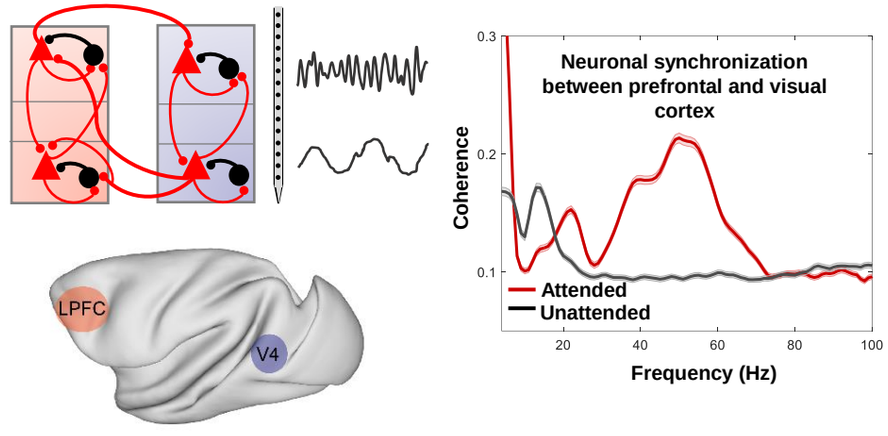
H.F.R.I.
Hellenic Foundation for Research & Innovation

Description of the funded research project

1st Call for H.F.R.I. Research Projects to Support Faculty Members & Researchers and Procure High-Value Research Equipment

Title of the research project: Micro- and mesoscopic study of neuronal interactions and network dynamics in cognition. The role of distinct prefrontal-temporal circuits in attention and memory.



Principal Investigator: Georgia Gregoriou

Reader-friendly title: The role of distinct prefrontal-temporal circuits in attention and memory.

Scientific Area: Life Sciences

Institution and Country: Greece

Host Institution: Foundation for Research and Technology Hellas, IACM

Budget: 180000 euro

Duration: 36 months

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Research Project Synopsis

One of the biggest challenges in Neuroscience today is to understand how the brain achieves flexible routing of information along selected neuronal populations according to behavioral demands. Attention is a prime example of a cognitive function that relies on such dynamic and selective routing of information by prioritizing behaviorally relevant inputs while filtering out irrelevant ones. Converging evidence from different approaches has suggested that the prefrontal cortex (PFC) is a critical part of an attentional control system that provides "top-down" signals, which modulate sensory processing in early visual areas in favor of attended stimuli. However, the role of distinct areas within PFC in attention and the neural mechanisms that mediate such selective communication and processing within the prefrontal-visual circuitry remain elusive. Some studies have suggested that oscillatory synchronization of neural activity provides a mechanism whereby activities of functionally related neuronal populations are coordinated to facilitate effective communication and integration. Nevertheless, a comprehensive understanding of how local and distant neuronal circuits and specific cell types contribute to long-range oscillatory synchrony between prefrontal and temporal visual areas in attention and memory is still missing.

In this project, we will employ large-scale invasive electrophysiological methods to address two broad questions. First, we will assess whether and how neurons in different anatomical entities within PFC and different cell types process spatial and feature-based information that is used to direct attention to behaviorally relevant stimuli. Second, we will examine the specificity of local (within PFC and visual cortex) and long-range (between PFC and visual cortex) neuronal interactions during different task epochs that have distinct cognitive demands. Our goal is to reveal how large-scale coordination of activity is implemented in the brain by anatomically distinct neural circuits.

Project originality

The proposed study is innovative and goes beyond the traditional single neuron approaches in the study of attention. Recording from multiple electrodes in the brain is an approach, which has recently been employed to study brain function. By recording simultaneously from areas involved in the attentional control system we expect to elucidate the role of each area in the allocation of attention and reveal how attentional selection arises through the interactions of diverse cell types and neuronal populations. Studying the dynamic nature of neuronal interactions *in vivo* and its relevance to cognition is a field of research that has only recently started emerging. The use of laminar and high-density electrode arrays, which have only recently been developed, will allow a detailed study of the circuits that give rise to attentional mechanisms and will help reveal the origin of brain rhythms, their modulation with attention and their role in long-range neuronal interactions between distant areas. Only a handful of studies so far have employed these methods and none of these has done so in the context of attention.

Expected results & Research Project Impact

Several decades of research have shown that cognitive functions such as attention cannot be attributed to a single structure but rather arise from the coordinated activation of neuronal populations across distant brain areas. Thus, understanding the neural mechanisms of attention at the large-scale level requires an appreciation of the neuronal interactions among different brain areas as well as a better understanding of the circuit level mechanisms that give rise to the observed modulations in long-range functional connections. By recording simultaneously from distinct PFC regions we expect to elucidate the role of different prefrontal regions in the allocation of attention and reveal how selective processing arises through the interactions of diverse neuronal populations. We also expect to identify the contribution of distinct circuits to visual processing and oscillatory coupling between distant areas in order to reveal more general principles of neuronal communication. Disruption of long-range communication and coordination of neural activity has been implicated in several neurological disorders, which can collectively be referred to as "disconnection syndromes". Studying the functional underpinnings of long-range neuronal interactions during attention and memory will deepen our understanding of cognitive functions in the healthy and diseased brain. Moreover, we will examine how cognitive information is encoded in distributed patterns of activity across populations of neurons using high-density multi-electrode arrays and machine learning algorithms. Understanding how neuronal populations encode visual and cognitive parameters is the first step to the development of effective cognitive BMIs and neurofeedback applications that can enhance or restore function in patients with visual, motor and cognitive impairments.

The importance of this funding

The funding from ELIDEK is important, as any research funding that aims to support scientific efforts producing new knowledge. It came after a long period during which there were practically no national funding opportunities for fundamental research projects. As a result, it allowed funded laboratories to continue research and support their staff, including PhD students and postdoctoral researchers, who are the cornerstones of research activity in Greece. Moreover, the relative flexibility in resource management (compared to rigid funding rules of past funding schemes) facilitates experimental research in which experimental needs can change over time based on research results. This funding scheme is a good start in the right direction but needs to be bolder so that ambitious excellent research programs can be supported for their duration and beyond the three years period, according to international standards and without financial cuts.

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COMMUNICATION

185 Syggrou Ave. & 2 Sardeon St. 2
171 21, N. Smyrni, Greece
+30 210 64 12 410, 420
communication@elidek.gr
www.elidek.gr