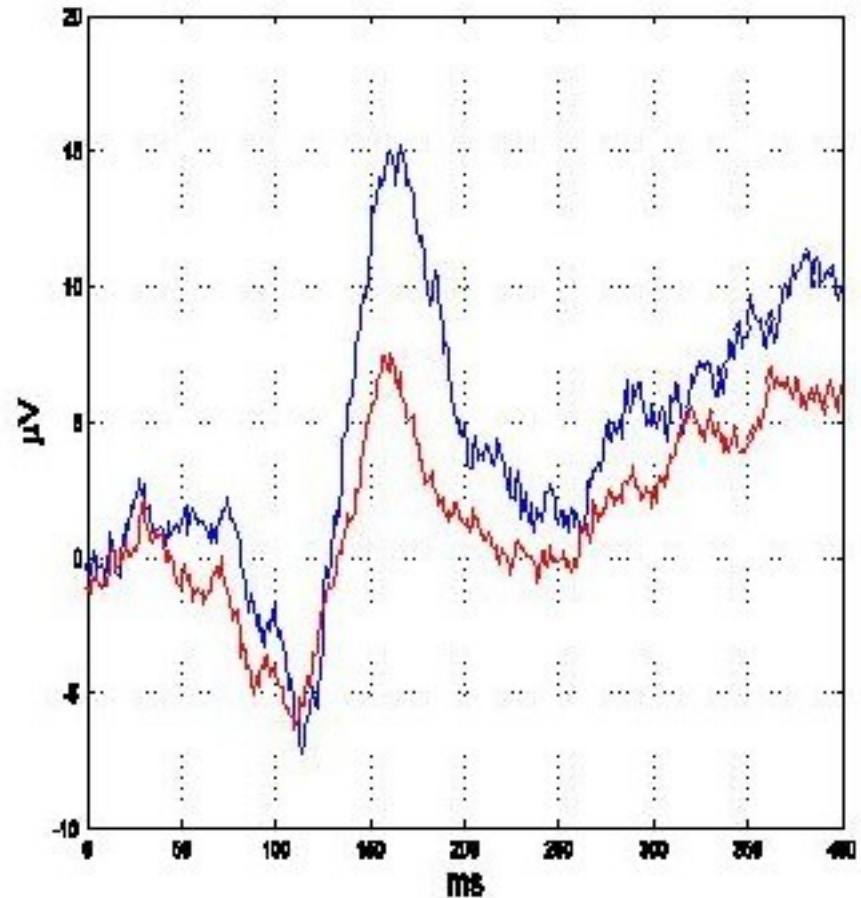
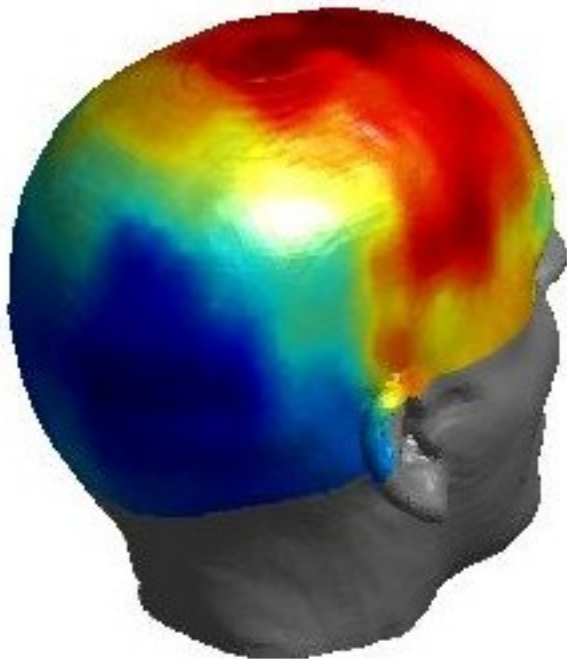
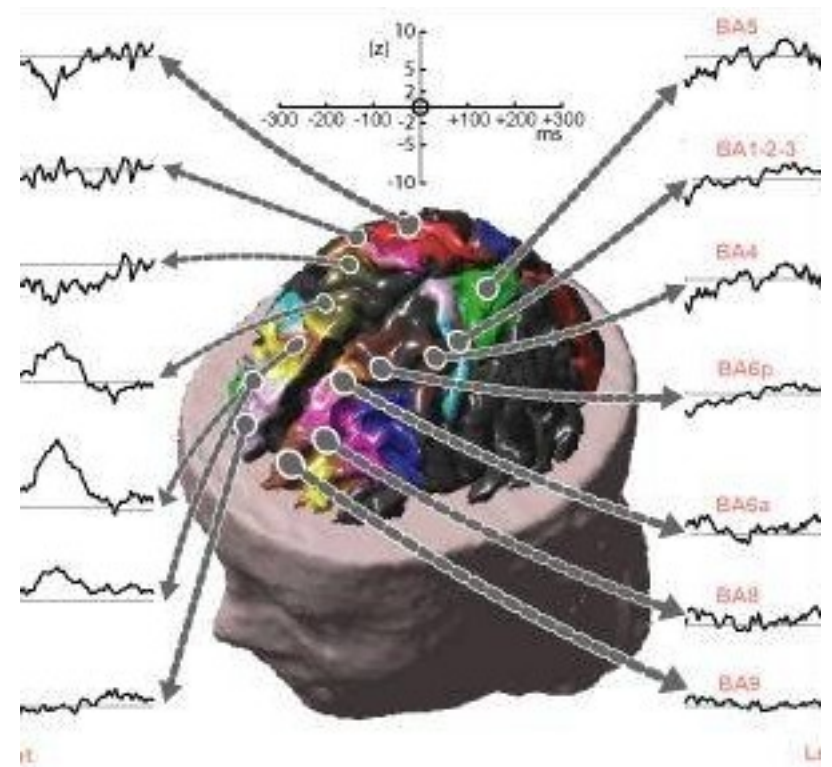


# Introduction to Electroencephalography (EEG)



# Outline

- Introduction & History
- Neurophysiological Basis of EEG
- Recording Standards
- Applications
- Example ERP Study



# Introduction

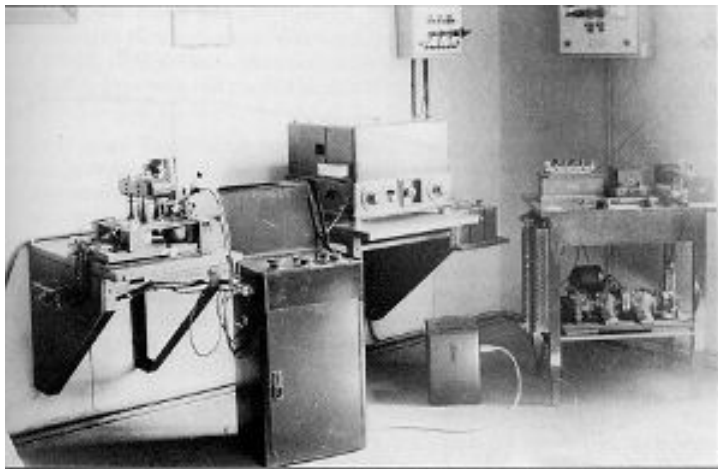
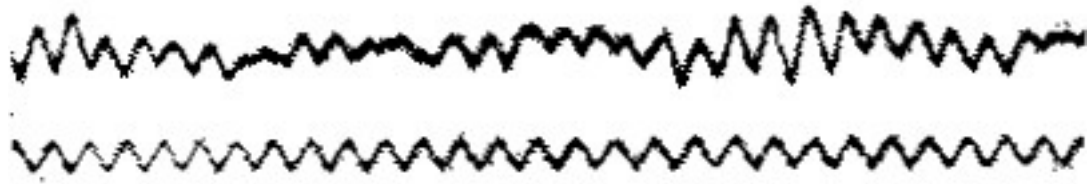


- EEG: electrical activity recorded via electrodes on the scalp
- High temporal resolution (millisecond scale) and low spatial resolution
- Relatively cheap neuroimaging technique

# Brief History

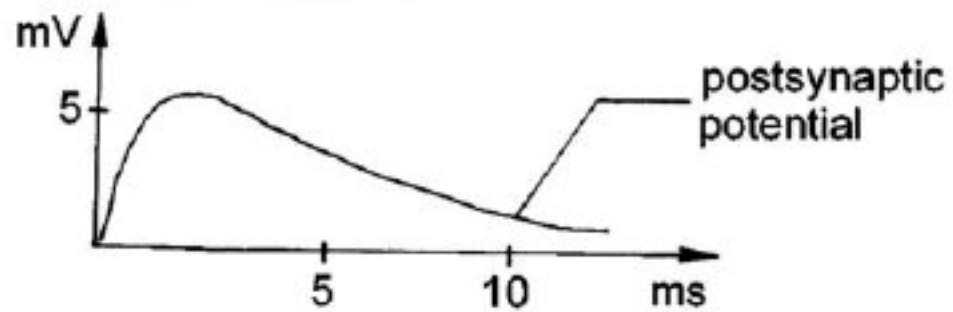
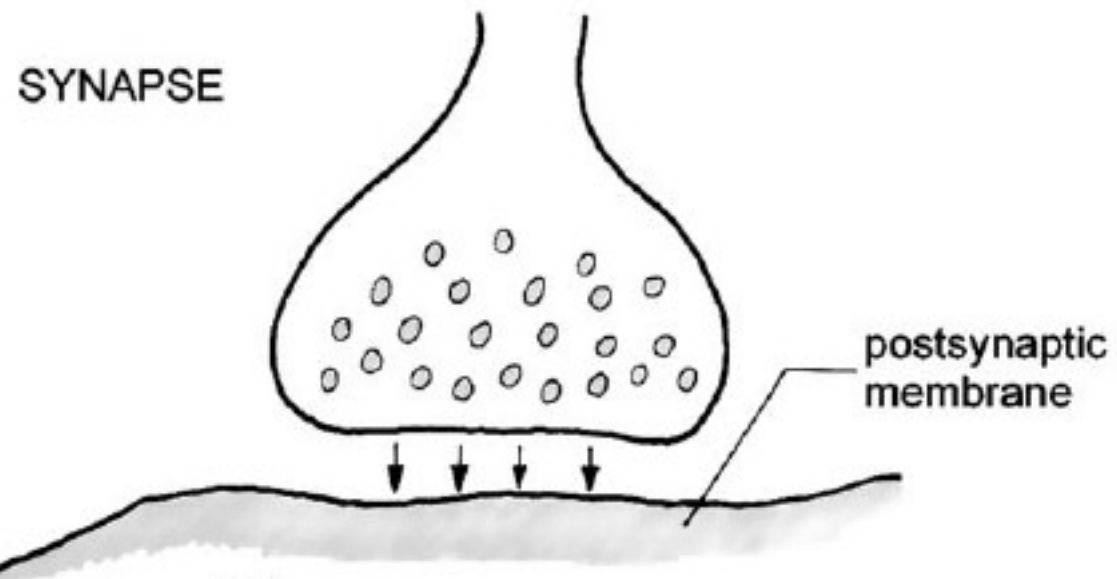
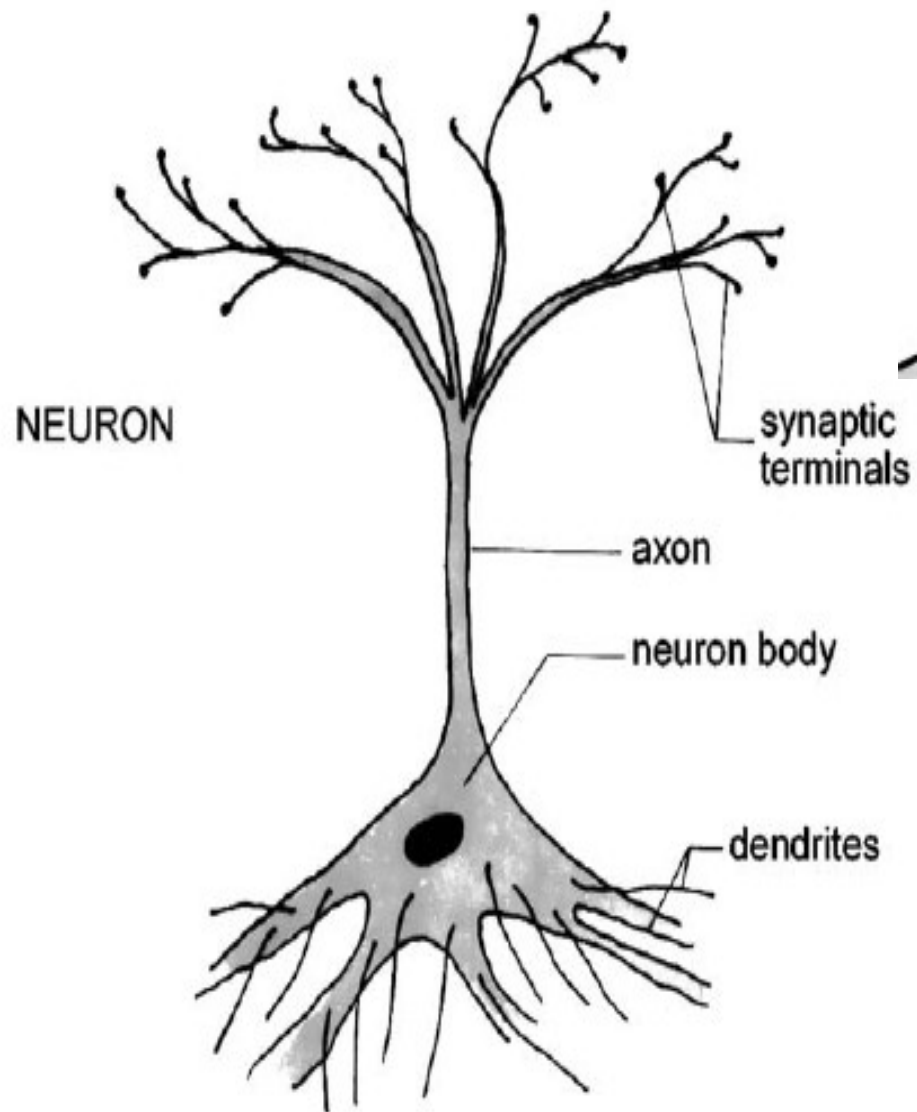
- Vladimirovich (1912)
  - first animal EEG study (dog)
- Cybulski (1914)
  - first EEG recordings of induced seizures
- Berger (1924)
  - first human EEG recordings
  - 'invented' the term electroencephalogram (EEG)
- American EEG Society formed in 1947
- Aserinsky & Kleitman (1953)
  - first EEG recordings of REM sleep

# Hans Berger (1924)



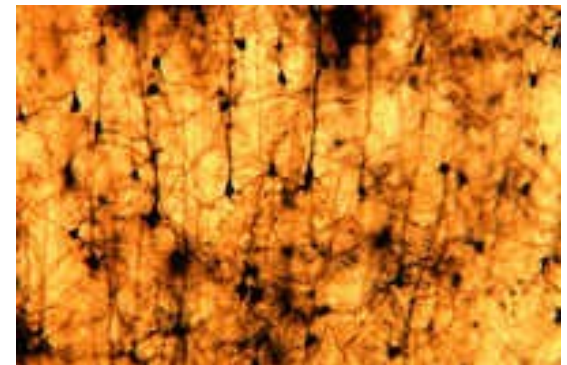


# Neurophysiological Basis of EEG



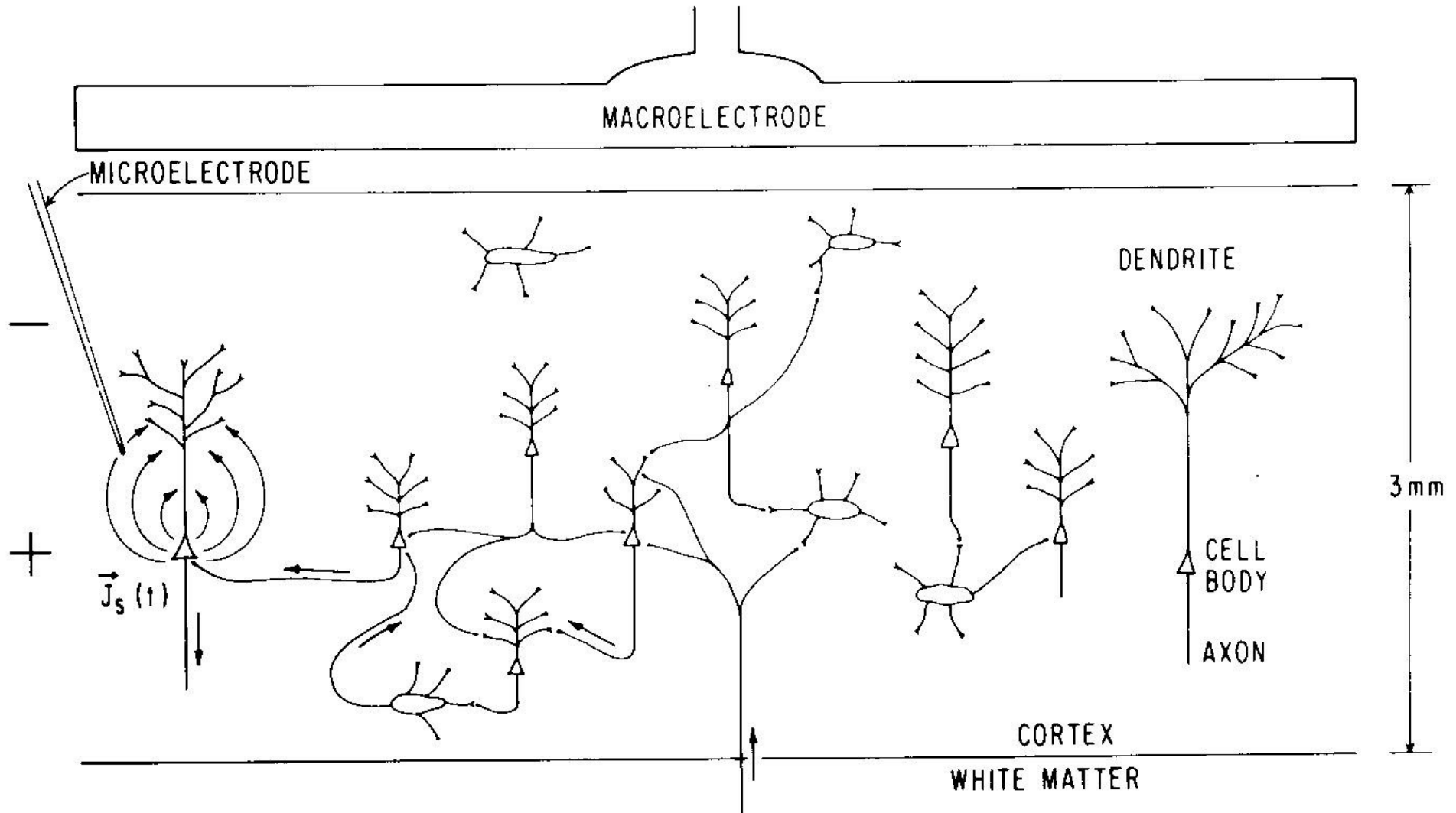
# Neurophysiological Basis of EEG

- Single neuron activity is too small to be picked up by EEG
- EEG reflects the summation of the synchronous activity of many neurons with similar spatial orientations
- Cortical pyramidal neurons produce most of the EEG signal
- Deep sources (subcortical areas) are much more difficult to detect than currents near the skull



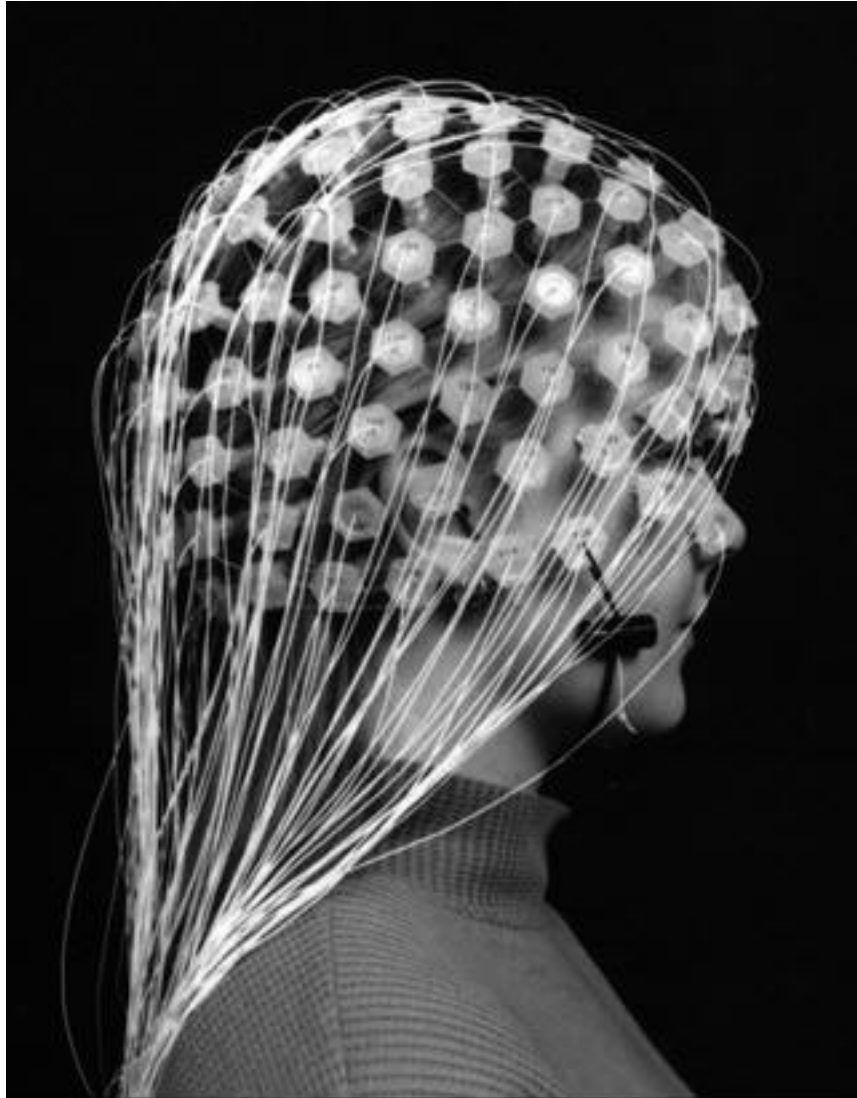


# Scalp EEG Recordings



# Recording Standards

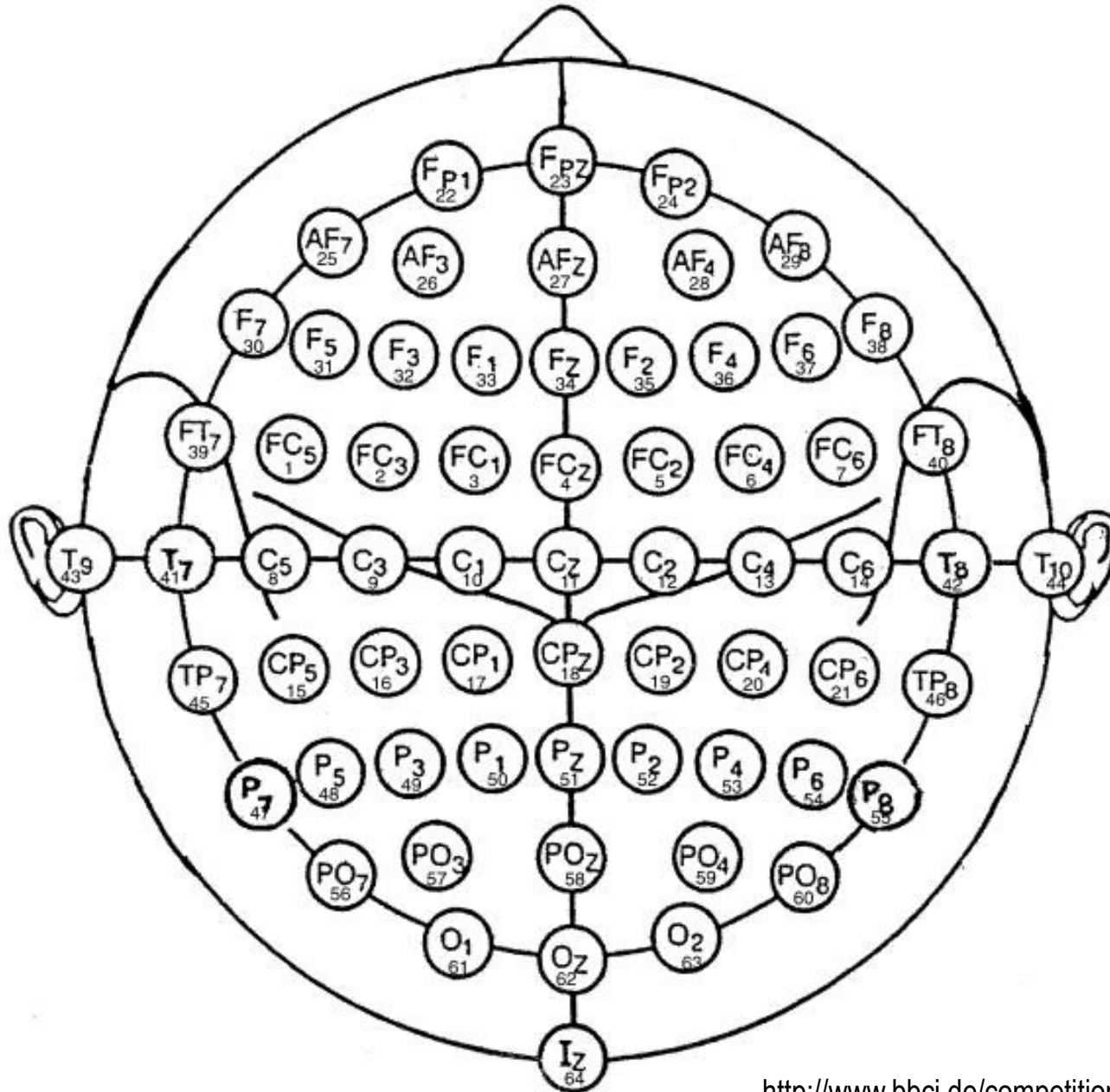
# EEG Systems



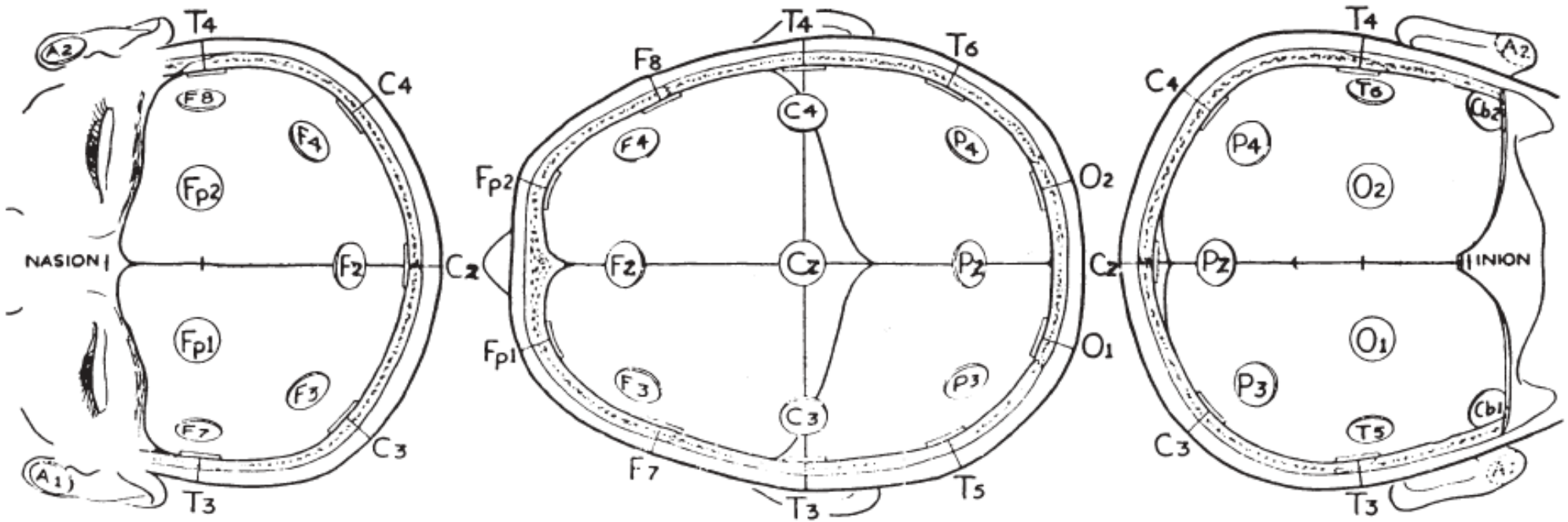
[http://www.thecnnh.org/ACEC/images/jimmysmile\\_phan.jpg](http://www.thecnnh.org/ACEC/images/jimmysmile_phan.jpg)

[http://www.scholarpedia.org/wiki/images/1/10/Electroencephalogram\\_figHead.jpg](http://www.scholarpedia.org/wiki/images/1/10/Electroencephalogram_figHead.jpg)

# Electrode Placement

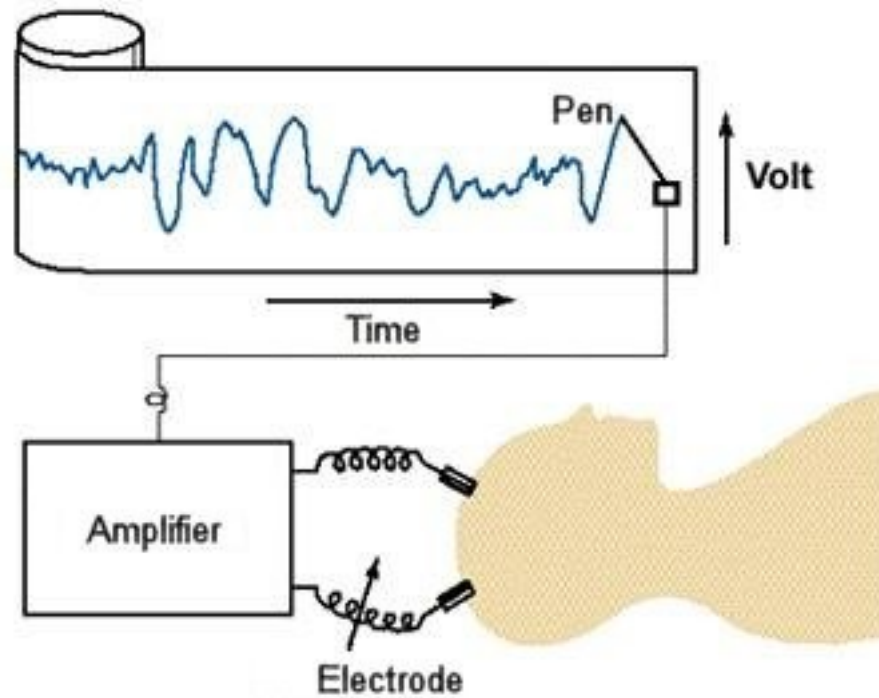


# Electrode Placement

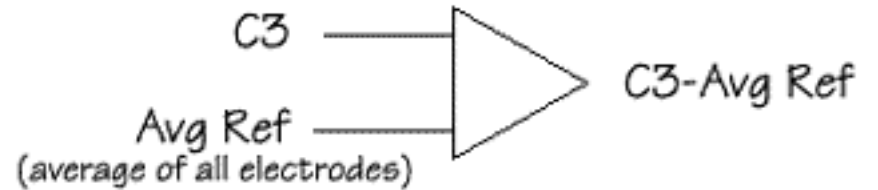
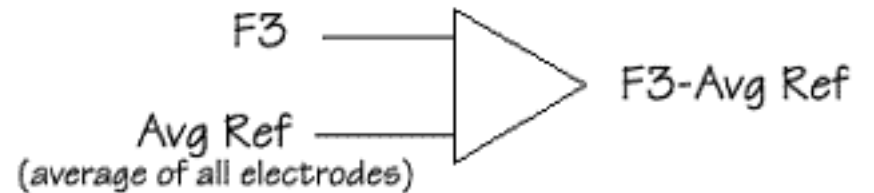
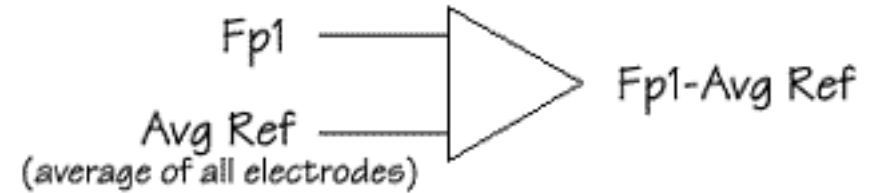
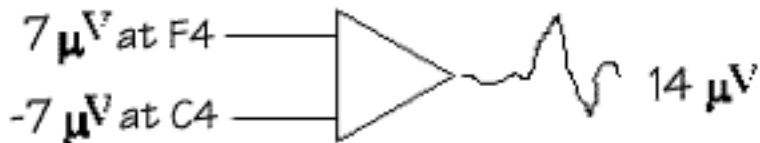
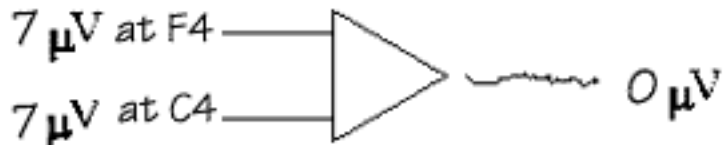
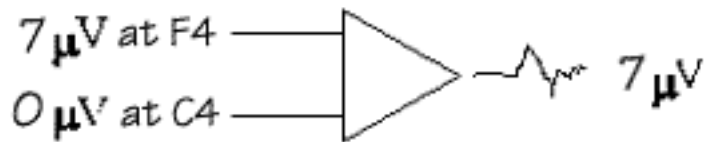
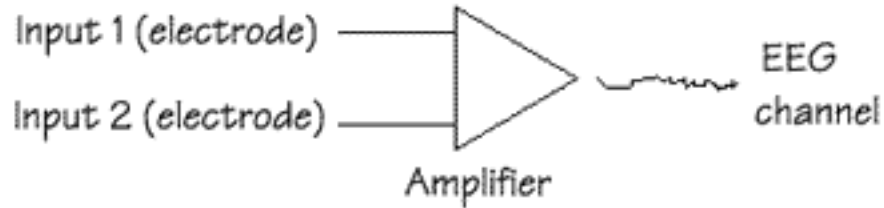


**Figure 3.** Electrodes placement in 10-20 system.

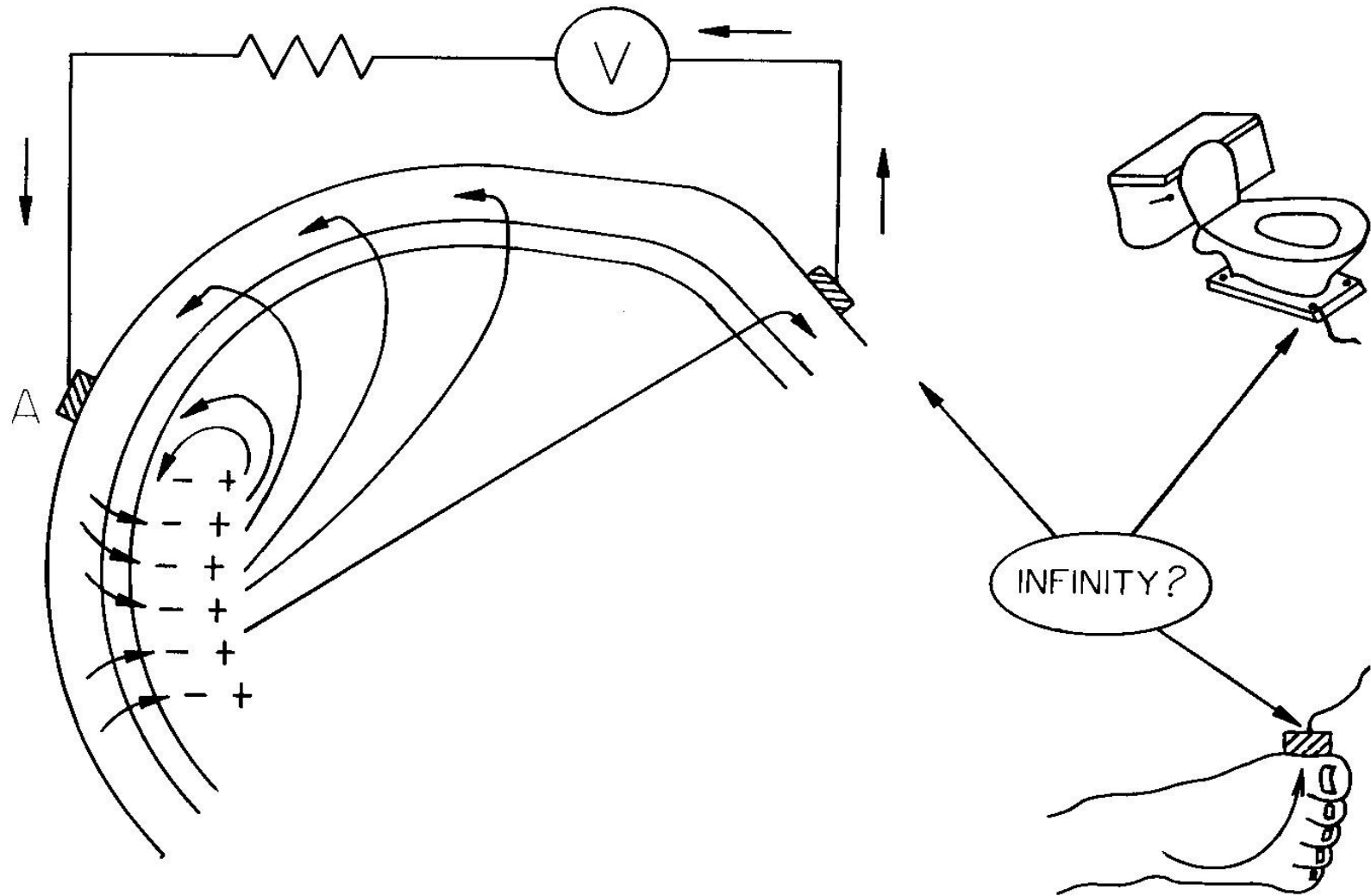
# Recording EEG Signals



# Referencing

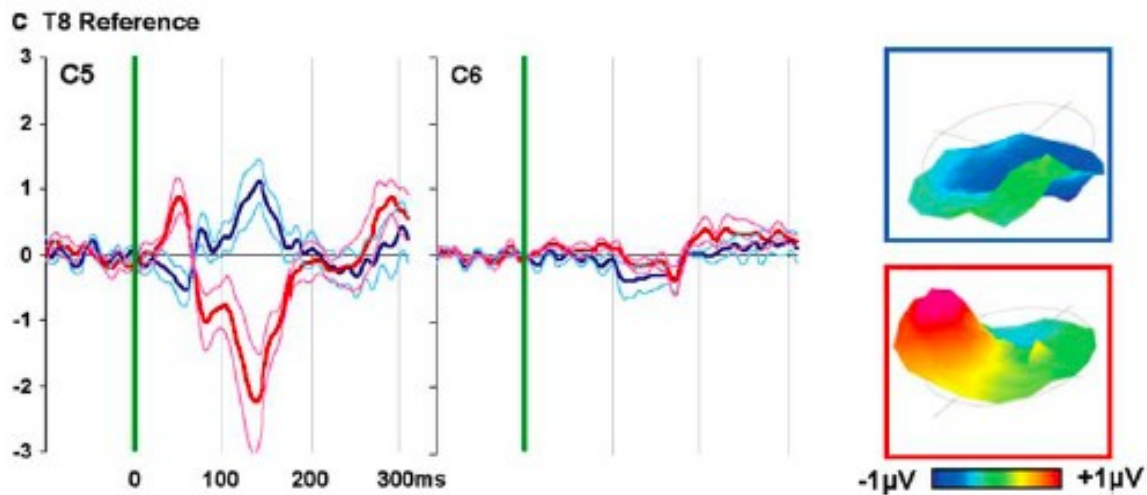
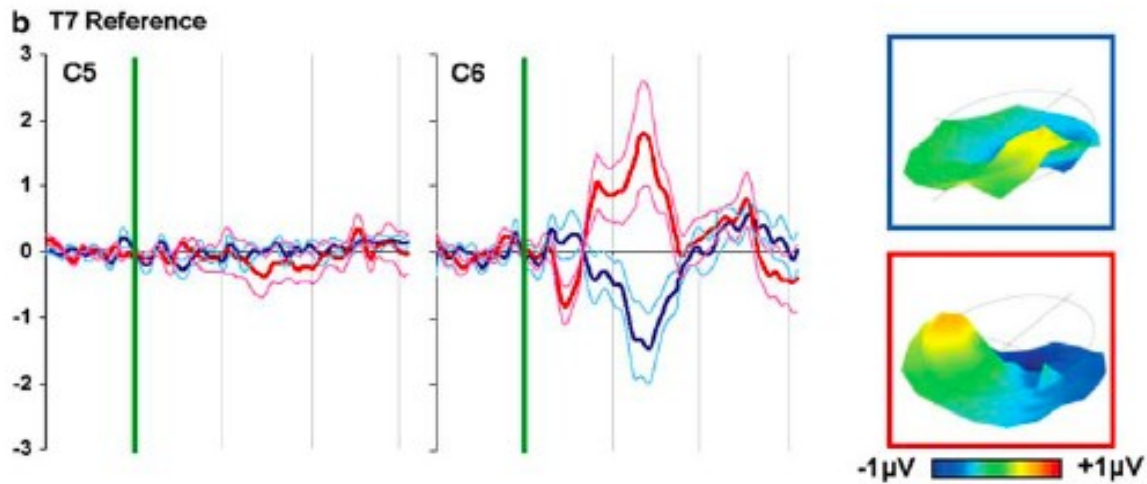
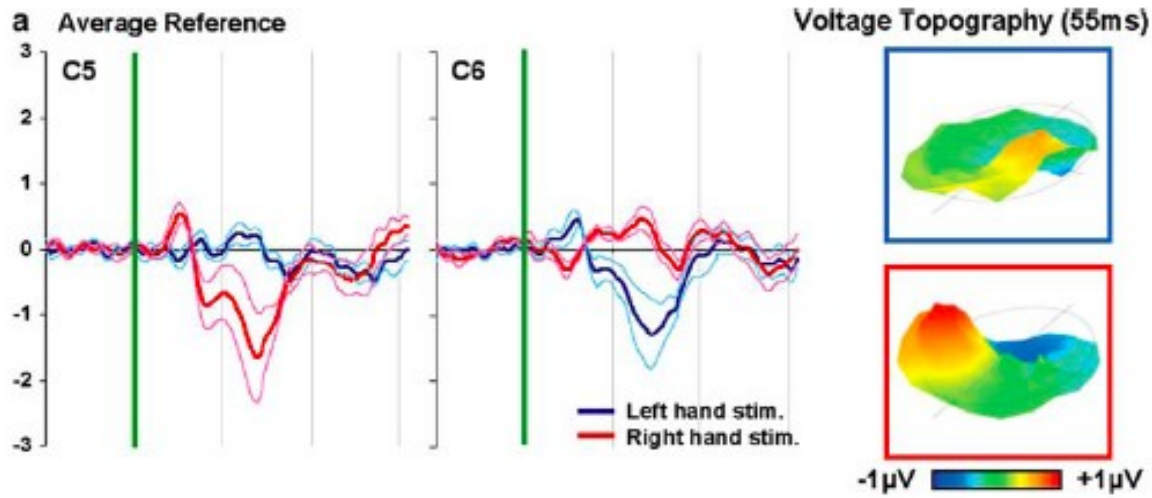


# Perfect Reference?





# Effect of the Reference Electrode



(Murray et al., 2008)

# Applications

# EEG Rhythms

**Aroused**



**Relaxed**



**Asleep**

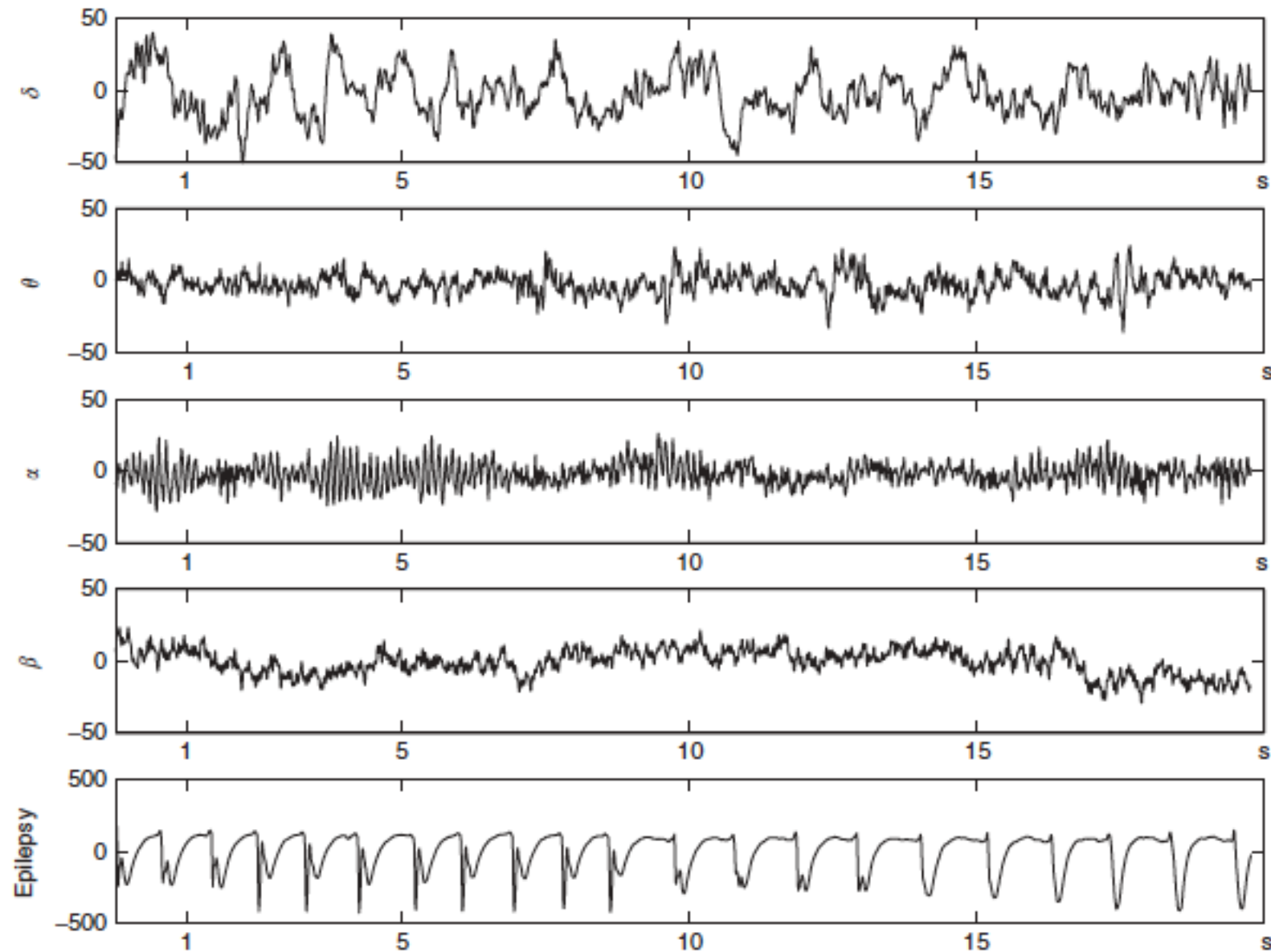


**Deep sleep**



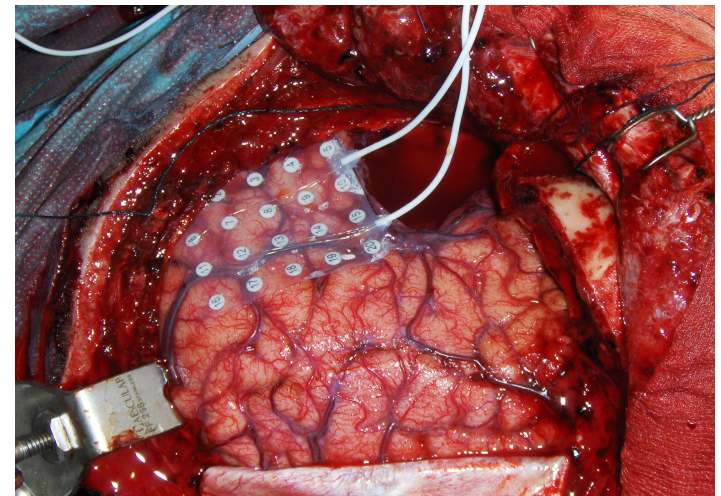
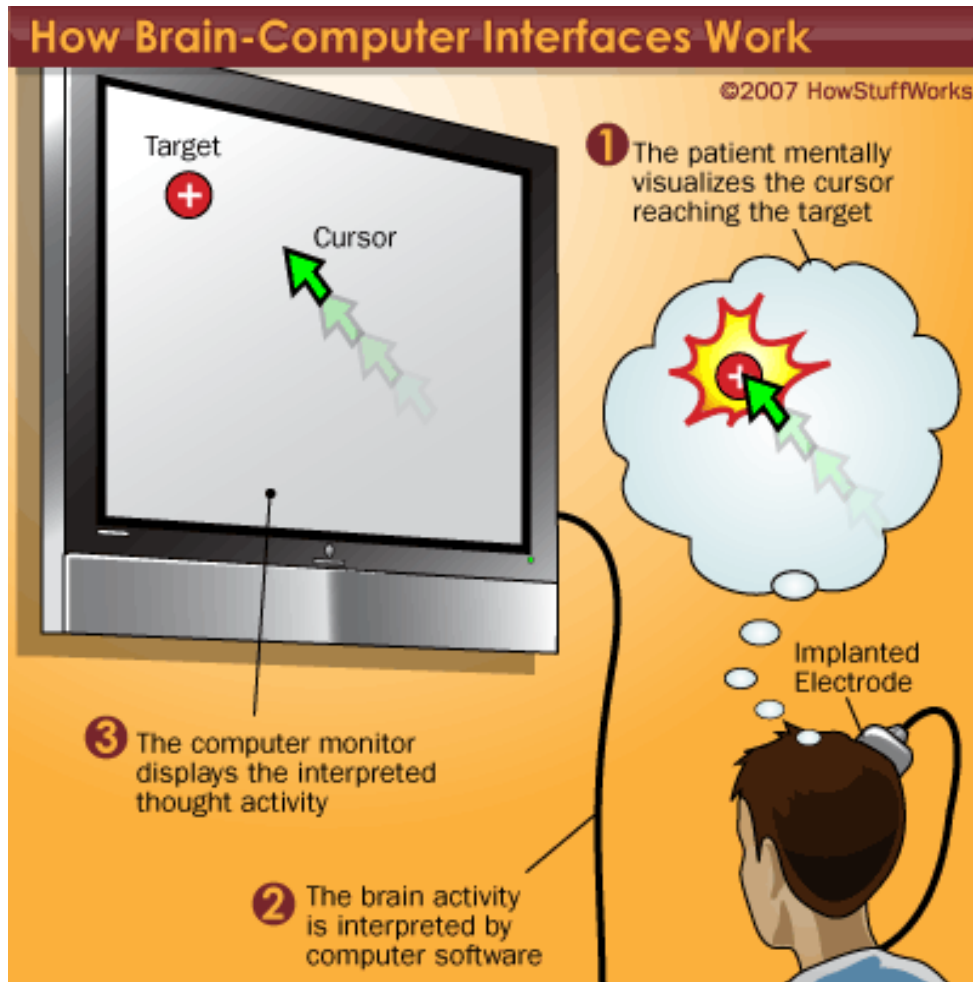
1 second

Characteristic EEG rhythms, from the top: delta (0.5–4 Hz), theta (4–8 Hz), alpha (8–13 Hz), beta (13–30 Hz).



(Blinowska & Durka, 2006)

# Brain-Computer Interfaces

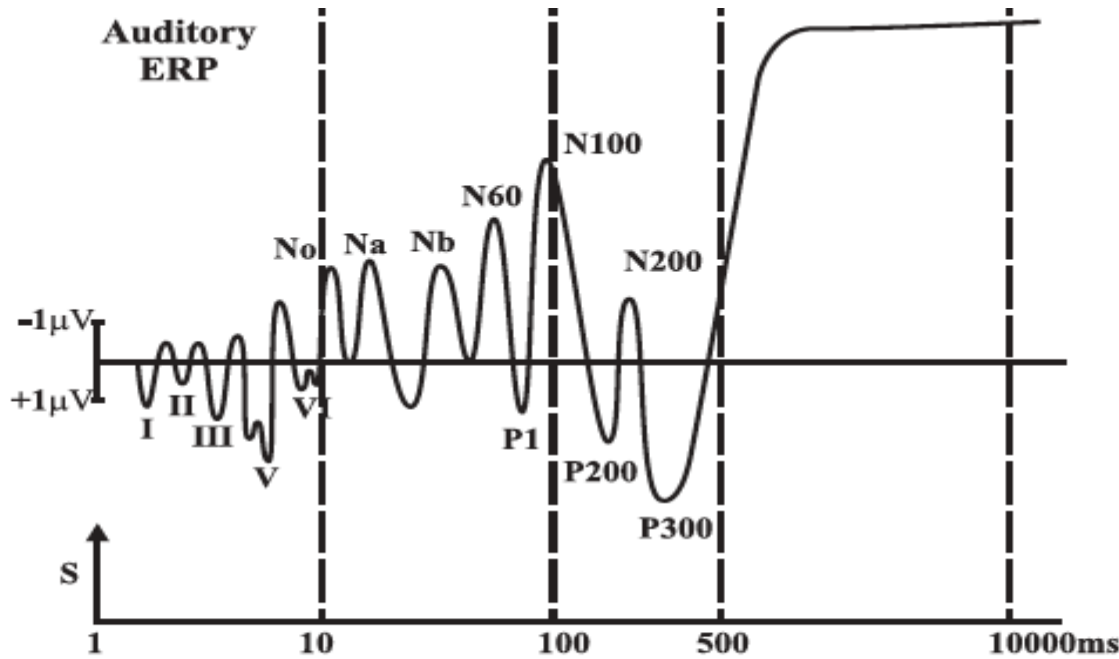


<http://static.howstuffworks.com/gif/brain-computer-interface-2.gif>

<http://loverev.files.wordpress.com/2010/03/bci-eeg-surgery.jpg>

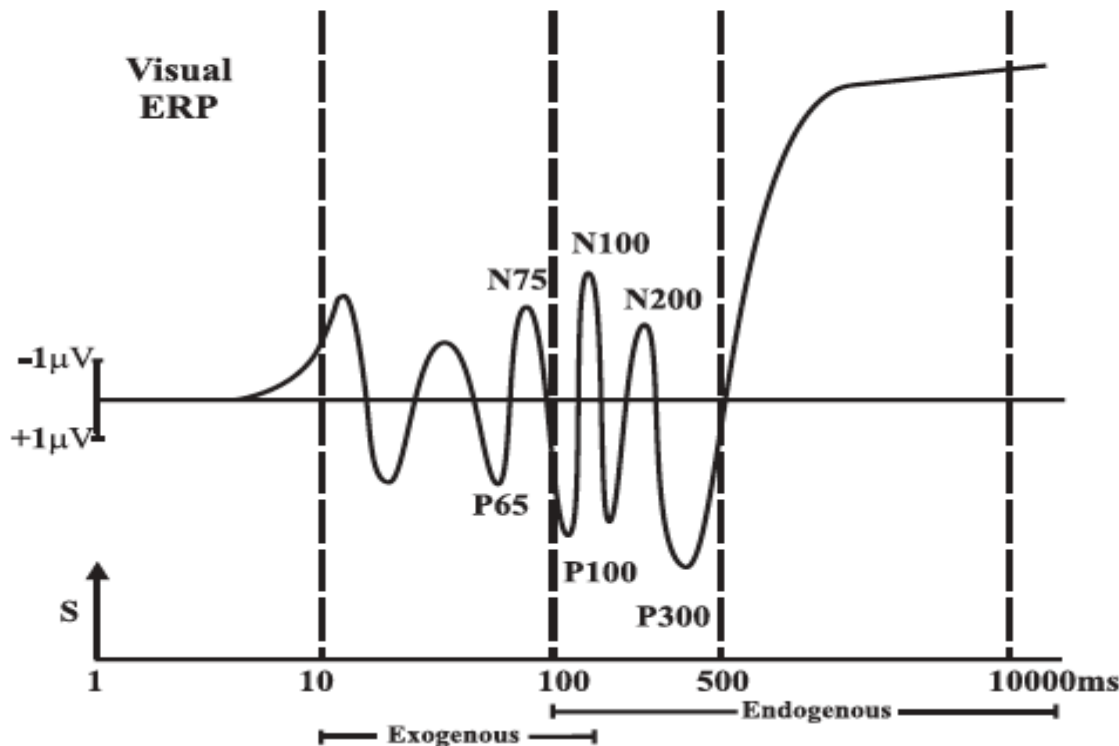
# Event Related Potentials (ERPs)

# ERPs



Average auditory ERP and visual ERP in logarithmic time scale, showing the commonly recognized components.

Auditory components marked by roman numbers are the brainstem-evoked responses (BAEP). They are followed by mid-latency exogenous components (MAEP).

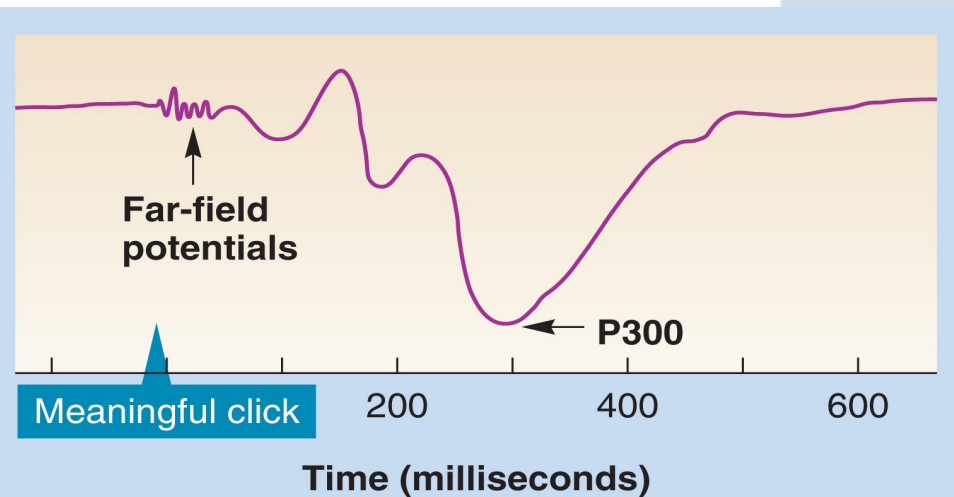


The first peak in exogenous visual ERP comes from ERG (electroretinogram).

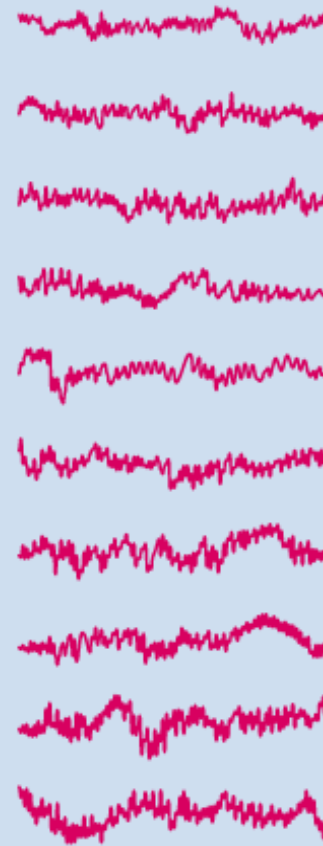
Exogenous ERPs exhibit modality-specific features

Endogenous ERPs are similar in both modalities.

# Event-related potentials (ERP)



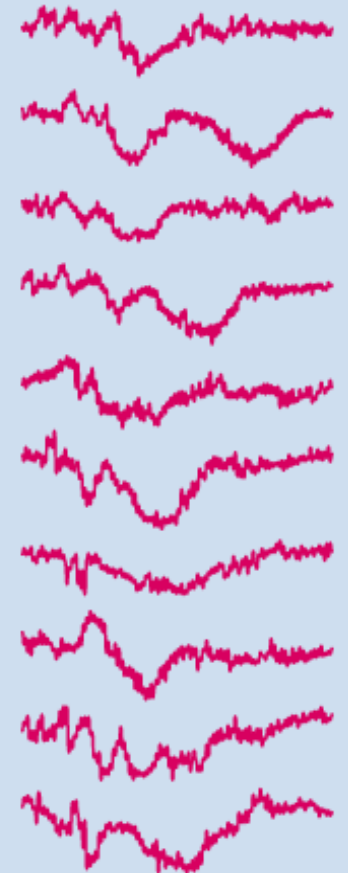
1-second segments of background EEG



Average background EEG



1-second segments of EEG with evoked potential



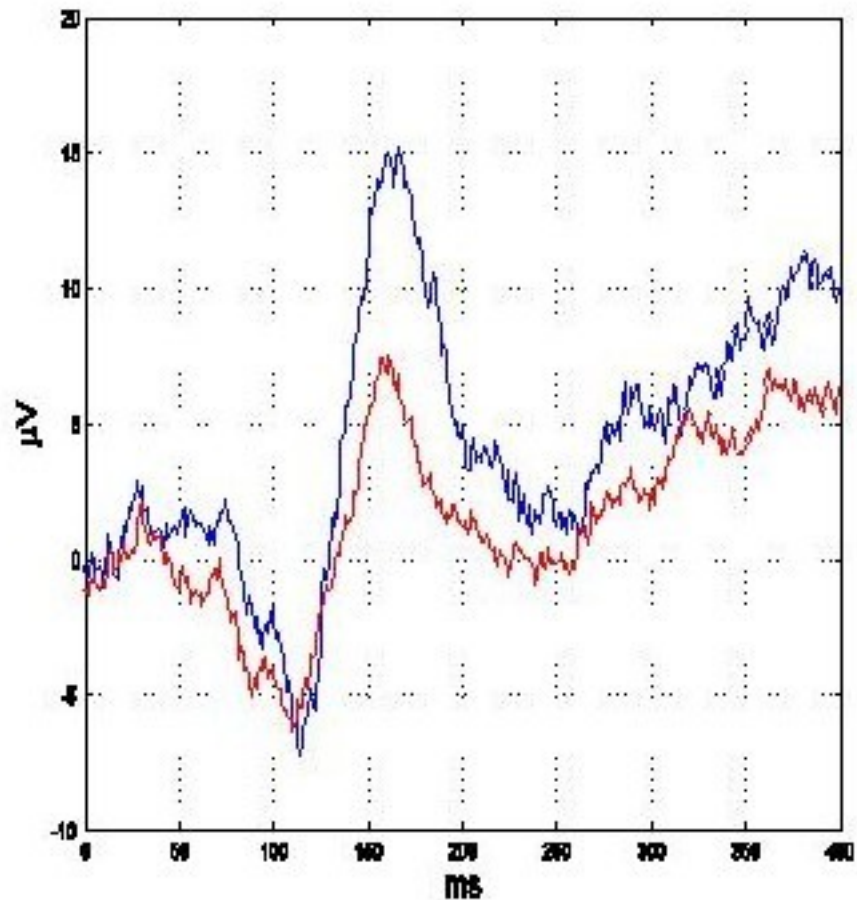
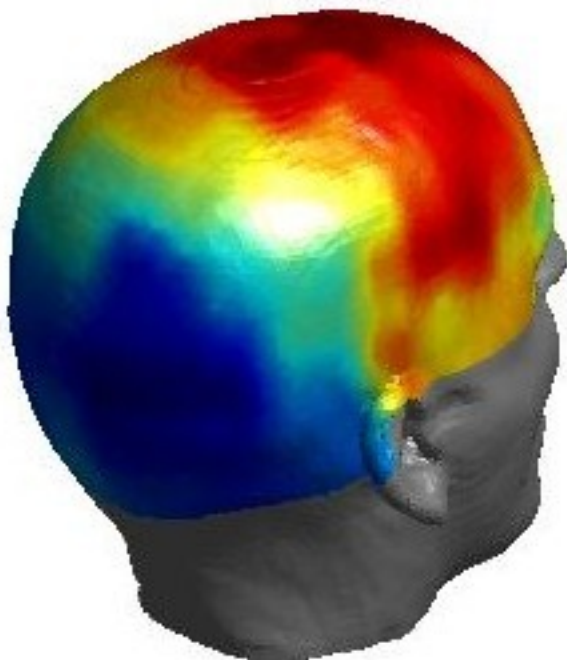
Average evoked potential



(Pinel, 2011)

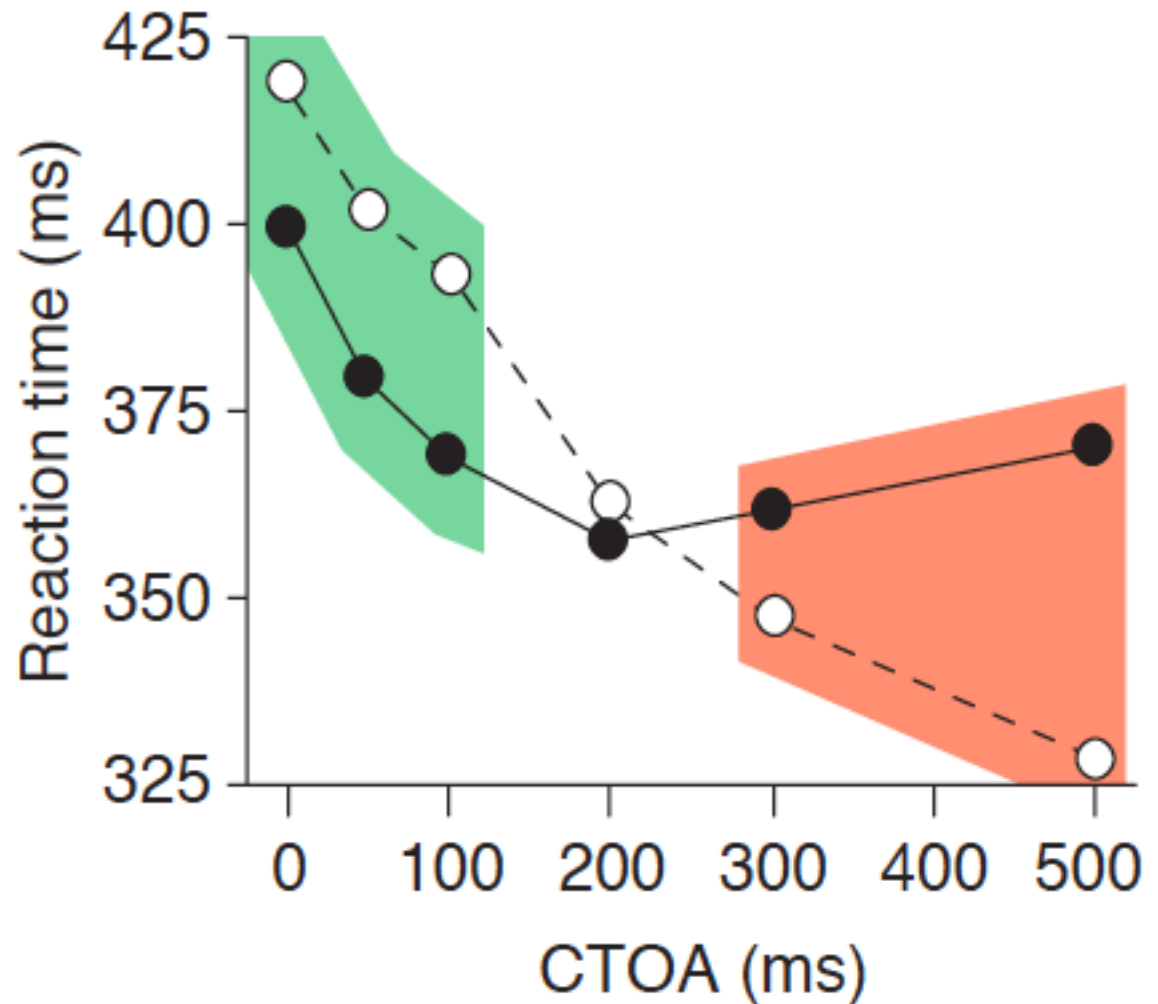
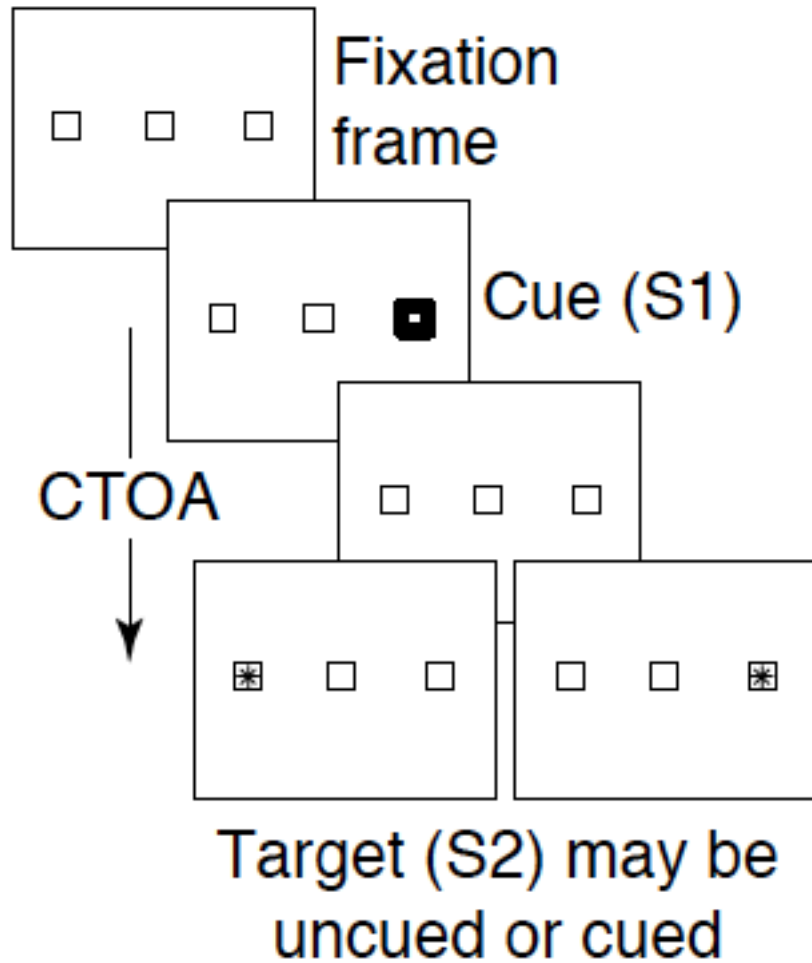


# Comparing ERP Components Across Conditions

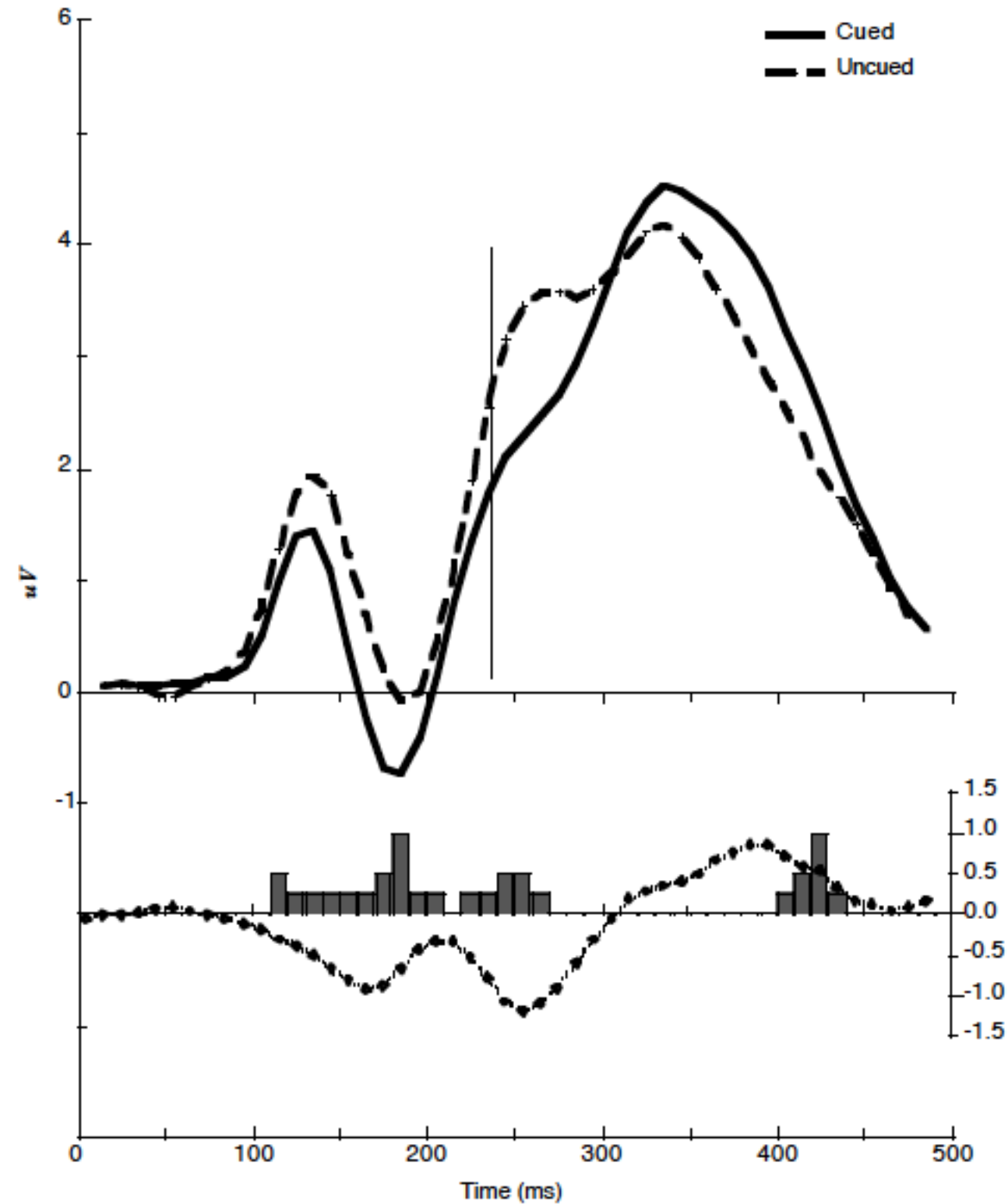


# Example ERP Study

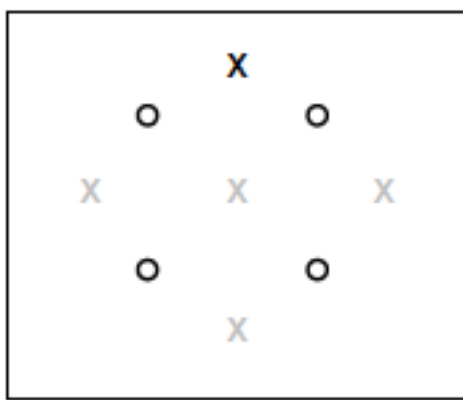
# Inhibition of Return (IOR)



# IOR and ERPs

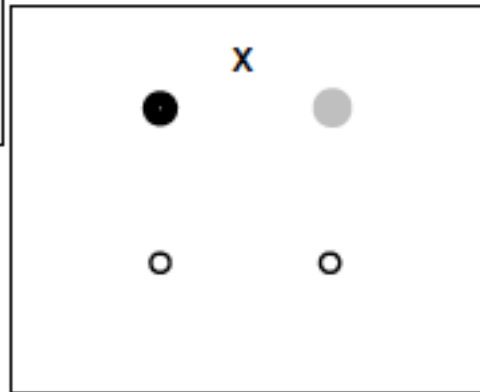


# Spatiotopic vs. Retinotopic IOR



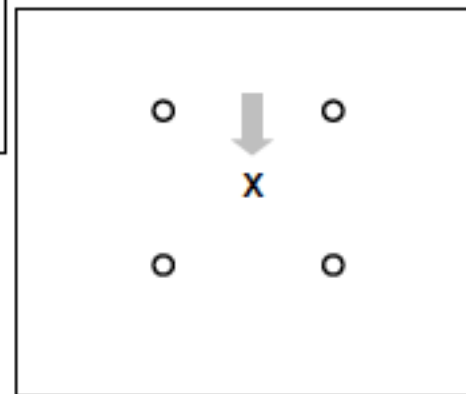
Initial fixation point (x) -  
(5 possible locations)

SOA (EM land-cue onset) -  
400 ms



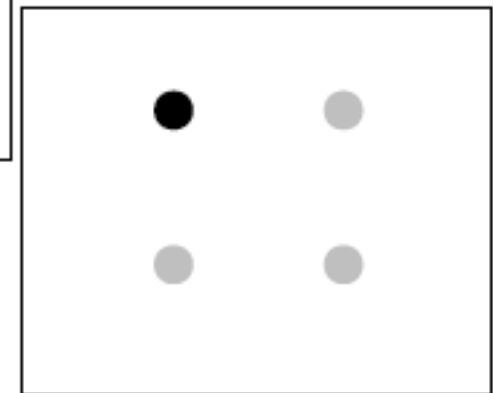
Cue presentation -  
200 ms  
(2 possible locations)

SOA (cue offset-central  
onset) -  
300 ms (*could be varied*)



Saccade to central  
fixation point (*or not*) -  
~250 ms (SRT)

SOA (EM land-target  
onset) -  
500 ms (*could be varied*)



(*Manual or saccadic*) response to  
target appearance -  
(4 possible locations)

