***Brain signals: EEG & MEG***

Electroencephalography measures electrical potential difference, while magnetoencephalography measures the magnetic fields generated by neuronal activity. EEG is a representation of the difference in voltage between two locations, while MEG is a representation of the difference in voltage between two locations. Neurons communicate through electrical events and action potentials, which sum in time through synchronization. EEG electrodes are mapped on the scalp in a specific way, with letters identifying lobes. Artifacts, such as physiological and non-physiological ones, should be identified and cleaned from the data.The data should be clean from muscle artifacts before running in-depth analysis. Multiple neurons generate magnetic fields that can be captured outside of the skull. Forward and inverse problems are used to understand the relationship between EEG and MEG. The most important details are that EEG and MEG use active electrodes to amplify the signal, while MEG uses a superconducting quantum interference device to measure extremely weak magnetic fields. Examples of perceptual EEG and MEG experiments show high temporal resolution and precision.Stable-state visual evoked potentials (SPNs) are periodic EEG or MEG responses elicited by period visual stimulations. SPN responses are found irrespective of the task, suggesting that the response to symmetry is generated by information in the image. EEG and MEG offer a great ground for measuring brain activity, but they come with pros and cons. EEG and MEG are non-invasive and more direct measures of neuronal function.

***Brain signals : fMRI***

Ogawa first observed the BOLD effect in 1990 and published the first functional images using it. fMRI is popular because it allows in vivo study of brain dynamics at a mesoscopic level and has spatial and temporal resolution. MRI is a technique used to measure the strength of a magnetic field and produce spatially localized activity. There are two types of MRI images: structural MRI, which produces high resolution images of structure, and functional MRI, which produces dynamic sequences of images over time. fMRI measures the blood oxygenation signal dependent (BOLD), which is caused by the hemodynamic response of neurons. When hemoglobin releases oxygen, it produces distortions of the magnetic field, reducing the intensity of the recorded MRI signal. Oxyhemoglobin does not distort the electrical fields, resulting in an increase of the MRI signal. Types of experiments can be carried out, such as block designs and event related designs, to compare different conditions and obtain a significant change in activity. Mitchell Valdes Sosa's Navon figures experiment and Bharat Biswal's Resting State Activity experiment are two types of fMRI experiments that measure the activity of the brain at rest. These experiments have been related to different conditions and experiments.

***Stimulus Representation-***

The brain is responsible for integrating sensory information from the environment and acting upon it in an appropriate manner. To measure the neuronal representation of sensory information, we can use a systems approach to measure inputs and outputs. Receptive fields of neurons in the visual system are important concepts that have been discovered over the last decades. Receptive fields are the area in the sensory environment that the neuron is selected for, and the visual world is mapped in a topographic manner onto the visual cortex. Spike-triggered averaging (STA) is a technique used to estimate receptive fields by taking visual stimuli and average them in relation to the spike time.The ON-Center and OFF-Surround cells in the retina and LGN are two major pathways in the visual system, with the ON pathway processing light increments and the OFF pathway processing light decrements. This is illustrated in the ON-Center and OFF-Surround cells in the retina and LGN. Receptive fields in the retina and LGN are dynamic and interact with oriented edges.Neurons in the visual cortex are selective to the orientation of an edge, which was discovered by Hubel and Wiesel in the 50s. The Nobel Prize was awarded for discovering the tuning curve, which is a fire rate as a function of the stimulus feature. It can be used to characterize the selectivity of neurons, and can also be used to determine the direction of motion of the visual stimulus. Neurons that have a certain response selectivity form a functional map in visual cortex, where the preferred orientation chain is systematically across the cortical surface. These tuning curves are important concepts for discussing sensory information representation at the brain level.Sensory information is represented at the cortical level in many ways, such as simple cells and complex cells that respond to lights and darks irrespective of spatial phase. This is important for computation of computer vision.Understanding the structure and mechanism of these structures is important for understanding how sensor information is represented. Receptive fields and tuning curves are important for understanding the sense information representation in the brain, and can be linked to other levels of representation.

***Neurotransmitters-***

Neurons are highly specialized cells with unique morphology, dendrites, axon, and oligodendrocytes. They are electrically excitable and signal to each other through synapses. Membrane potential is the difference in charge between the inside and outside of the neuron, with an average resting membrane potential of -70 mV. The resting membrane potential is maintained by protein pumps to maintain the concentration of ions between the sides of the neuron. Stimulation in the dendritic tree triggers an action potential, which travels through the axon until it reaches the synapses. Neurotransmitters bind to two broad families of neurotransmitter receptors, ionotropic (ligand gated ion channels) and metabotropic (G protein-coupled) receptors. When the neurotransmitter binds to the ionotropic receptor, it opens a channel and changes the membrane potential of the neuron. Neurotransmitters can activate both ionotropic and metabotropic receptors to produce both fast and slow postsynaptic potentials. Glutamate is an excitatory neurotransmitter, while GABA is an inhibitory neurotransmitter. Dopamine is a neuromodulator, released diffusely via volume transmission.Neuromodulators such as dopamine can alter neuronal signal transmission by controlling the amount of neurotransmitters synthesized and released by presynaptic neurons. LTP is the cellular mechanism by which learning occurs, allowing for more easily recalling previous experience.

***Neurons to consciousness-***

The brain is studied for various motivations, including to ameliorate the impact of psychiatric and neurological conditions, to understand consciousness, to extend the capabilities of the normal brain using artificial means, and to prove that intelligence can exist. Cell types in the brain vary by shape, morphology, dendritic and axonal architecture, and protein expression. Transcriptomics is the most popular technique to study this, as well as projection targets and developmental trajectory. Understanding brains requires understanding these cell types and how they relate to function. To understand the types of cells in the visual brain, it is important to understand the cortex, which is a 2+ dimensional technology. Cell types in the human brain are divided into inhibitory, excitatory, and non-neuronal cell types, which can be distinguished by their morphology, shape, and electrical behavior in response to stereotyped injection of current under slice conditions. The human and mouse brains have evolved over 65 million years, with the mouse having a smaller cortical surface area than the human. The number of cell types in the human is comparable to the number in the mouse per cortical area, with no feed forward in cortex. Neurons are the atoms of perception, consciousness, memories, and thought, so specialized observatories are needed to record a large part of the brain at the relevant level.An alternative attempt is the IBL, which tries to do brain wide recording under standardized conditions. The Neuronal Correlate of Consciousness is a lifelong interest of neuroscientists who use contrastive techniques to understand consciousness and experience. This technology works at 30 hertz and 10,000 or 30 000 Hz, and can be downloaded from brain-map. Neuronal correlates of consciousness are the minimal neuronal mechanisms sufficient for any one conscious experience, and must distinguish sharply from the background condition. Neuroscientists face computational challenges due to the complexity of mammalian brains, which are organized into 1000 different cell types and interconnected massively and recurrently.