Louisiana EPSCoR
EXPERIMENTAL PROGRAM TO STIMULATE COMPETITIVE RESEARCH VOL.11 NO.06

Louisiana researchers unlocking the mysteries of brain networks in crisis

In 2003, the world's largest collaborative biological project—the Human Genome Project—was declared complete after the international research collaborations successfully mapped the entire the human genome. Ten years later, President Obama launched a national research collaboration—the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) initiative—a bold, 12-year research strategy for "the development and application of innovative technologies that can create a dynamic understanding of brain function." Developing this next generation of technological tools will help researchers to unlock the mysteries of the brain from the individual atoms and cells to the brain as a whole and its complex behaviors. This will help revolutionize treatments for brain disorders like Alzheimer's, schizophrenia, autism, traumatic brain injury, and epilepsy.

Investigators Dr. Teresa Murray, Dr. Leon Iasemidis, Dr. Mark DeCoster, and Dr. Prabhu Arumugam in front of their team of students at Dr. Iasemidis' Brain Dynamics Laboratory at LATech in Ruston, Louisiana. Photo by Donny Crowe.

An interdisciplinary team of Louisiana Tech University researchers in collaboration with the medical centers at the University of Alabama in Birmingham (UAB) and the University of Arkansas in Little Rock (UAMS) are now part of this brain research thrust. The team was recently selected by the National Science Foundation (NSF) to receive a $6 million Research Infrastructure Improvement Track-2 Focused EPSCoR Collaboration (RII Track-2 FEC) grant.

Led by Dr. Leon Iasemidis, principal investigator (PI) of biomedical engineering at LATech, Dr. Jerzy Szaflarski (lead co-PI) at UAB, and Dr. Linda Larson-Prior of neurobiology and psychiatry (lead co-PI) at UAMS, the researchers are investigating the underlying causes of epileptic seizures and their effects on brain functions. The team will be developing innovative tools for acquiring and analyzing electrical, magnetic and biochemical signals and cellular images over the course of weeks to months from the brain of patients and rodents with epilepsy.

"This 4-year NSF EPSCoR grant presents us with an excellent opportunity to study the epileptic brain and the underlying molecular and neuronal mechanisms of its transitions to seizures," said Dr. Iasemidis. "We have assembled a unique team of investigators with expertise in neuroengineering, neuroscience, mathematics and statistics, neurology, clinical neuropsychology and neurosurgery to study in vivo and in long term the dynamics of the epileptic and memory brain networks in humans and animals."

Epilepsy is a common neurological disorder affecting 1% of the global population. According to the Epilepsy Foundation, more people live with epilepsy than with autism spectrum disorders, Parkinson's disease, multiple sclerosis and cerebral palsy combined.

Epilepsy has been called "a window to the brain's function" because, depending on the location and extent of the underlying epileptogenic network, different brain functions are impaired. Despite decades of research into epilepsy, a cure and understanding the mechanisms of seizure generation have yet to be found. This is partially due to the limited tools currently available for long-term recording and mathematical analysis of brain dynamics, shortcomings that this research effort will directly address.

There are many causes of seizures (A.K.A. convulsions), such as genetic predisposition, illness, head injury, low blood sugar and drug use. In the case of epilepsy, abnormal or excessive neuronal activity in brain regions causes unprovoked seizures that result in intermittent disruptions of normal brain function. These often cause lasting effects on the brain, such as memory impairments and mood disorders. Further, people living with epilepsy

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endure many social, psychological and financial hardships. The unpredictable nature of seizure occurrences is largely responsible for these impediments.

A cohort of treatments is currently available for epilepsy, including medication, brain surgery and, more recently, neuromodulation via electrical stimulation. However, about 35% of patients still do not respond to treatment, and, the ones that do, often encounter undesirable side effects. Therefore, there is an urgent need for improvement of the current remedies and development of new treatment modalities.

The LATech research team is developing innovative recording tools and computational analysis techniques to study the underlying causes of epileptic seizures and the resulting effects on brain's function (e.g., memory). The new recording tools that will be developed include electrochemical probes that can monitor neurotransmitters that are essential in neuronal communication and optical imaging tools to monitor changes of neuronal cells and their networks. It will be the first time that pairing molecular and cellular data with concurrently recorded electrical (EEG) and magnetic (MEG) activity of the brain will be attempted, and will thus offer the opportunity to monitor and correlate brain dynamics and susceptibility to seizures at the micro and macro levels.

The computational scientists on the research team are developing advanced mathematical algorithms— based on the theory of chaos, modern measures of network connectivity and machine learning, to analyze the vast amount of data to be generated from these experiments. These analyses are expected to lead to the development of more accurate identification of the epileptogenic focus and its network. The tools will help to provide reliable seizure prediction and find immediate translational applications to the diagnosis and treatment of epilepsy. Indeed, accurate localization of the epileptogenic network is a cornerstone for successful brain surgeries.

Another important aspect of this research effort is the planned investigations into the identification of memory networks which, when combined with the results from identification of the epileptogenic network, is expected to lead to better selection of patients for surgical removal of their epileptogenic focus with less memory impairment and side effects.

Finally, the results of this research into epileptic brain dynamics could also open the door for more successful investigations into other brain dynamical disorders, like Parkinson's disease and psychiatric disorders.

Louisiana Tech University research team leadership

Dr. Leon Iasemidis, Principal Investigator, Professor of Biomedical Engineering, Director of the Brain Dynamics Laboratory and the Center for Biomedical Engineering & Rehabilitation Science, Fellow of the National Academy of Inventors and the American Institute of Medical and Biological Engineers.

Dr. Katie Evans, Associate Professor of Mathematics and Statistics, Academic Director of Mathematics & Statistics and Industrial Engineering, Director of the Integrated STEM Education Research Center.

Dr. Prabhu Arumugam, Assistant Professor of Mechanical Engineering and Institute for Micromanufacturing, Director of the Advanced Materials Research Laboratory.

Dr. Teresa Murray, Assistant Professor of Biomedical Engineering, Director of the Integrated Neuroscience Imaging Laboratory.

Dr. Mark DeCoster, Professor of Biomedical Engineering, Director of the Cellular Neuroscience Laboratory.

Dr. Ioannis Vlachos, Assistant Professor of Mathematics and Statistics.

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