Plugging into memory

Human intracranial research

Ward and Thomas (1955) were the first to successfully record human single neurons. They did so in the posterior temporal lobe using glass micropipettes while surgeons tried to localize the epileptic focus and repair a bone defect in the patient’s skull. The type of microwire electrodes that are still in use today (Fried et al., 1999) have been described in the early 70s by Babb and colleagues (Babb et al., 1973; electroenc & clinic neurophysiol). They consist of a hollow-depth intracranial macroelectrode through which the microwire electrode is inserted. Microwires radially protrude at the tip and allow the recordings of multiple single neurons amalgamated with local field potentials.

These electrodes remain implemented for typically 1-2 weeks to gain an understanding which brain regions are responsible for the generation of epileptic seizures and will be resected. The clear advantage of intracranial electrophysiological recordings over traditionally used non-invasive methods is a spatially confined (vs. surface EEG) and well localized signal with a high temporal resolution (vs. fMRI). In contrast to invasive recordings in animals, humans can typically perform a task after minimal instructions and can provide comprehensible verbal feedback when prompted.

A severe disadvantage of intracranial recordings is a relatively limited coverage of the brain compared to traditionally used brain recording methods. This downside is exacerbated by the fact that the spatial position of the intracranial electrodes are determined by clinical need and not scientific experimentation. Furthermore, access to epileptic patients that are willing to participate in scientific research is limited. Finally, even if these hurdles are overcome, it is important to ascertain that pathologic epileptic activity does not influence the obtained results.

Concept Cells

Concept cells are neurons in the MTL that fire in response to specific concepts in an all-or-none way (Rey et al., 2018). They exhibit a high degree of multimodal invariance (i.e., they respond to Jennifer Aniston as an image or her spoken name) and context invariance (i.e., a concept neuron tuned to Jennifer Aniston would activate when you see her in a park or in a café) (xx).

Curiously, the latency of their firing rate is much later than would be required by simple sensory processing and object recognition, which is an indication of their involvement in memory processing (Mormann et al., 2008). This lines up with the observation that most concept neurons are tuned to personally relevant concepts and depend on the subjective and conscious perception rather than objective sensory properties (Quiroga et al., 2014, 2008).

These concept neurons are not topographically organized, i.e., spatially close concept neurons might code for vastly different concepts (Quiroga 2016?). This spatial organization benefits episodic memory processing as it allows association between any two concepts without connecting distant areas (plugging into memory xx). According to Quian Quiroga (Cell 2019; tics; 2012 paper) these CN are the building blocks of episodic memory formation and retrieval. If you met your best friend in your favourite café the concurrent activation of two assemblies of CN (one for your friend and one for the café) would represent the episode in the hippocampus. These assemblies would then project back to the neocortex reinstating the sensory activity pattern first induced during the formation of the episode. This back-projection parallels the one described in the indexing theory (Teyler 1 & 2 xx) with the important difference that the hippocampal representation consists of previously existing concept specific representations/assemblies.

A separate memory of the same friend in a park would in turn be represented by the simultaneous activity of the same assembly coding for your friend and another assembly representing the park.

Once implanted these electrodes yield typically around a dozen separate neurons per microwire bundle.

The indexing theory DONE

Episodic memory NOT SURE

The hippocampus KINDA

The LFP – theta and high gamma NOT DONE BUT HAVE A LOT OF NOTES AROUND IN A WORD DOCUMENT?

Describe Behnke fried (1999 paper, 9 month report or early MS version has a summary)

Include a figure showing the LFP with AP