We currently have very few therapeutic options to treat problems with memory and cognitive functions, which are impaired not only in brain diseases but also decline with natural aging. Emergence of recent technologies for electrical stimulation makes it possible to apply treatment in specific brain regions instead of affecting the entire body with drugs and their side effects. The problem with treating memory functions is that we know neither the brain regions nor the electrical activities that are responsible for making and retrieving our memories. Hence, the stimulation technologies have been more successful in treating movement and mood disorders that have well described regions and mechanisms in the brain. Our understanding of the brain regions and electrical activities involved in forming our memories for particular facts and events is much more limited, requiring implantation of electrodes inside the human brain.

In this project, we propose to take advantage of the unique opportunity to implant electrodes and record inside the human brain in rare cases of treating medically resistant epilepsy. These recordings in adult patients were started for the first time in Poland as part of our current project funded by the Foundation for Polish Science in collaboration with the Medical University of Wroclaw and the American Mayo Clinic. Together with our new collaborator at St. Anne's University Hospital in Brno, we will now be able to collect data from these recordings from the patients in Poland and in the Czech Republic, performing the same memory tasks with tracking of eye movements in both countries. Data will be stored into one international database coordinated at the Gdansk University of Technology to provide the first such collection of human intracranial signals during memory performance with tracking of eye movements.

The data are going to be acquired and analyzed by an international team of experts in neuroscience, biomedical engineering and neurosurgery. Implantation of special hybrid electrodes and recording of a large scale of brain activities, ranging from firing of individual neurons to brain waves of synchronized cortical areas, is led by the neurosurgical team of Prof. Pawel Tabakow at the Medical University of Wroclaw and the neurological team of Prof. Milan Brazdil at St. Anne's University Hospital in Brno. Data analysis and coordination of the entire project is led by the Brain and Mind Electrophysiology laboratory directed by Dr. Michal Kucewicz at the Gdansk University of Technology. Dr. Jan Cimbalnik leads the data collection and analysis efforts at the St. Anne's University Hospital. Our goal is to find the fast brain wave activities, which are responsible for remembering specific memories in our mind, and to discover how to improve memory performance in the patients. Tracking eye movements will provide a window into the cognitive processes to track when and how well patients are attending to remembered items. Therefore, the processes of our mind and the fast activities of the brain will be explored and connected together by the leading researchers and clinicians in the field.

The project takes advantage of the latest technology for recording and stimulation in the human brain at the highest possible spatiotemporal resolution. These tools allow us to elucidate the electrical activities that underlie formation and remembering of new memories at the level of specific neurons in particular areas of the brain. Reading and modulating these activities with brain stimulation is the most direct way to improve memory and cognitive deficits in brain disorders. Our results will accelerate development of new brain-computer interface technologies and therapies for not only epilepsy but also degenerative, developmental and psychiatric diseases.