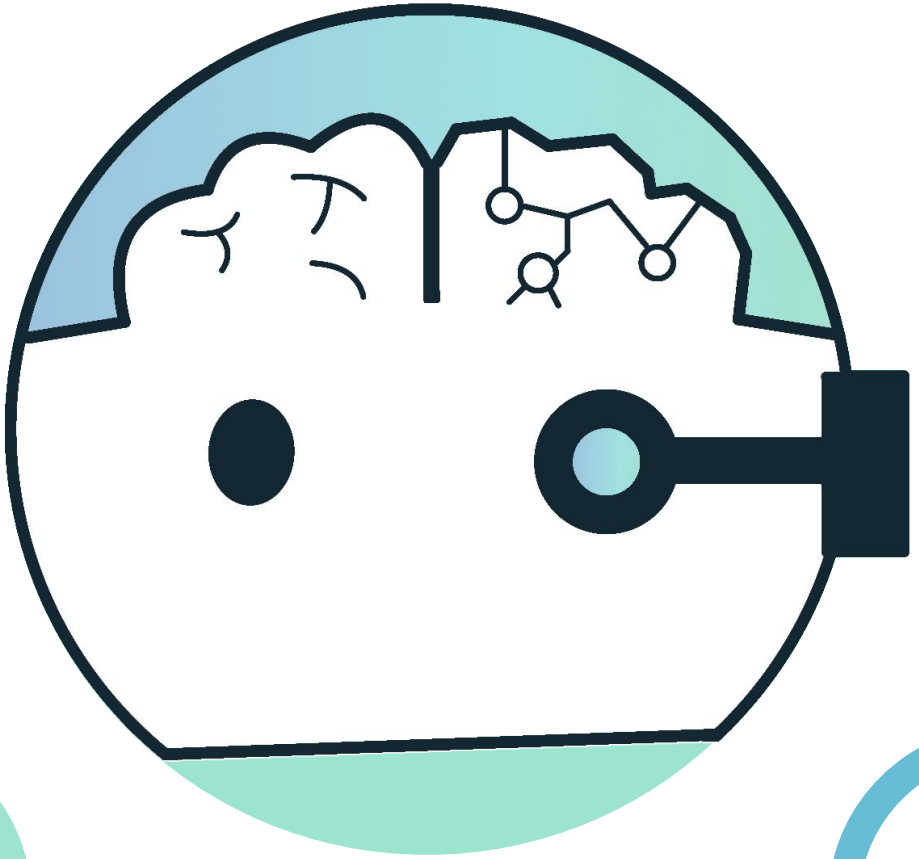


Who We Are

Maggie Chen
Workshop Co-Director

Julia Ye
Workshop Co-Director

Melanie Davie
Co-President, Community

Plus our team of mentors:

Anahita Dhru
Juan Pablo Escorcia
Vyom Kapadia
Yu Xin Li
Gurpreet Mukker
Reihaneh Teimouri

Our Goal

to share our knowledge of the many ***interdisciplinary*** topics involved in **neurotechnology** and in the creation of a **brain-computer interface**

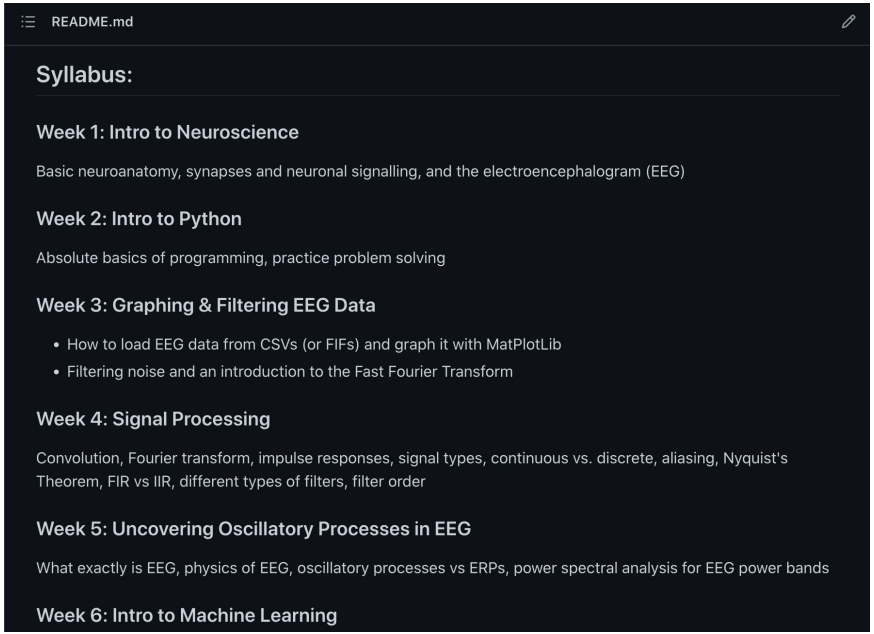
brain-computer interfaces have immense potential as ***therapeutic tools***, and our project teams at **NeurotechUofT** collaborate year-round to produce **innovative applications**

Schedule

Week 1	Intro to Neuroscience
Week 2	Intro to Python
Week 3	Graphing & Filtering EEG Data
Week 4	Signal Processing
Week 5	Oscillatory Processes in EEG
Week 6	Intro to Machine Learning
Week 7	Event-Related Potentials
Week 8	Intro to React
Week 9	Intro to MuseJs
Week 10	Real-time Analysis & Cloud

Main Resource: *GitHub*

Bookmark → github.com/neurotechuoft/workshops



Overview

Basic Neuroanatomy

How are functions organized in the brain?

Synapses & Signalling

How does communication work in the brain?

Electroencephalogram (EEG)

How do we monitor communication in the brain?

Basic Neuroanatomy

Frontal Lobe

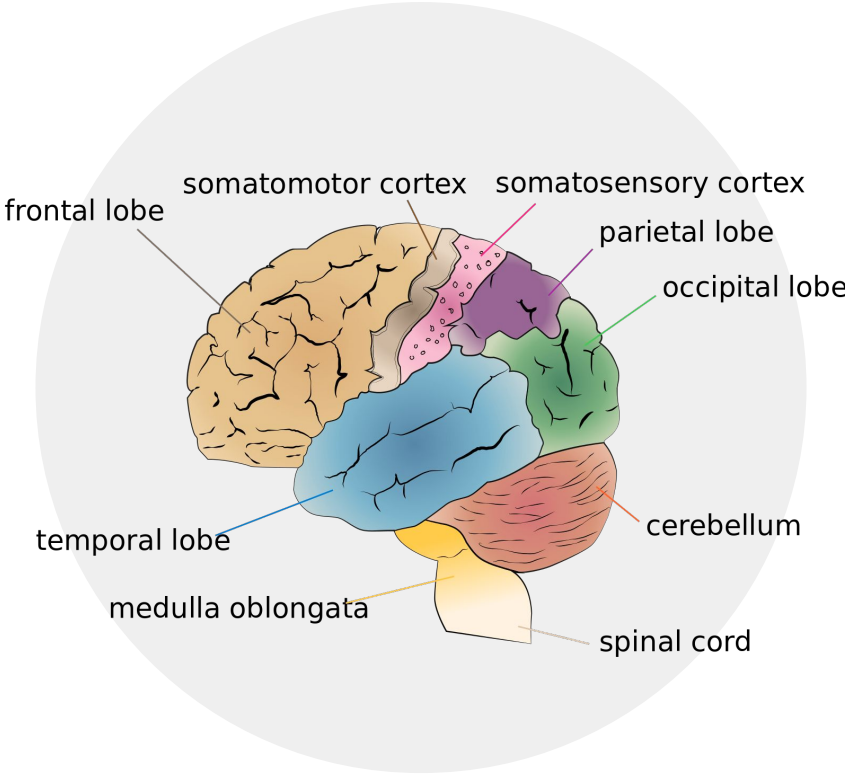
Information processing, decision making

Temporal Lobe

Hearing + sensory aspects of speech and memory

Motor Cortex

Motor intention, coordination



Parietal Lobe

Sensation, perception, sensory integration (visual)

Occipital Lobe

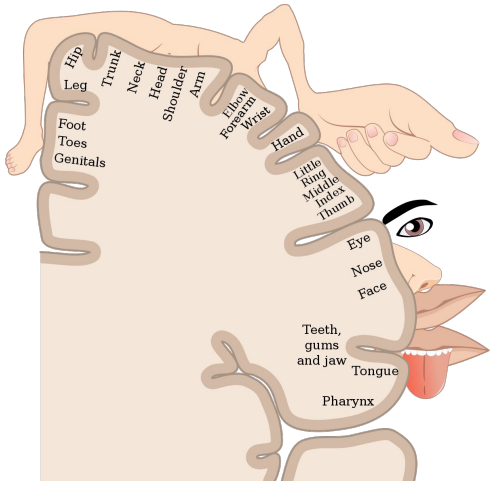
The main visual processing centre

Somatosensory Cortex

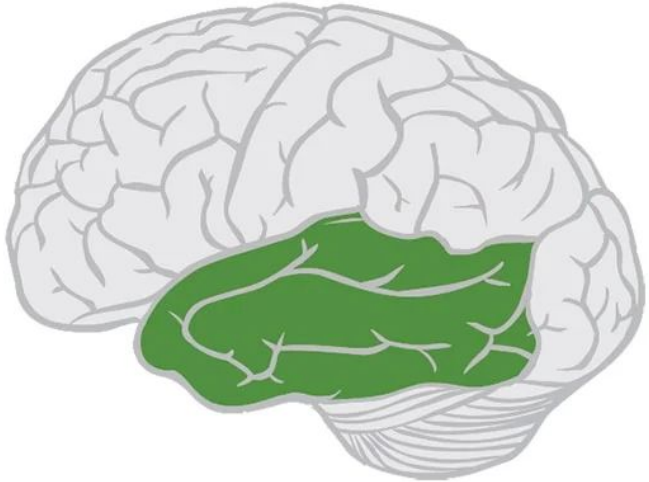
Temperature, pain, vibration, proprioception, fine touch

Frontal Lobe

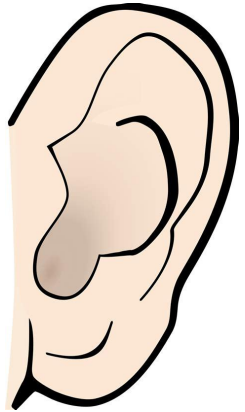
- **Prefrontal cortex**
  - Processes intellectual & emotional information
  - Facilitates judgement & decision making
- **Motor cortex**
  - **Primary motor cortex**
    - Integrates signals from diff brain regions to modulate motor function
  - **Premotor area & supplemental motor cortex**
    - Assist in organizing movements & actions
  - **Frontal eye fields**
    - Voluntary control of horizontal eye movements
- **Broca's area**
  - Produces motor component of speech
    - Verbal fluency, phonological processing, grammar processing, attention during speech



Temporal Lobe

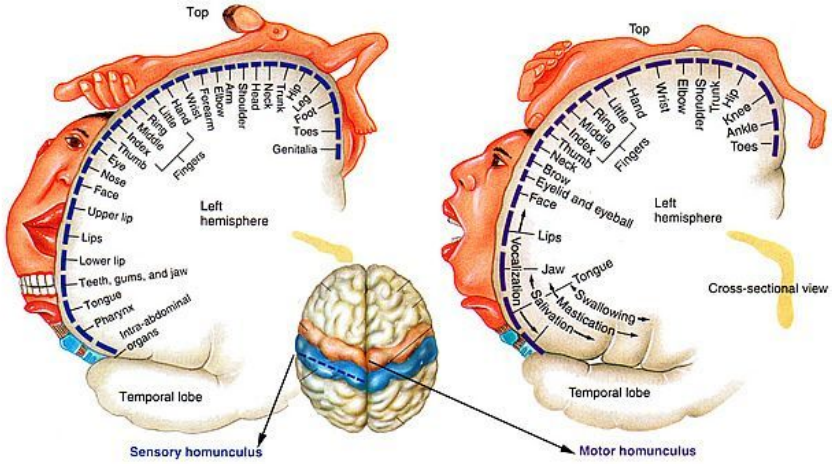


- **Primary auditory area**
  - Receives auditory information
- **Secondary auditory area**
  - Further processes auditory information
  - Receives impulses from primary auditory area and thalamus
- **Middle temporal gyrus**
  - Perception of movement within visual field
- **Fusiform face area**
  - Facial recognition



Parietal Lobe

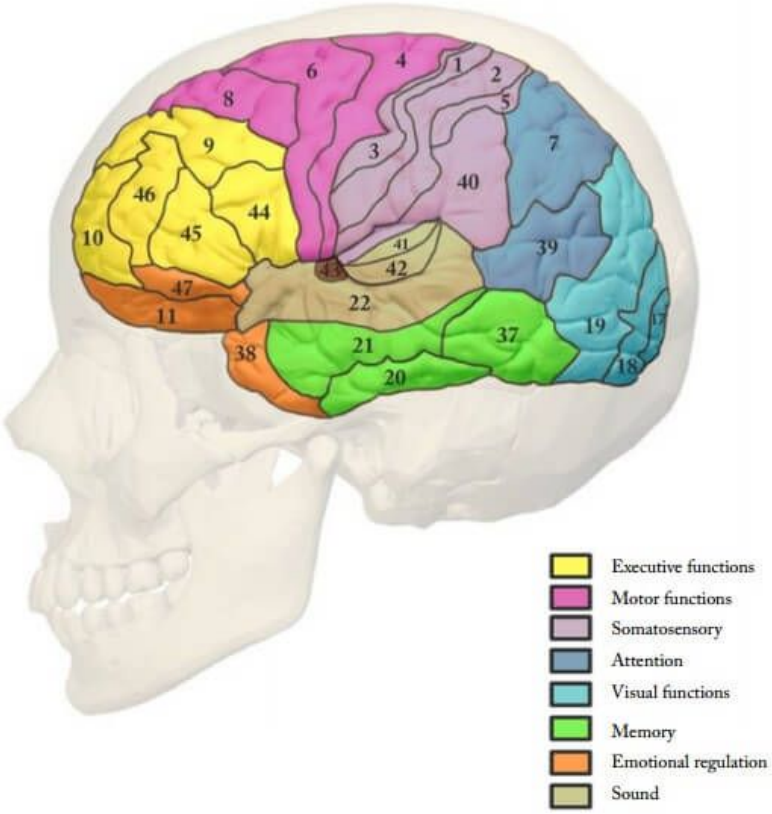
- **Primary somatosensory cortex (postcentral gyrus)**
  - Receives sensory information from all sensory receptors related to:
    - temperature, pain, vibration, proprioception, fine touch
- **Superior parietal lobule**
  - Contributes to sensorimotor integration
- **Inferior parietal lobule**
  - Contributes to auditory & language functions



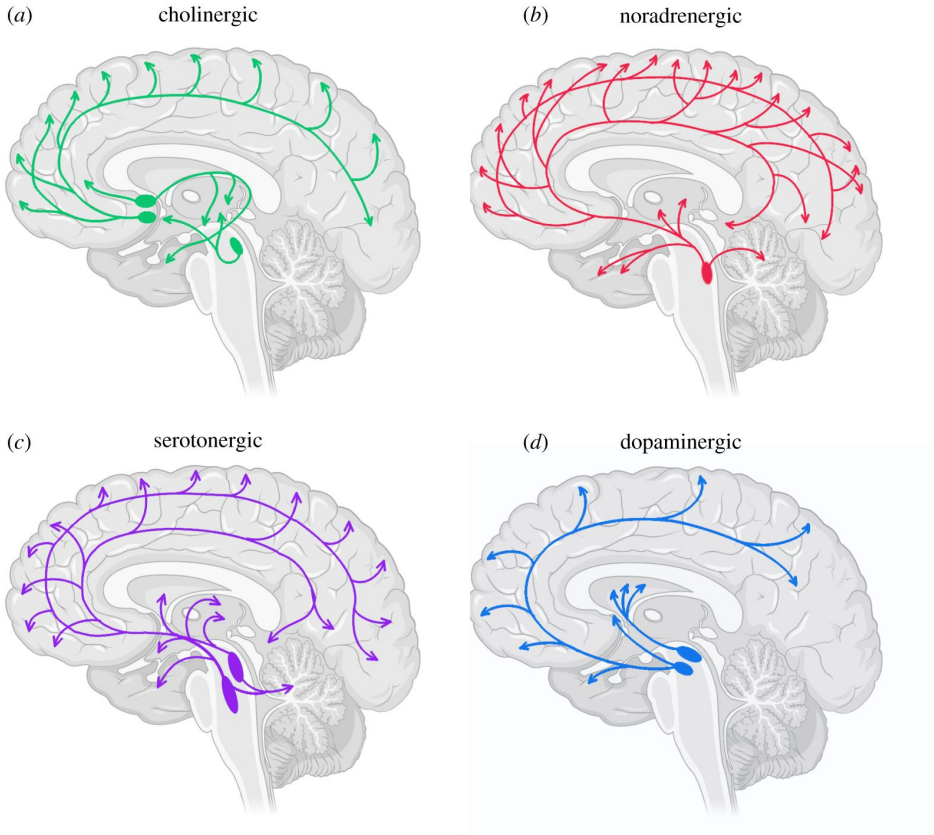
Occipital Lobe

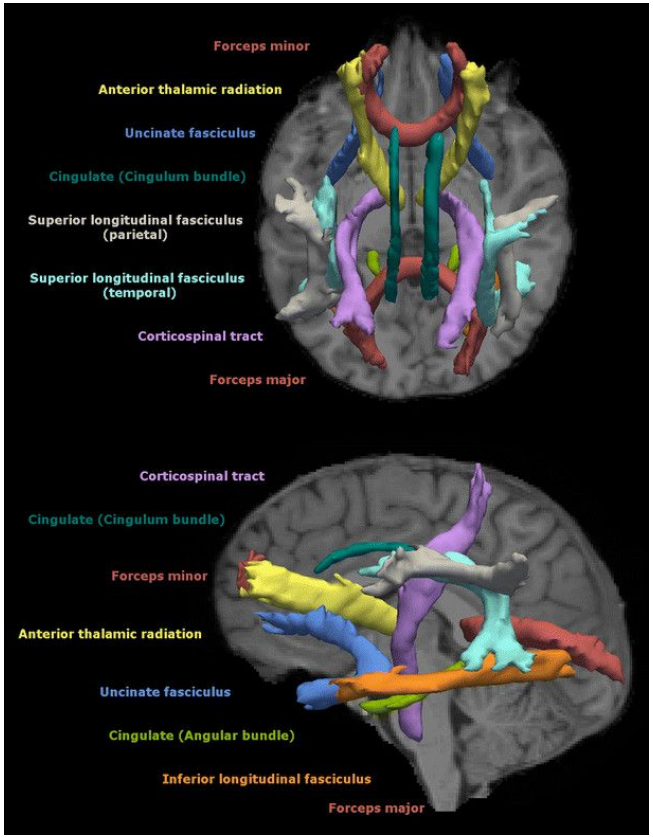
- **Primary visual cortex**
  - Visual perception
- **Visual association cortex**
  - Interprets visual images
- **Overall associations:**
  - Colour determination, facial recognition, depth perception, visuospatial processing, role in memory formation

Brodmann Areas

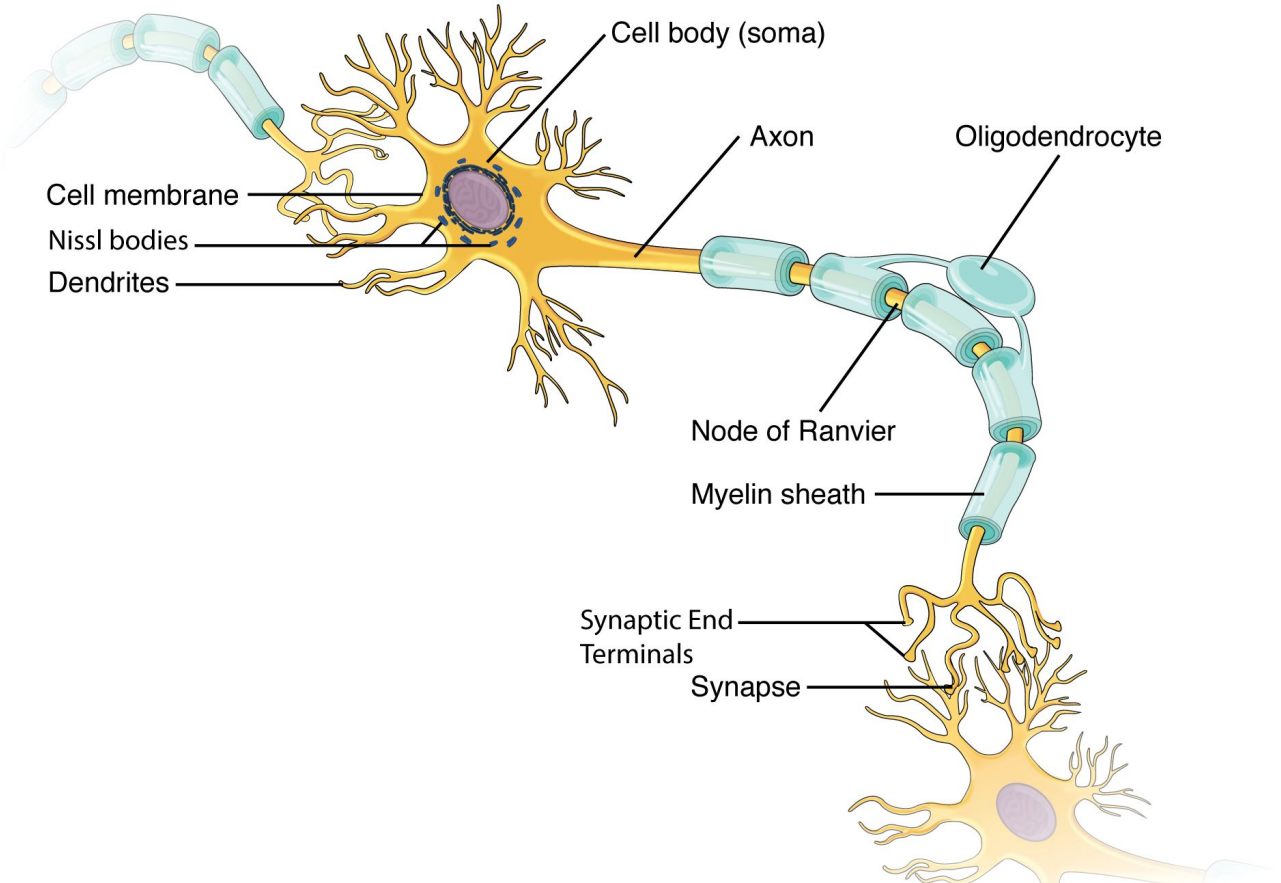


Neuromodulation and White Matter Tracts

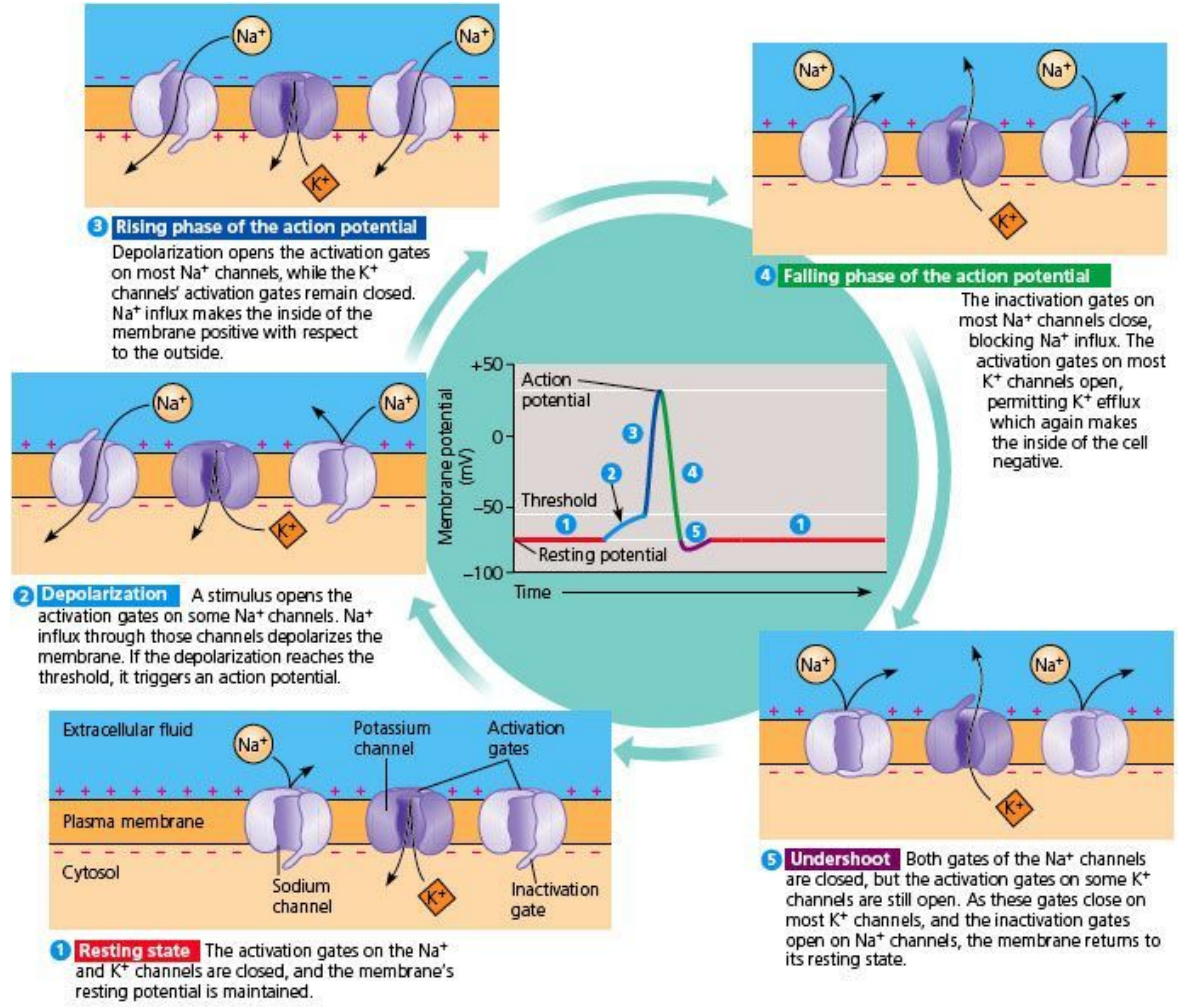




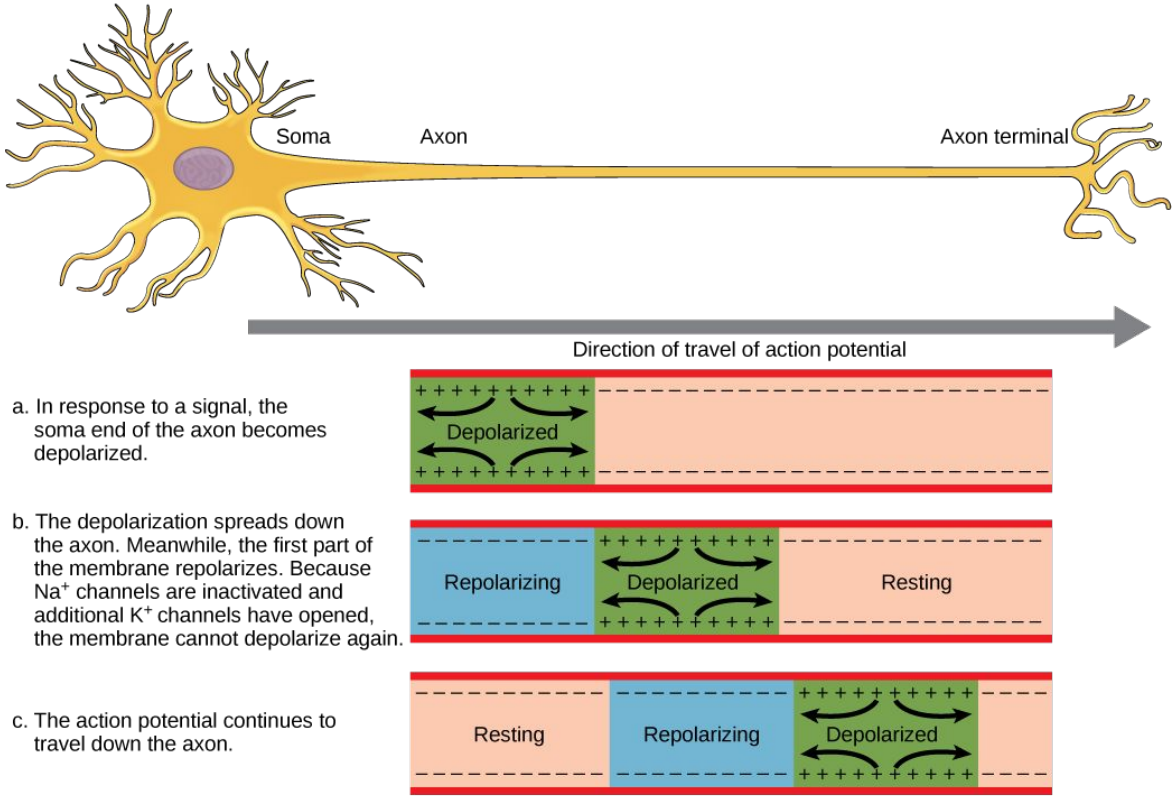
The Neuron


Cell body (soma)
Axon
Oligodendrocyte
Cell membrane
Nissl bodies
Dendrites
Node of Ranvier
Myelin sheath
Synaptic End Terminals
Synapse

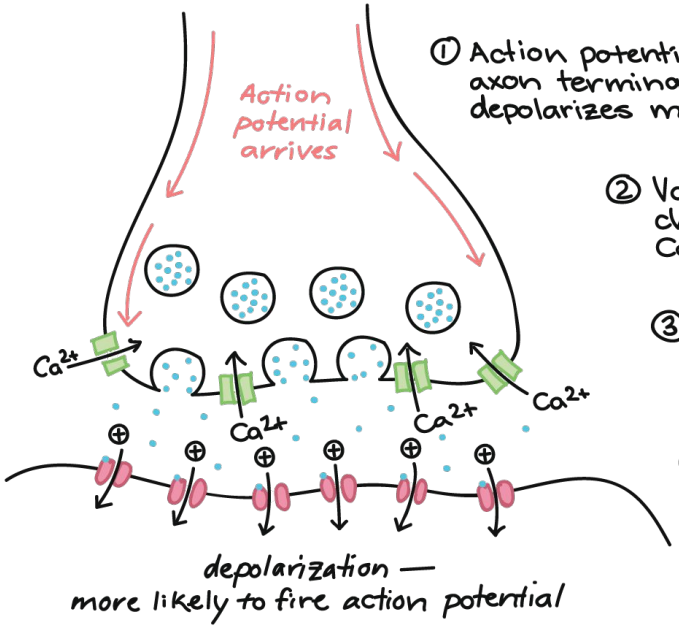
The Action Potential



Action Potential Propagation



The Synapse & Postsynaptic Potential



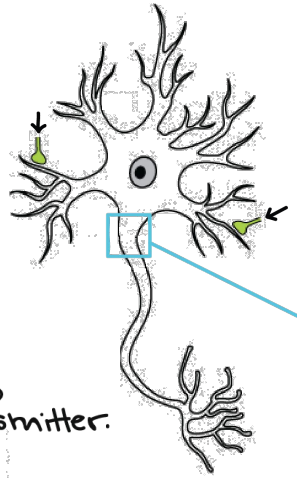
depolarization — more likely to fire action potential

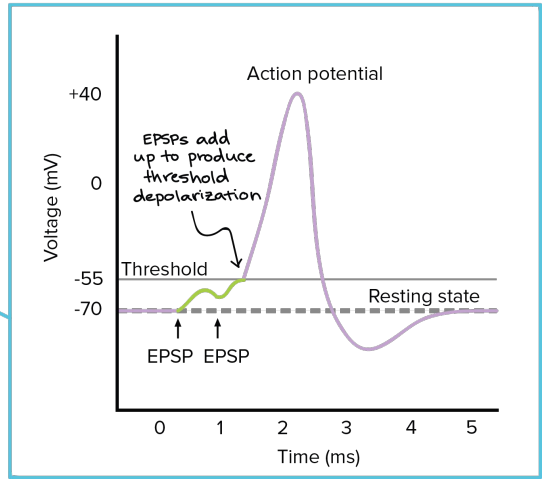
① Action potential reaches axon terminal and depolarizes membrane.

② Voltage-gated Ca^{2+} channels open and Ca^{2+} flows in.

③ Ca^{2+} influx triggers synaptic vesicles to release neurotransmitter.

④ Neurotransmitter binds to receptors on target cell (in this case, causing positive ions to flow in).

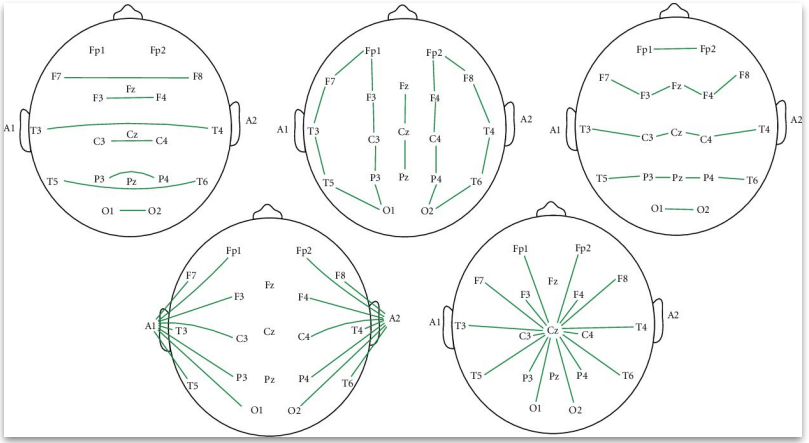




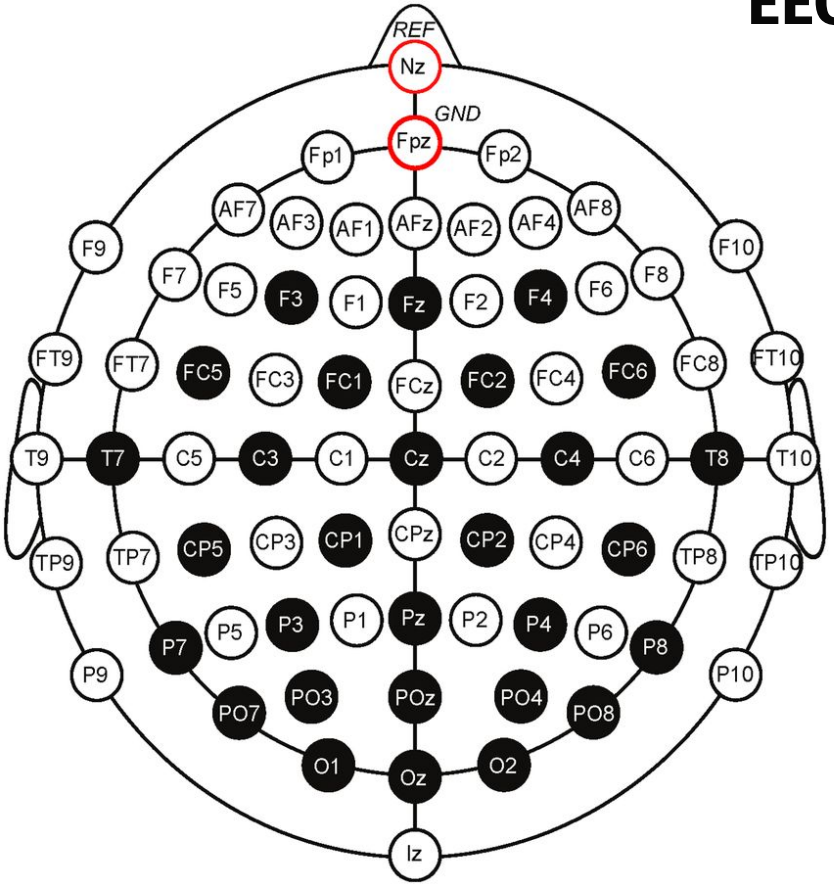
Electroencephalography (EEG)

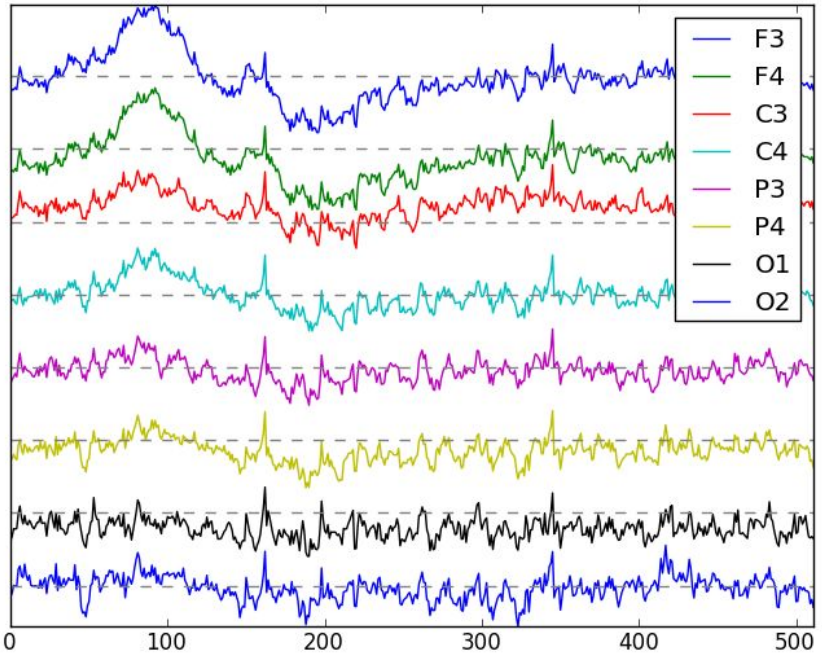
What we record: post-synaptic excitation (of dendrites) from *hundreds of thousands of neurons* firing in synchrony

- less neurons or less synchrony → more flatline EEG



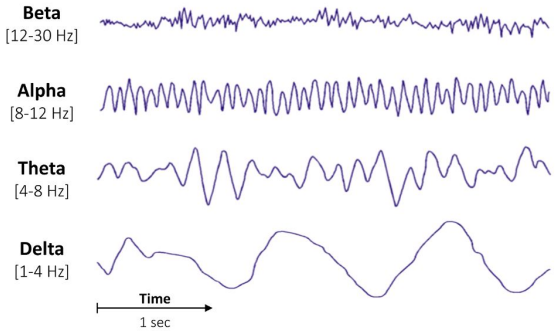
EEG Data


REF
Nz
GND
Fpz
Fp1
Fp2
AF7
AF3
AF1
AFz
AF2
AF4
AF8
F9
F7
F5
F3
F1
Fz
F2
F4
F6
F8
F10
FT9
FT7
FC5
FC3
FC1
FCz
FC2
FC4
FC6
FC8
FT10
T9
T7
C5
C3
C1
Cz
C2
C4
C6
T8
T10
TP9
TP7
CP5
CP3
CP1
CPz
CP2
CP4
CP6
TP8
TP10
P9
P7
P5
P3
P1
Pz
P2
P4
P6
P8
P10
PO7
PO3
POz
PO4
PO8
O1
Oz
O2
Iz

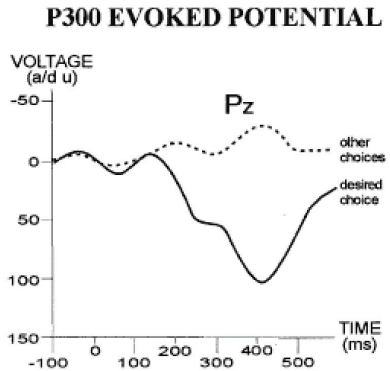

F3
F4
C3
C4
P3
P4
O1
O2
0
100
200
300
400
500

What are we looking for in EEG data?

- **Oscillatory processes**
  - Neurons fire together at different frequencies
    - Different frequencies indicate different cognitive processes

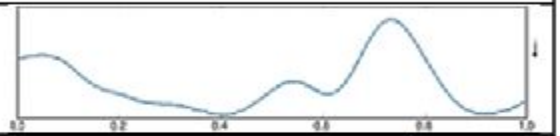
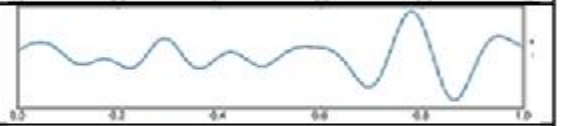
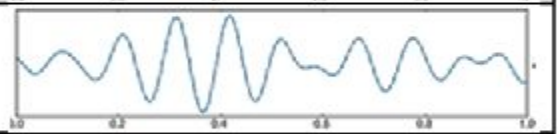
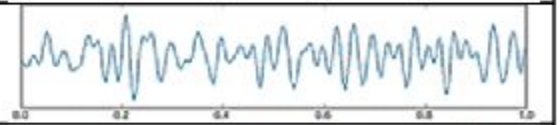
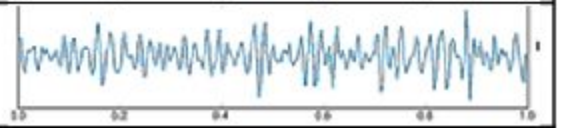


- **Event-related or evoked potentials**
  - Automatic voltage responses to specific stimuli (like seeing a face, doing mental math)



in specific locations & at specific times

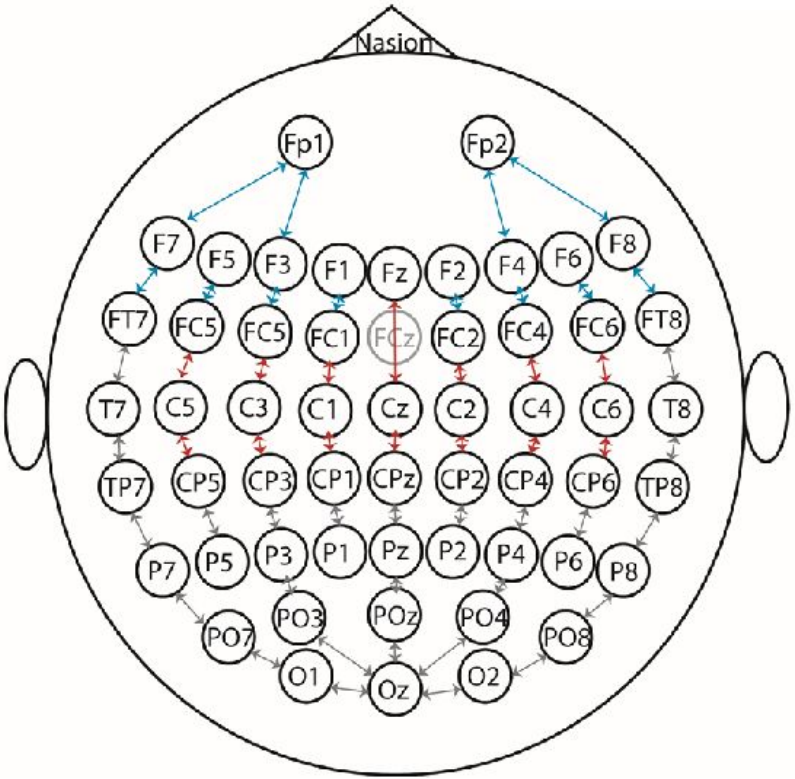
EEG Frequencies

Waves	Frequency bands (Hz)	Behaviour Trait	Signal Waveform
Delta	0.3 – 4	Deep sleep	
Theta	4 – 8	Deep Meditation	
Alpha	8 – 13	Eyes closed, awake	
Beta	13 – 30	Eyes opened, thinking	
Gamma	30 and above	Unifying consciousness	

Exercise

Select a random electrode from the 10-10 EEG system

Pick An Electrode



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journal homepage: www.elsevier.com/locate/ynimg

Automated cortical projection of EEG sensors: Anatomical correlation via the international 10–10 system

L. Koessler [a,b], L. Maillard [b], A. Benhadid [a], J.P. Vignal [b], J. Felblinger [a], H. Vespignani [b], M. Braun [a,c,d,*]

[a] INSERM U947, Nancy University, France
[b] Neurology Department, University Hospital, Nancy, France
[c] Neuroradiology Department, University Hospital, Nancy, France
[d] Anatomy Department, Nancy University, France

Find its associated Brodmann Area

Find That Region

Labels	Macro-anatomical variabilities	Main macro-anatomical structures	Main BA	Cytoarchitectonic (Brodmann) variabilities
Fp1	GFS (65%) GFM (35%)	Superior frontal G	10	10 (100%)
Fpz	GFd (66%) SI (17%) GFM (17%)	Medialis frontal G	10	10 (100%)
Fp2	GFS (75%) GFM (25%)	Superior frontal G	10	10 (100%)
AF7	GFM (100%)	Middle frontal G	10	10 (75%), 46 (25%)
AF3	GFS (56%) GFM (44%)	Superior frontal G	9	9 (75%), 10 (19%), 8 (6%)
AFz	GFS (75%) GFd (19%) SI (6%)	Superior frontal G	9	9 (62,5%), 6 (12,5%), 8 (19%), 10 (6%)
AF4	GFS (75%) GFM (25%)	Superior frontal G	9	9 (69%), 10 (25%), 8 (6%)
AF8	GFM (81%) GFS (13%) GFI (6%)	Middle frontal G	10	10 (81%), 49 (19%)
F7	GFI (100%)	Inferior frontal G	45	45 (56%), 47 (38%), 46 (6%)
F5	GFM (88%) GTS (6%) GFI (6%)	Middle frontal G	46	46 (50%), 9 (38%), 45 (6%), 22 (6%)
F3	GM (75%) GFS (25%)	Middle frontal G	8	8 (75%), 6 (19%), 46 (6%)
F1	GFS (88%) GFM (12%)	Superior frontal G	6	6 (63%), 8 (31%), 9 (6%)
Fz	GFS (81%) SI (19%)	Superior frontal G	6	6 (81,5%), 8 (12,5%), 9 (6%)
F2	GFS (75%) GFM (25%)	Superior frontal G	6	6 (69%), 8 (31%)
F4	GFM (63%) GFS (31%) GPREC (6%)	Middle frontal G	8	8 (69%), 6 (6%), 9 (25%)
F6	GFM (75%) GFI (25%)	Middle frontal G	9	9 (43,5%), 46 (37,5%), 45 (19%)
F8	GFI (88%) GFM (12%)	Middle frontal G	45/47	45 (37,5%), 47 (37,5%), 46 (25%)
FT7	GTS (82%) GTM (12%) GFI (6%)	Superior temporal	22	22 (75,5%), 21 (12,5%), 38 (6%), 44 (6%)
FC5	GPREC (63%) GFI (37%)	Precentral G	6	6 (63%), 9 (25%), 44 (6%), 45 (6%)
FC3	GFM (63%) GPREC (37%)	Middle frontal G	6	6 (75%), 4 (12,5%), 8 (12,5%)
FC1	GFS (88%) GFM (12%)	Superior frontal G	6	6 (100%)
FCz	SI (50%) GFS (31%) GFM (19%)	Interhemispheric sulcus	6	6 (100%)
FC2	GFS (56%) GFd (38%) GPREC (6%)	Superior frontal G	6	6 (100%)
FC4	GFM (75%) GPREC (19%) GPSTC (6%)	Middle frontal G	6	6 (82%), 123 (6%), 8 (6%), 9 (6%)
FC6	GPREC (63%) GFI (25%) GFM (6%) GPSTC (6%)	Precentral G	6	6 (56,5%), 9 (19,5%), 43 (6%), 44 (6%), 45 (6%), 8 (6%)
FT8	GTS (81%) GTM (13%) GPREC (6%)	Superior temporal G	22	22 (75%), 21 (13%), 38 (6%), 44 (6%)
T7	GTM (69%) GTS (19%) GPSTC (12%)	Middle temporal G	21	21 (81,5%), 22 (12,5%), 43 (6%)
C5	GPSTC (69%) LPI (25%) GPREC (6%)	Postcentral G	123	123 (44%), 40 (37,5%), 43 (12,5%), 6 (6%)
C3	GPSTC (69%) GPREC (19%) LPI (12%)	Postcentral G	21	21 (62,5%), 22 (25%), 20 (6,5), 42 (6%)
C1	GPREC (63%) GPSTC (25%) GFS (13%)	Precentral G	4/6	4 (37,5%), 6 (37,5%), 123 (25%)
Cz	SI (81%) GFS (6%) GFM (6%) LPARAC (6%)	Interhemispheric scissure	4	4 (62,5%), 6 (37,5%)
C2	GPREC (63%) GPSTC (25%) GFS (13%)	Precentral G	123	123 (56,5%), 40 (25,5%), 4 (12,5%), 6 (6%)
C4	GPSTC (81%) GPREC (13%) LPI (6%)	Postcentral G	123	123 (81,5%), 6 (12,5), 40 (6%)
C6	GPSTC (50%) LPI (25%) GPREC (25%)	Postcentral G	123/40	123 (25%), 40 (25%), 4 (12,5%), 6 (12,5%), 43 (12,5%), 2 (12,5%)
T8	GTM (56%) GTS (38%) GTI (6%)	Middle temporal G	4	4 (50%), 123 (25%), 6 (25%)
TP7	GTM (82%) GTI (12%) GTS (6%)	Middle temporal G	21	21 (50%), 37 (25%), 22 (19%), 20 (6%)
CP5	GTS (5%) GSM (24%) GTM (13%) LPI (13%)	Superior temporal G	22	22 (44%), 40 (37,5%), 39 (12,5%), 21 (6%)
CP3	LPI (75%) GPSTC (13%) LPS (6%) GA (6%)	Inferior parietal L	40	40 (82%), 123 (6%), 5 (6%), 39 (6%)
CP1	LPS (50%) GPSTC (50%)	Postcentral G–Superior parietal L	7	7 (62,5%), 5 (31,5%), 123 (6)
CPz	GPSTC (44%) SI (38%) PC (18%)	Postcentral G	7	7 (56%), 5 (19%), 123 (12,5%), 4 (12,5%)
CP2	GPSTC (56%) LPS (44%)	Postcentral G	5	5 (62,5%, 7 (25%), 123 (12,5%)
CP4	LPI (88%) GPSTC (12%)	Inferior parietal L	40	40 (77,5%), 123 (12,5%)
CP6	GSM (38%) GTS (38%) LPI (24%)	Superior temporal G–GSM	40	40 (62,5%0), 22 (37,5%)
TP8	GTM (56%) GTI (31%) GTS (13%)	Middle temporal G	21	21 (62,5%), 22 (12,5%), 20 (12,5%), 37 (12,5%)
P7	GOM (38%) GTM (25%) GTI (25%) GTS (6%) GF (6%)	Middle occipital G	37	37 (44%), 19 (38%), 39 (18%)
P5	GTM (56%) GA (13%) GOM (13%) GSM (6%) GTS (6%) LPI (6%)	Middle temporal G	39	39 (62,5%), 19 (19%), 37 (12,5%), 40 (6%)
P3	LPI (38%) PC (25%) GA (19%) LPS (12%) GTM (6%)	Inferior parietal L	39	39 (37,5%), 7 (25%), 19 (25%), 40 (12,5%)
P1	PC (50%) LPS (44%) GPSTC (6%)	Precuneus	7	7 (87,5%), 19 (12,5%)
Pz	PC (62%) LPS (19%) SI (19%)	Precuneus	7	7 (88%), 5 (6%), 19 (6%)
P2	PC (63%) LPS (31%) GPSTC (6%)	Precuneus	7	7 (81,5%), 19 (12,5%), 5 (6%)
P4	LPI (31%) GA (31%) LPS (19%) PC (13%) GOS (6%)	Inferior parietal L	39	39 (31%), 7 (25%), 40 (25%), 19 (19%)
P6	GTM (69%) GA (13%) LPI (6%) GTS (6%) GOM (6%)	Middle temporal G	39	39 (75,5%), 19 (12,5%), 40 (6%), 37 (6%)
P8	GTI (44%) GOM (31%) GTM (19%) GTS (6%)	Inferior temporal G	19	19 (56%), 37 (19%), 20 (12,5), 39 (12,5%)
PO7	GOM (63%) GOI (31%) GA (6%)	Middle occipital G	19	19 (62,5%), 18 (31%), 39 (6,5%)
PO3	GOM (50%) PC (18%) C (13%) GOS (13%) GTM (6%)	Middle occipital G	19	19 (75,5%), 7 (6%), 39 (6%), 18 (12,5%)
POz	C (69%) PC (25%) LPS (6%)	Cuneus	19	19 (56%), 18 (25%), 7 (19%)
PO4	GOM (38%) GOS (19%) GTM (19%) C (12%) LPS (6%) PC (6%)	Middle occipital G	19	19 (69%), 39 (12,5%), 18 (12,5%), 7 (6%)
PO8	GOM (44%) GOI (44%) GOS (6%) GTM (6%)	Middle occipital G	19	19 (69%), 18 (31%)
O1	GOM (38%) C (19%) GL (19%) GOI (19%) PC (5%)	Middle occipital G	18	18 (81%), 19 (19%)
Oz	C (98%) GL (5%) GOM (6%)	Cuneus	18	18 (62,5), 17 (31%), 19 (6,5%)
O2	C (38%) GOM (31%) GL (25%) GOI (6%)	Cuneus	18	18 (81%), 19 (19%)

Exercise

Select a random electrode from the 10-10 EEG system

Pick An Electrode

Find its associated Brodmann Area

Find That Region

Do some research to find your BA's function(s)

What's The Function?

Note: kenhub.com is a great place to start

KEN HUB

Exercise

Select a random electrode from the 10-10 EEG system

Pick An Electrode

Find its associated Brodmann Area

Find That Region

Do some research to find your BA's function(s)

What's The Function?

Share your discovery with your group!

Share It

see you next week!