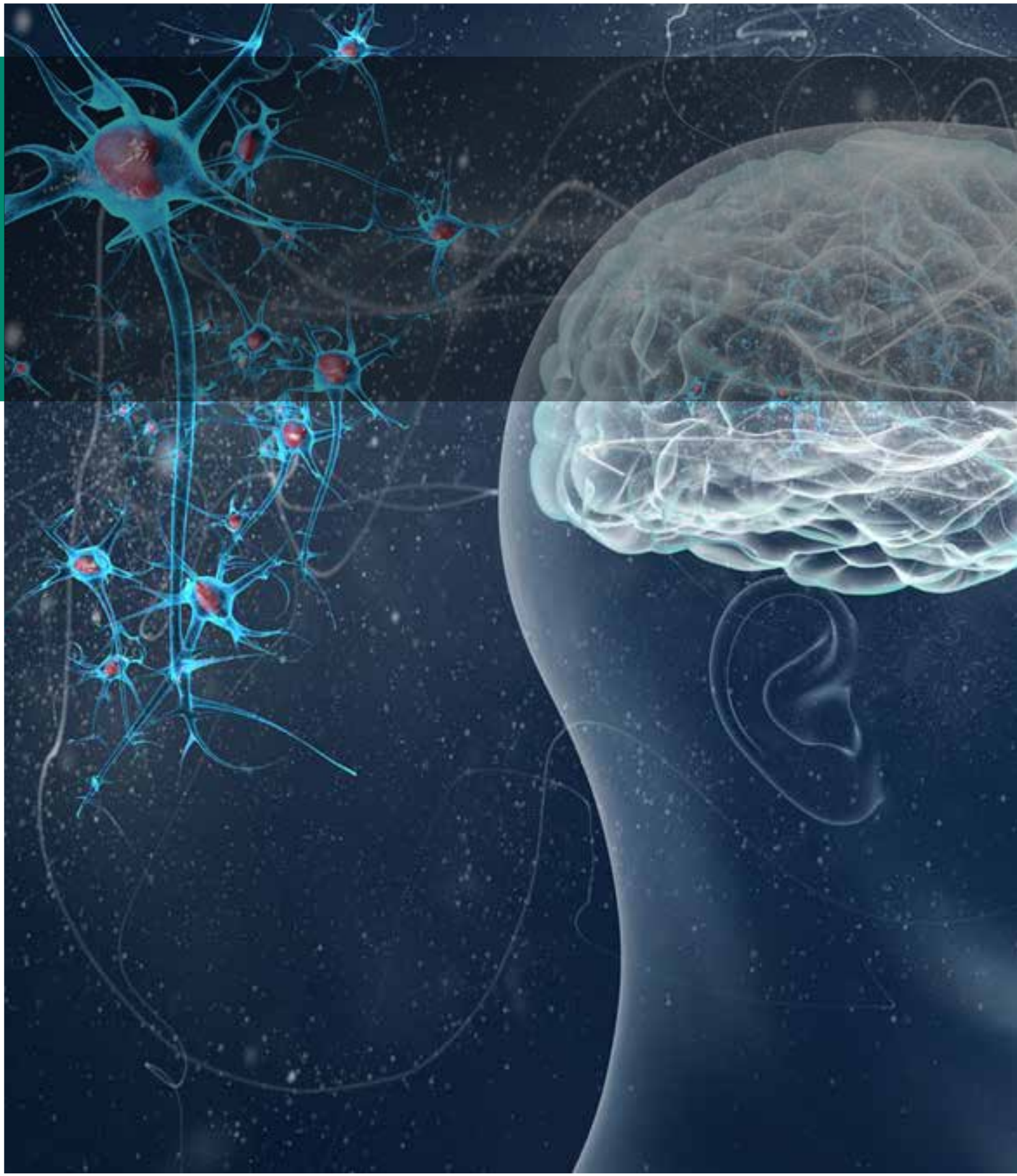
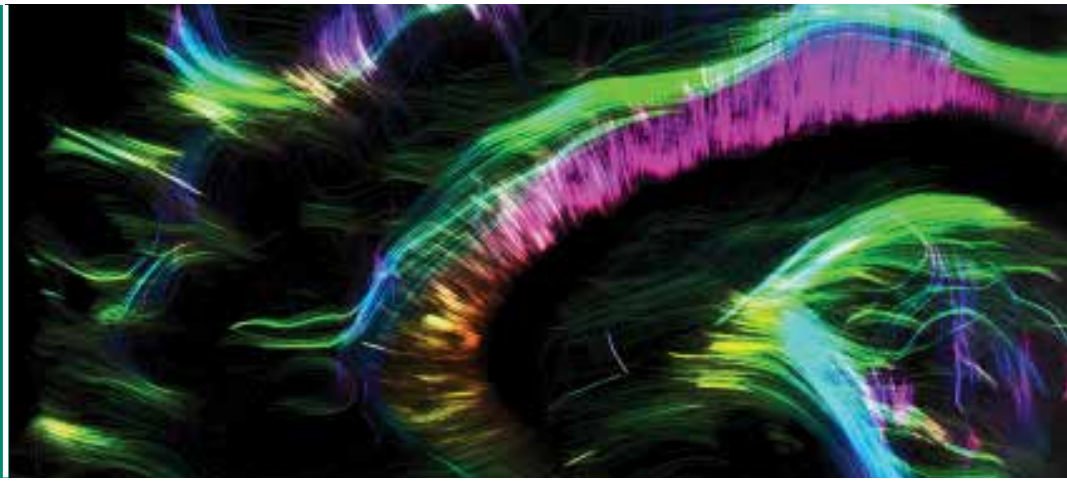


5 Cognitive Sciences

Cognitive Sciences



I. History and Background

Over the last four decades, cognitive sciences and technologies have proved to be extremely fruitful for human; the 1990s was named "The Decade of Brain". Nations today invest widely on this new realm of knowledge and compete vigorously to gain a more profound understanding of brain mysteries. Cognitive sciences adopt a process-oriented approach. Cognitive scholars see human brain as a complex network that receives, stores and retrieves information and it can manipulate or transfer such information. The processed outputs are speaking or locomotion.

Since late 50s and 60s, cognitive scholars focused on mental representations and the processing thereof. That was how a new interdisciplinary field called "cognitive sciences" emerged.

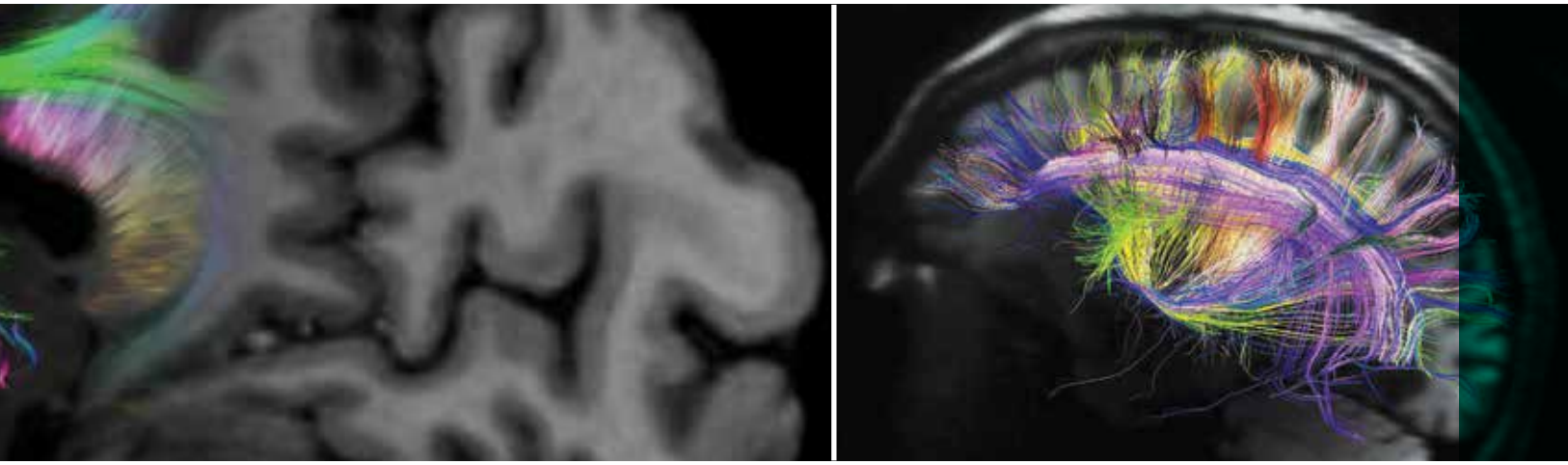
Starting in 1990s, imaging technologies and studying brain using modern devices have given neuroscience a more significant role in advancement of the cognitive sciences.

Early attempts to introduce cognitive sciences to the Iranian society were made by Dr. Caro Lucas, the well-known professor at the College of Engineering, Tehran University in 1996. Through his great efforts, the "Institute for Intelligent Systems" was founded in the theoretical physics and mathematics center called Institute for Research in Fundamental Sciences (IPM).

In this line, the Institute for Cognitive Studies (ICS) was founded in 1998 as a non-profit institute with the mission to conduct research on cognitive sciences. In 2003, this institute was approved and accredited by the Ministry of Science, Research, and Technology to offer doctoral and master's degree programs and train students under the title of the Institute for Cognitive Science Studies (ICSS). This institute offers a wide range of doctoral degree programs including cognitive neuroscience (brain and cognition field), cognitive psychology, cognitive linguistics, cognitive modeling, and philosophy of mind and also Master's degree programs in cognitive psychology and mind, brain and education.

The strategic document for development of cognitive sciences and technologies was approved by the Supreme Council of the Cultural Revolution on October 25, 2011, and under the terms of this document, the Cognitive Sciences and Technologies Council of Iran (CSTC) was founded in 2012 under the Vice-Presidency for Science and Technology.

The main objective of CSTC is promoting cognitive sciences and technologies in Iran for wellbeing of all Iranians. This objective is accomplished through formulating policies, supporting scientific activities and technology development, and securing successful implementation of cognitive systems and procedures in different sectors and everyday life. CSTC supports human resource development at the graduate level, research through financial aids for graduate and postgraduate activities, publishing scientific articles in highly-ranked journals, and providing research infrastructures including



laboratory facilities and networking. In addition, CSTC supports research projects on human brain mapping for cognitive studies, development of cognitive assessment tests and rehabilitation, cognitive education, cognitive linguistics and its applications nationwide, stem cells research and its applications in cognitive sciences and technologies, development of cognitive games, and brain implant in the country.

II. Objectives and Strategies

Some of the most important objectives and strategies set in the strategic document for development of cognitive sciences and technologies are as follows:

A. Macro Level Objectives

- Producing and developing scientific theories on the functions of mind, studying procedure thereof, its cognitive relation with the brain based on Islamic anthropology principles of the nature of self, mind, and their functions;
- Advancing basic sciences in brain and cognitive studies;
- Achieving and developing methods for growing and enhancing cognitive capabilities and functions;
- Utilizing and developing technologies and tools to be used in brain-computer interfacing and human-machine interaction applications;
- Inventing and developing methods to treat mental disorders and overcoming cognitive disabilities;
- Developing artificial systems inspired by human brain and its cognitive functions;
- Securing the first place in the region and holding scientific authority in cognitive sciences and technologies.

B. Macro Level Strategies

- Conducting interdisciplinary research and academic and seminary co-studies on cognitive sciences and technologies;
- Training the necessary human resources for research and education in cognitive sciences and technologies;
- Theorizing and advancing cognitive sciences and technologies; philosophy of the mind, in particular;

- Strengthening international scientific cooperation and interactions in cognitive sciences and technologies;
- Increasing quality and quantity of scientific and technological production in cognitive sciences and technologies in order to stabilize the scientific position of the country.

III. Capacities and Capabilities

A. Human Resources

As many people contributing to this area are from a range of vastly different disciplines, it is not easy to provide precise statistics on the country's human resources. However, it is possible to produce the estimated statistics of the active researchers based on the number of users registered on the portal of the Cognitive Sciences and Technologies Council of Iran (CSTC): The total number of the registered people on the council's portal is 2892, of whom 1432 people are students, 480 graduates, and 980 faculty members.

B. Research Areas Supported by the Council

• Brain Activity Mapping and Recording

Functional MRI: In the recent years, Functional MRI (Magnetic Resonance Imaging), which operates based on hemodynamic response in different areas of brain, is considered as one of the important techniques for studying cognitive activities of the brain. The projects that the council supports in this area include developing tools and analyzing fMRI and combining the optimized structural and functional data aiming to increase spatial precision to make exact diagnosis of the cognitive disorders (such as Alzheimer and Schizophrenia) possible.

fNIRS: Another new non-invasive technique to analyze brain cognitive activities is functional near-infrared spectroscopy (fNIRS) for cerebral cortex. Currently, the council supports studies on new methods for optical imaging of neural signals in order to be used in brain-computer interface (BCI) systems as well as manufacturing portable fNIRS system. Most significant achievements of these projects would be equipping laboratories to study brain networks and timing activities, and manufacturing optical imaging systems to study neural signals and acquire the technical knowledge of brain-computer interface based on optical model. These triple goals play an important role in developing cognitive foundations of the brain activities.

EEG: Electroencephalogram (EEG) is a key device, brain-machine interface, to assess and identify neurophysiological disorders. CSTC supports different projects such as creating local database, determining brain key areas via recorded data, investigating relation of sleep spindles, performing memory tests, and studying brain growth pattern, etc.

ECoG: Electrocorticography (ECoG) records neural activities from the surface of the brain. The ECoG approach is sometimes preferred over its two other counterparts as it provides signals with larger amplitudes and higher temporal and spatial resolution compared with EEG, and can be less invasive than the intra-cortical approach. In this technique, electrodes are directly placed on the exposed surface of the brain. Designing and manufacturing a data recording system and studying the effects of FEF (Frontal Eye Fields) stimulation on the focus of attention are among the projects supported by the council.

• Brain Implants

Brain implant panel of the council has proposed a macro project with the purpose of advancing brain implant in the country. Different parts of the brain implants including stimulating and recording

fNIRS System for Laboratory Application

Brain-computer Interface System

electrodes, stimulating and recording electronic, wireless interfacing for data and power telemetry are among the projects announced by CSTC as the first call for proposal with pre-defined specifications.

• Optogenetics

Optogenetics is a new neural engineering technology and genetic technique that controls a particular population of neurons without affecting the other neurons using light. It is possible to find a mechanism to treat neurological disorders and develop brain-machine interface systems using optogenetics. Controlling nervous system by optogenetics and behavioral and electrophysiological studies using optogenetics are among the projects supported by the council.

• Brain-machine Interface and Neurofeedback

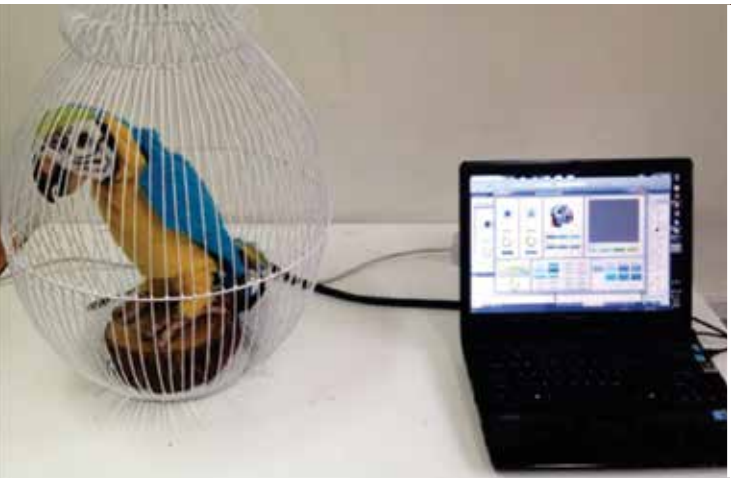
One of the objectives of supporting projects in this area is to build a system including a software by which disabled people with speech difficulties and mobility impairments would be capable of typing. A new generation of neurofeedback systems (second generation) with higher efficiency and faster effect is supported by the council as a research project. The council also supports a project for manufacturing a neurofeedback robot controllable by attention level. It is based on treatment protocols of the Attention-Deficit/Hyperactivity Disorder (ADHD). It is hoped that this robot would be effective in treatment of the ADHD.

• Cognitive Education

Cognitive education is aimed to integrate the findings of the systematic studies in cognitive sciences into education system. Accordingly, the council's cognitive committee has conducted several studies on designing cognitive pattern of education and behavior modifications on its agenda.

• Cognitive Rehabilitation

Cognitive rehabilitation is the process of relearning cognitive skills which have been lost or altered as a result of some brain injury. Robots can help treat patients with such impairments. Designing and manufacturing an internet-controlled robot can improve the internet communications technology in cognitive diagnosis and rehabilitation. Designing and manufacturing robots can also develop their applications in assessment and rehabilitation of cognitive parameters. Accordingly, the council supports projects such as manufacturing a parrot-like robot for rehabilitation of autistic individuals and studying the effect of two humanoid robots as assistant for therapists in treating and educating autistic children.



Parrot-like Robot for Rehabilitation of Autistic Children

Humanoid Robots for Rehabilitation of Autistic Children

• Cognitive Linguistics

Developing clinical language tests to assess language, cognitive, and communication difficulties of the adults with neurocognitive disorders like stroke, dementia and Alzheimer is highly important in diagnosis, rehabilitation, and clinical and basic researches in cognitive sciences and neuroscience. The supported projects are expected to be aiming at localizing the "Western Aphasia Battery-Revised (WAB-R)" test in terms of language, culture, and structure as well as evaluating its assessment criteria and indices for patients with brain injury.

• Cognitive Games

Especially-designed computer games are among useful available tools to increase and improve cognitive capabilities. Hence, the country's capacity and capability in developing computer games and software and the extensive role of cognitive games in enhancing cognitive capabilities of the community are prioritized. The council, in line with this trend, supports the research projects aiming at developing cognitive games and establishing knowledge-based companies in the area of cognitive games.

• Application of Stem Cells in Cognitive Sciences and Technologies

The neurodegenerative disorders are generally characterized by loss of neurons, oligodendrocytes, astrocytes, axons and other cellular communication. Since the foundations for cell therapy are laid, environmental enrichment to protect endangered cells, strengthening endogenous repair mechanisms, and cell transplantation are in focus in modern treatments. Replacement of cells is aimed at finding cells appropriate to pathobiology of disease or their laboratory production.
Currently, stem-cell therapy is advancing and researches are underway to apply stem-cell treatment for neurodegenerative diseases. This new field can have an influential role in treating cognitive diseases through producing healthy functioning cells. Thus, the council's priority is to support the research project on stem cells and their applications in cognitive sciences and technologies.

• Cognitive Assessment Tools

Cognitive assessment is performed by psychology, neurology, or education specialists in order to determine the level of cognitive function of the brain. Cognitive assessment tests may serve a

variety of purposes beyond an initial diagnosis. Assessments may be used to guide treatment decisions by identifying an individual's strengths, weaknesses, and needs; design individual treatment programs tailored to these findings; evaluate changing treatment needs; and monitor treatment efficacy. Cognitive assessment tests allows the examiner to avoid subjectivity in traditional examinations by conducting assessments that lead to quantifiable standardized scores, thereby increasing the reliability of the assessment as well as paving the ground for a more sensitive baseline for comparisons across time. So, appropriate application of the existing assessment tools plus development of new tools is considered to be a common need in the modern world. The council in line with its research priorities supports development and standardization of some cognitive assessment tests including aphasia memory and IQ tests.

• Deep Brain Stimulation

Deep Brain Stimulation (DBS) involves implantation of a medical device called neurostimulator which sends electrical signals to specific areas in the brain through implanted electrodes (parts responsible for thinking, planning, and memory). Recent studies indicate that DBS can be helpful in treating Parkinson and other tremor disorders plus several mental and nervous system diseases. Today, the credited scientific centers of the world are working on enhancing cognitive skills of the brain through DBS. The council also supports designing and manufacturing a system for deep brain stimulation and several other related projects.

• Transcranial Stimulation

Transcranial stimulation is a non-invasive method that uses a direct or alternating current to stimulate a particular zone in the brain. Primary researches show that it is useful for patients' rehabilitation particularly post-stroke, addiction, and psychological disorders such as depression and for treatment of Parkinson's disease, tinnitus, and migraine. This method is also used in identifying functions of different zones in the brain. The technique in combination with other brain mapping techniques can be used to study issues such as time and location of the brain activities, flexibility and connections of the neural circuits, and involvement of a brain zone in a cognitive task. Therefore, advances in this field can have numerous implications for neuroscience and the related fields while opening promising horizons to treat brain injuries. The council then supports the related projects such as studying long-term impact of transcranial direct current stimulation (tDCS) to reduce drug craving in methamphetamine consumers as well as designing and manufacturing a system to treat Parkinson's disease.

• Cognitive Approach in Addiction Studies

Significant growth in cognitive sciences and technologies over the recent years has provided unique opportunities to develop effective packages of interventions in substance abuse prevention, treatment, and rehabilitation. The council thus supports the pioneering groups in the related research projects. It also supports projects employing different cognitive approaches in behavioral, electrophysiologic, and rehabilitating dimensions.

• Electrophysiology in Small Animals and Primates

Electrophysiology is the study of electrical activities in biological cells and tissues. Using this technique, voltage changes and electrical activity can be measured on a wide variety of scales from single ion channels to a whole organ. Nowadays, cognitive sciences use this technique to study different dimensions of the neurons such as their molecular, cellular, structural and functional aspects. This technique is also useful in studies on different laboratory models like the primates (e.g. monkeys) and small animals (e.g. rats). The council supports projects that use this valuable technique in their studies. These projects study different cognitive processes such as memory and learning, synoptic plasticity, punishment/reward-based decision making, attention, and the changes in these processes caused by cognitive disorders such as Alzheimer, autism, or addiction.

IV. Authorities

Research centers and universities conducting research on cognitive sciences and technologies include: School of Cognitive Sciences, the Institute for Research in Fundamental Sciences (IPM); the Institute for Cognitive Science Studies (non-profit); Research Institute for Cognitive and Brain Sciences, Shahid Beheshti University; Faculty of Psychology and Educational Sciences, Tabriz University; Faculty of Psychology and Educational Sciences (ICBS), Ferdowsi University of Mashhad; Faculty of Psychology and Educational Sciences, Kurdistan University; Faculty of Psychology and Educational Sciences, Semnan University; Neuroscience Research Center, Kerman University of Medical Sciences; and Faculty of Psychology and Educational Sciences, Azarbaijan Shahid Madani University.

V. International Cooperation

Giving mutual visits to cognitive research centers in Iran and Russia, Iranian council and Kurchatov Institute signed an MoU in order to increase their mutual collaborations.

To increase the country's interactions with Switzerland in cognitive sciences and technologies, the council has negotiated with professors at the Zurich University and the follow-up measures have already resulted in some co-supervised PhD theses.

Several negotiations have been conducted between Iran and Brazil on mutual cooperation on cognitive sciences and technologies followed by an MoU for co-projects and student/professor exchange between the countries.

Iran's efforts to ensure international cooperation on cognitive sciences and technologies have not been limited to the mentioned countries. The country has accomplished to sign a number of MoUs with the leading research centers in South Korea, Germany, and China as well.