*COMPUTATIONAL NEUROSCIENCE*

*WEEK 1*

*YELEENA AND DEBARPITA*

*Key goal of neuroscience is to relate all human experiences to neural activity*

**DICHOTOMY OF MIND & BRAIN**

Brain has its own chemistry and physiology these interacting components give rise to the dynamics which in turn implements the mind.  
Mind has the ability to compute instructions, find invariances, spot irregularities

**STRUCTURE OF BRAIN**

* Brain uses 20% O2
* Occipital Lobe has Primary Visual Cortex : Early processing of visual information
* Area of Wernicke and Broca's : Language comprehension
* Hippocampus : Memory formation, spatial navigation
* Amygdala :Fear processing ,emotions

**HARDWARE OF BRAIN**

* Neurons(86 billion in human)
* Synapses( Electrical, Chemical)
* Dale's Dogma :two responses - excitatory (positive deflection), inhibitory(negative deflection)

**NEOCORTEX**

* 6 layers with interlayers
* Information at 4th layer
* Higher cortical regions layer 4 is missing

**BRAIN FUNCTION**

* It records brain activity v/s behavior
* Connection speed- 220 mph
* Learning & development changes strength of connection
* Connectivity influenced by the genetic makeup
* Connections determine complexity of brain (over number of neurons)

**PSYCHOPHYSICS**

* Introduced by Gustav Fechner in 1860
* Relationship between stimulus and sensation
* Examples:  
  1)Contrast sensitivity  
  2)Trichromacy( 3 primary colours)

**WEBER-FECHNER LAW**

* Smallest change when person notices the difference
* Logarithmic encoding
* Percept =log Stimulus
* (del Stimulus) =(del Percept )\* Stimulus

**DETECTION TASK**

* Yes/No Design  
  Decision criterion shifts the psychometric function(plot b/w probability of saying yes and amount of light ) . Doesn't give idea about sensitivity
* Two interval forced Choice detection task  
  Sensitivity=1/Threshold

**MEASURING THRESHOLD**

**CONSTANT STIMULI**

* Fits a curve and then deduces it
* Highly reliable
* Time consuming

**STAIRCASE PROCEDURE**

* Starts off with high intensity, if positive response then stimulus is decreased, else stimulus is increased.
* Much faster
* Few errors can throw it off
* More complex to code but several libraries exist

**JND AND PSE**

Neural correlation: Centre surrounded neurons in thalamus and retina

* *PSE Point of subjective equivalence* Each response is equally likely
* *JND* *Just noticeable difference*

**BEHAVIORAL READOUTS**

**WHY READOUT BEHAVIOR?**

*Relate to neural activity* We try to study brain of animal when performing task

**DECISION MAKING**

**Two Alternative Forced Choice TASK (2AFC )**

Since animals can't tell us their choice so we have to do a behavioral readout

* How do mice indicate decisions?  
  1)Turning the wheel  
  2)Mice licking spout which has stimulus
* How do monkey indicate decisions?  
  1)Look left or right  
  2)Use of joystick
* **Uninstructed movements**(cortex wide activity dominated by it) that can't be detected using Deep Lab Cut (Hindlimb movt, pupil diameter, whisking)
* Mice navigation also used as **behavioral readout of memory** like in Morris Water Maze Task
* Natural behavior of mouse used to study **internal state and memory** (like freezing on seeing eagle)
* Eye tracking in monkeys (similar to humans) concentrate on eyes of image

**LIVE LAB**

**Neural Responses that support decision making**

* use Neuropixel system to do ephys neural activity recording to get neural spikes
* Behavioral analysis in sound isolated booth with minimal light

**Setup**

* Excitation module has blue LED and violet LED.
* Blue LED-->  
  -sends light into mouse's brain  
  -light reaches cortex  
  -it excites GCamp which sends green light back  
  -green light is filtered  
  -light now passes camera  
  -data acquired and analyzed using NeuroCAAS(Cloud based platform for analyzing all data.)
* Violet LED-->  
  -sends light so that we can correct for hemodynamics.

**BRAIN SIGNALS SPIKING ACTIVITY**

Nervous system communicates through electrical signals  
1)Dendrites collect electrical signals  
2) Then it passes through Soma(cell body)  
3) It triggers generation of action potential at base "Axion Hillock"  
4) It is propagated along axon to the axon terminal  
5) Neurotransmitter at synapse trigger same cycle in adjacent neuron

**ACTION AND GRADED POTENTIAL**

* Graded Potentials- electric signals of various intensities . It is sum of various potentials recieved by dendrites
* Action potential- Rapid change in polarity of membrane potentials
* Different distribution of ions creates membrane potential
* Influx of Na+ ions and efflux of K+ ions
* Action potentials have a set amplitude and duration

**Electrophysiology**

* Action potentials have set intensity from -70 to 30 and set duration 2 to 4 ms
* spikes represent action potential fired by neurons
* Neuronal properties are key to spikes
* Voltage gated channels - allow Na+ into cells and K+ out
* Leaky channels: allow some amount of +ve ions into cell, over time-triggered action potential
* All electrical properties of neuron are subject to change
* Relate spiking activity to external stimuli
* Trigger activity based on Receptive Fields
* Diseased neuron -same stimuli gives different spikes
* neural plasticity - capacity of neuron to modify its functionality and structure in response to experience

**Neural connections**

* Interconnected neurons give birth to array of network properties
* Neurons with endogenous bursting( persistent spiking which is periodically suppressed) set up rhythmic behavior

**Drawbacks**

* Records single cell activity not many cells simultaneously so may miss whole picture
* Each cell belongs to plastic network
* longevity of cell questionable
* sorting out of data