

Recording Neural Activity

Informatics 1 Cognitive Science

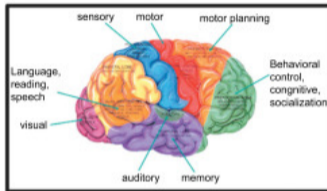
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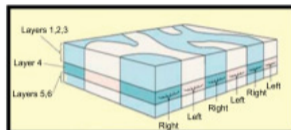
Topics

- Non-invasive versus invasive methods
- Different types of signals: electrical, optical, magnetic
- Spatial and temporal resolution

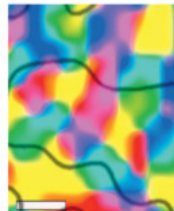
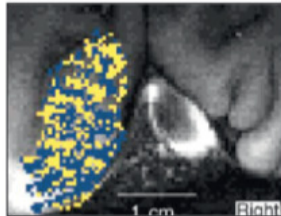
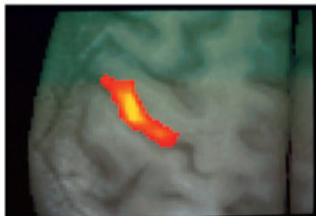
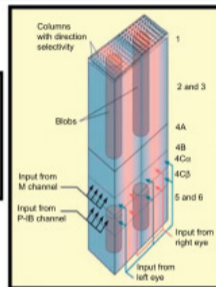
Observing the brain at different scales



Regions



Columns



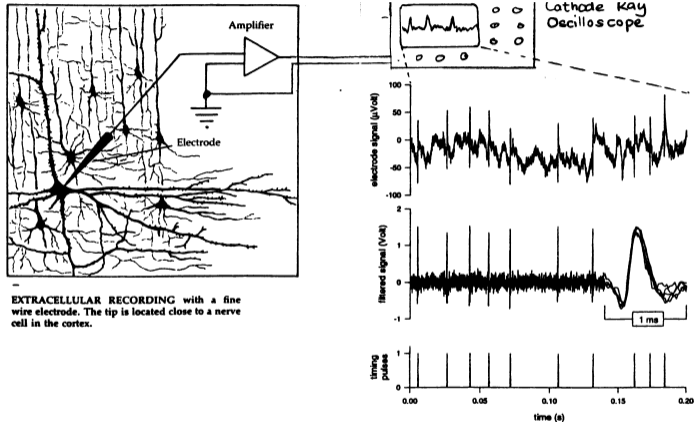
Summary of Methods

- Electrical measurements:
 - Intracellular electrodes to measure membrane voltage
 - Extracellular electrodes report spiking activity
 - Single neuron resolution: single or multiple electrodes, multi-electrode arrays
 - Population response: field electrodes, ECoG, EEG
- Magnetic measurements:
 - Population response: MEG
- Optical measurements:
 - Fluorescence signals emitted from neural activity indicators
- fMRI (functional Magnetic Resonance Imaging):
 - Reports blood oxygenation level

Recording Methods

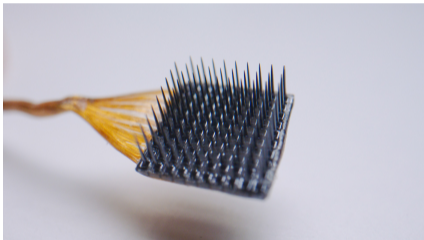
1. Electrical recordings

Extracellular electrodes



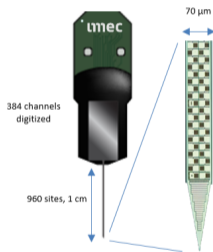
One or few neurons at a time. High precision in time, sub-millisecond resolution.

Implantable Arrays

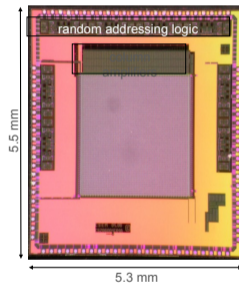


Arrays with multiple recording channels, these can be implanted chronically (prosthetics, see e.g. BrainGate Consortium).

Dense arrays



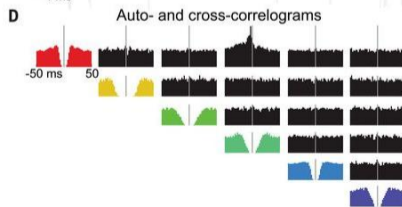
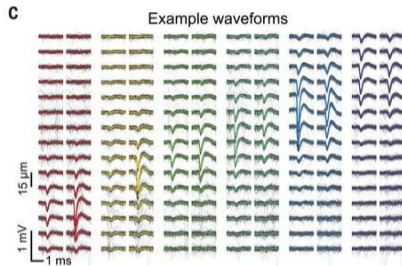
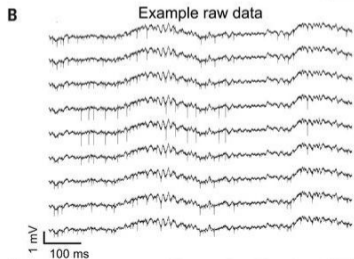
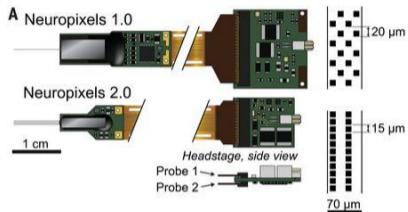
Neuropixel Probe
384 channels at 30kHz
22 MB/s



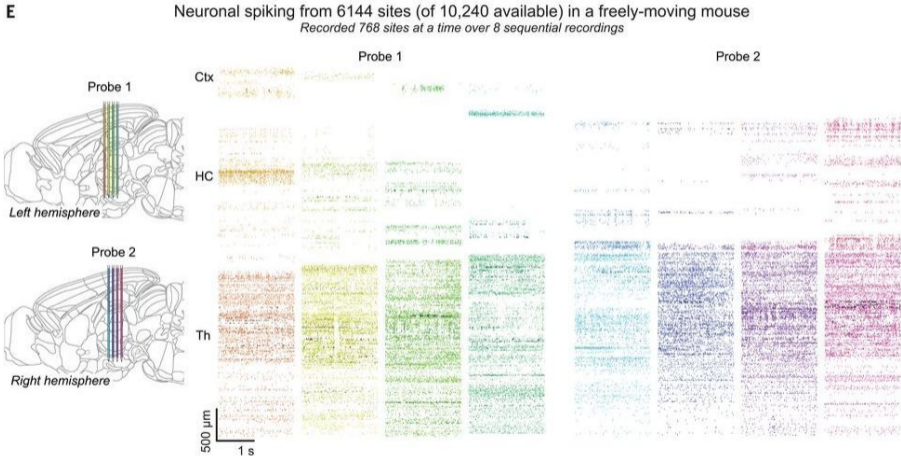
Biocam Array
4,096 channels at 18kHz
142 MB/s

100+++ neurons close to the array simultaneously.

Dense arrays

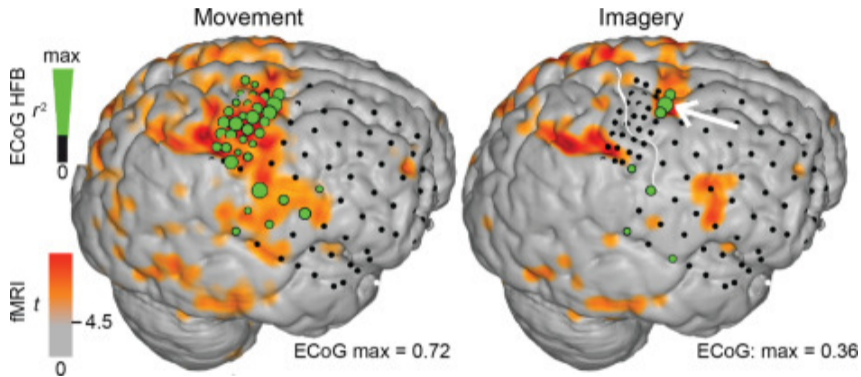


Dense arrays



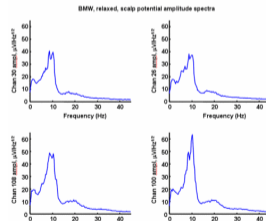
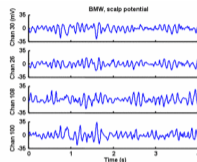
Multiple shanks to record from different areas simultaneously.

Electrocorticography (ECoG)



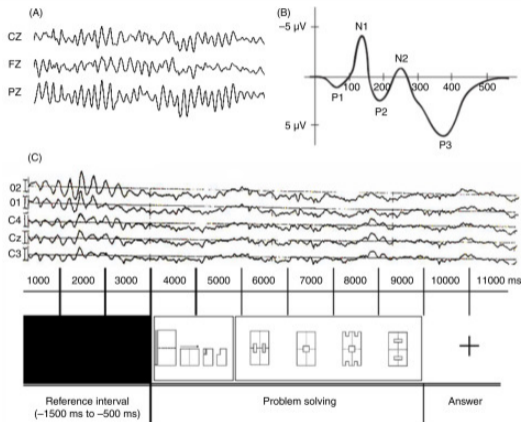
Electrodes placed directly on the surface of the cortex. Can record from large areas, and is used in clinical settings for epilepsy surgery planning.

Electroencephalogram



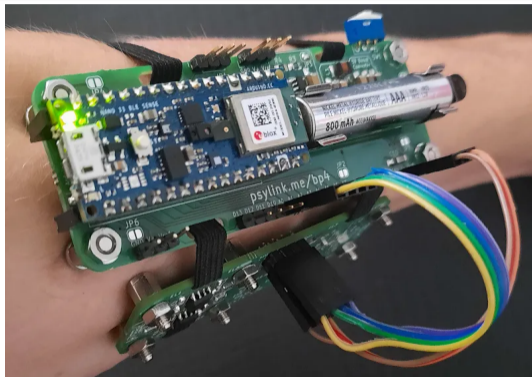
Scalp electrodes (a few to several 100). Records mostly synaptic activity from thousands of neurons in the volume around electrodes. Cannot resolve single neurons, but high time resolution (sub-millisecond).

Electroencephalogram: Event Related Potentials (ERPs)



ERPs are computed over many stimulus repetitions to cancel out noise. They reflect the average activity of the brain during stimulation and cognitive processes.

Electromyography: recording motor neurons

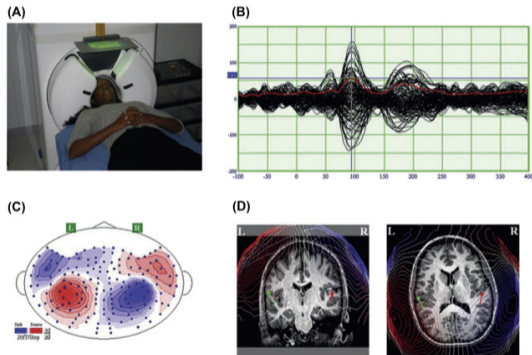


EMG records the electrical activity of motor neurons. There is a current effort to use EMG to control prosthetic limbs, and there may even be consumer devices in the future.

Recording Methods

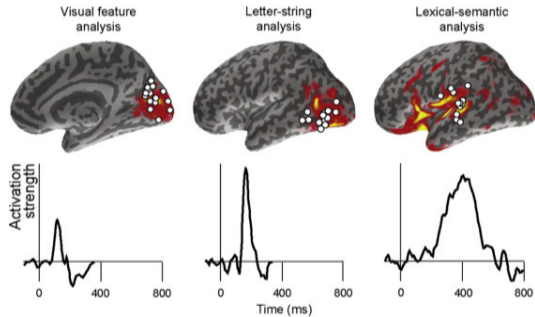
2. Magnetic recordings

Magnetoencephalography (MEG)



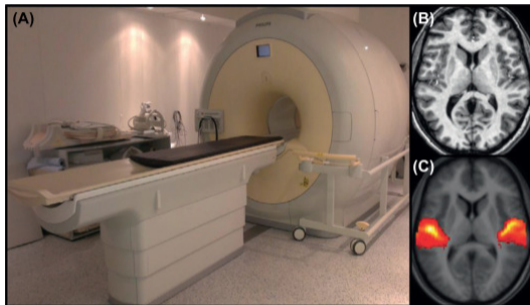
MEG records the magnetic field generated by neural activity. It has a similar spatial resolution to EEG, but is less sensitive to distortions by the skull and scalp.

Magnetoencephalography: localising function



MEG allows breaking signals down in time, here an example of localising the source of a signal in time and space during reading.

Functional Magnetic Resonance Imaging (fMRI)

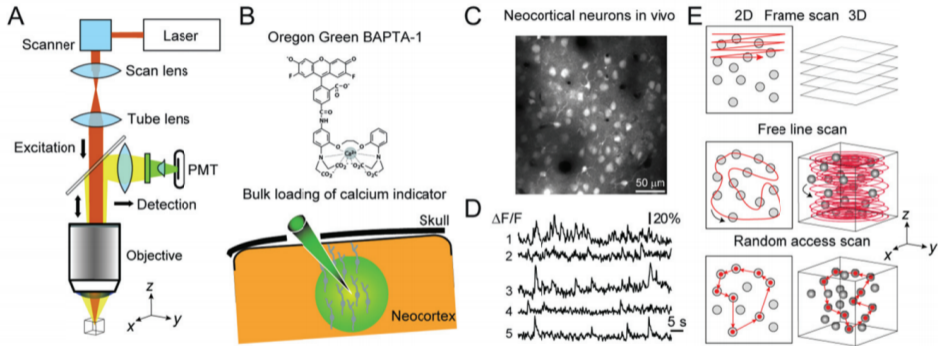


Measures blood-oxygen-level dependent (BOLD) contrast, a proxy for increased metabolic activity due to neural (synaptic) activity, in voxels (3D volumes). Low spatial resolution: a single voxel contains up to millions of neurons. Low time resolution: 1 sample per 1 or 2 seconds.

Recording Methods

3. Optical recordings

Fluorescence Imaging



100-10,000 neurons at a time, using a fluorescent calcium indicator to measure neural activity. Low time resolution (30 frames/second or less), fluorescent dyes react slowly (decay in seconds). Single neurons are easy to identify. Can record all neurons in a large volume (unlike electrodes).

Video

Summary

METHODS FOR OBSERVING THE LIVING BRAIN

