Dialogues in Clinical Neuroscience & Mental Health

DOI 10.26386/obrela.v1i0.37

ISSN 2585-2795

Athenian Symposia: Cerebral Instantiation of Memory, Under the auspices of the Hellenic Clinical Neurophysiology Society, Athens, March 30-31, 2018

Guest Editors: Andrew C. Papanicolaou, Ioannis Evdokimidis, Theodoros S Constantinidis

Lecture

Diversity in pathway recruitment for memory processing

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Abstract

Ideas about retrieval of memories are based largely on localization of function inferred after brain damage. On the other hand, communication in the cerebral cortex occurs through an intricate network of connections, suggesting highly distributed circuits. Loss of memory after lesions thus affects not only the damaged area, but also its rich inputs and outputs. The discussion here is based on a structural model of neural communication that can help explain the process of recruiting highly distributed relevant signals for conceptual and sensory recognition and memory. Discussion of cortical communication has traditionally been sensory-centric, based on the flow of information from the periphery to primary sensory areas and beyond, or in the reverse direction. However, visual signals often do not activate areas along a sequential route as predicted by a hierarchical model, exemplified by the fact that some visual signals activate prefrontal areas earlier than some visual association areas. On the other hand, the structural model for connections is based on the fundamental principle of systematic variation in laminar architecture of the cortex and applies to all cortical systems. The structural model is relational: it predicts that laminar-specific connections in the cortex depend on the structural (laminar) relationship between linked areas. Thus, connections that link an area with simpler laminar structure originate mainly – but not exclusively – in the deep layers and terminate mainly in the upper layers of an area with more elaborate laminar structure. In the opposite direction, connections originate in the upper layers and terminate in the middle-deep layers. Because the laminar architecture across cortical areas is graded, so is the distribution of connections within layers. The structural model holds for connections in all cortical systems and diverse species. Moreover, laminar-specific connections as predicted by the structural model terminate within inhibitory microenvironments that also differ by the distribution of functionally distinct classes of inhibitory neurons that can dynamically shift activity among layers and change cortical rhythms. The relational nature of the structural model and predictions of graded patterns of connections thus suggest that distributed areas and layers are recruited dynamically to meet task demands, including recollection of concepts and events.

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