RUHR-UNIVERSITÄT BOCHUM

RUB

SFB-COLLOQUIUM /Hippocampus-Club

Tuesday, May 27th, 16.00 (s.t.), GA 04/187

A theory of hippocampal function, and how it incorporates spatial view cells and place cells

Prof. Edmund T Rolls

Oxford Centre for Computational Neuroscience, Oxford, UK

Abstract:

A quantitative computational theory of the operation of the hippocampus as an episodic memory system is described. The CA3 system operates as a single attractor or autoassociation network to enable rapid, one-trial, associations between any spatial location (place in rodents, or spatial view in primates) and an object or reward, and to provide for completion of the whole memory during recall from any part. The theory is extended to associations between time and object or reward to implement temporal order memory, also important in episodic memory. The dentate gyrus performs pattern separation by competitive learning to produce sparse representations, producing for example neurons with place-like fields from entorhinal cortex grid cells. The dentate granule cells produce by the very small number of mossy fiber connections to CA3 a randomizing pattern separation effect important during learning but not recall that separates out the patterns represented by CA3 firing to be very different from each other, which is optimal for an unstructured episodic memory system in which each memory must be kept distinct from other memories. The direct perforant path input to CA3 is quantitatively appropriate to provide the cue for recall in CA3, but not for learning. The CA1 recodes information from CA3 to set up associatively learned backprojections to neocortex to allow subsequent retrieval of information to neocortex, providing a quantitative account of the large number of hippocampo-neocortical and neocortical-neocortical backprojections. Tests of the theory including hippocampal subregion analyses and hippocampal NMDA receptor knockouts are described, and provide support for the theory.

Recordings from single hippocampal neurons in locomoting macaques reveal that some neurons are tuned to „spatial view“. These hippocampal neurons (1) respond to a view of space “out there”, not to the place where the monkey is; (2) have responses that depend on where the monkey is looking, as shown by measuring eye position; (3) can still occur (especially for CA1 neurons) if the view details are obscured with curtains; (4) that the cells (in e.g. CA1) retain part of their „space“ tuning even in complete darkness, for several minutes; (5) that the spatial representation is allocentric; and (6) that the information about spatial view increases linearly with the number of cells in the representation. The spatial representation may be different from that of place cells in rats because of the smaller field of view of primates. It has also been shown that some hippocampal encode for objects, others for places in a room, and others for a combination of objects and places, while a monkey is performing an object-place memory task. This task is prototypical of episodic memory, and provides evidence that the primate hippocampus does associatively link information about objects and allocentric information about places “out-there”.

SFB 874

DFG Deutsche Forschungsgemeinschaft