CIN SYMPOSIUM 2013 – ABSTRACTS

Anatomical and Functional Organization of the Primate Insular Cortex

Henry C. Evrard

The insula exerts a crucial role in processing interoceptive and emotional states, and in interdependently engendering subjective feelings of self-awareness and empathy. One major problem in understanding how this occurs is that little is known about the insula's anatomical organization, including its architecture and hodology. We re-examined the architecture of the macaque insula and found that each of its three classical "sectors" contains several smaller, reproducibly distinct and sharply delimited areas including 8 agranular areas, 4 dysgranular areas and 4 granular areas. Each area appears to be subdivided into smaller sub-areas organized in a series of anteroposterior stripes. Using intra- and extra-insular injections of neuronal tracers, (1) we confirmed the existence of smaller areas and of a stripe-like hodological pattern and (2) we observed that each area harbours a complex but highly organized topography. On the basis of this and other works, we proposed a new working model of the primate insular organization that resonates to some extent with models recently proposed on the basis of human imaging studies. We are currently completing the analysis of our tract-tracing to test and refine our model. Finally, using careful anatomical examination, we found that one specific area of the macaque insula contains von Economo neurons (VENs), an atypical form of projection neurons previously thought to occur only in humans and great apes among primates and known to be particularly vulnerable in the behavioural variant of frontotemporal lobe dementia. In connexion with our other studies, this finding offers new and much needed opportunities to investigate the primal connections and physiology of a neuron and brain area that could be crucial for human self-awareness, social cognition, and related neuropsychiatric disorders.

Exploring Origins of Neuronal Variability in Early Visual Cortex

Hendrikje Nienborg

During perceptual decision tasks, the activity of sensory neurons correlates with a subject's percept, even when the physical stimulus is identical. This correlation can be used to predict a subject's choice at the end of a trial from the activity of these sensory neurons during the trial. It is still poorly understood how these neuron-behavior correlations arise, what the relevant circuit elements are and whether there are general principles why they are found for some sensory areas but not others. We will address these questions using extracellular single unit recordings from early visual cortex during visual discrimination tasks.

Structural Determinants of Spatial Representations in Layer 2 of Medial Entorhinal Cortex

Andrea Burgalossi

Extracellular recordings in the entorhinal-hippocampal system have identified the neural components of a “cognitive map” of the external space. The Medial Entorhinal Cortex (MEC) has been shown to contain grid cells – spatially-modulated neurons which fire in a strikingly regular hexagonal grid pattern. In this talk, I will focus on the cellular and circuit basis of spatial representations in MEC layer 2. Extracellular recordings have shown that layer 2 contains neurons which discharge with strong theta-rhythmicity and in hexagonal grid patterns. However, we still know little about how principal cell heterogeneity (pyramidal *versus* stellate neurons) and cell-type specific microcircuits relate to entorhinal theta-rhythmicity and grid cell activity. To address these issues, we recorded from morphologically & cytochemically identified layer 2 neurons from freely-moving animals by using an improved version of our juxtacellular recording/labeling procedure (as in Burgalossi et al., 2011). Our results show that, while calbindin-negative stellate cells were uniformly distributed in the cortical plane, calbindin-positive pyramidal neurons formed patches arranged in a hexagonal grid that was aligned to layer 1 axons, the parasubiculum and cholinergic inputs. Theta rhythmicity of calbindin-positive pyramidal neurons was cholinergically sustained and two-fold stronger than that of calbindin-negative stellate cells. Thus, layer 2 theta-modulation is cell-type specific, but does not correlate as originally thought with cell-intrinsic properties of stellate neurons. Theta-modulation, cholinergic innervation and hexagonality make us wonder if the calbindin pyramidal grid is an embodiment of the brain’s representation of space in hexagonal grids.