Electroencephalogram (EEG)

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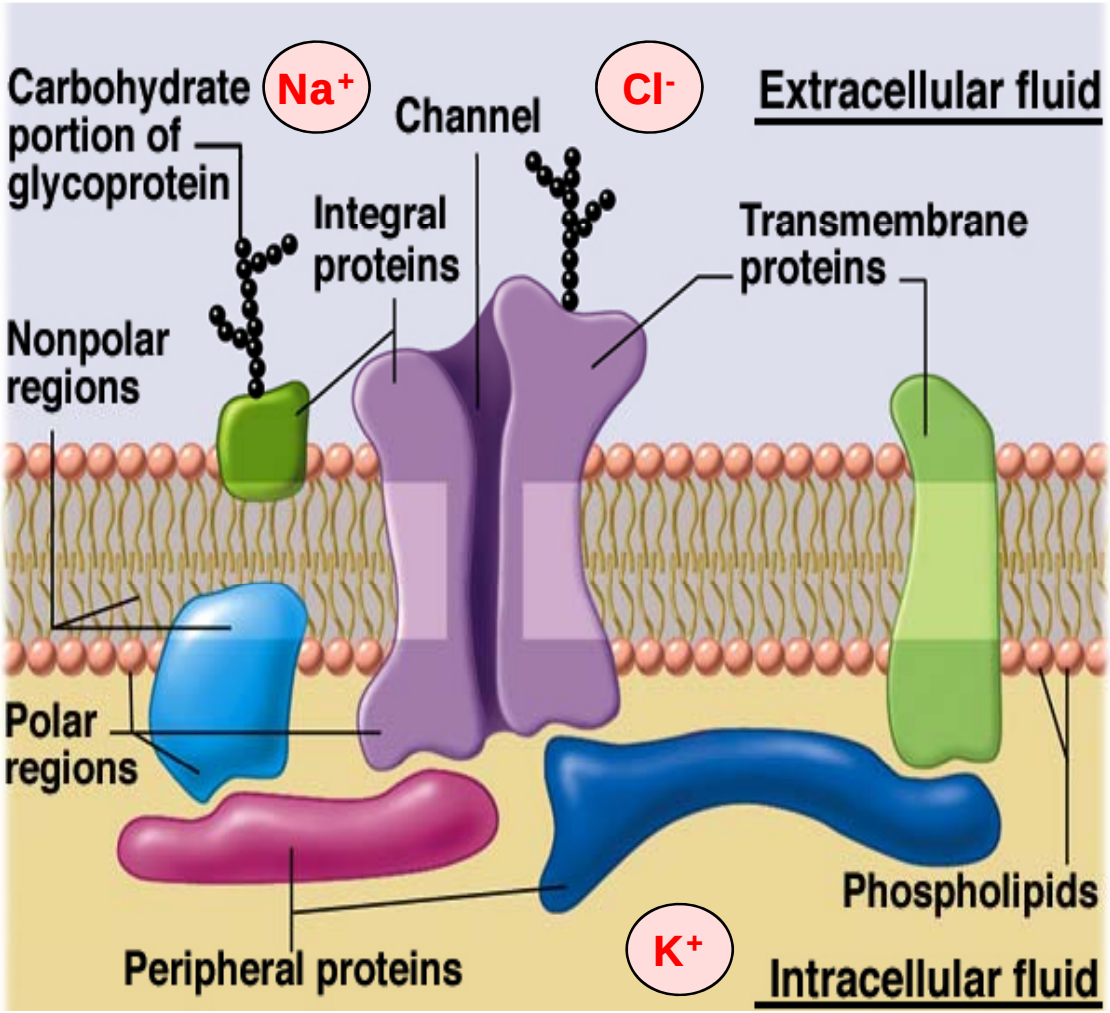
Origin of biopotentials

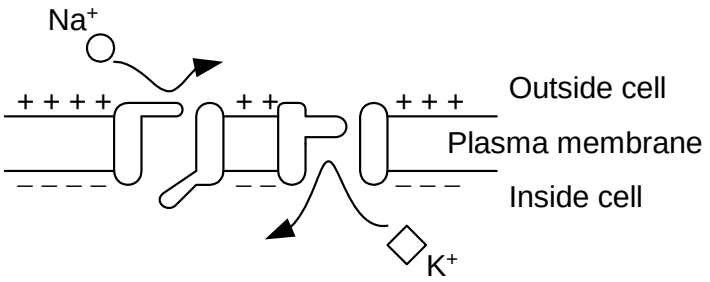


Extracellular domain

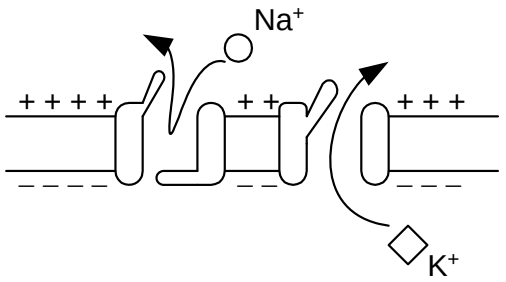
Phospholipid bilayer

Intracellular domain

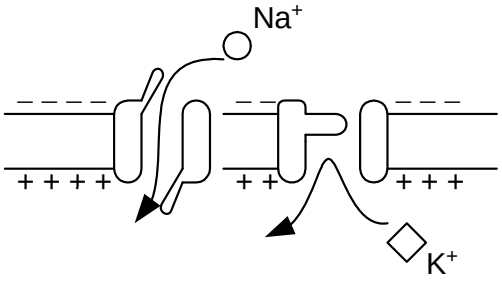
Action potential



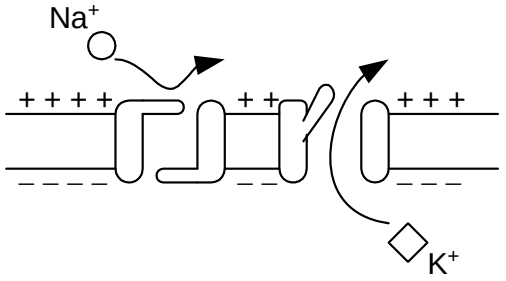
① Resting phase



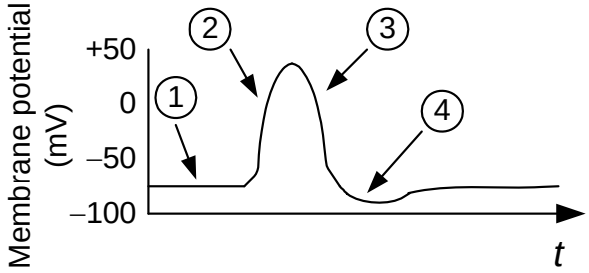
③ Repolarizing phase



② Depolarizing phase

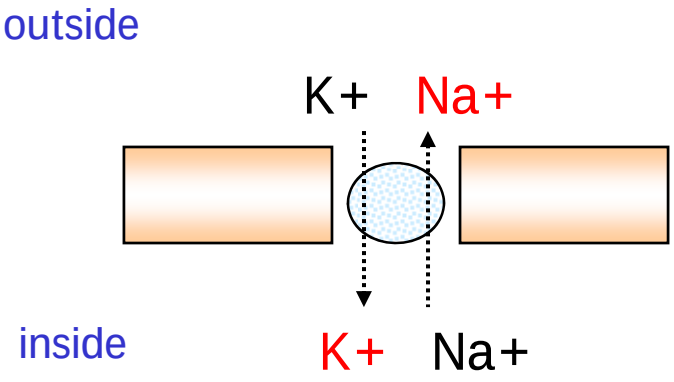


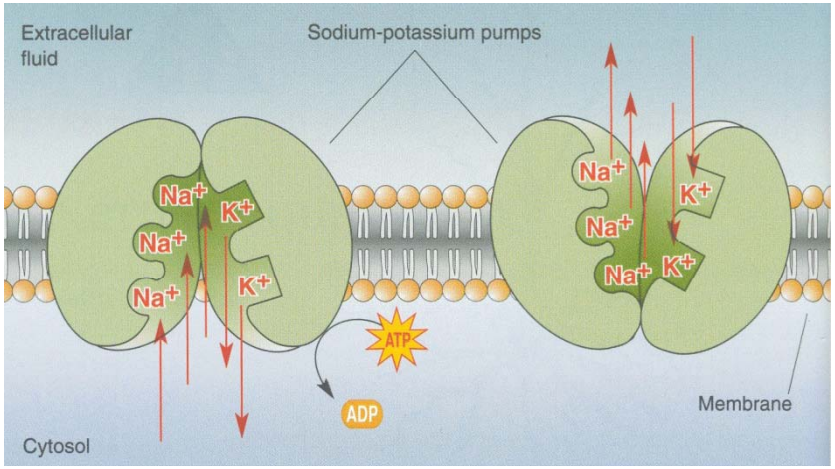
④ Undershoot phase



Active channel: sodium-potassium pump

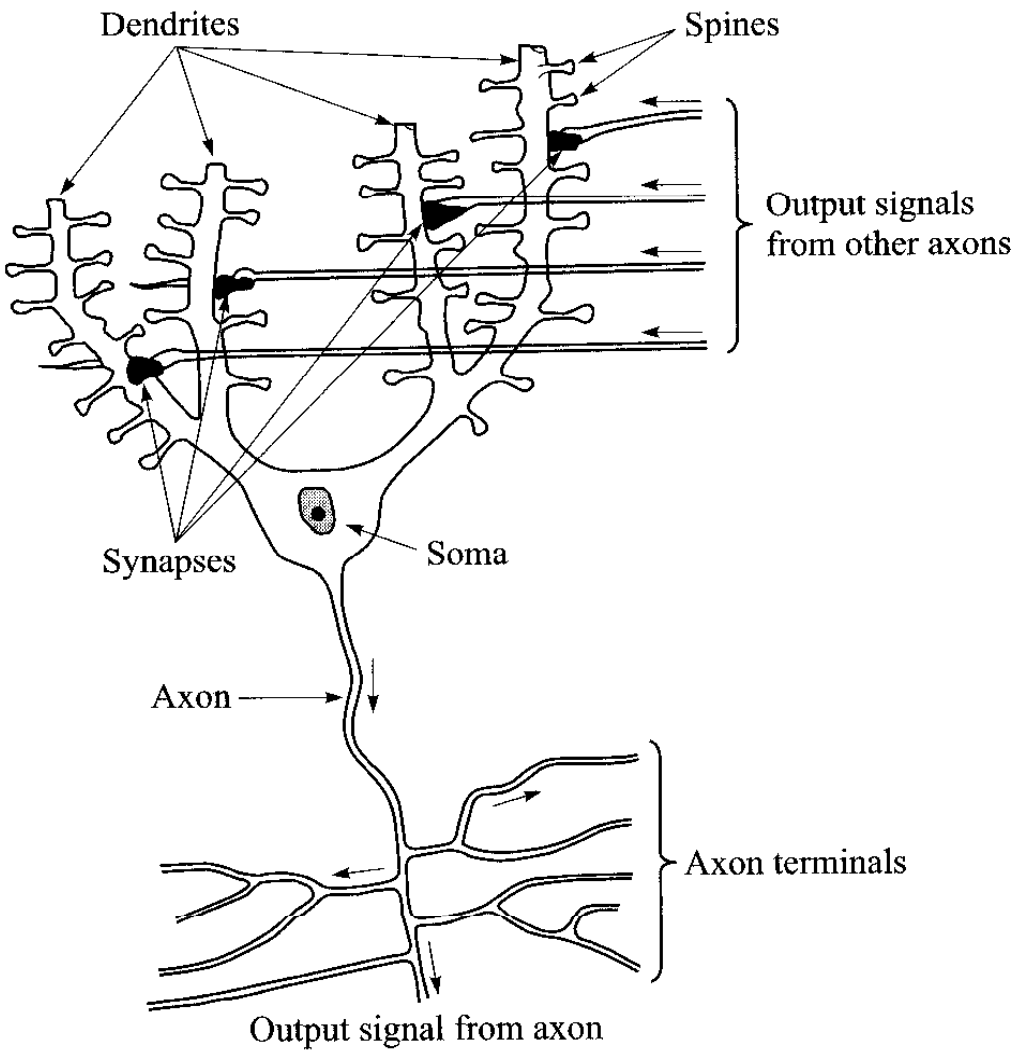
- Remove 3 Na^+ for every 2 k^+



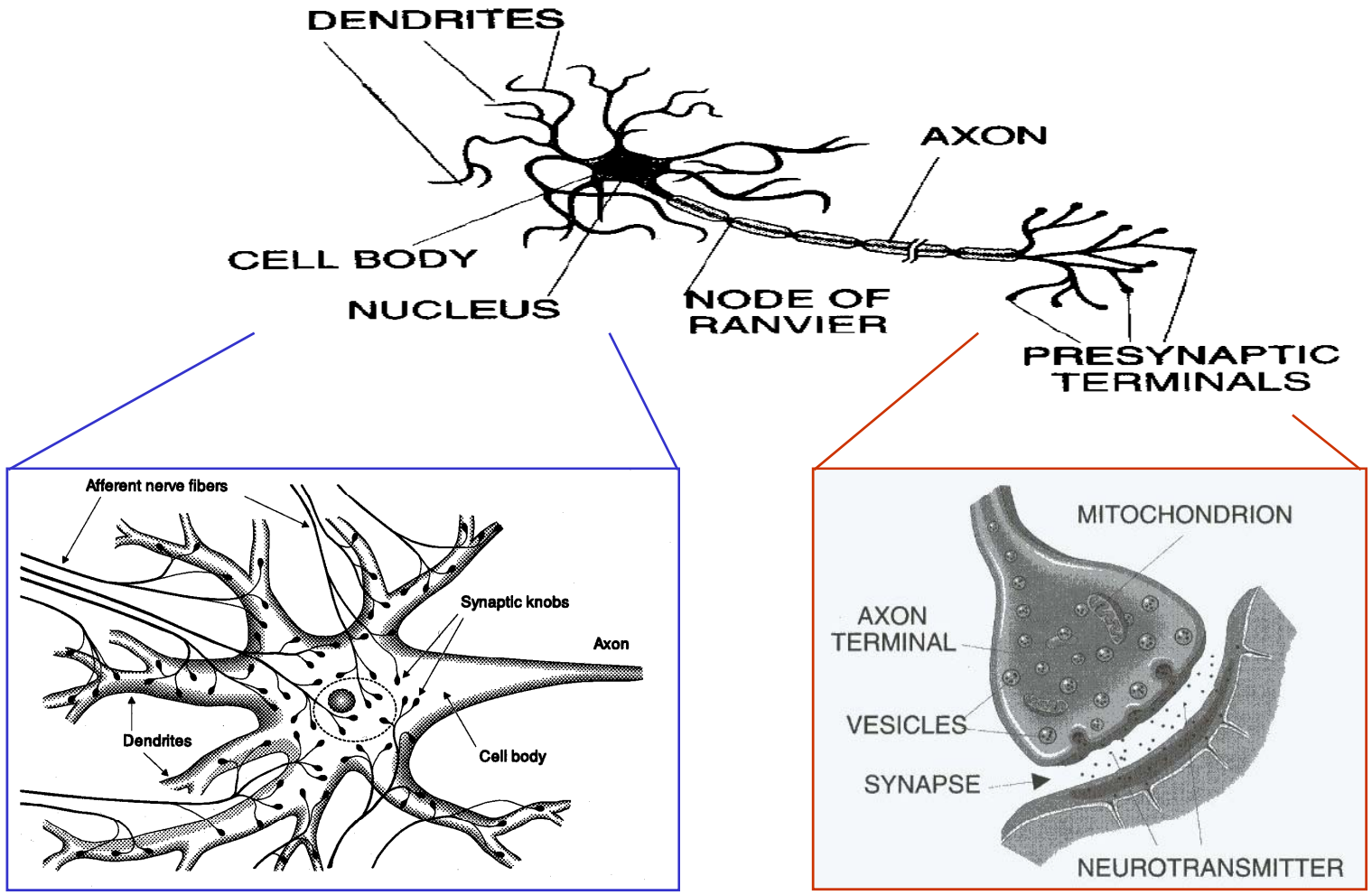


M. Bear *et al*, Neuroscience: exploring the brain, Lippincott Williams & Wilkins, 2001.

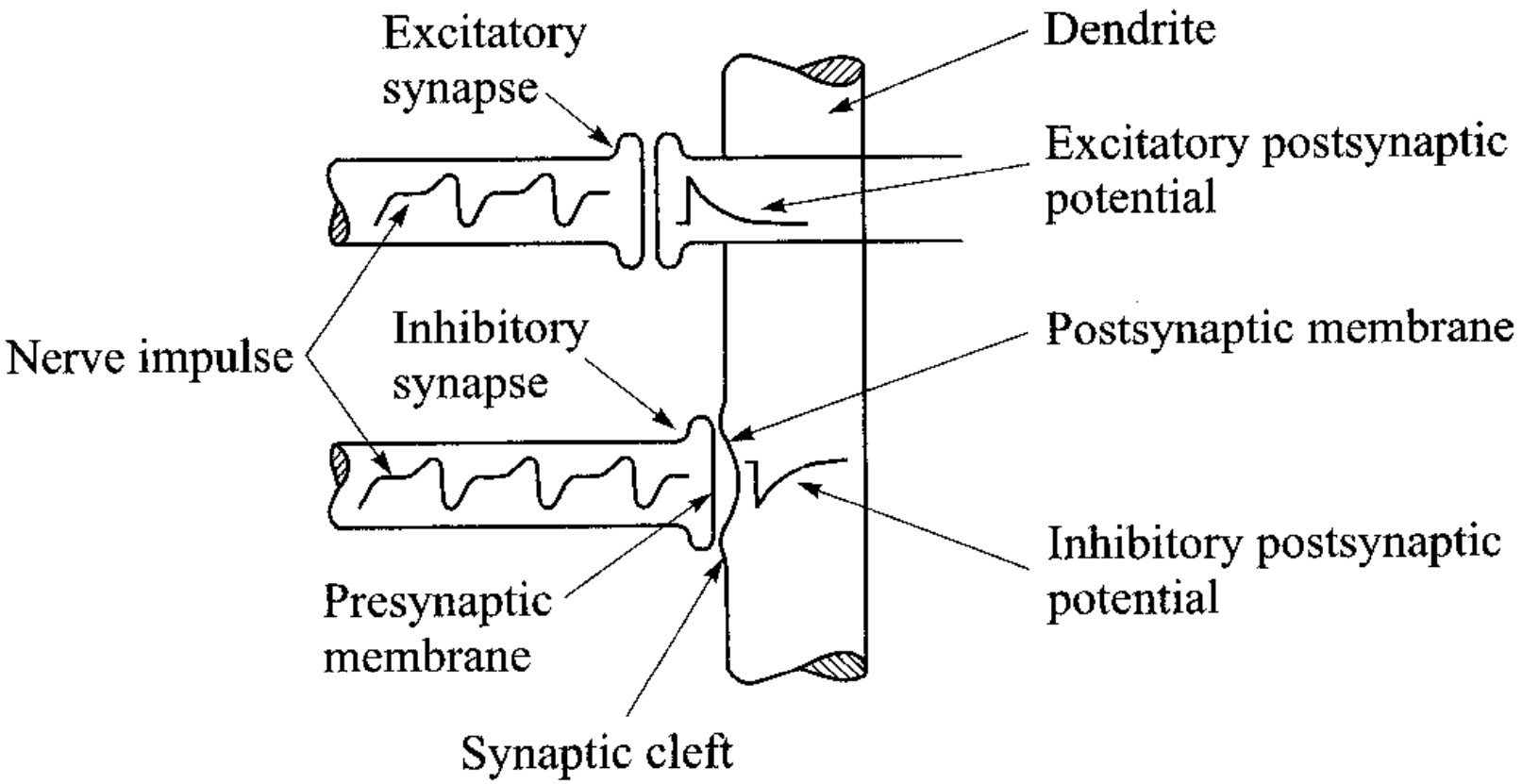
Biologocal neuron



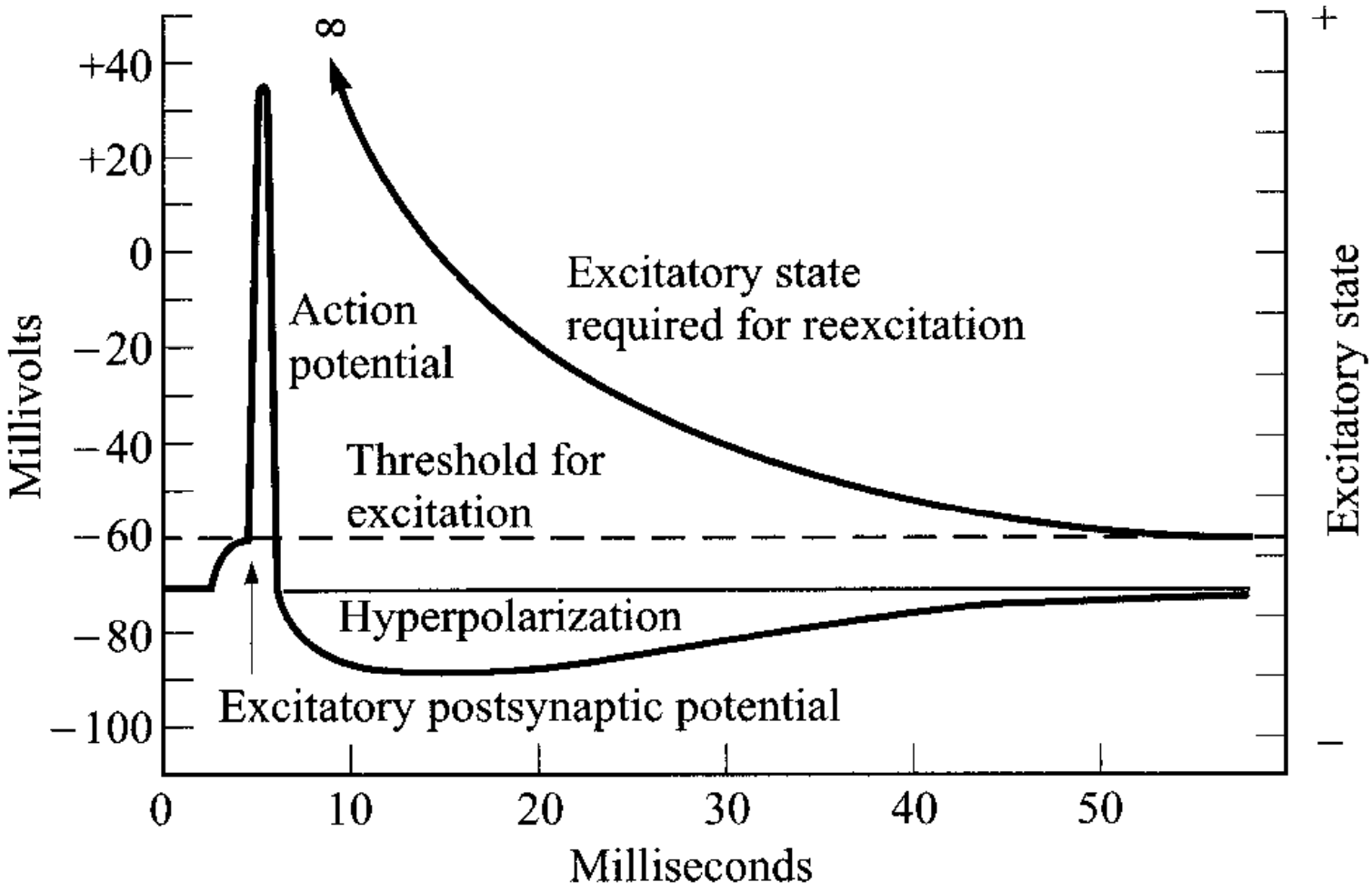
Axon to synapse via neurotransmitter



Simplified synapse in biologocal neuron



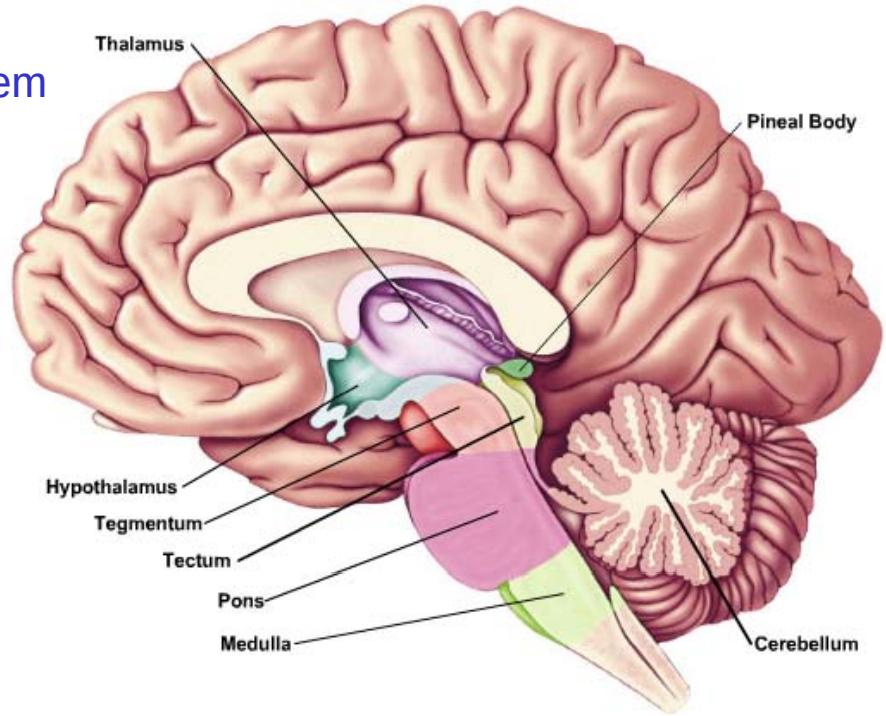
Action potential



Brain

Cerebrum (大腦)

Thalamus (丘腦)
- Sensory and motor system
- Human behaviors ...



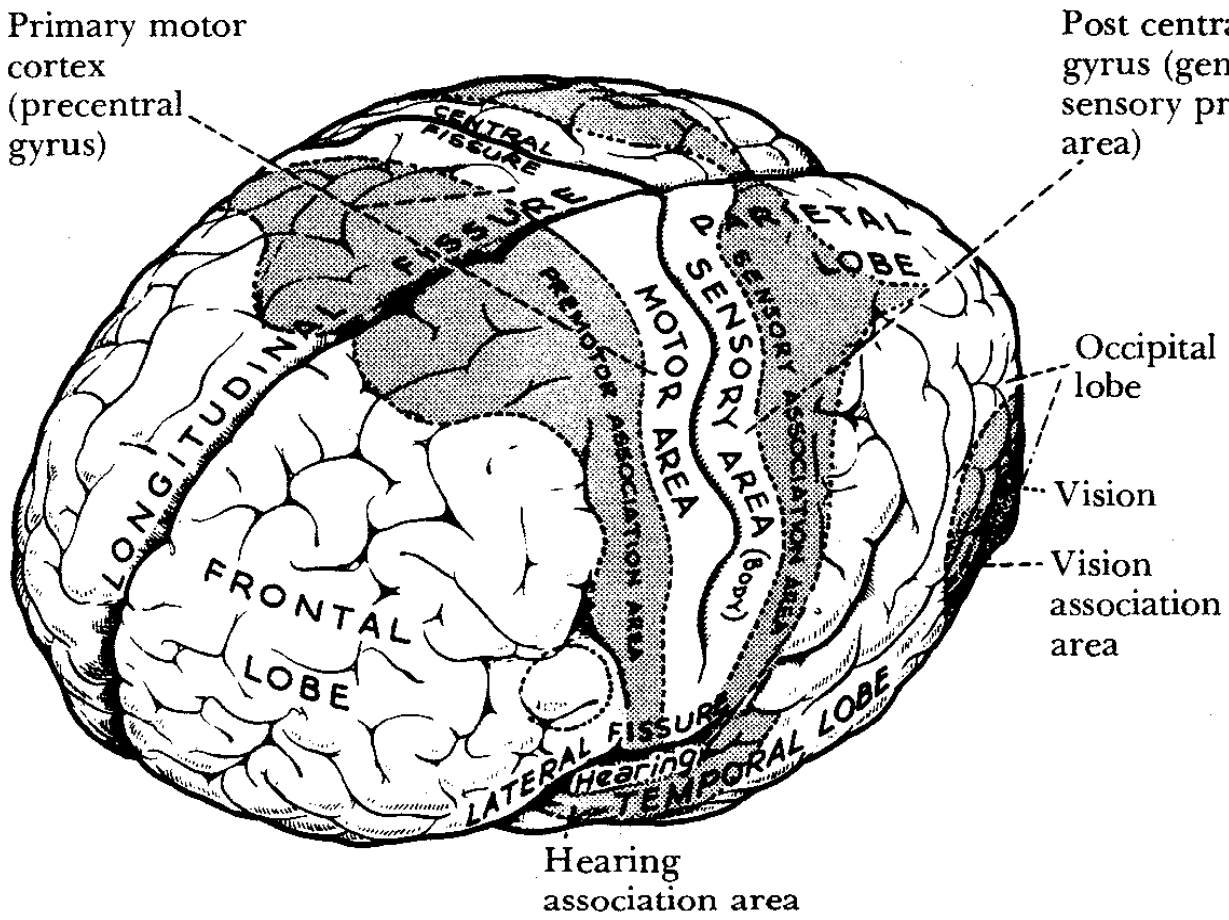
Hypothalamus (丘腦下部)
- Autonomic nervous system
- Temperature regulation
- Water and electrolyte balance
- Behavior response to emotion
- Endocrine control
- Sexual response ....

Medulla Oblongata (延腦)
- Vital centers that regulates heart rate, respiratory rate, blood pressure, blood vessel, etc.

Cerebellum (小腦)
- Coordinating skeletal muscles and impulses from cerebral cortex

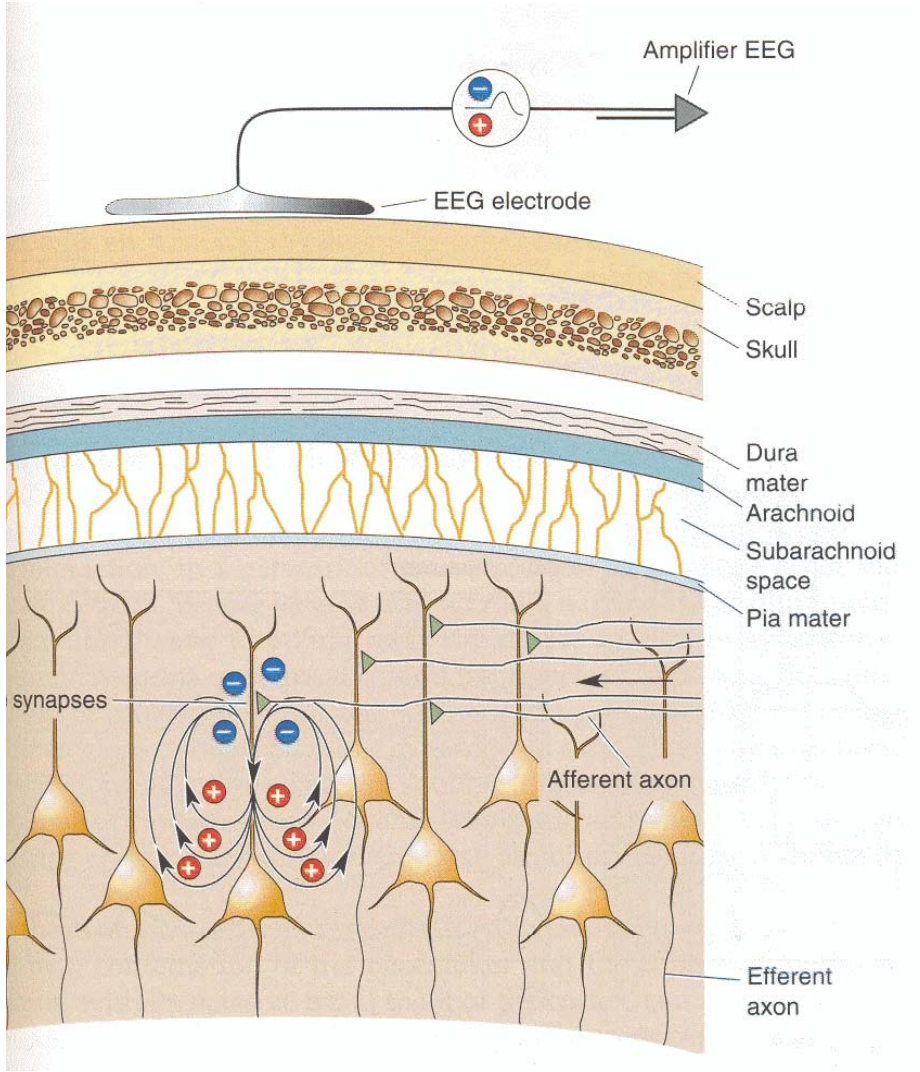
M. Bear *et al*, Neuroscience: exploring the brain, Lippincott Williams & Wilkins, 2001.

Cerebrum
(Frontal,Parietal,Temporal and Occipital lobes)



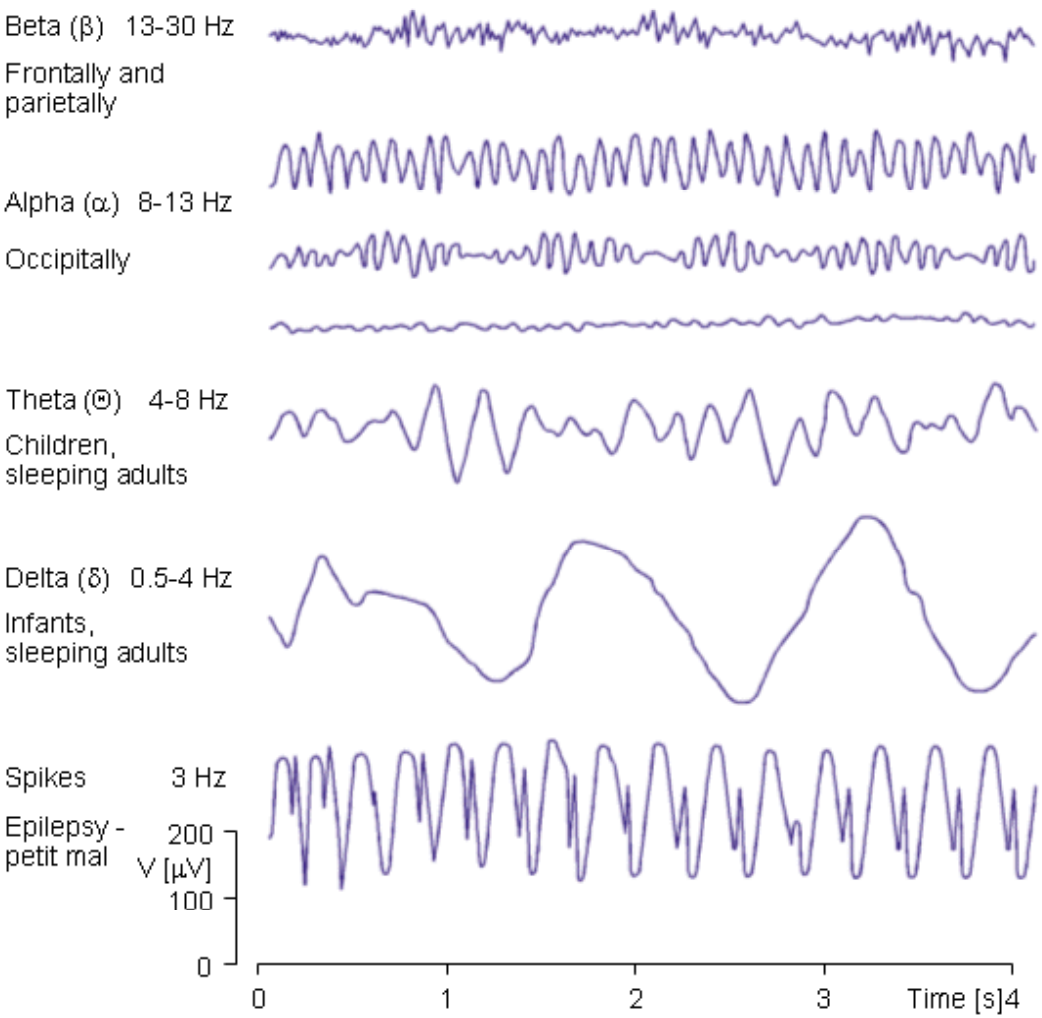
From JJ Carr, Introduction to Biomedical Equipment Technology, Prentice-Hall, 1998.

Electroencephalogram (EEG)

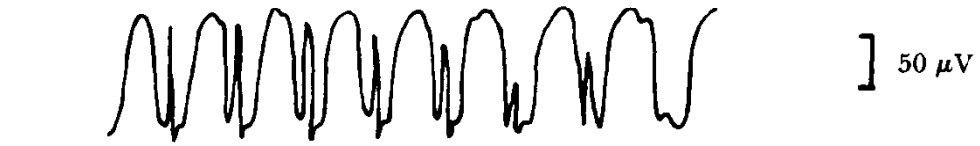


M. Bear *et al*, Neuroscience: exploring the brain, Lippincott Williams & Wilkins, 2001.

Electroencephalogram (EEG) rhythms

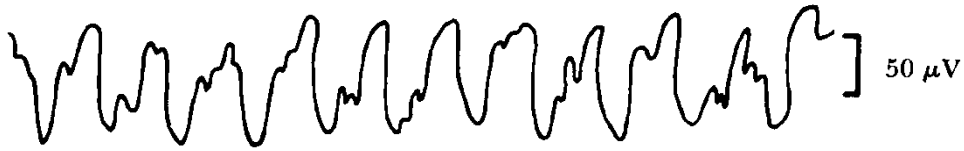


EEG spikes or abnormal waveform in epilepsy



Petit mal

Grand mal epilepsy



Psychomotor

(c)

Figure 4.27 *(Continued)*

John G. Webster, Medical Instrumentation, application and design, 3rd Ed., Houghton Mifflin, 2000.

EEG changes in sleep

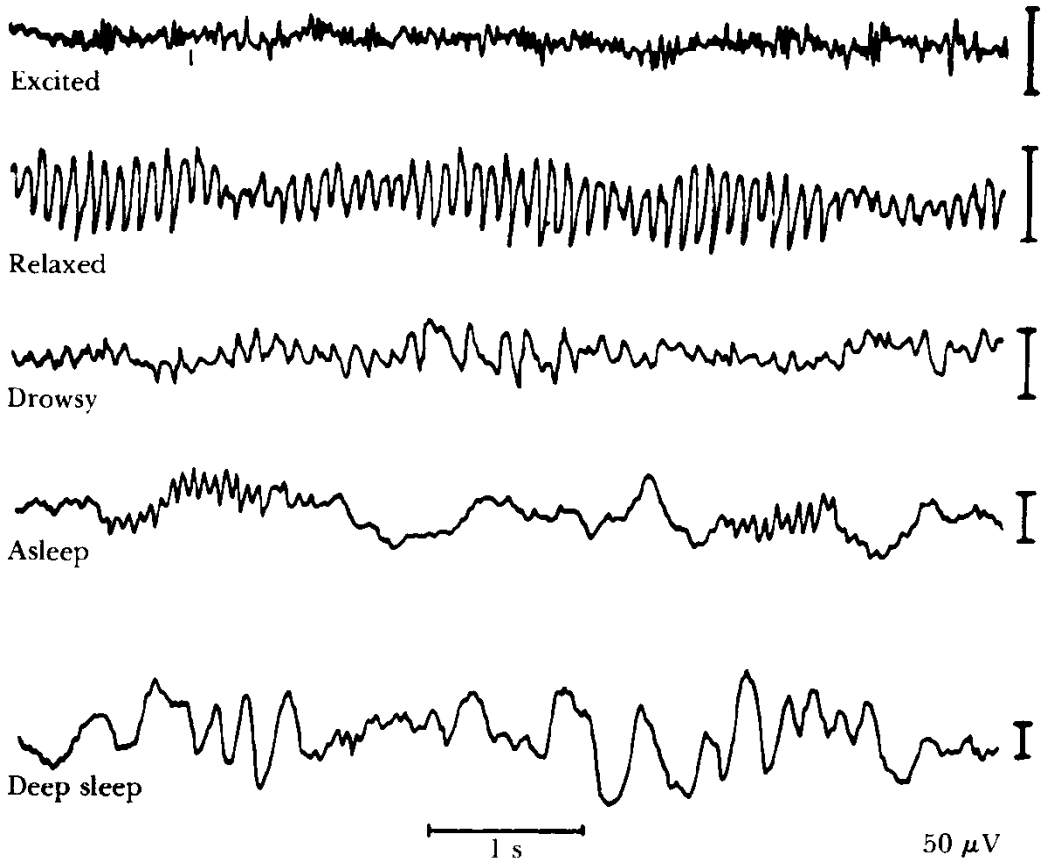
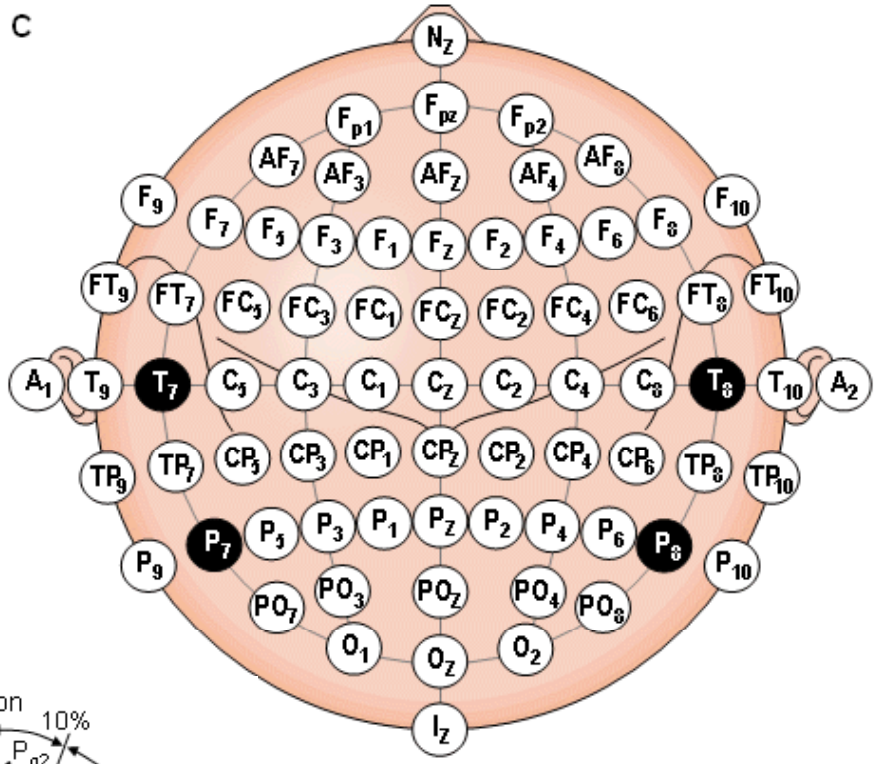
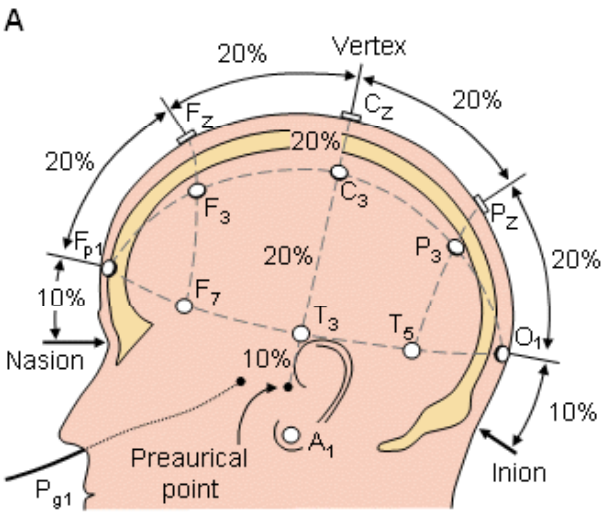
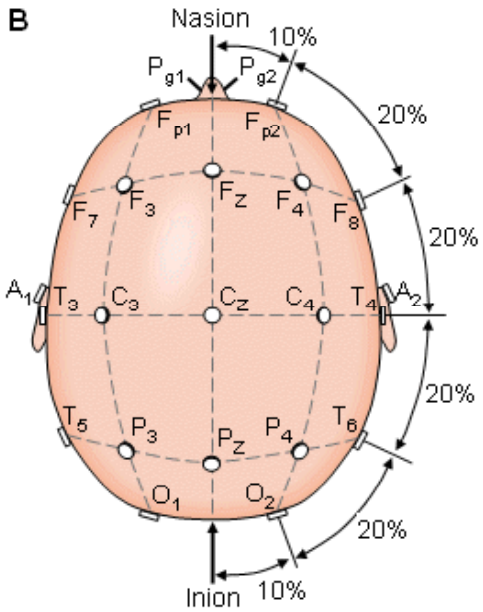


Figure 4.29 The electroencephalographic changes that occur as a human subject goes to sleep The calibration marks on the right represent 50 μV. (From H. H. Japser, "Electrocephalography," in *Epilepsy and Cerebral Localization,* edited by W. G. Penfield and T. C. Erickson. Springfield, Ill.: Charles C. Thomas, 1941.)

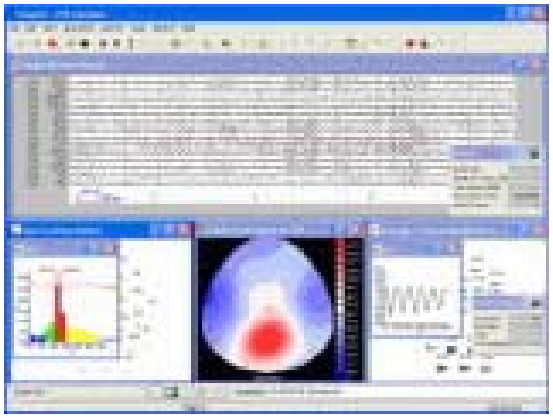
EEG electrode placement

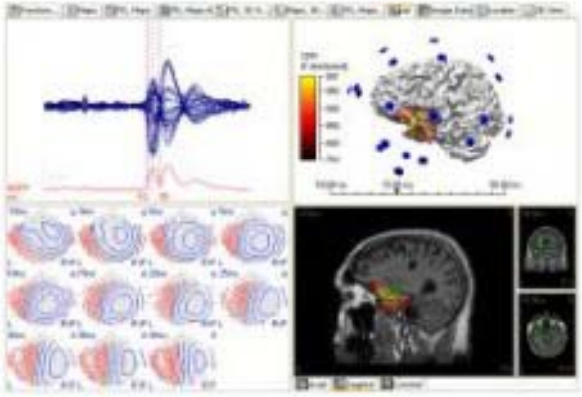




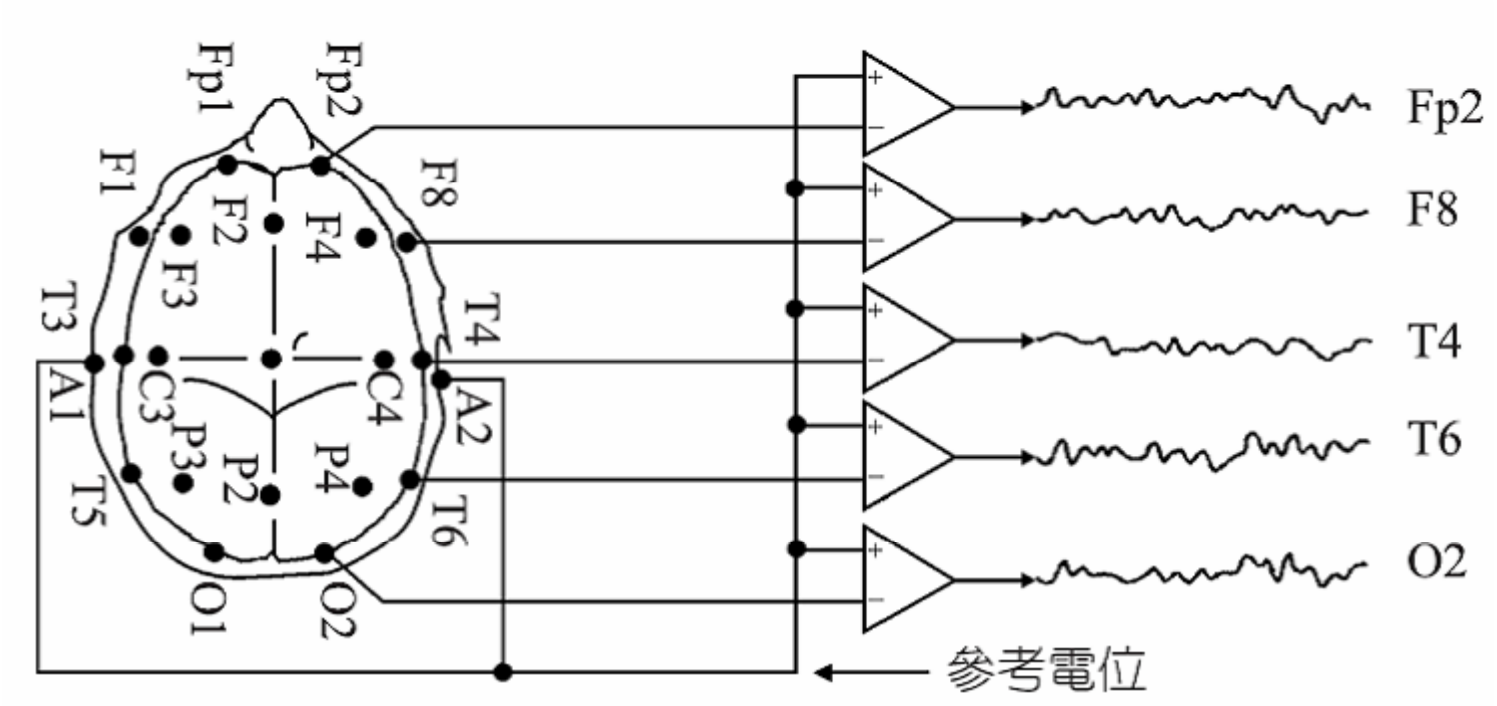


Multichannel EEG recodeings: Neuroscan™

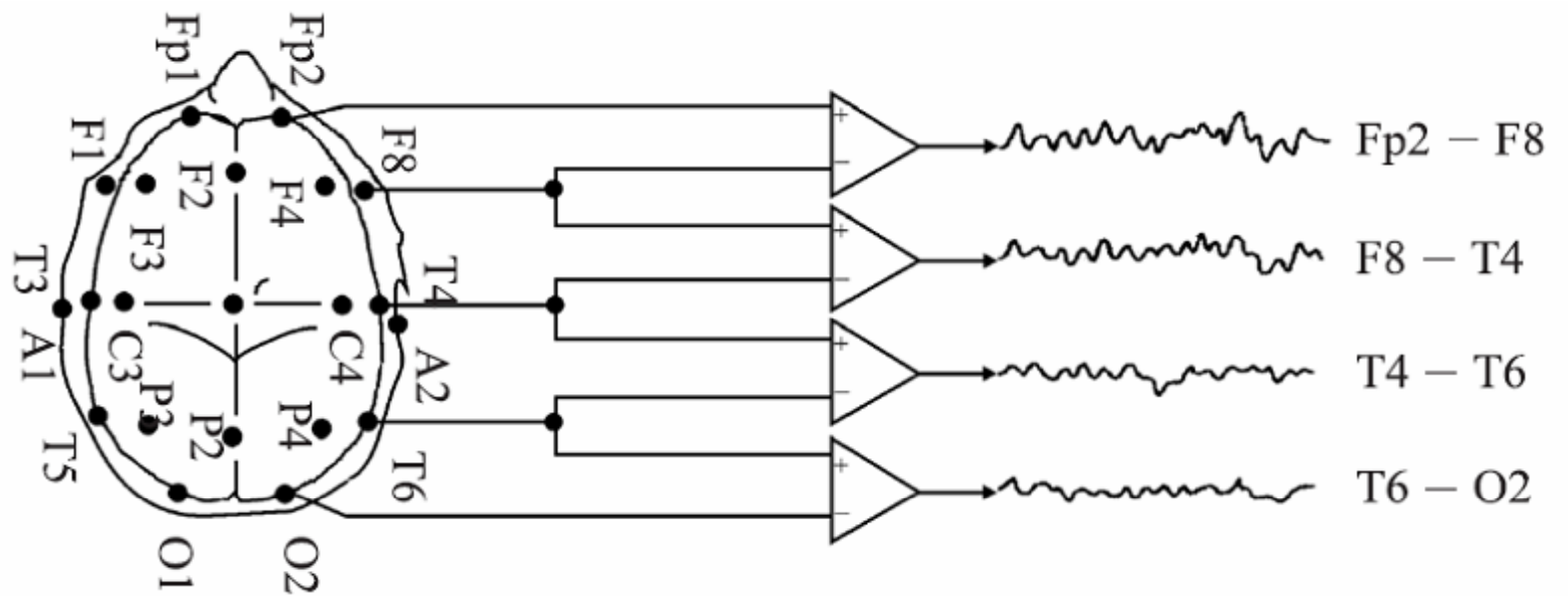




Monopolar measurements

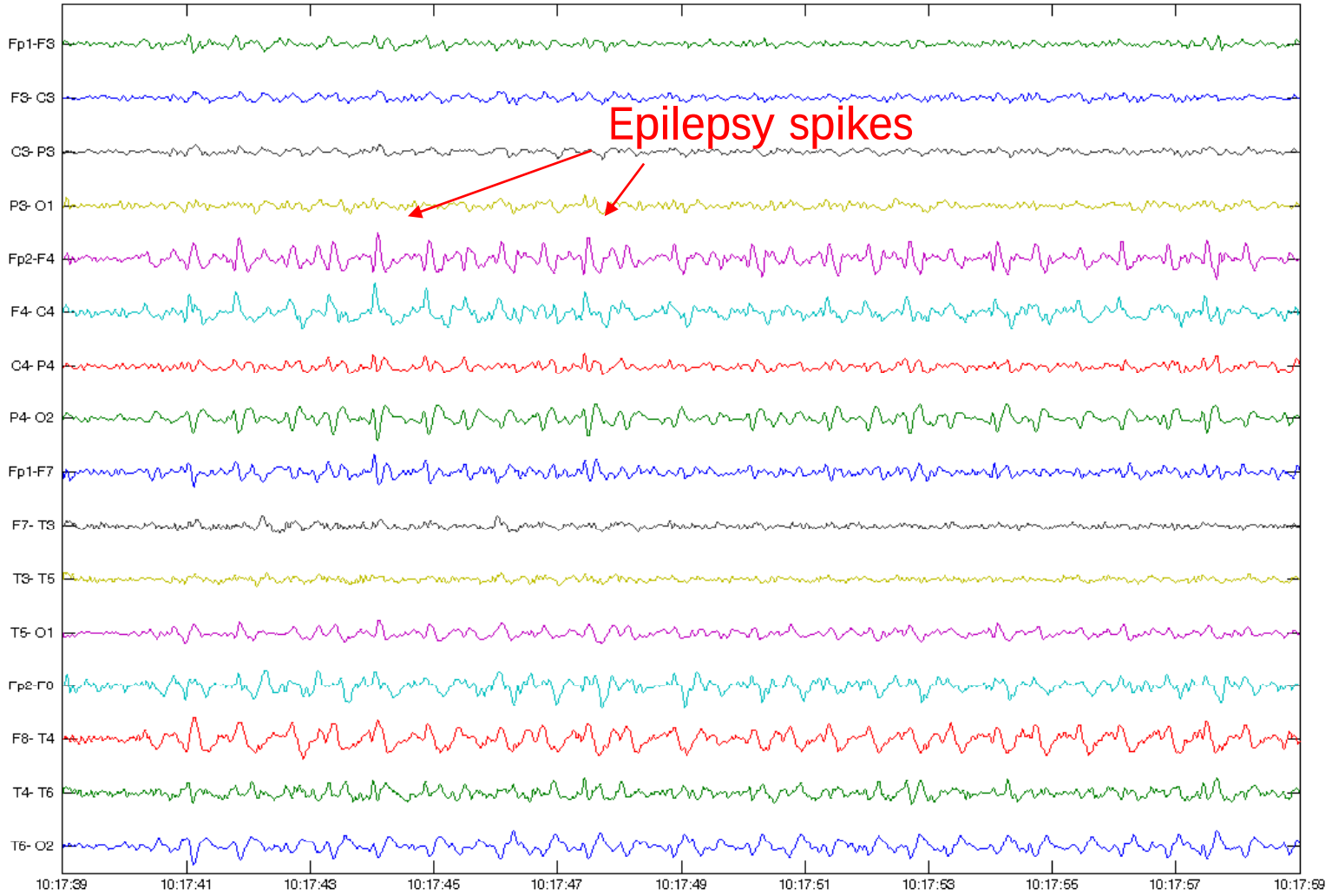


Bipolar measuremesnts



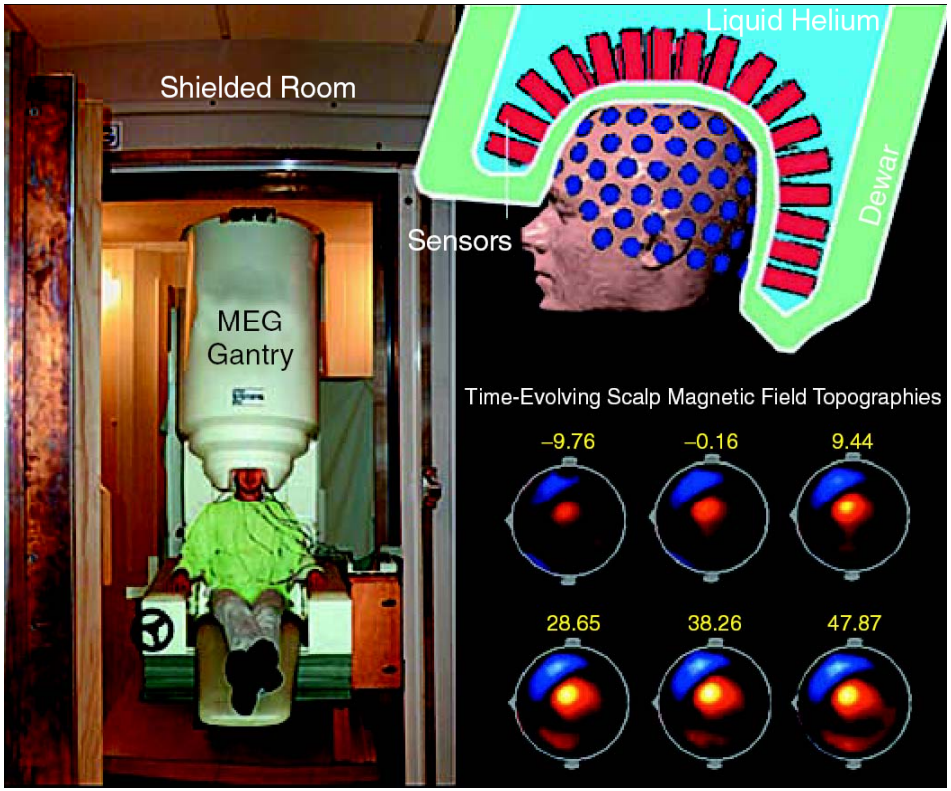
Monopolar montage

Bipolar montage




Blink artifact
Fp1-F3
F3- C3
C3- P3
P3- O1
Fp2-F4
F4- C4
C4- P4
P4- O2
Fp1-F7
F7- T3
T3- T5
T5- O1
Fp2-F8
F8- T4
T4- T6
T6- O2
10: 9:12
10: 9:14
10: 9:16
10: 9:18
10: 9:20
10: 9:22
10: 9:24
10: 9:26
10: 9:28
10: 9:30
10: 9:32

Megnetoencephalography (MEG)



- Typical scalp magnetic fields are on the order of a 10 billionth of the earth's magnetic field.
- MEG fields are measured inside a magnetically shielded room for protection against higher-frequency electromagnetic perturbations.
- This MEG recording was acquired as the subject moved his finger at time 0. Data indicate early motor preparation prior to the movement onset before peaking at about 20 ms after movement onset.

Sylvain Baillet, Electromagnetic brain mapping, IEEE Signal Processing, 2001

MEG

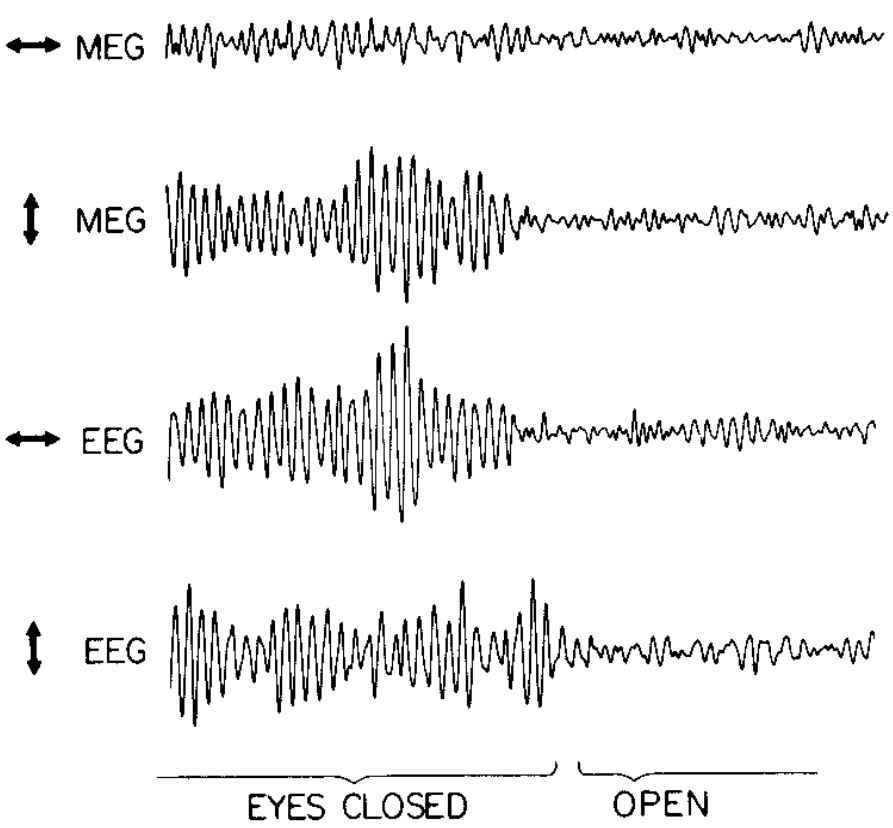
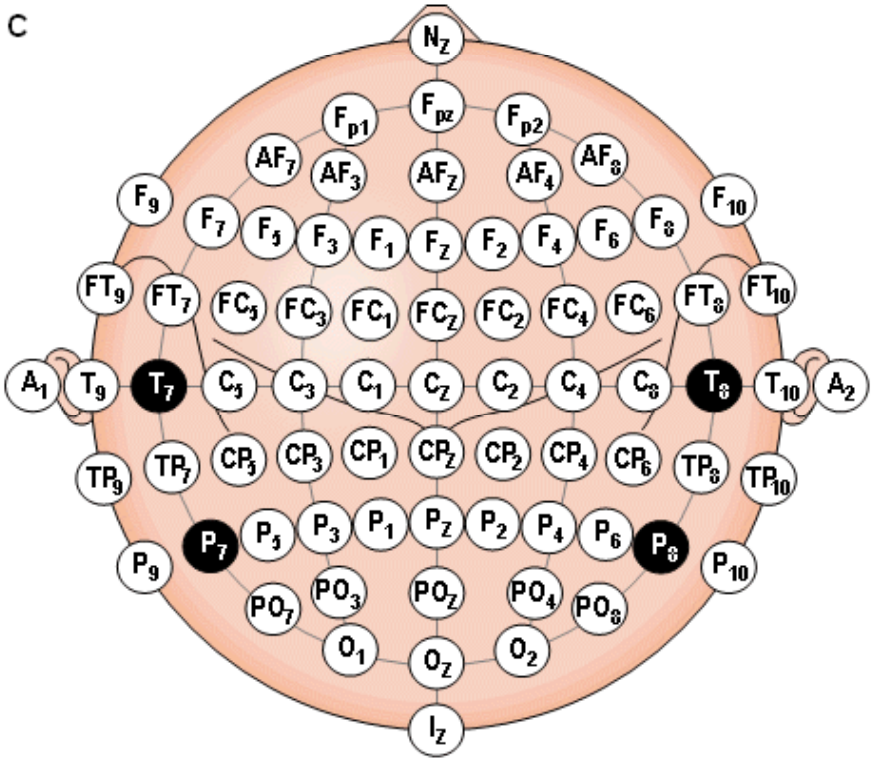


FIGURE 18. Magnetoencephalogram (MEG) with EEG. (From Cohen, D. and Cuffin, B. N., *Electroencephalogr. Clin. Neurophys.*, 56, 1983. With permission.)

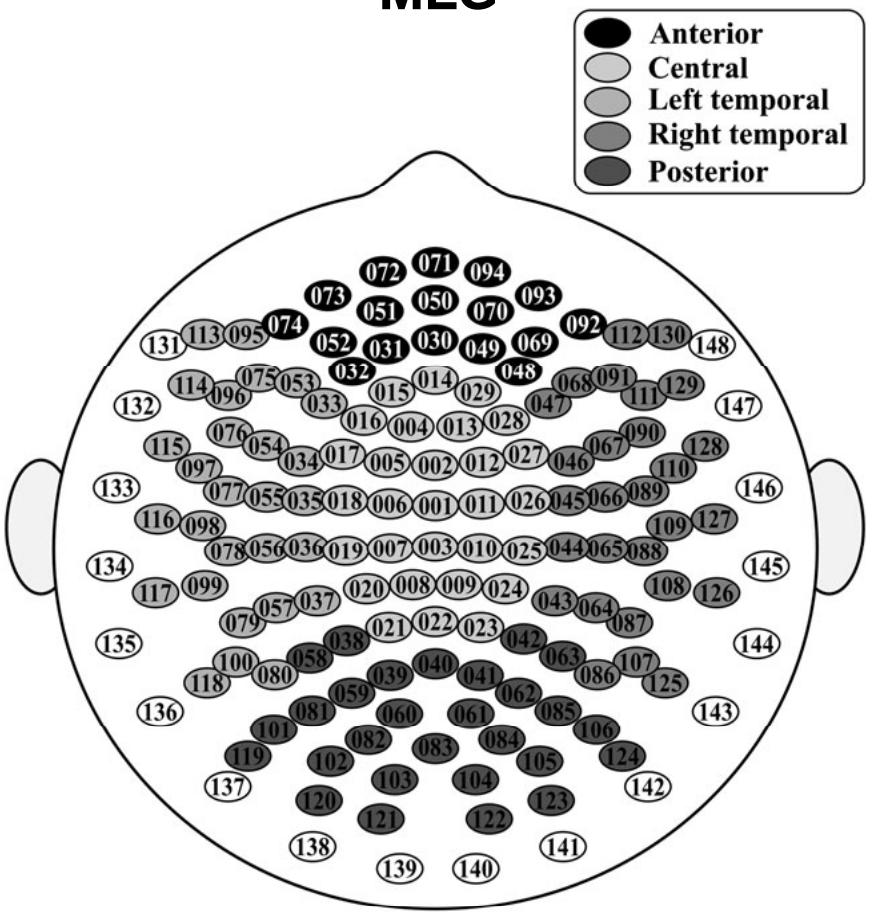
From A.Cohen, Biomedical Signal Processing, CRC Press, 1986.

Sensor placement

EEG

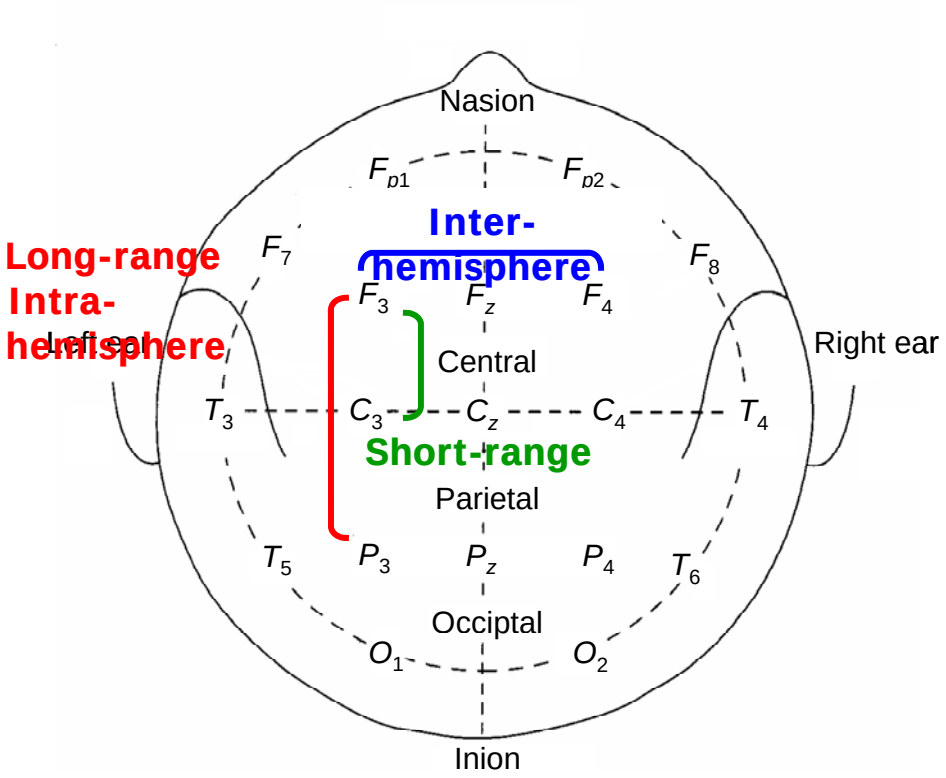


MEG

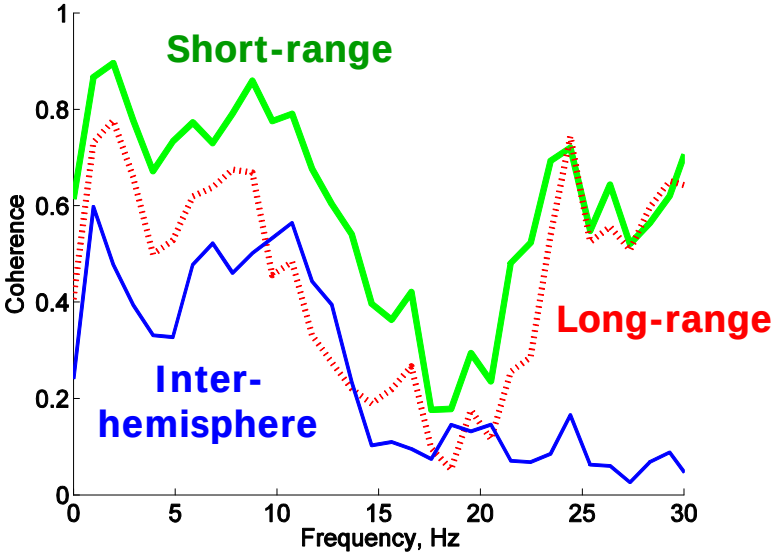


Magnitude squared coherence (MSC)

- Functional coupling by the normalized cross spectrum at specified frequencies between brain regions

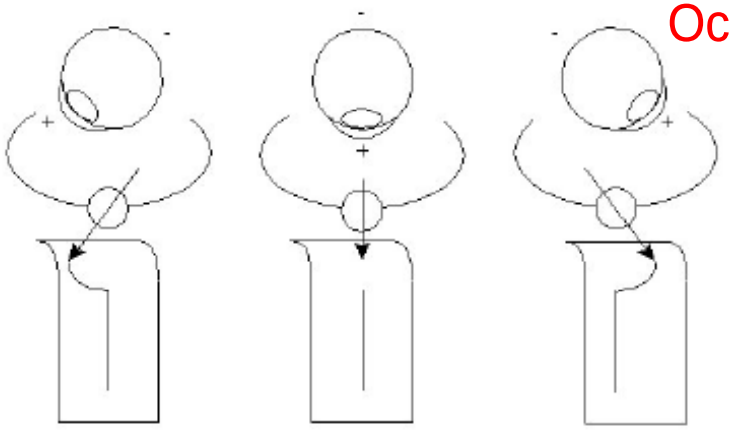


$$c_{xy}(f) = \frac{|X(f)Y^*(f)|^2}{|X(f)|^2|Y(f)|^2}$$

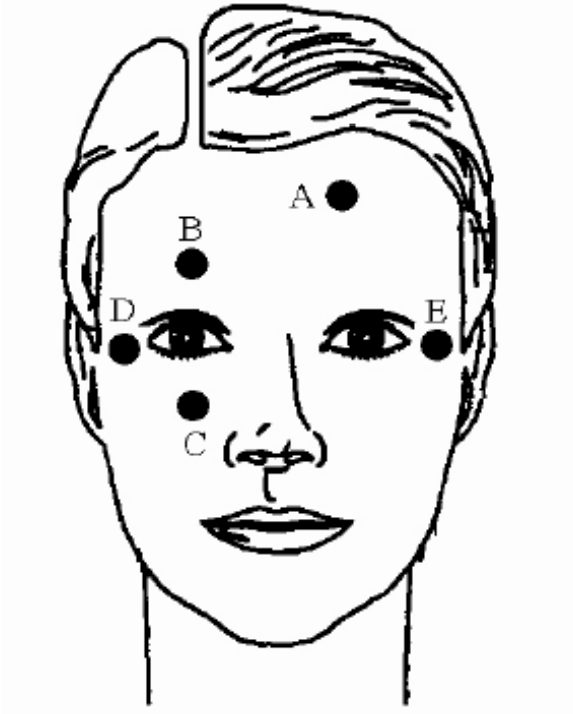


Electrooculogram (EOG)

Ocular dipole



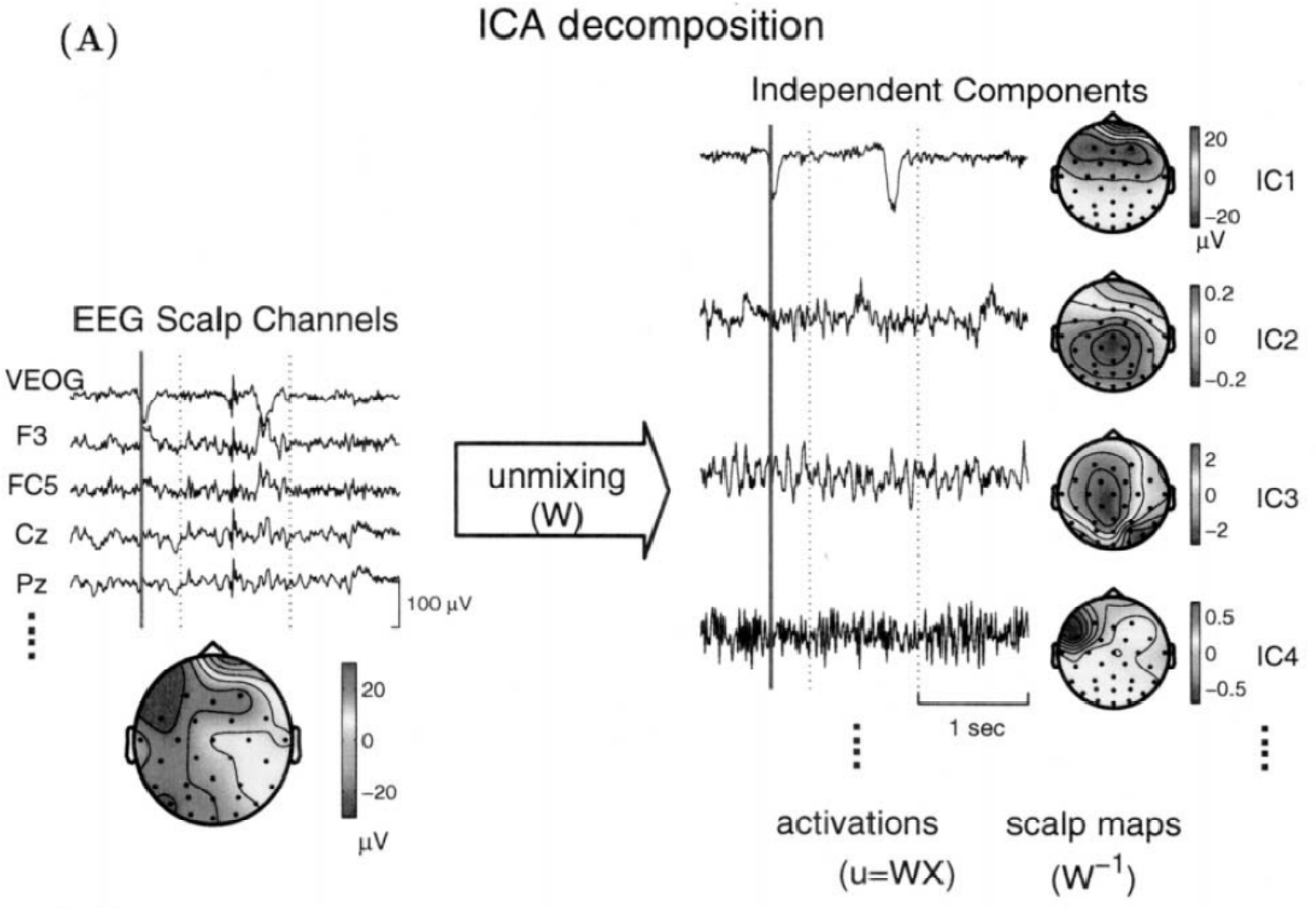
(a)



(b)

R. Berea et al, IEEE Trans. Neural Sys. Rehab Eng. 2002.

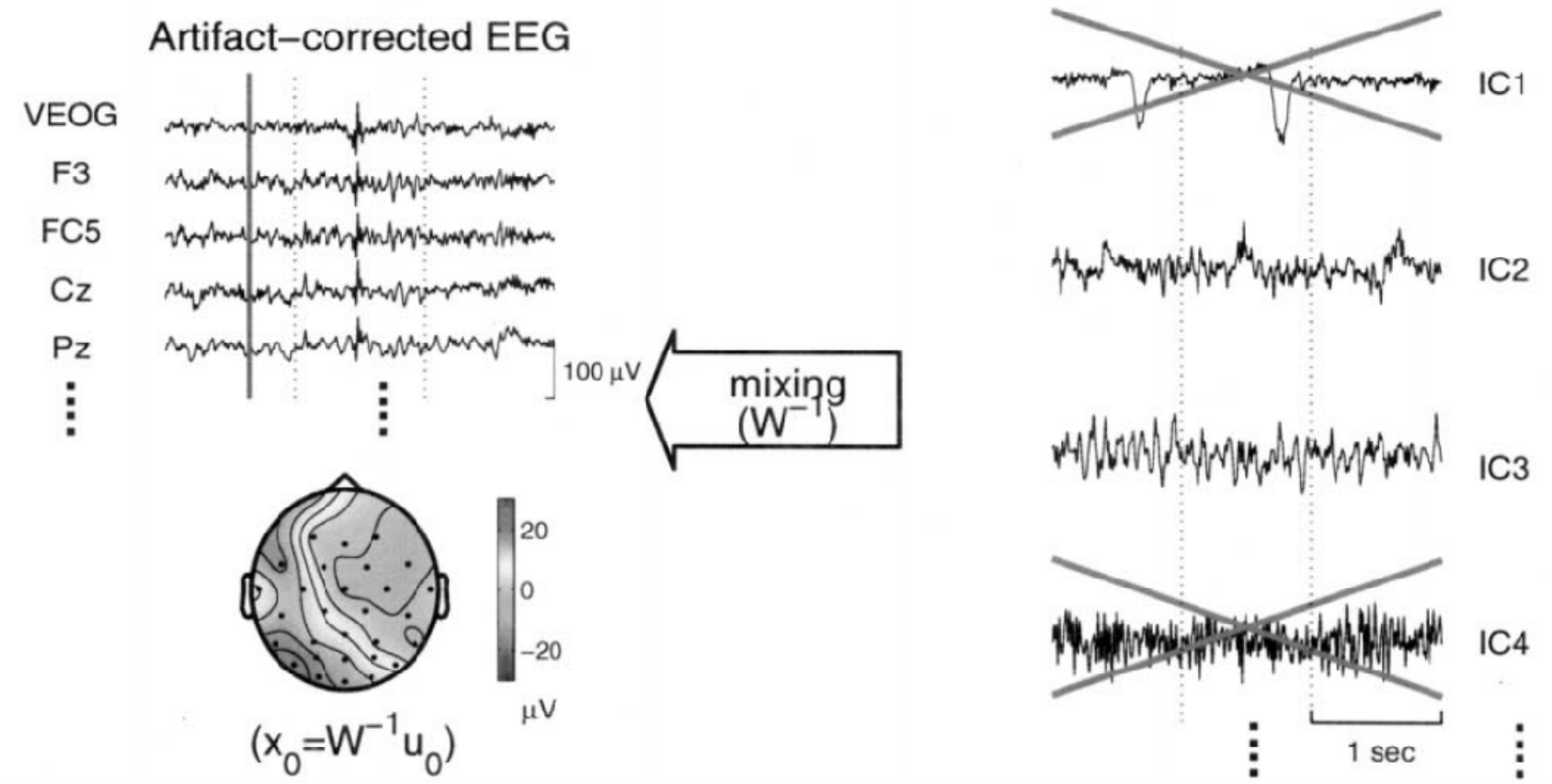
Independent component analysis (ICA)



T.P. Jung et al, Clinical Neurophysiology, 2000

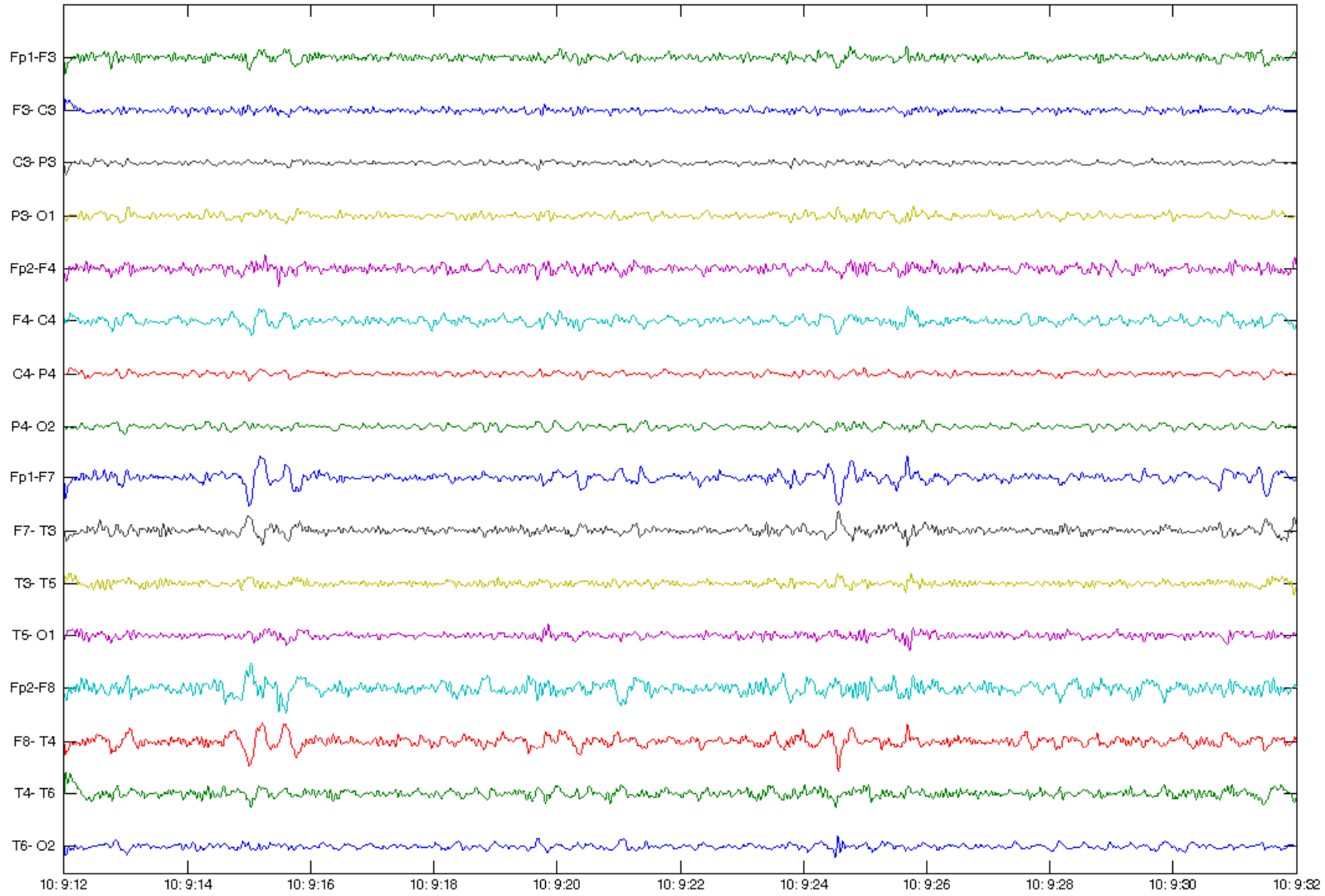
(B)

Summed Projection of Selectrd Components

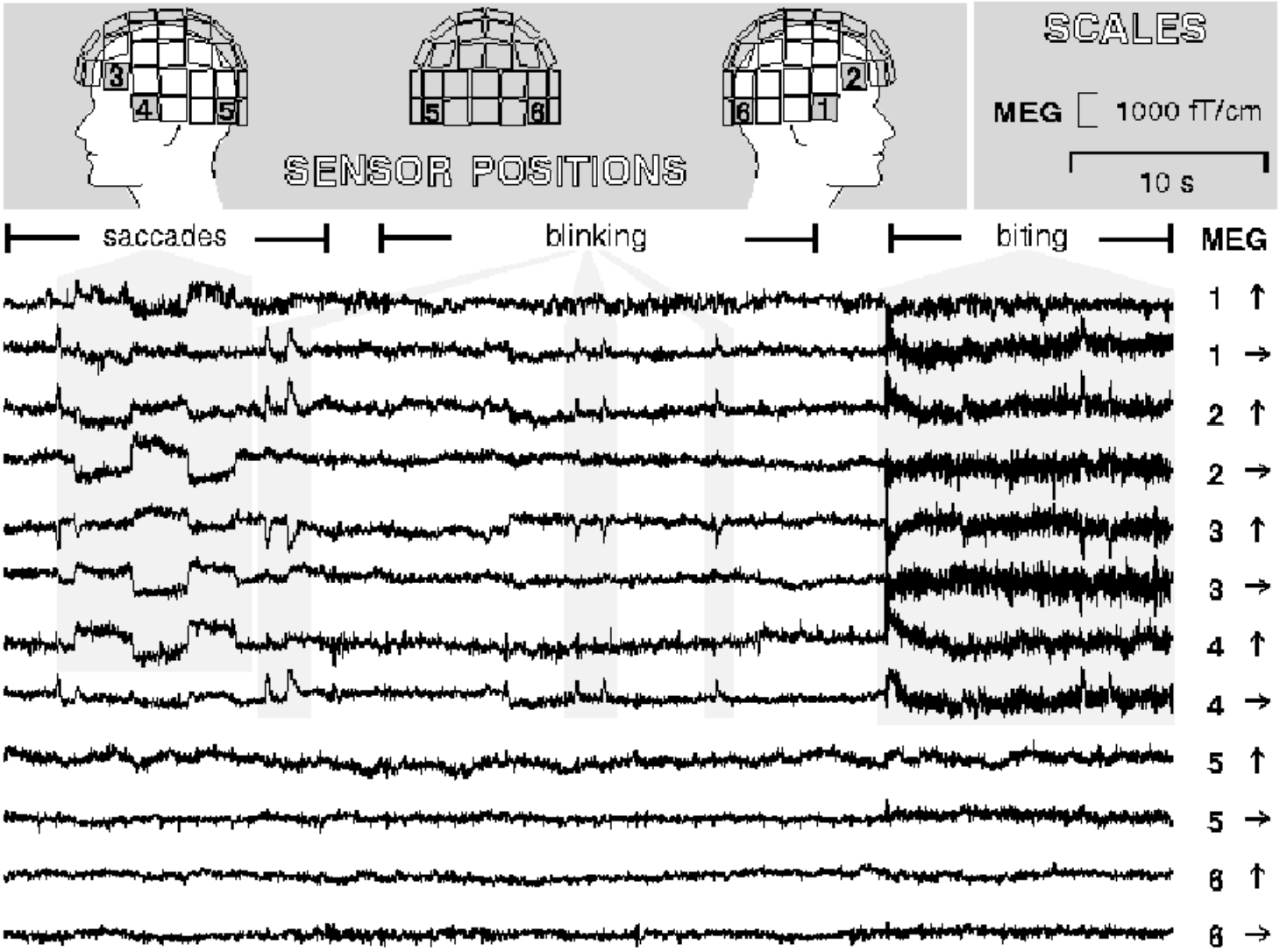


T.P. Jung et al, Clinical Neurophysiology, 2000

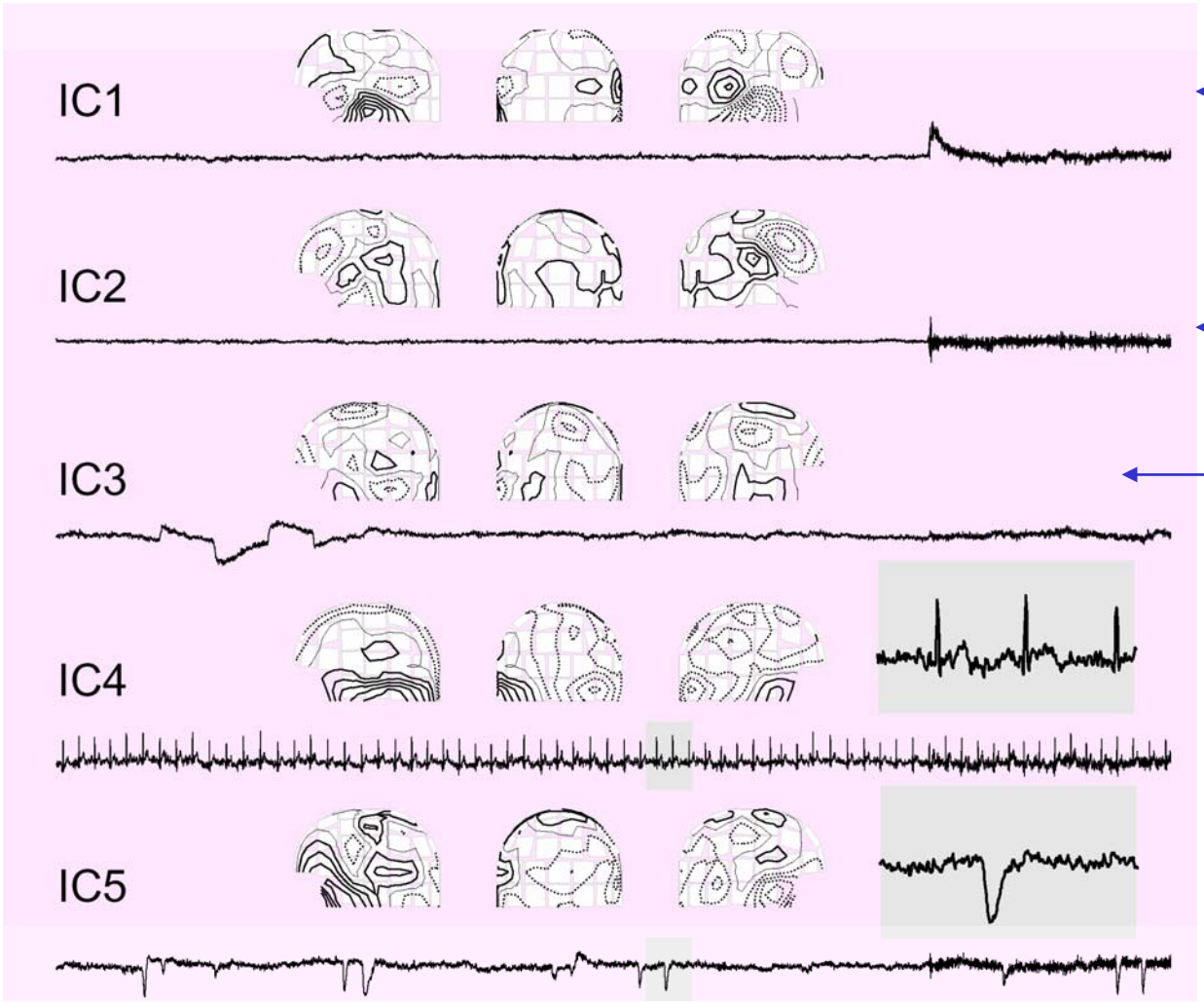
After blind source separation



12 spontantaneous MEG



Independent Components Extracted from MEG

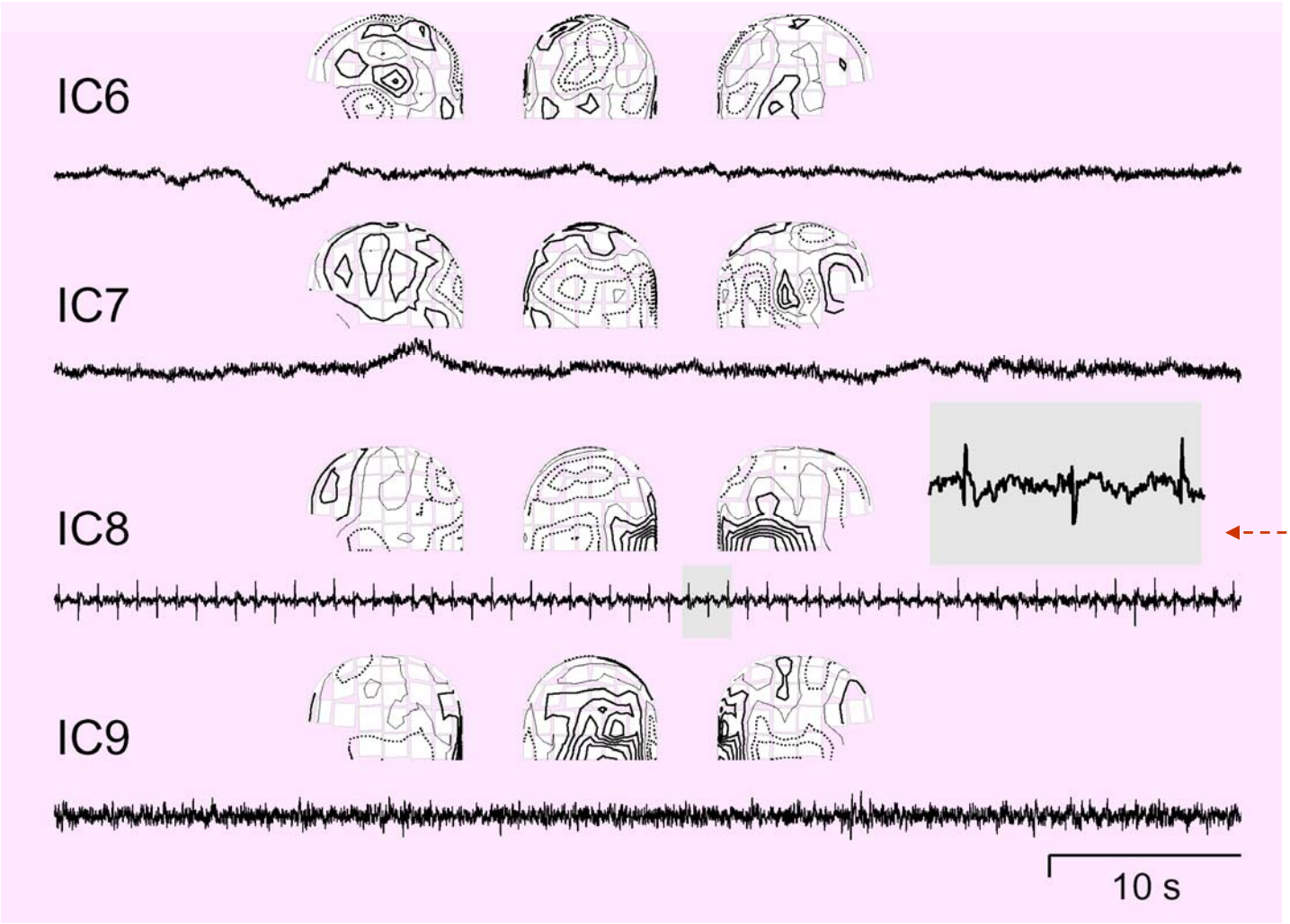


Activation of two different muscles

horizontal eye movements and blinks

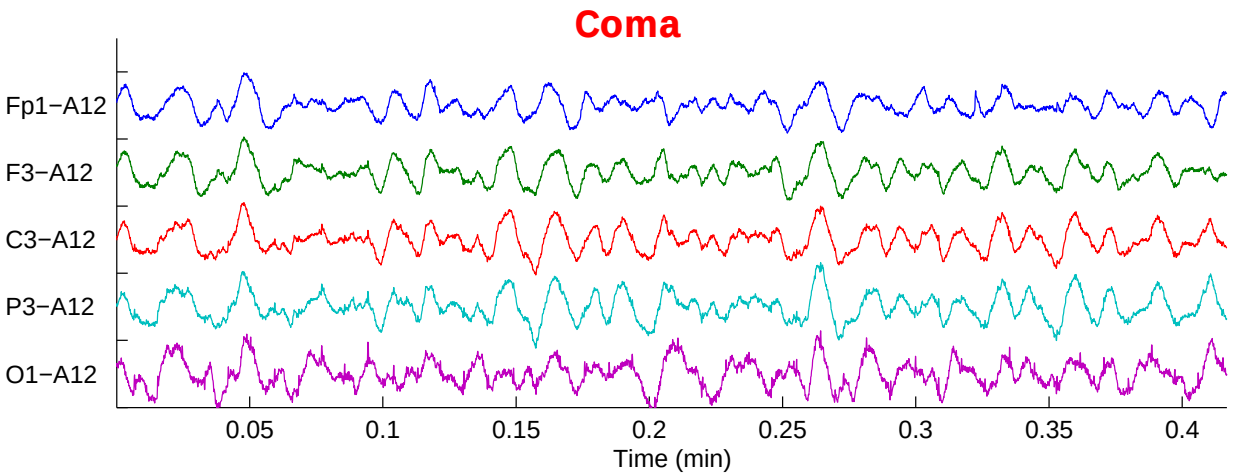
Disturbance due to heartbeat

Independent Components Extracted from MEG

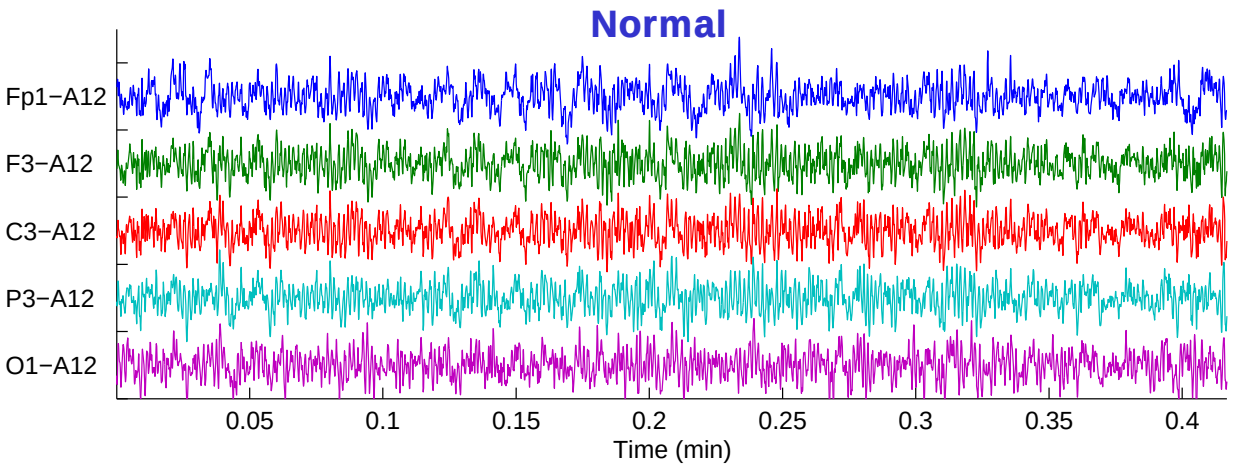


Disturbance due to digital watch

Brain waves in coma

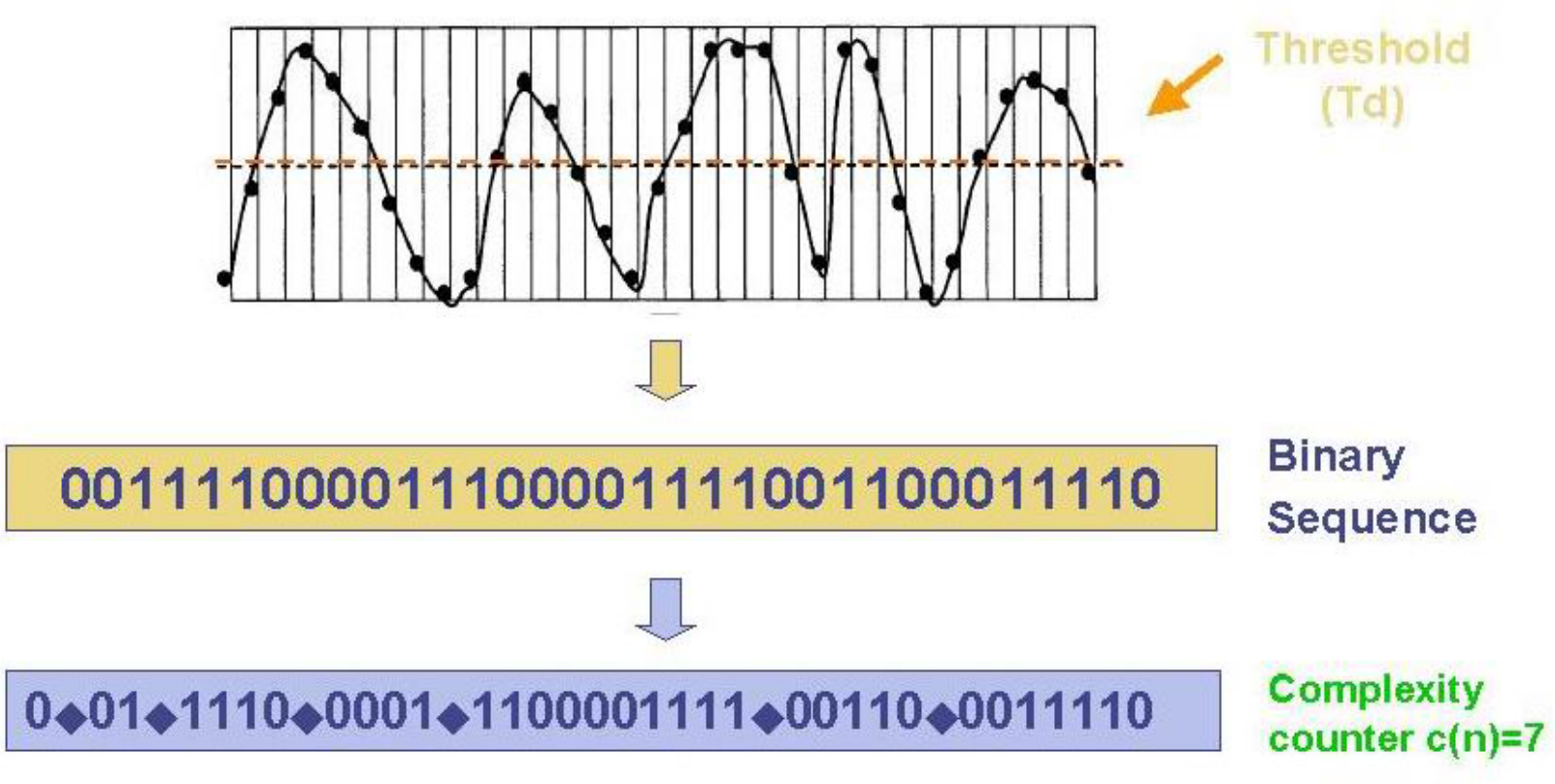


Slow wave

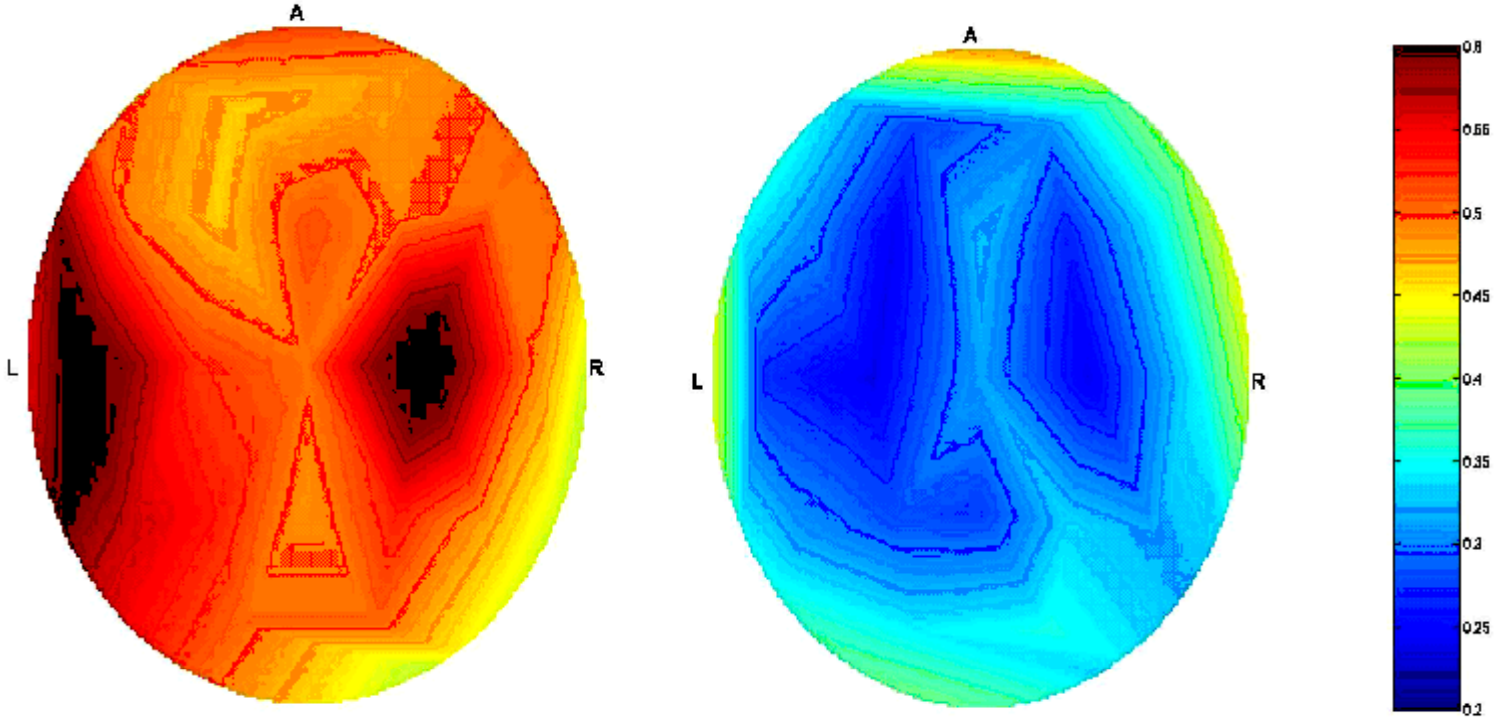


Fast and more complex waveshape

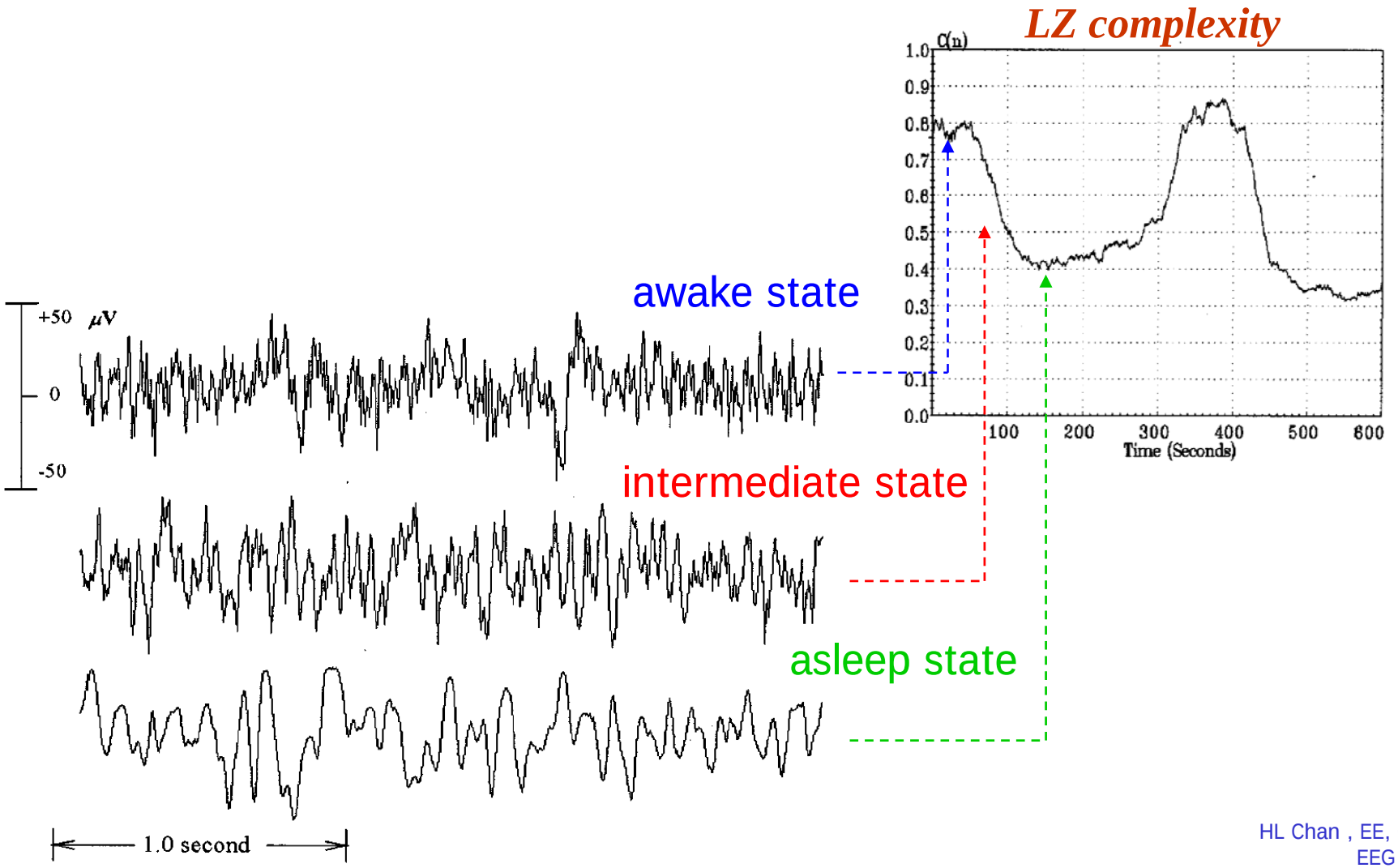
Lempel-Ziv complexity



EEG complexity of normal (left) and coma (right)



EEG waveform recorded from one patient under sevoflurane in different states



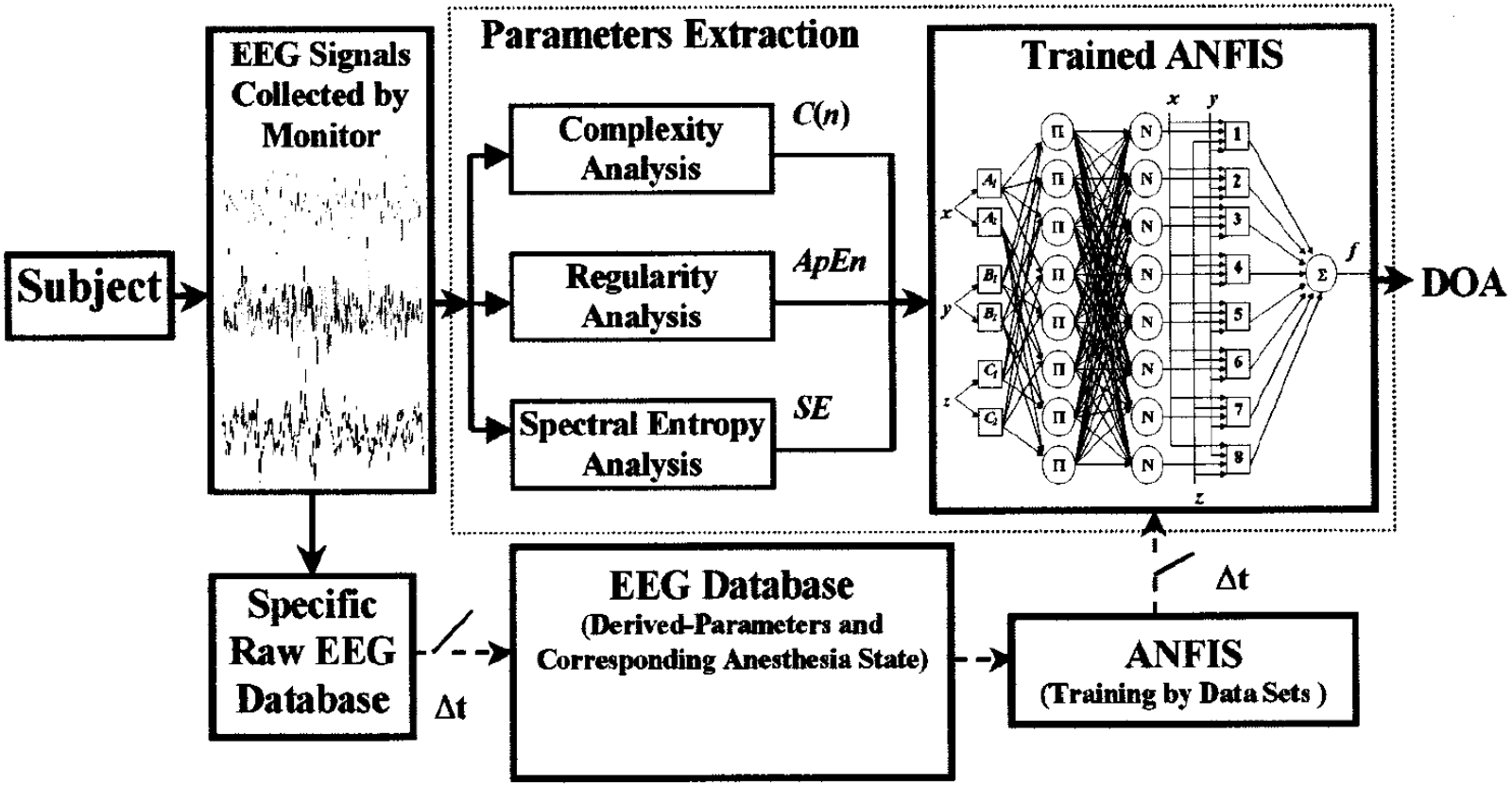
Estimation of depth of anesthesia by EEG/AEP

EEG monitoring

Audio evoked potential monitoring

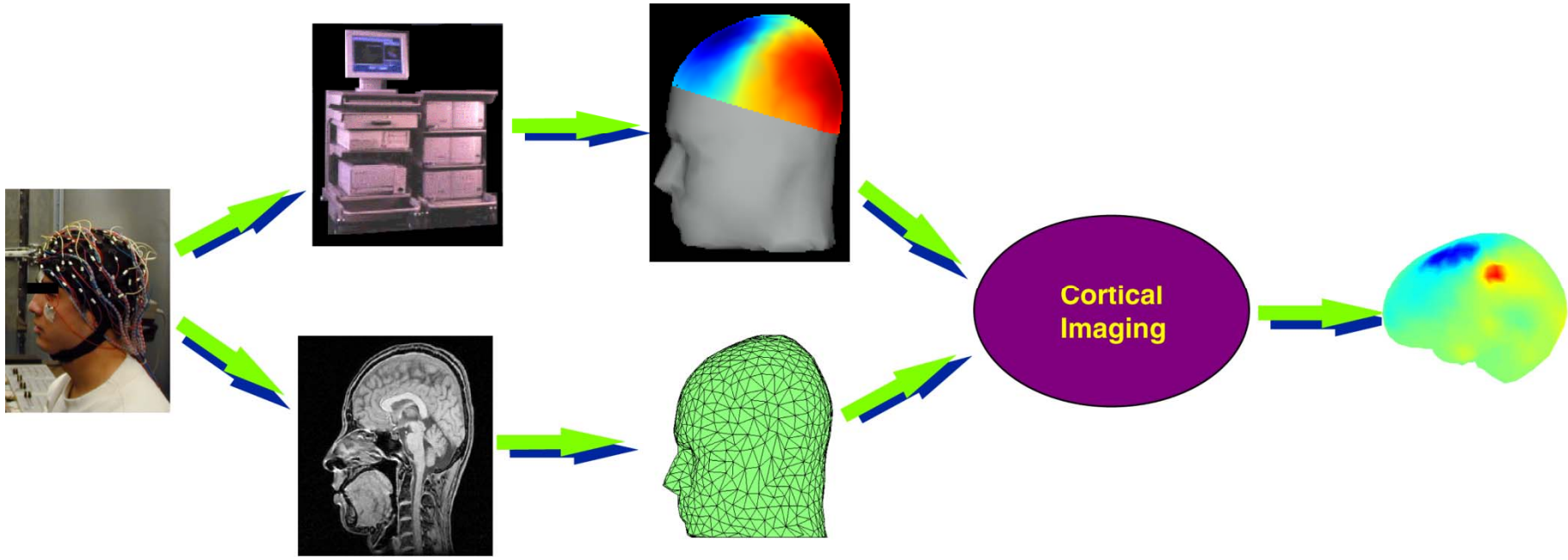
http://www.danmeter.dk/

Estimating depth of anesthesia based on neuro fuzzy model (XS Zhang, IEEE Trans. BME,2001)



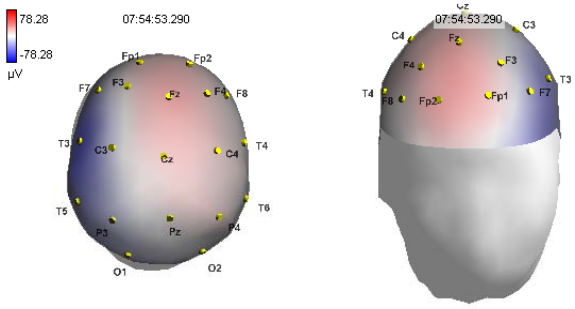
Two-dimensional cortical imaging

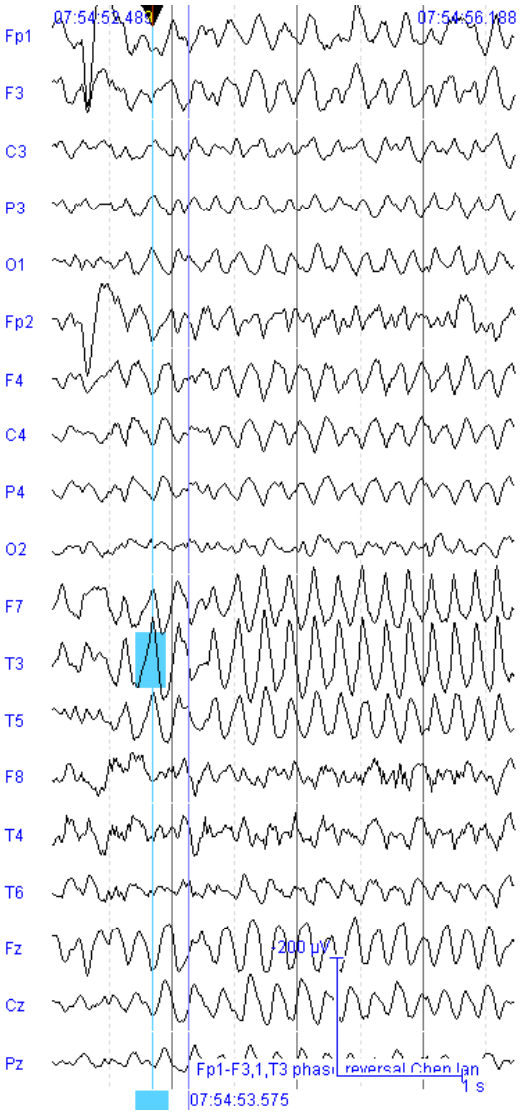
- Employs a distributed source model, in which equivalent sources are distributed in 2D cortical surface



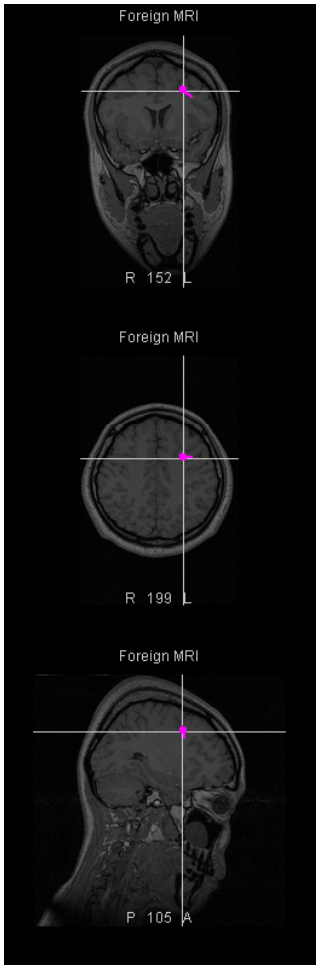
Bin He, Neural engineering, Kluwer Academic, 2005.

Source localization of epilleptic spike (Figure provided by Dr. Yu-Tai Tsai)

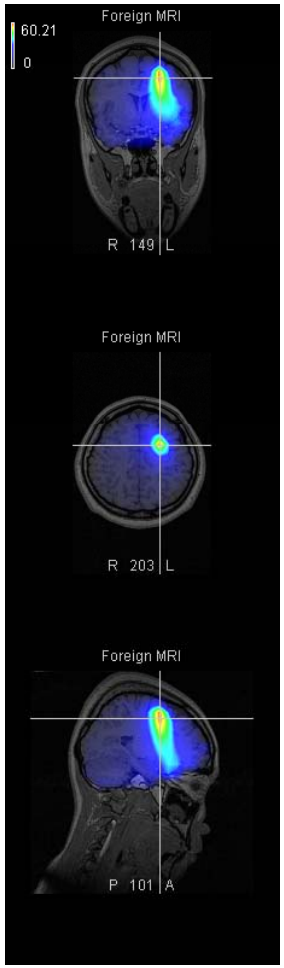




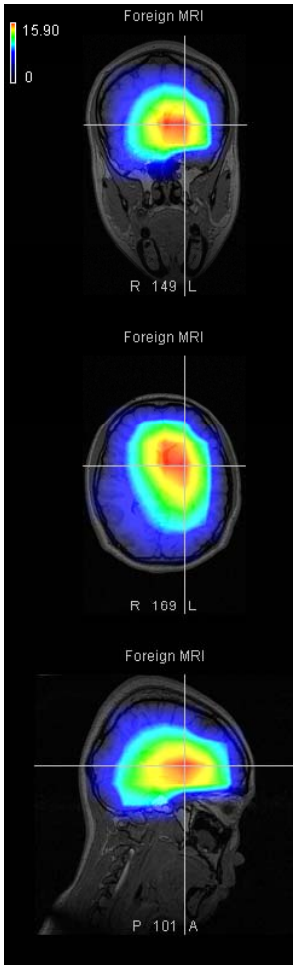
Single Dipole Fit



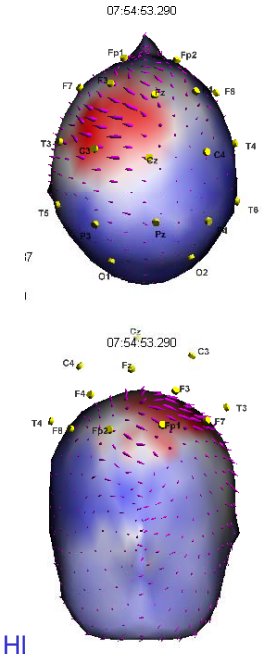
MUSIC



LORETA



Cortical Imaging



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