ΜΕΤΑΠΤΥΧΙΑΚΟ ΠΡΟΓΡΑΜΜΑ : "ΕΦΑΡΜΟΣΜΕΝΗ ΝΕΥΡΟΑΝΑΤΟΜΙΑ"

LERNS - LABORATORY FOR EDUCATION & RESEARCH IN NEUROSCIENCE

INTRODUCTION TO ELECTROENCEPHALOGRAPHY

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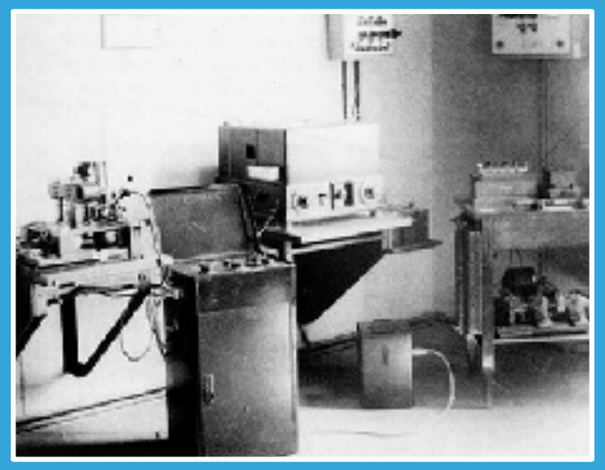
1ST DEPARTMENT OF NEUROLOGY, ATHENS UNIVERISTY

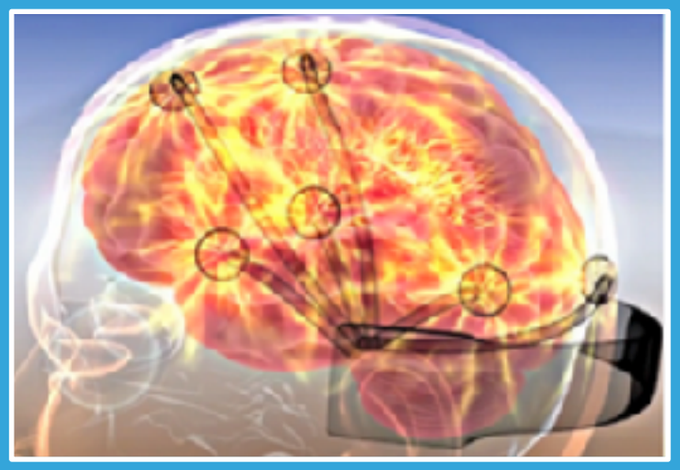
EEG LAB, EGINITION HOSPITAL

OUTLINE

- History
- Electrical fields of the brain
- Techniques of recording (EEG)
- What we try to record and why ?
- Examples of usefulness in clinical practice

HISTORY





Because it matters . . .

The history starts with the demystification

William Gilbert (1554-1603)

"DE MAGNETES", 1600

THE GREAT MAGNET OF THE EARTH AND A NEW PHYSIOLOGY DEMONSTRATED BY MANY ARGUMENTS AND EXPERIMENTS

- He was the private physician of Queen Elisabeth and provided scientific explanations of phenomena which until then were considered mystical and supernatural

and continues scientifically...

Luigi Galvani (1737-1798)

Proves the existence of internal electricity in animals

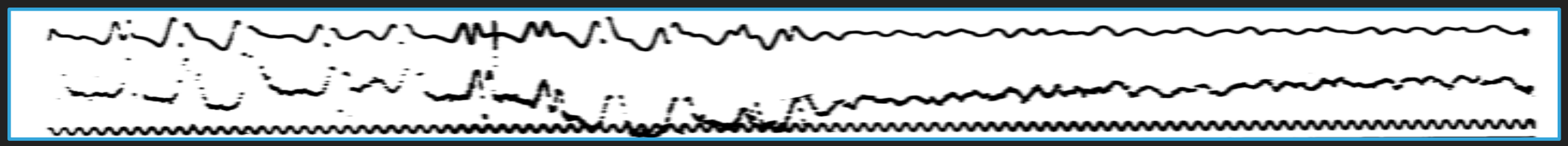
Richard Caton (1842-1926)

Records electricity in animals

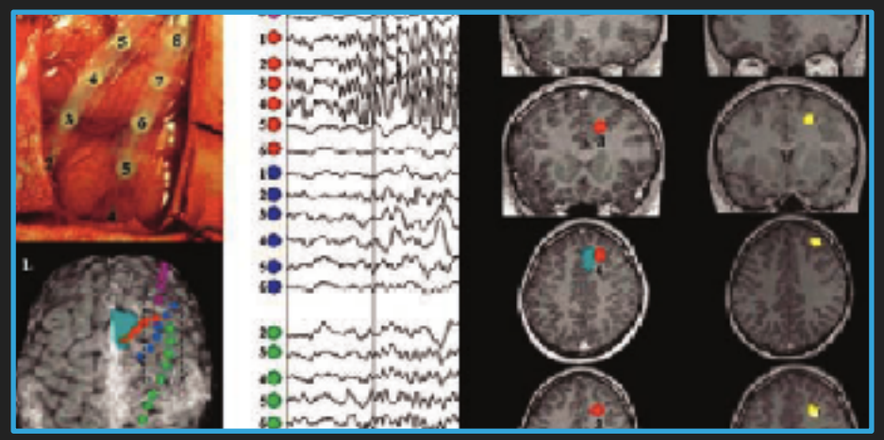
Hans Berger (1873-1941)

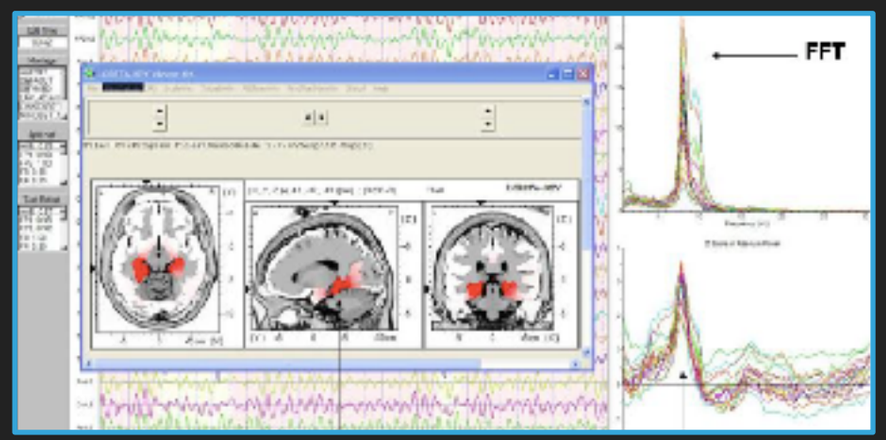
Records electricity in humans

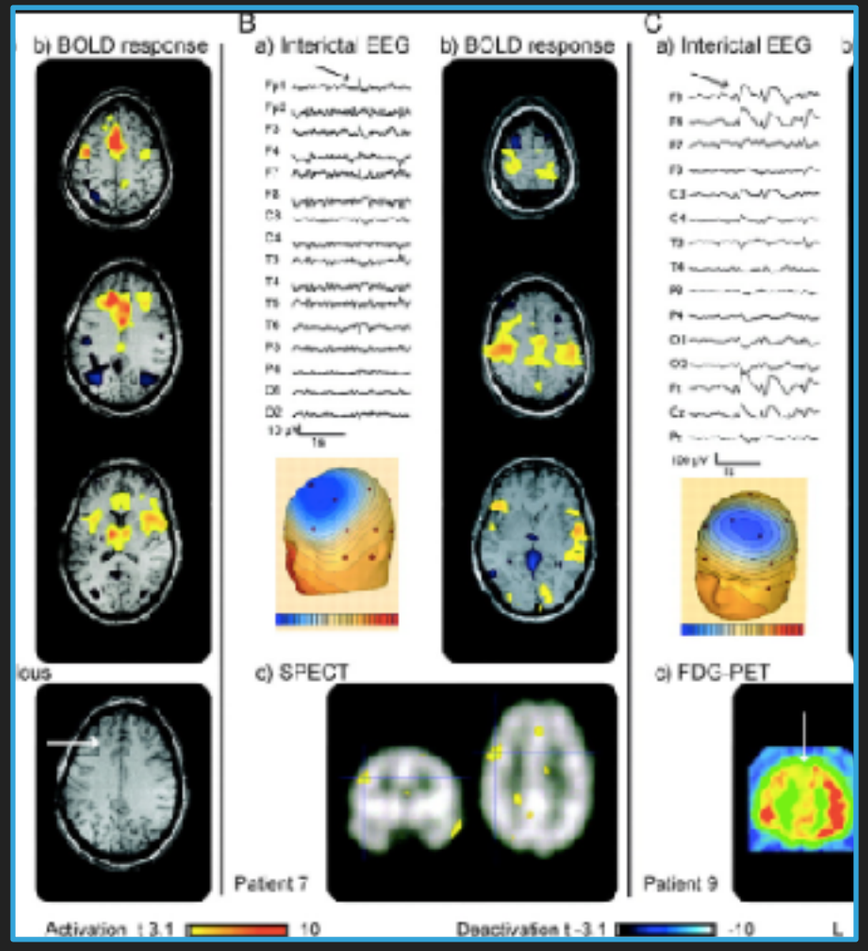
The first human EEG trace

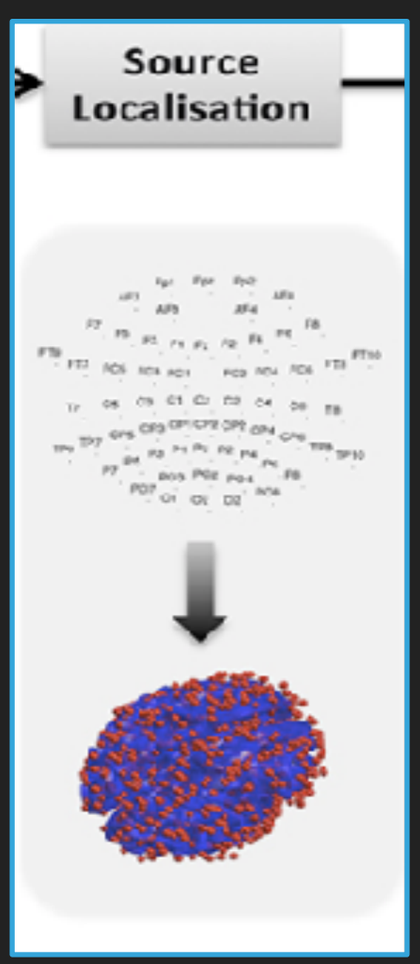


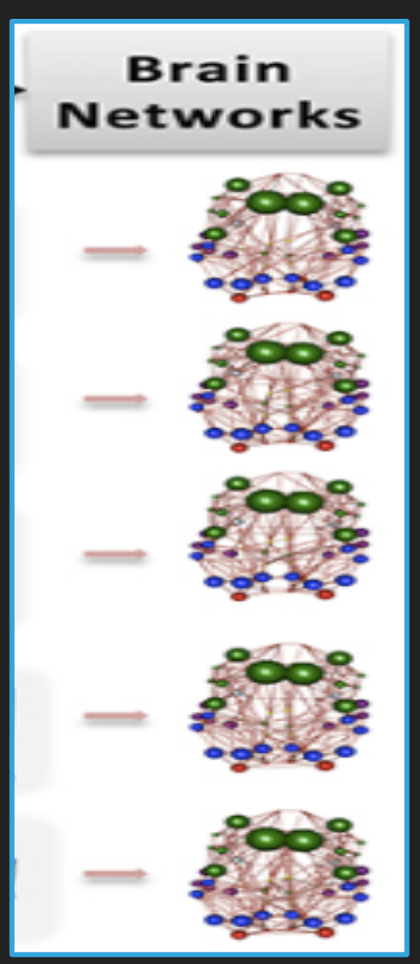
to come up today with more sophisticated techniques



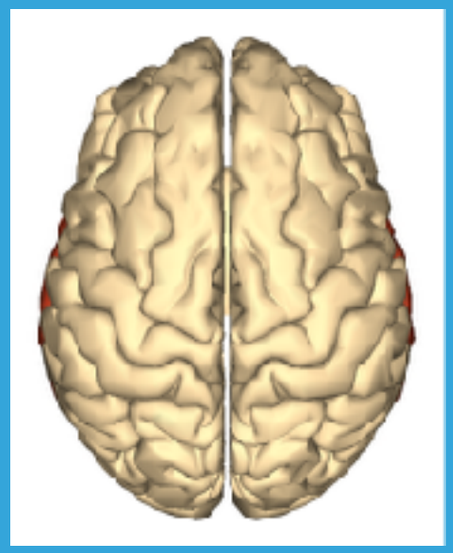








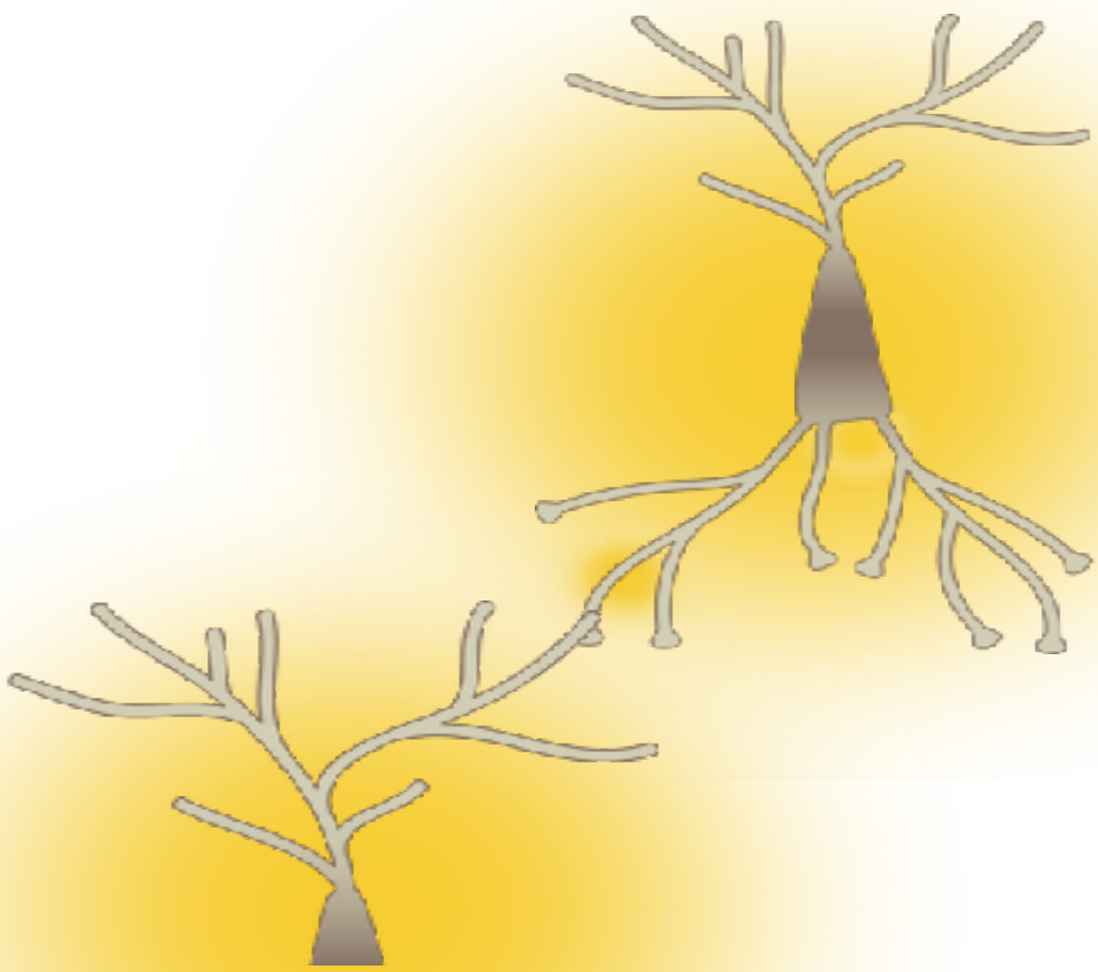
GOING DEEP INTO HUMAN BRAIN

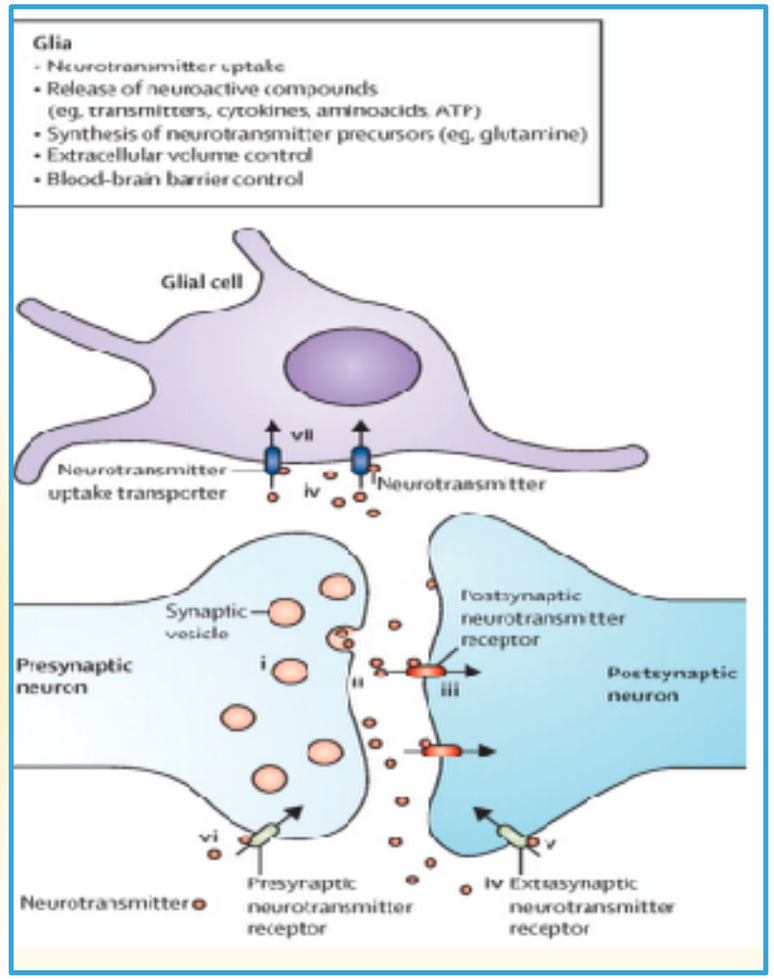


- Billions of neurons need to communicate
- The electrical currents play the main role

To move, to sense, to feel, to think. . .

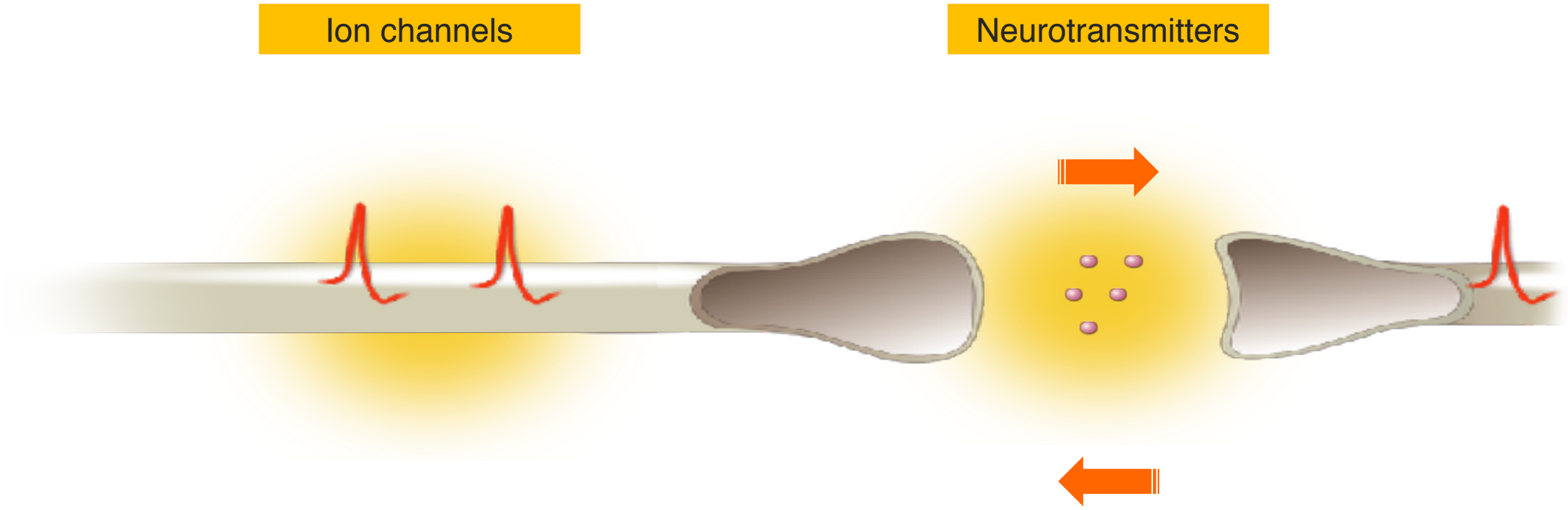
THE SIGNAL TRAVELS WITH ELECTRICAL CURRENTS (IN GENERAL)





Galanopoulou A. Mutations aff ecting GABAergic signalling in seizures and epilepsy. *Pfl ugers Arch 2010*

NEURO TRANSMISSION (IN SPECIFIC)

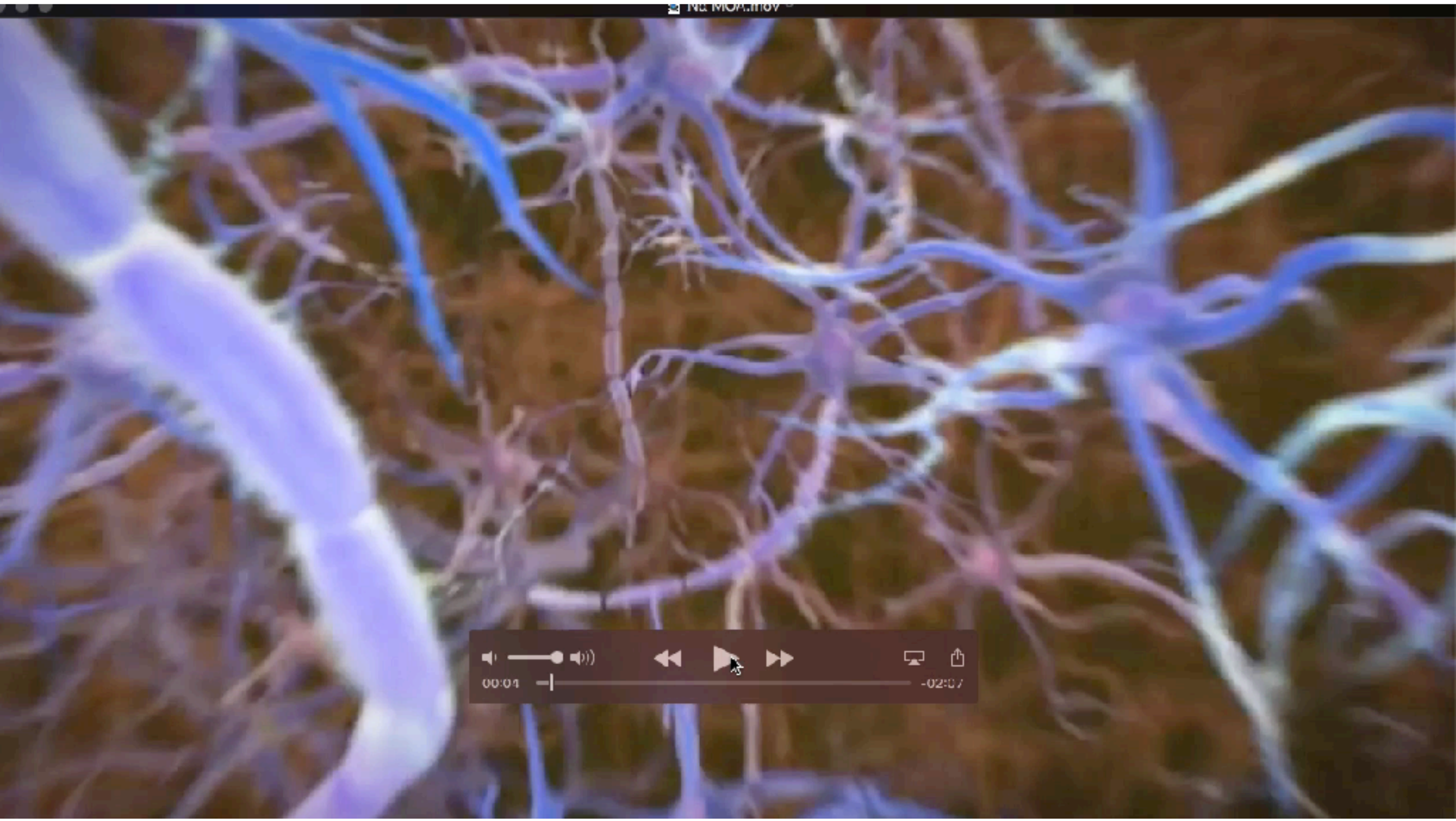


1. Electrical transmission **along** nerve cells

2. Chemical transmission **between** nerve cells

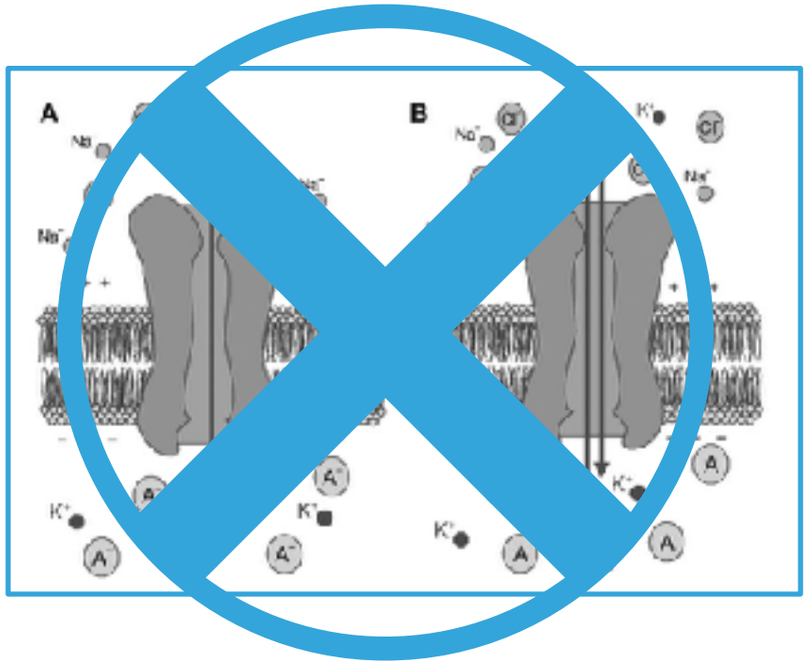
Rang HP *et al. In: Pharmacology*. 1995

NEUROTRANSMISSION



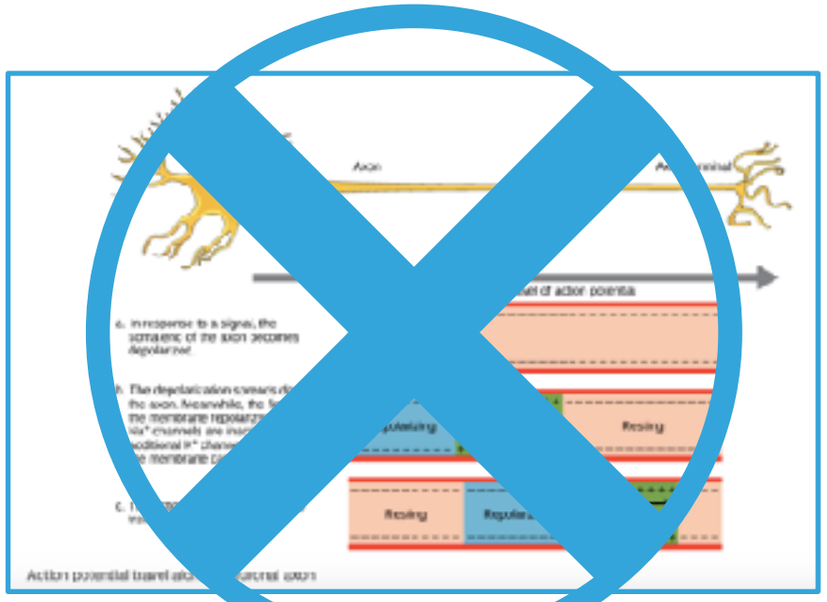
ABILITY TO RECORD IN CELLULAR LEVEL

RESTING POTENTIALS,



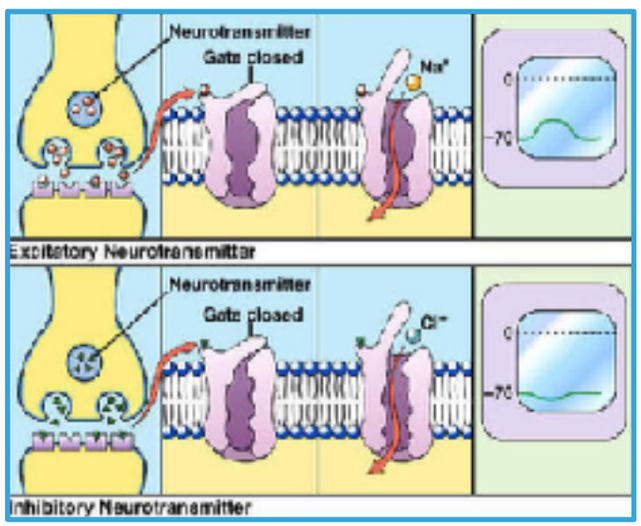
Very small

ACTION POTENTIALS,



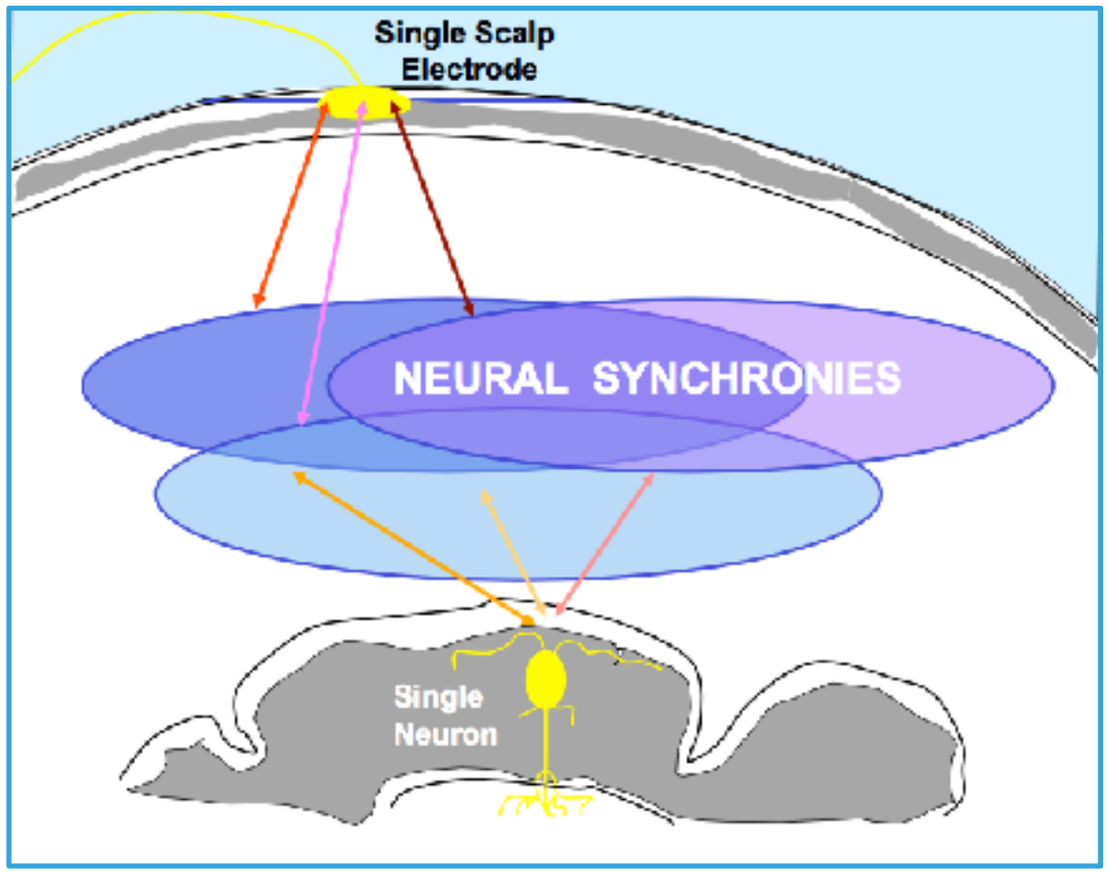
Very short

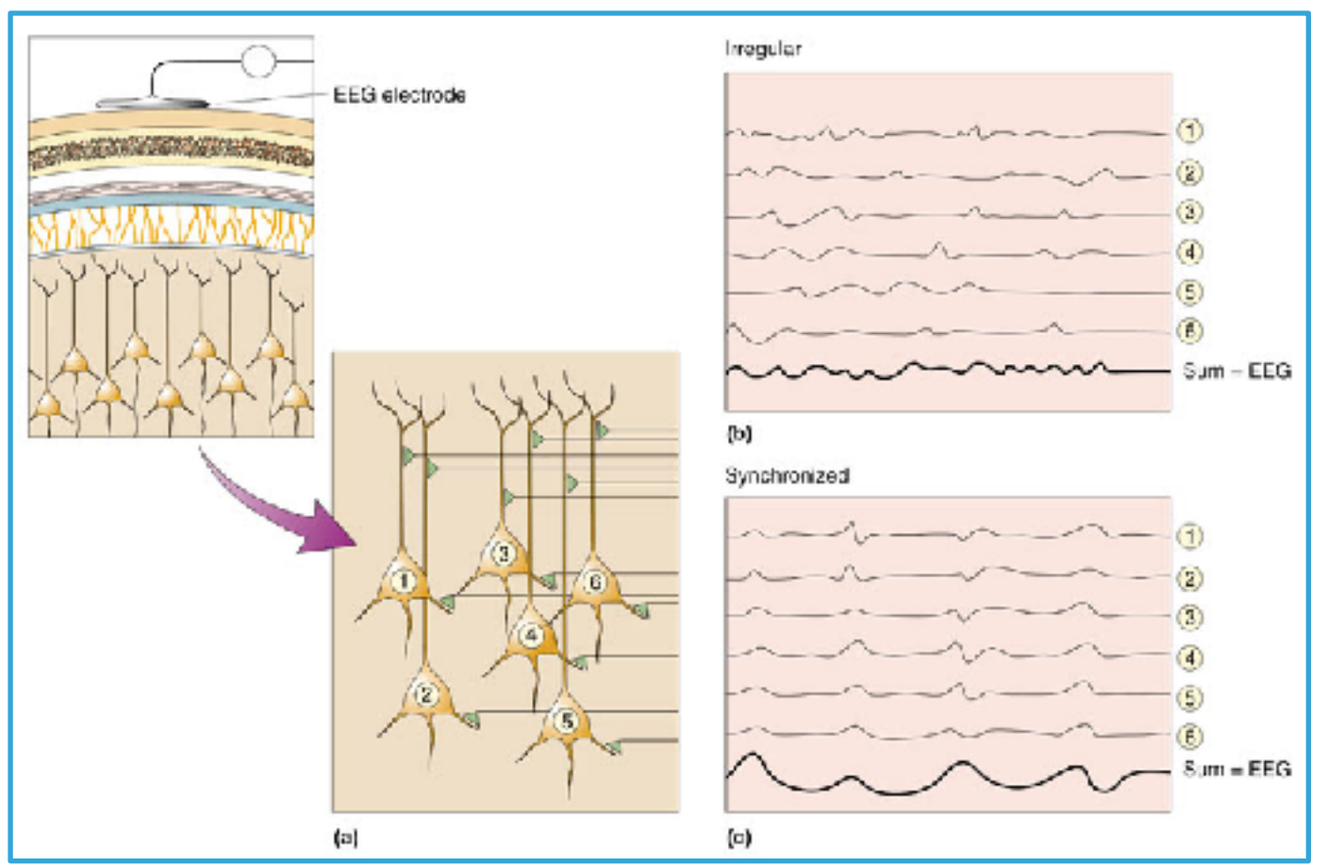
POSTSYNAPTIC POTENTIALS



Large and lasting enough

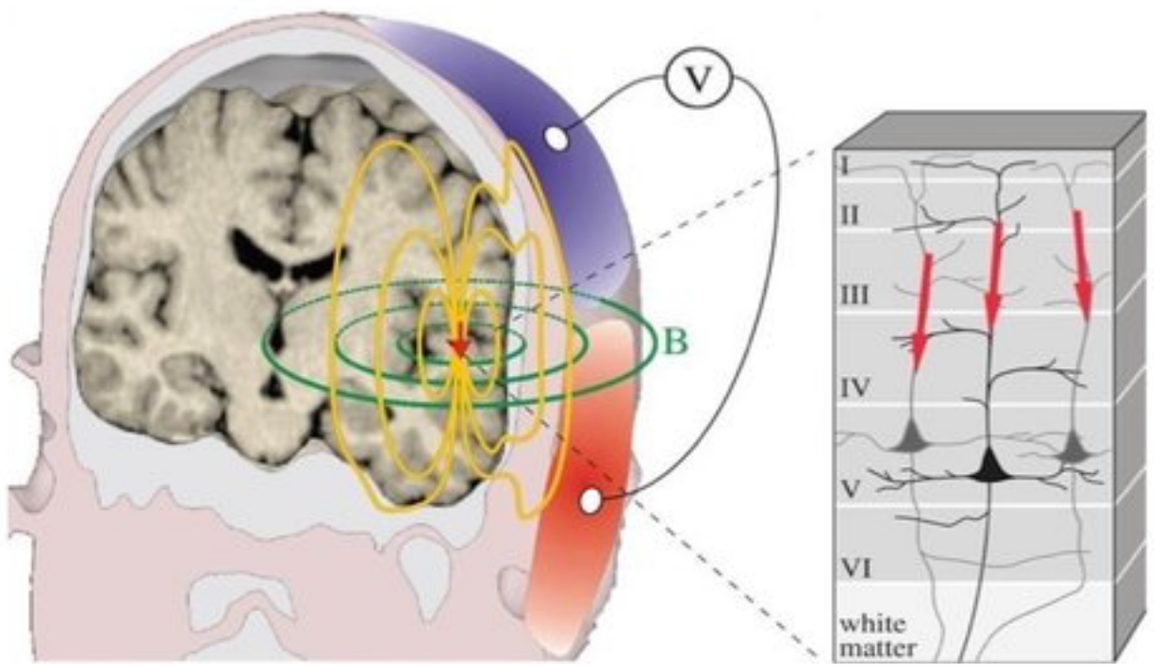
IN ORDER TO BE RECORDED. . . .NEED TO BE MASSIVE AND SYNCHRONIZED

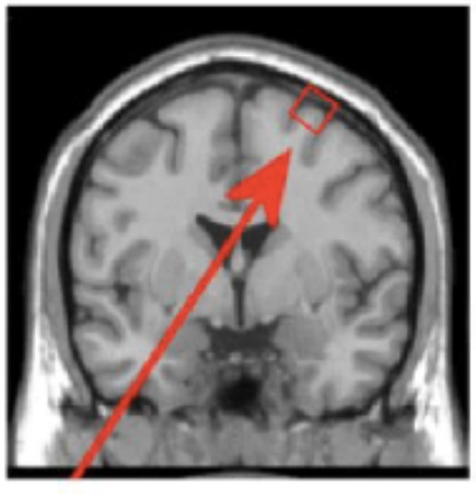


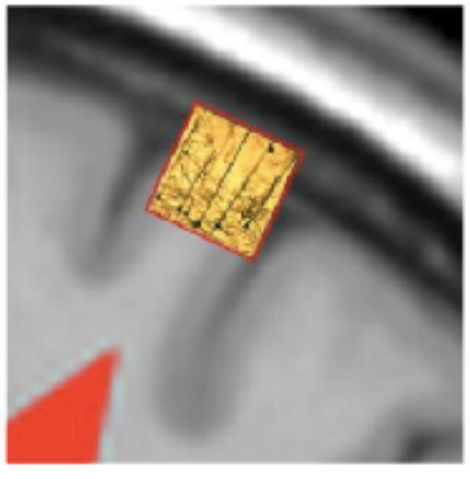


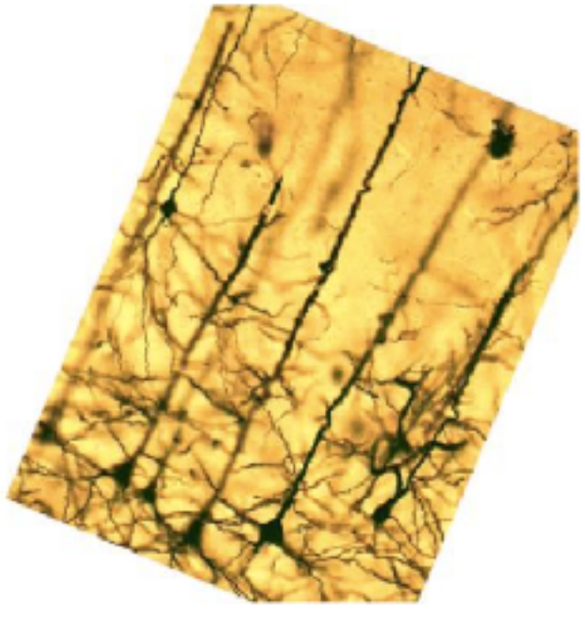
MAIN SOURCE

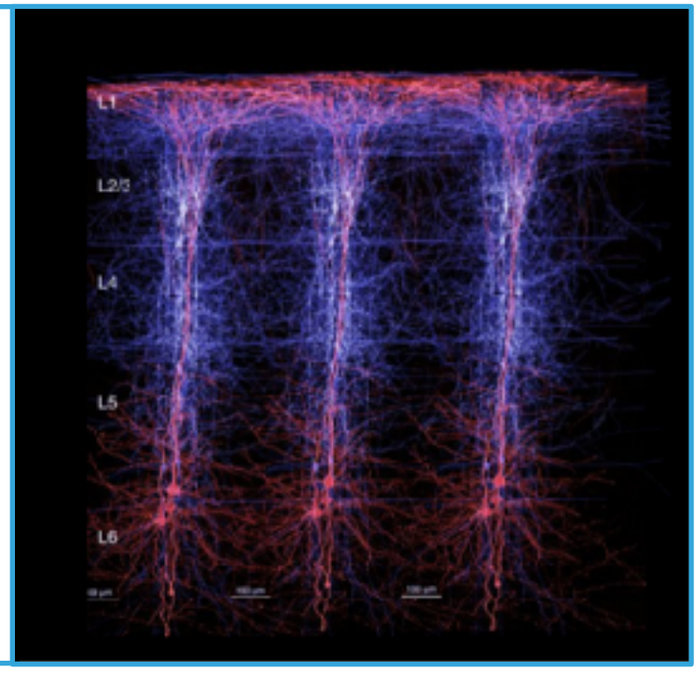
LARGE PYRAMIDAL NEURONS OF CORTEX



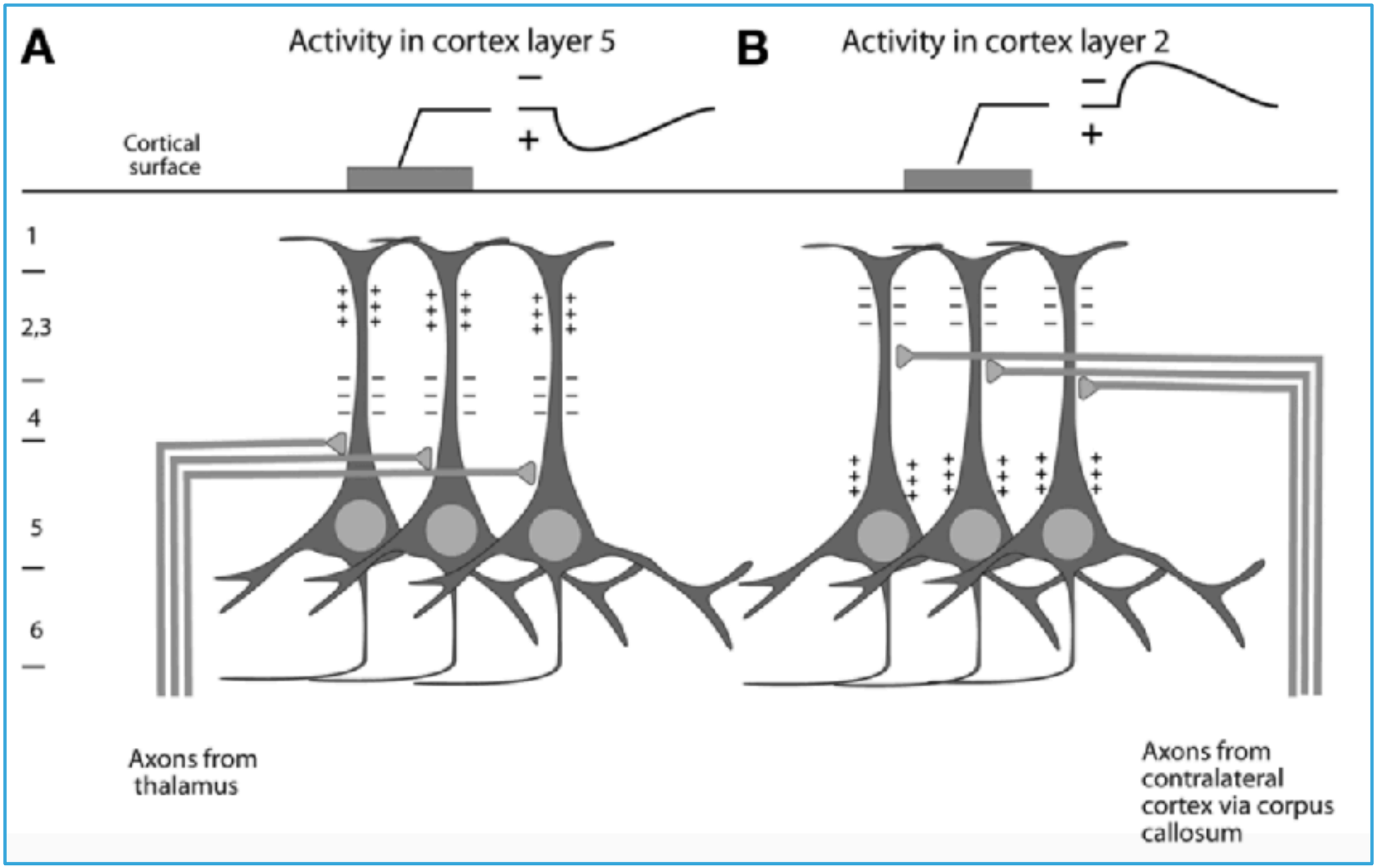








EXCITATORY AND INHIBITORY EFFECTS

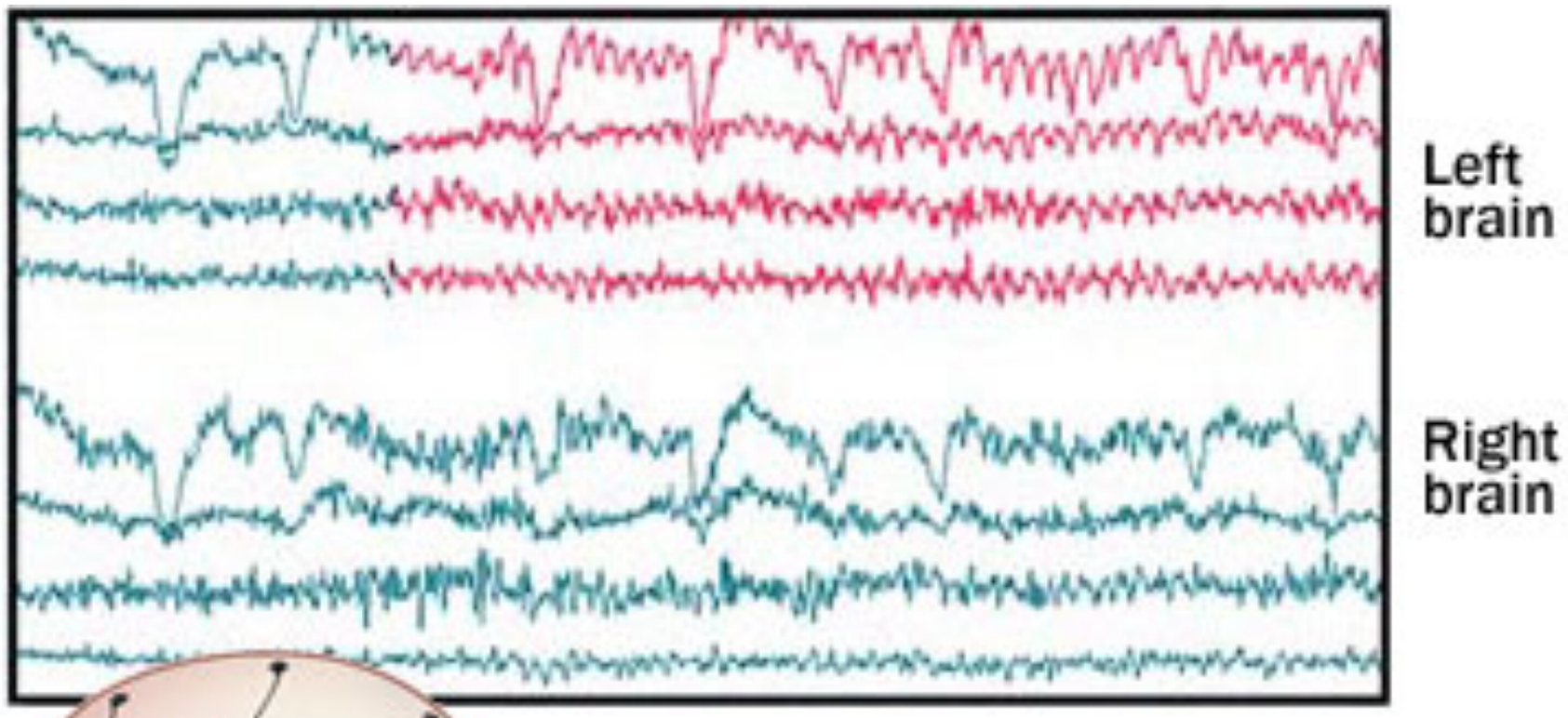


by Kandel, 2000

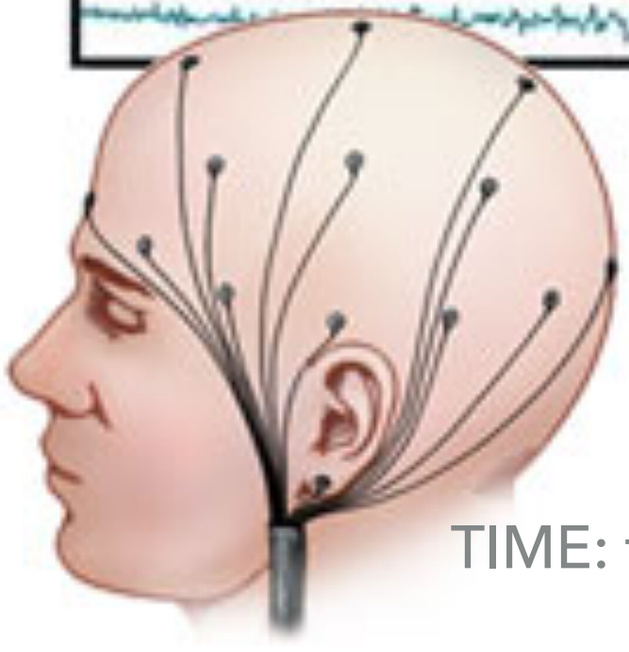
ELECTROENCEPHALOGRAPHY (EEG)

Basic principles and limitations

A LIVE GLANCE AT A BRAIN WORKING

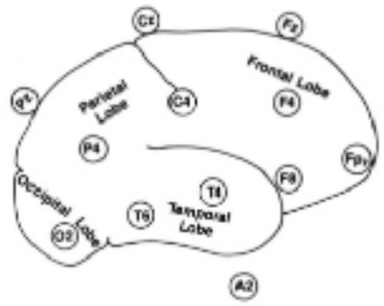


An electroencephalogram (EEG)

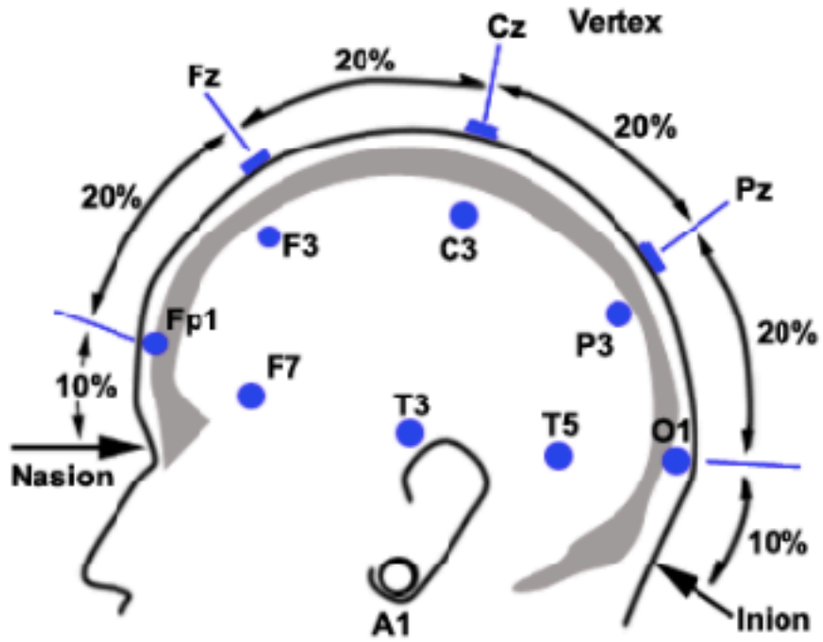


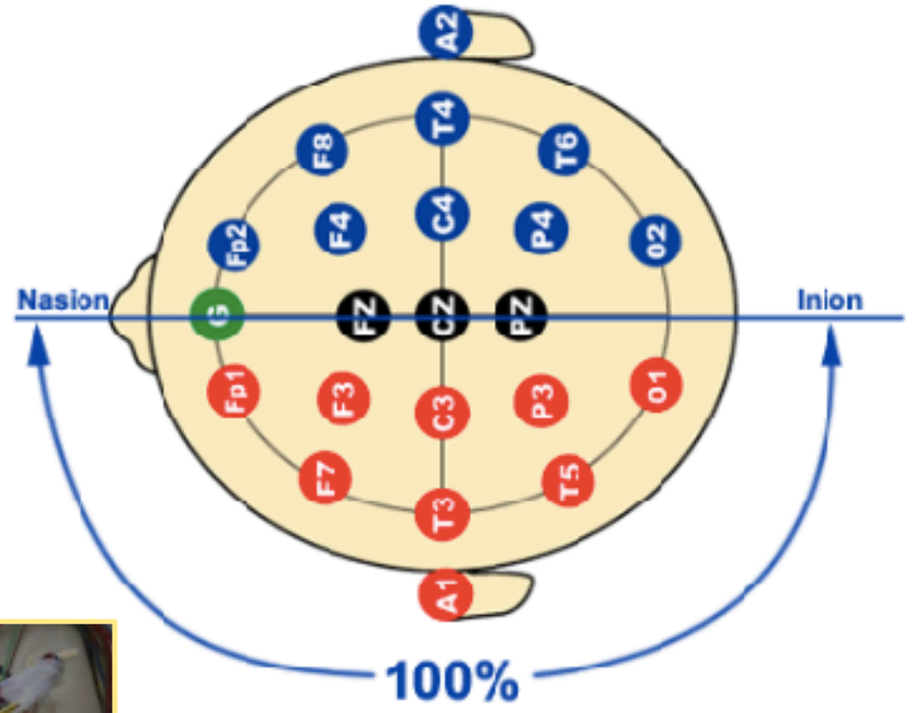
TIME: the temporal resolution is the main advantage of EEG

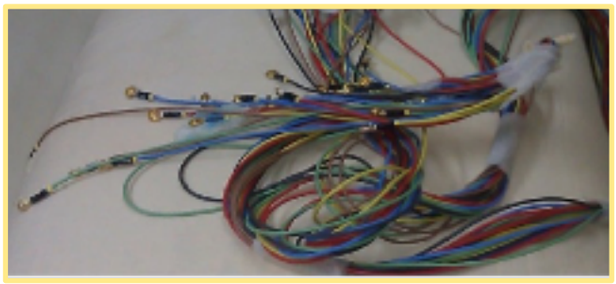
TECHNIQUE



We put sensors (electrodes) in the scalp to collect the electrical field of the brain



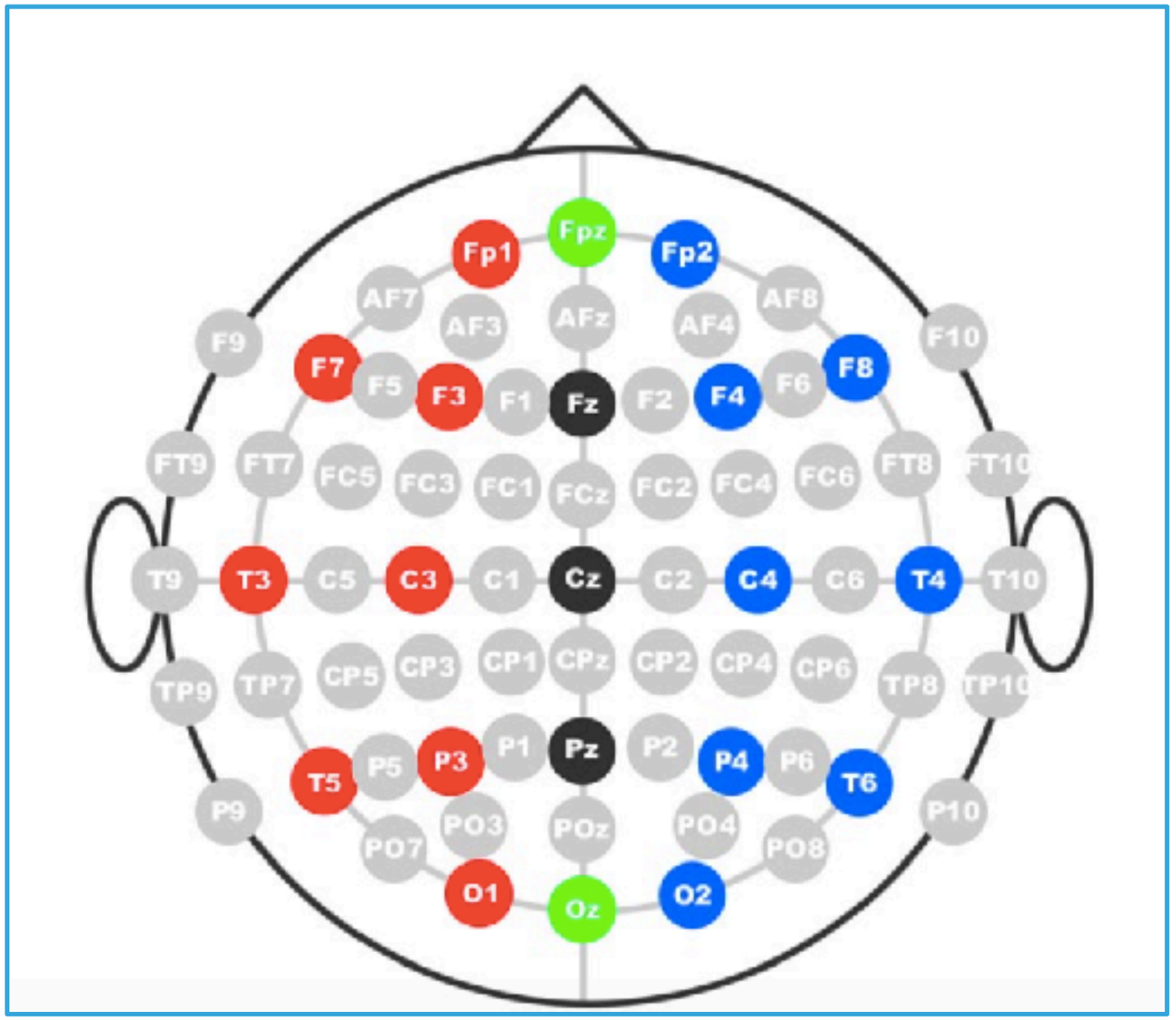




10/20 System of electrode placement

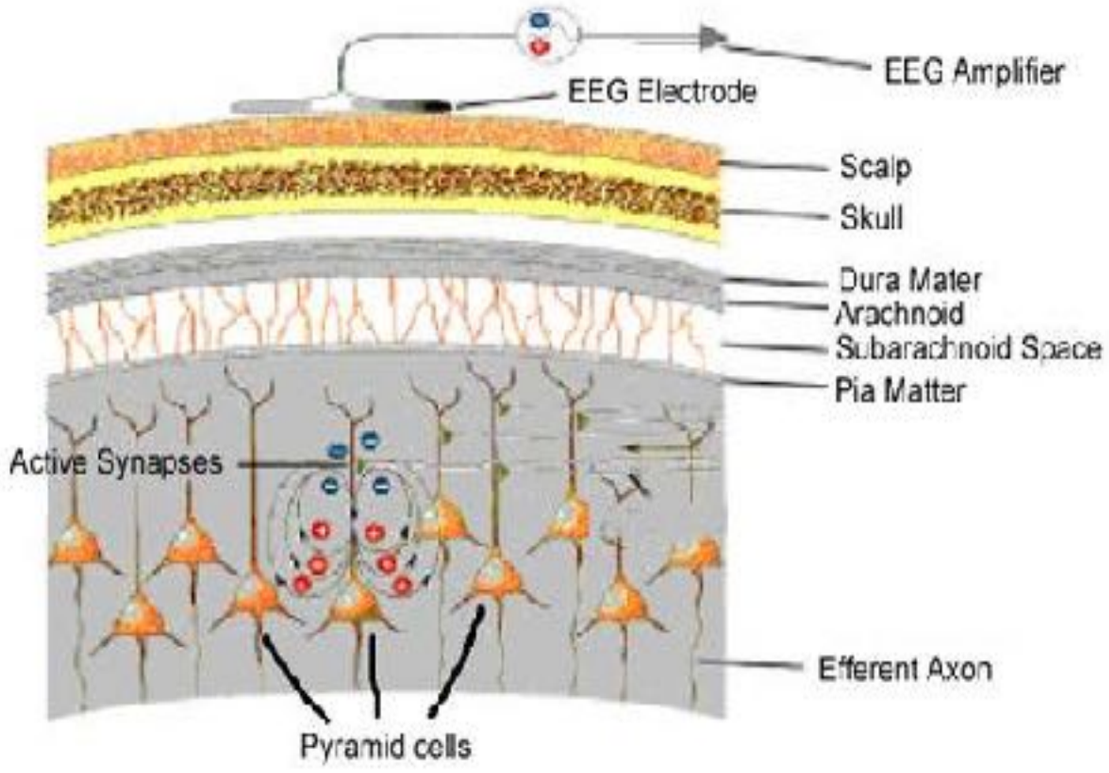
It is not possible to cover the whole brain... called spatial limitation of EEG

Even with more electrodes



We cannot record deep or small areas

RECORDING FROM AWAY

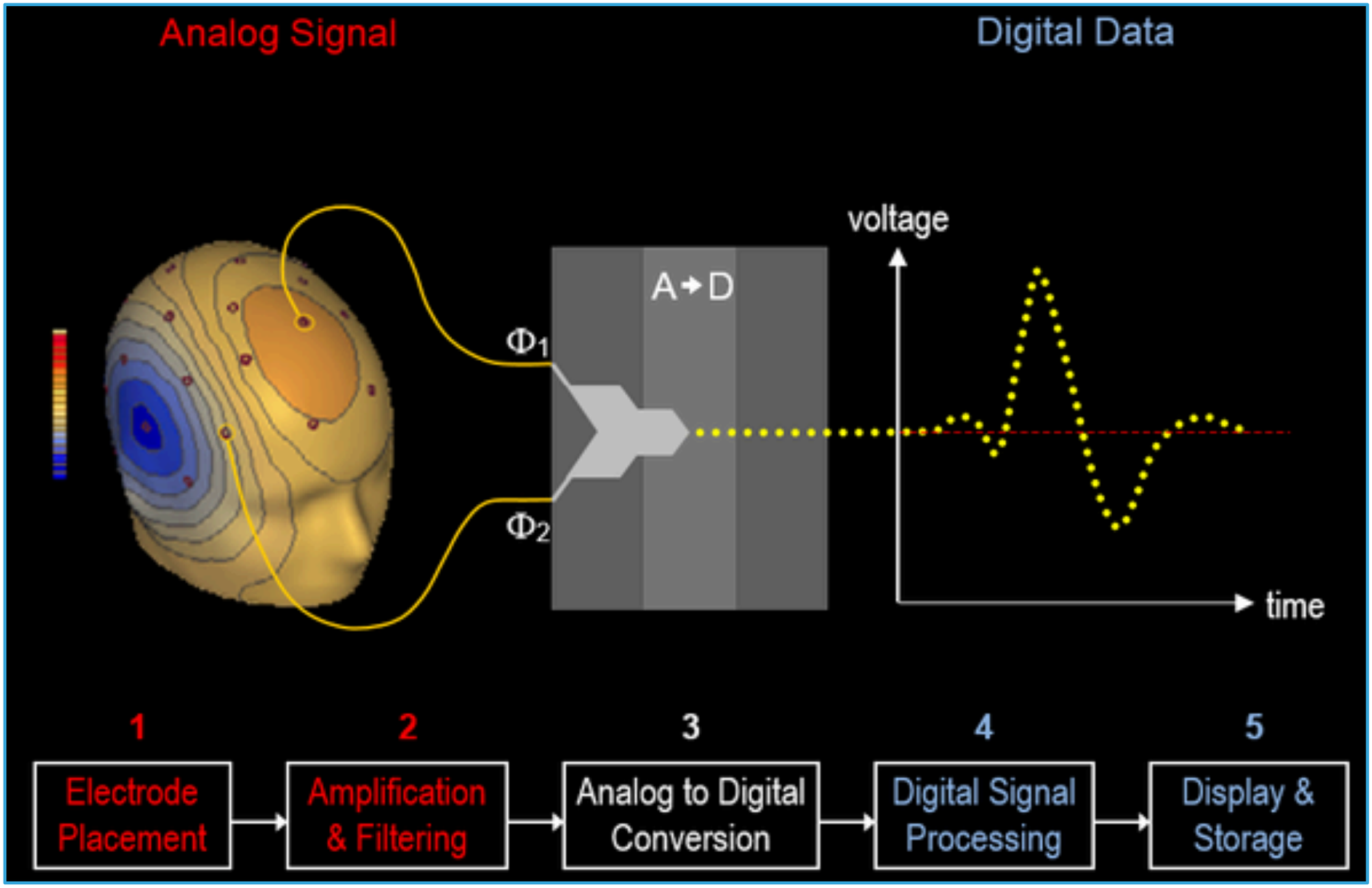


"THE DROP PARADIGM"

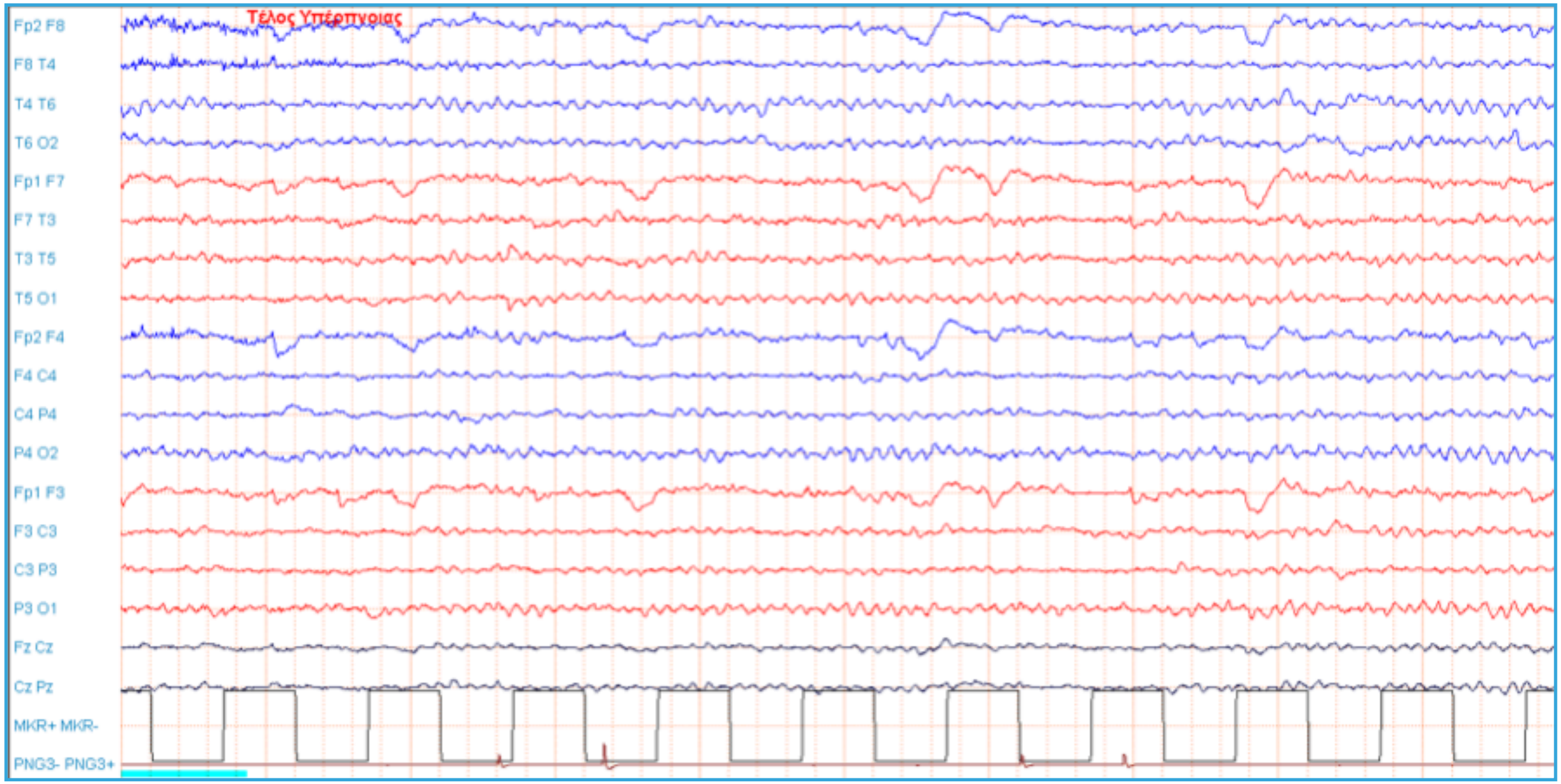
Imagine..

Suppose I drop a pebble (**neuron**) into the middle of a still pond (**brain surface**).
That action creates a pure wave (**brainwave**).
Meanwhile, as my official wave collector, you are eagerly waiting for that wave to arrive to you on the shore so you can measure it (**electrode**).
On its way, your wave encounters a few disturbances such as a floating log, swimming fish, and a motor boat (**artifacts**).
These encounters disrupt and transform the wave such that, by the time it arrives, it's no longer in its original shape.

SIGNAL PROCESSING



EEG TRACE


Τέλος Υπέρπνοιας
Fp2 F8
F8 T4
T4 T6
T6 O2
Fp1 F7
F7 T3
T3 T5
T5 O1
Fp2 F4
F4 C4
C4 P4
P4 O2
Fp1 F3
F3 C3
C3 P3
P3 O1
Fz Cz
Cz Pz
MKR+ MKR-
PNG3- PNG3+

"THE DROP PARADIGM" NO 2

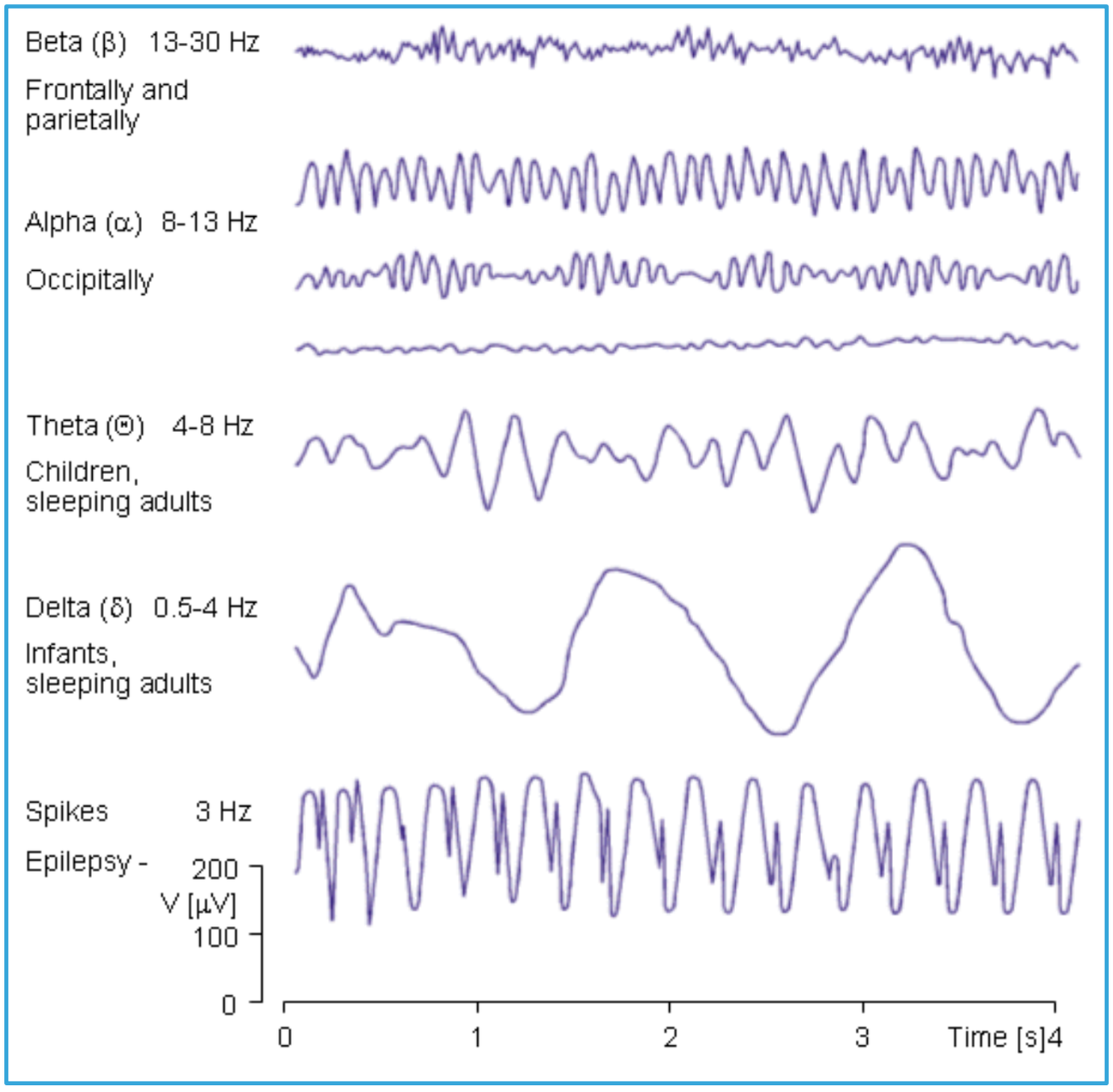
Imagine ...

Assume that instead of one pebble, many different-sized pebbles (**multiple neurons**) are dropped at random times into the pond, creating a multitude of overlapping waves.

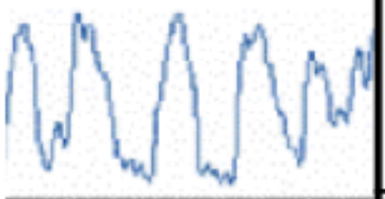
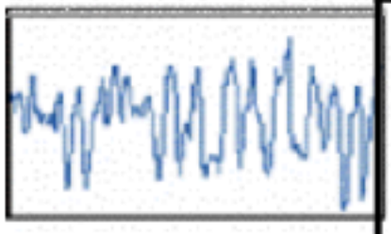
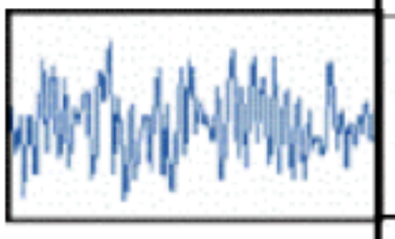
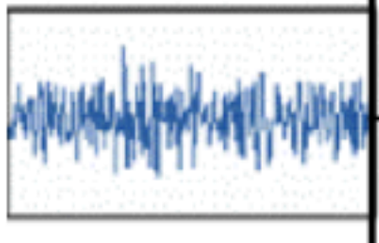
Thus, the wave you see at the shore (**electrode**) is made up of a composition of many other waves having different heights (**amplitudes**) and speeds (**frequencies**), all sort of running into each other.

Your job, as the wave collector, is to separate out and classify these individual waves (**band frequencies**)

DIFFERENT RHYTHMS (FREQUENCIES)

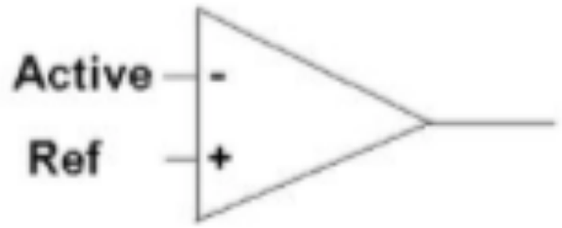


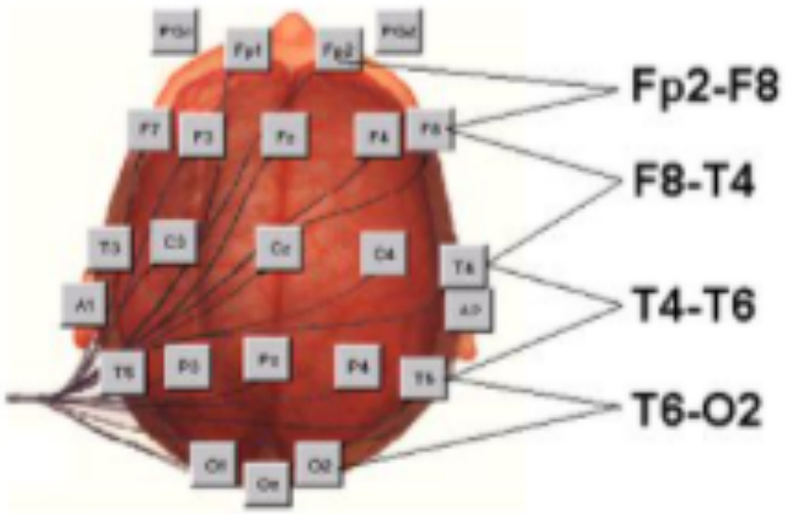
THEORIES AND CORRELATIONS

	EEG Bands (Hz)	Distribution	Subjective feeling	Associated tasks & behaviors	Physiological correlates
	**Delta 0.1-3**	Distribution: generally broad or diffused	deep, dreamless sleep, non-REM sleep, unconscious	lethargic, not moving, not attentive	not moving, low-level of arousal
	**Theta 4-8**	usually regional, may involve many lobes	intuitive, creative, recall, fantasy, imagery, creative, dreamlike, drowsy	creative, intuitive; distracted, unfocused	healing, integration of mind/body
	**Alpha 8-12**	regional, usually involves entire lobe	relaxed, not agitated, but not drowsy	meditation, no action	relaxed, healing
	**Beta 12-30**	localized	alertness, agitation	mental activity, e.g. math	alert, active
	Gamma >30	very localized	Focused arousal	high-level information processing, "binding"	information-rich task processing

WE RECORD "DIFFERENCES"

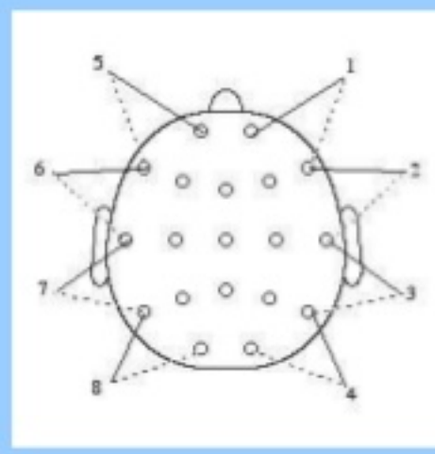
1 channel is composed by 2 electrodes



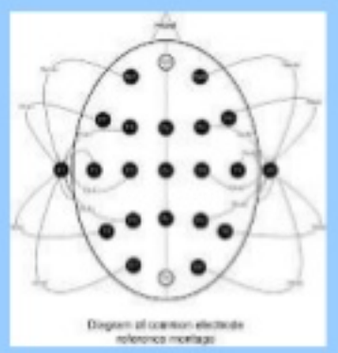


Montages

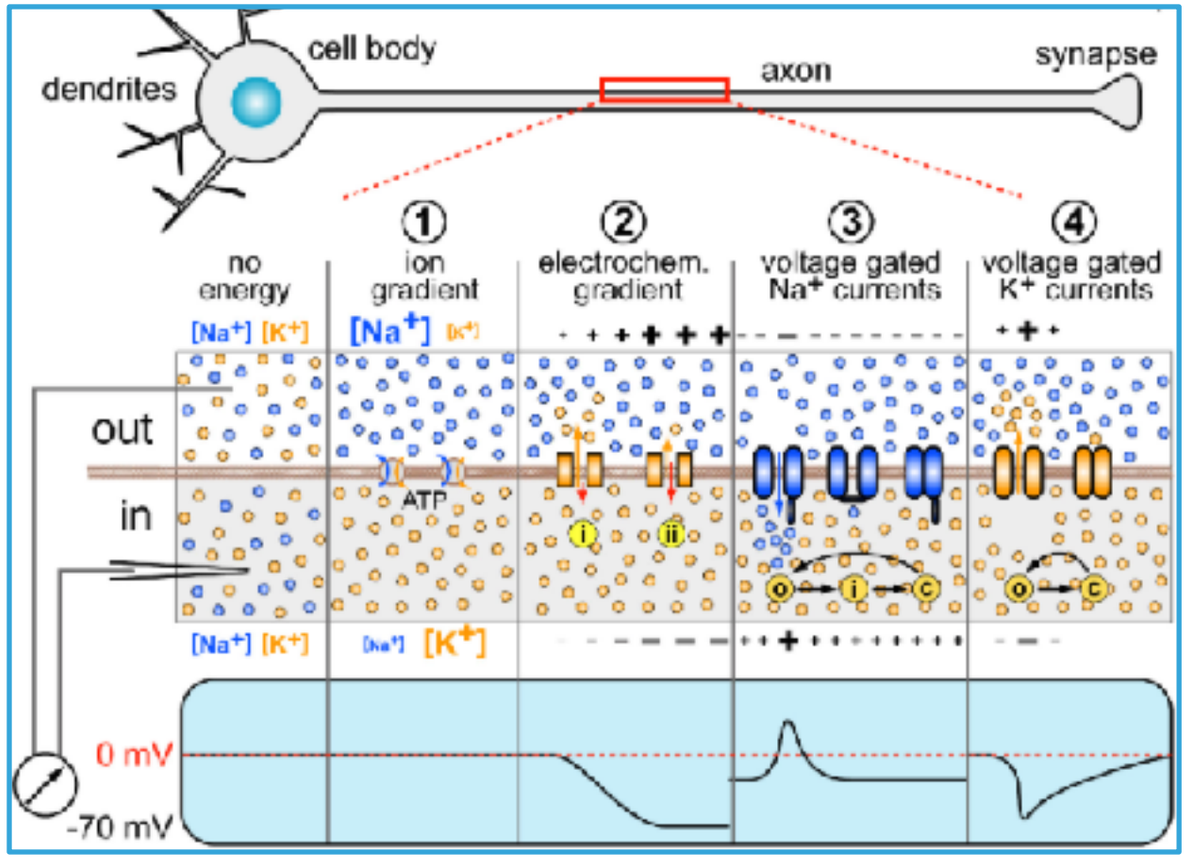
Bipolar: the potential difference between 2 active electrodes

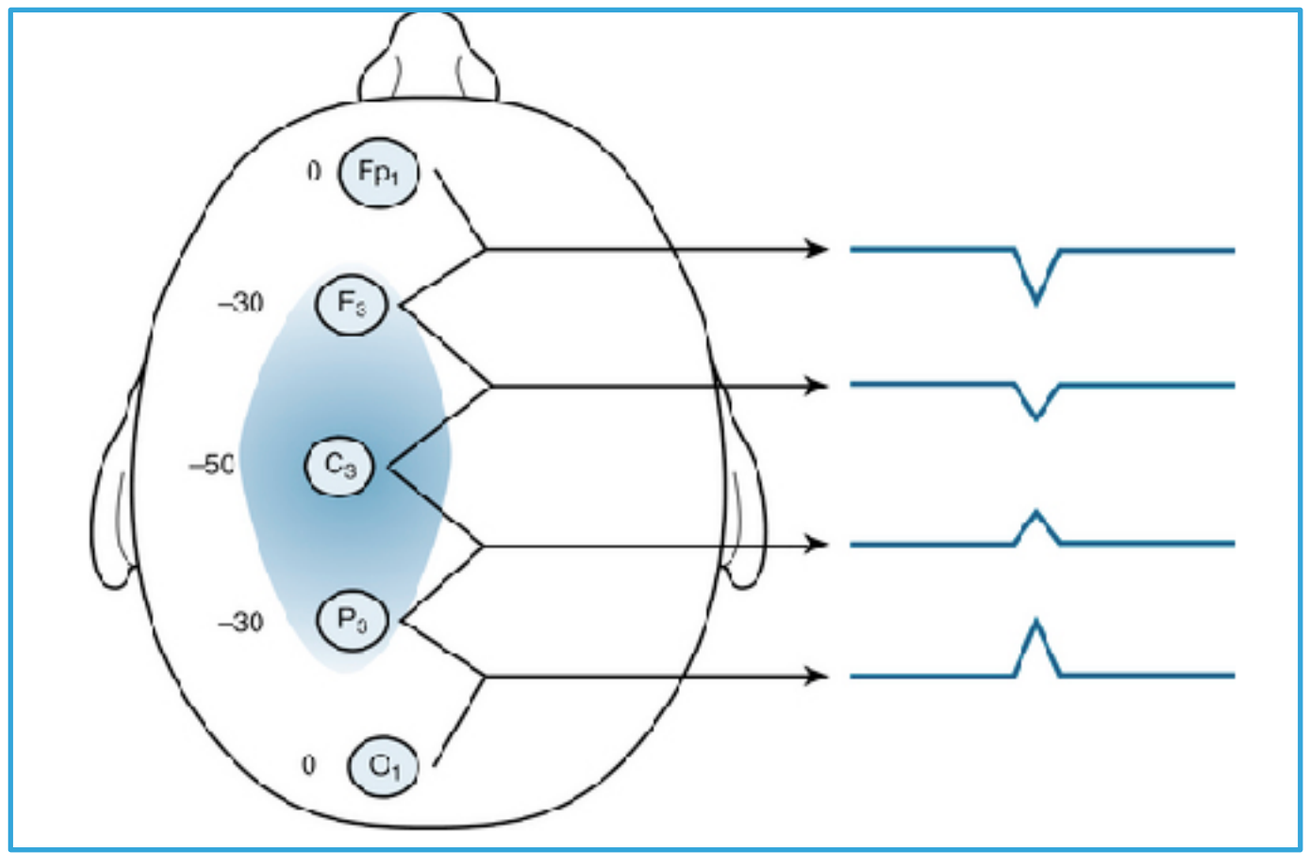


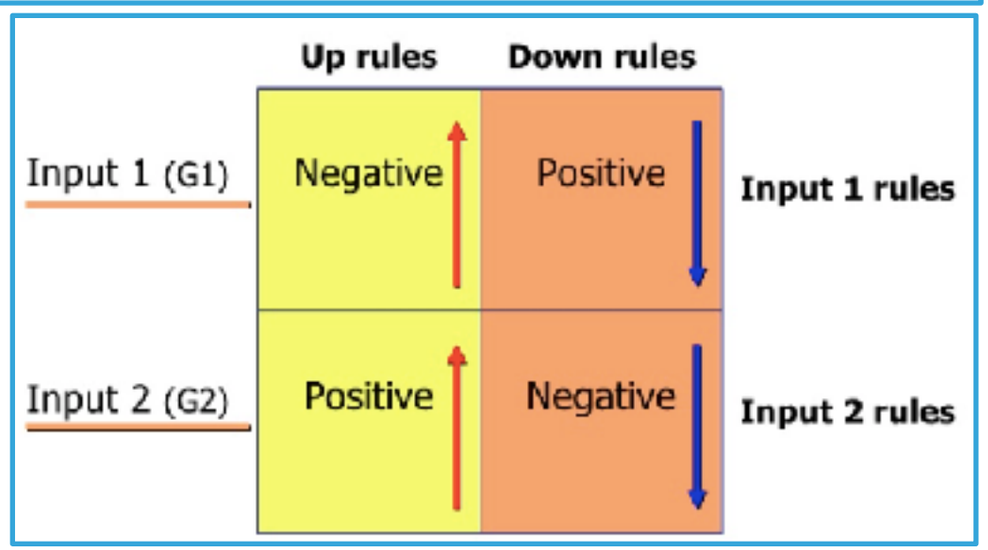
Referential: potential difference between 1 active and 1 inactive electrode

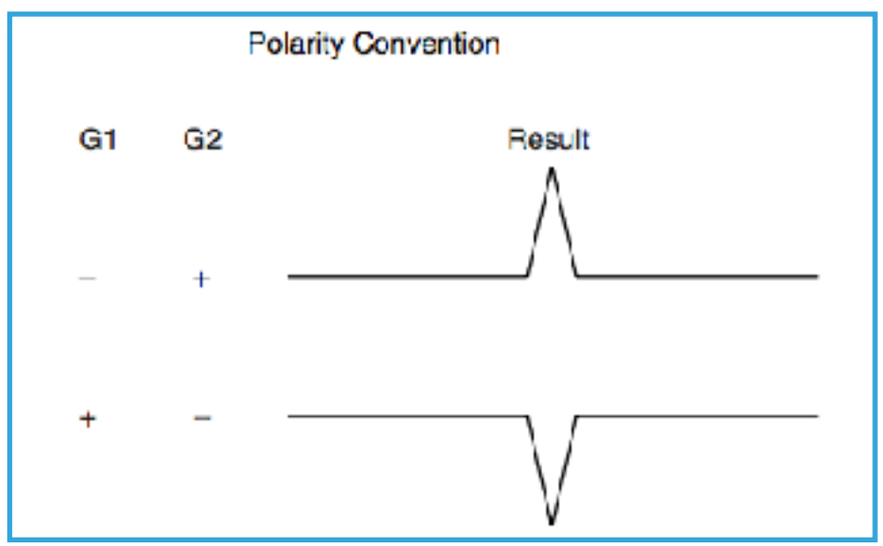


THE NEGATIVITY (DEPOLARIZATION) GOES UP





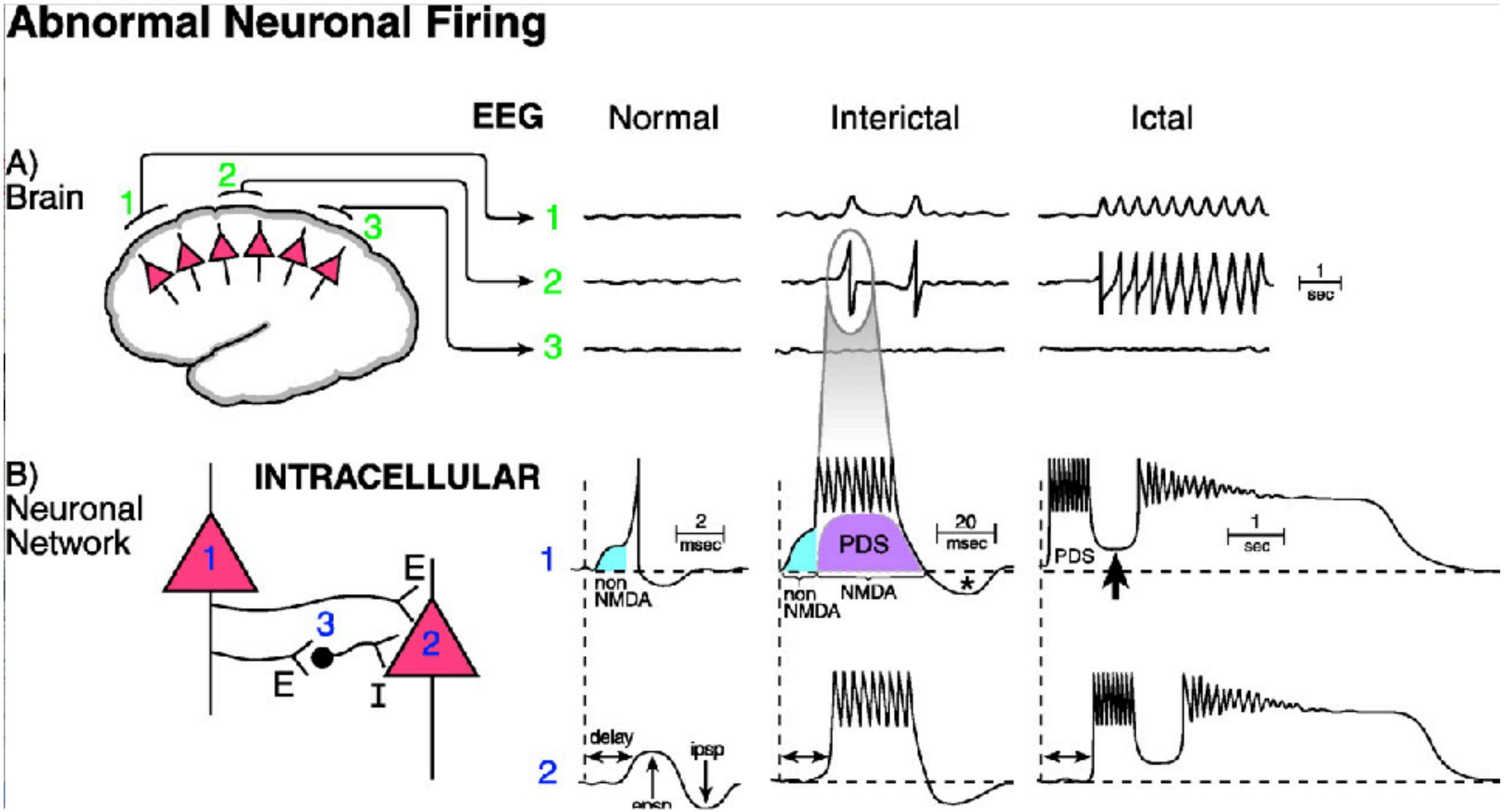




WHAT WE TRY TO RECORD ?

and why ?

WHAT ?

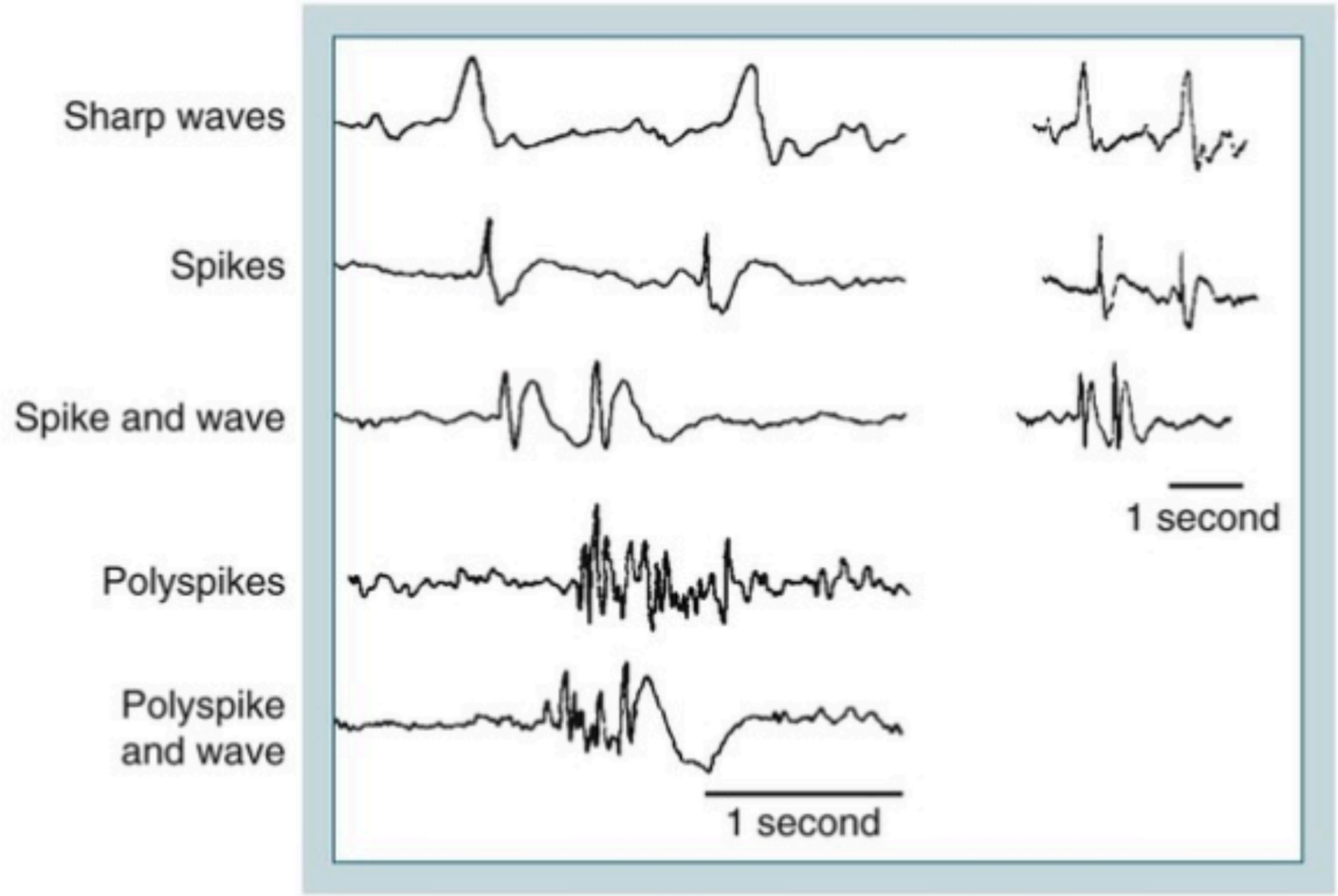

Abnormal Neuronal Firing
EEG
Normal
Interictal
Ictal
A)
Brain
1
2
3
1
2
3
1
sec
B)
Neuronal
Network
INTRACELLULAR
1
2
3
E
E
I
2
msec
non
NMDA
PDS
20
msec
non
NMDA
NMDA
*
PDS
1
sec
delay
ipsp

SEIZURES AND EPILEPSY

- An epileptic seizure is a transient occurrence of signs and/or symptoms due to abnormal excessive or synchronous neuronal activity in the brain.
- Epilepsy is a disease characterized by an enduring predisposition to generate epileptic seizures and by the neurobiological, cognitive, psychological, and social consequences of this condition.
- Translation: a seizure is an event and epilepsy is the disease involving recurrent unprovoked seizures.

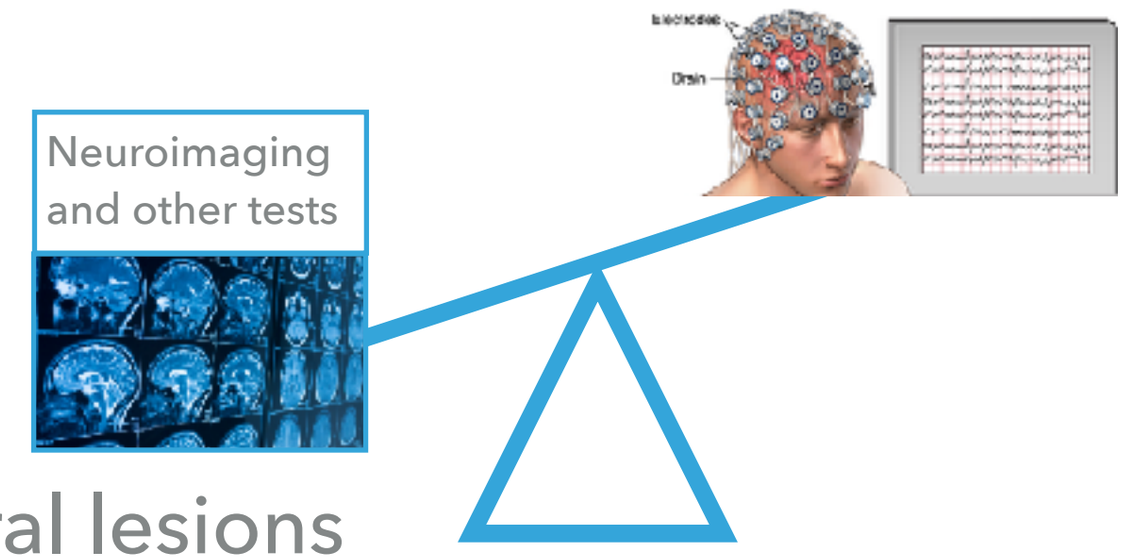
EPILEPTIFORM DISCHARGES

"distinctive waves or complexes, distinguished from background activity, and resembling those recorded in a proportion of human subjects suffering from epileptic disorders…."



USEFULNESS

- EPILEPSY
- Coma
- Degenerative diseases of CNS
- Stroke, tumours and other structural lesions
- CNS infections
- Psychiatric disorders
- Autism



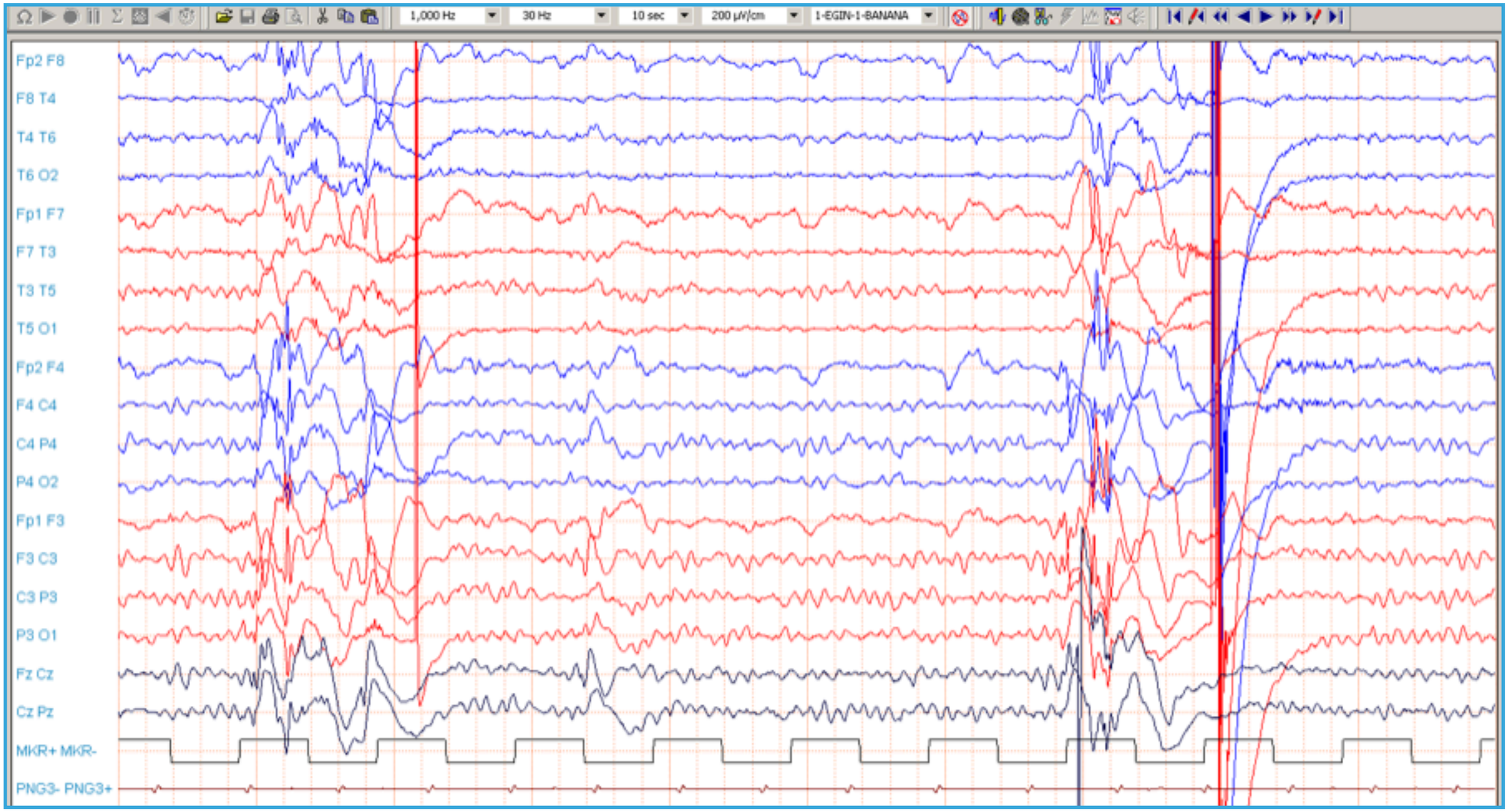
EXAMPLES OF USEFULNESS IN CLINICAL PRACTICE

ROUTINE EEG

Performed in 20–30 min duration

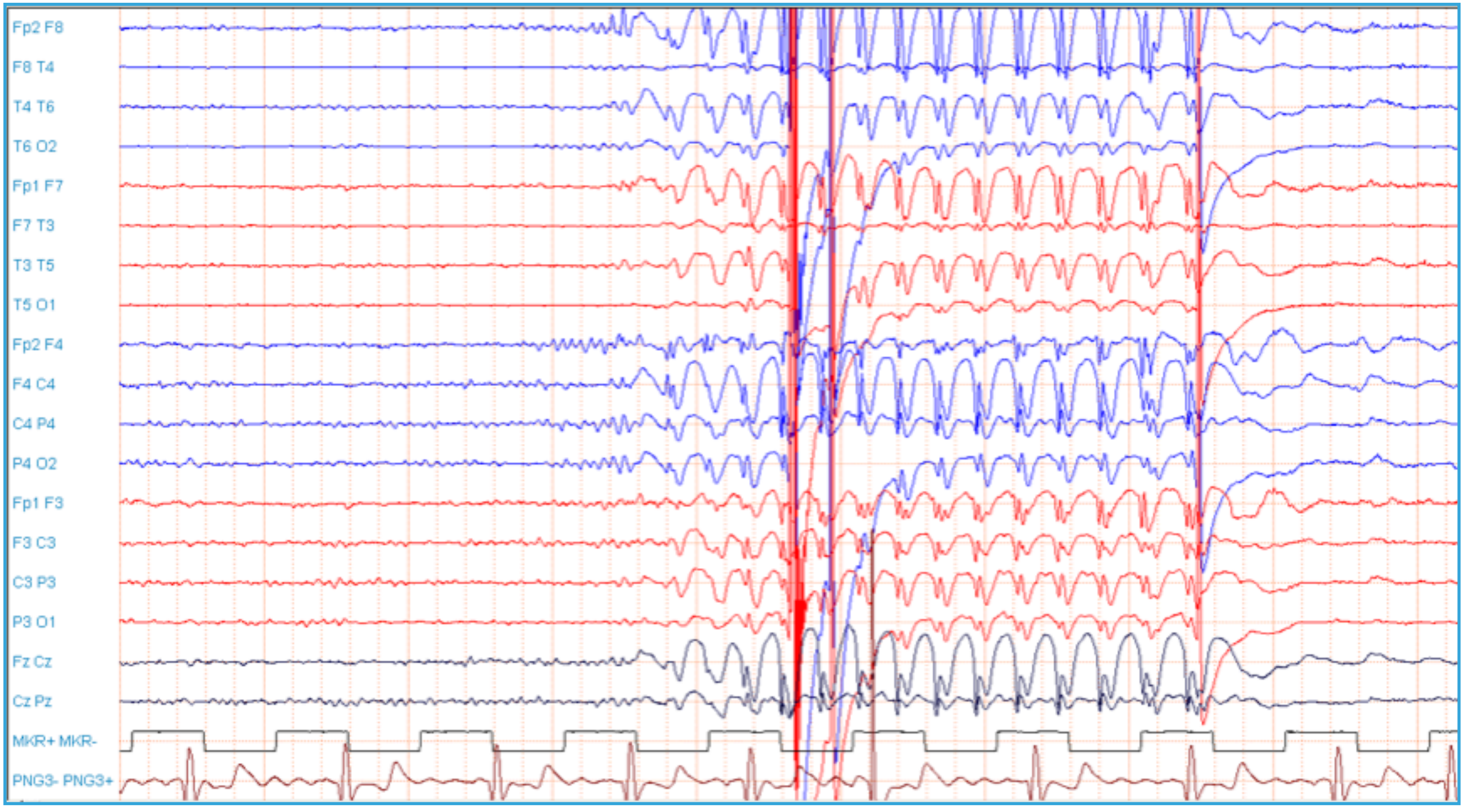
1. Cheap,
2. non invasive,
3. minimum cooperation

15 years old student with a recent history of brief morning jerks



POLYSPIKES/WAVES COMPLEXES: HALLMARK OF JUVENILE MYOCLONIC EPILEPSY

Young man with episodes of “lapses”

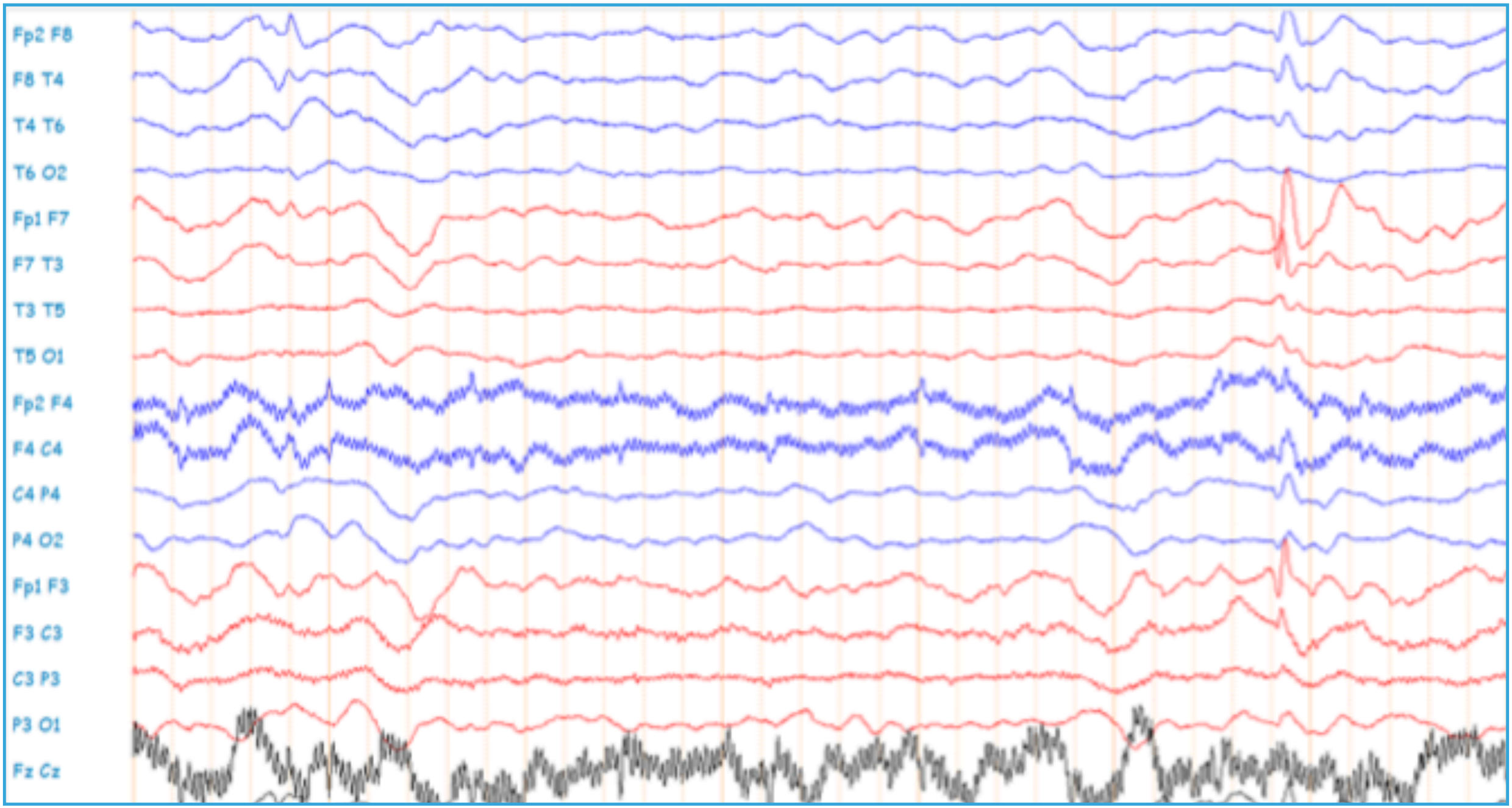


3HZ SPIKE/WAVES COMPLEXES: HALLMARK OF JUVENILE ABSENCE EPILEPSY

25 years old woman with episodes of staring and loss of consciousness

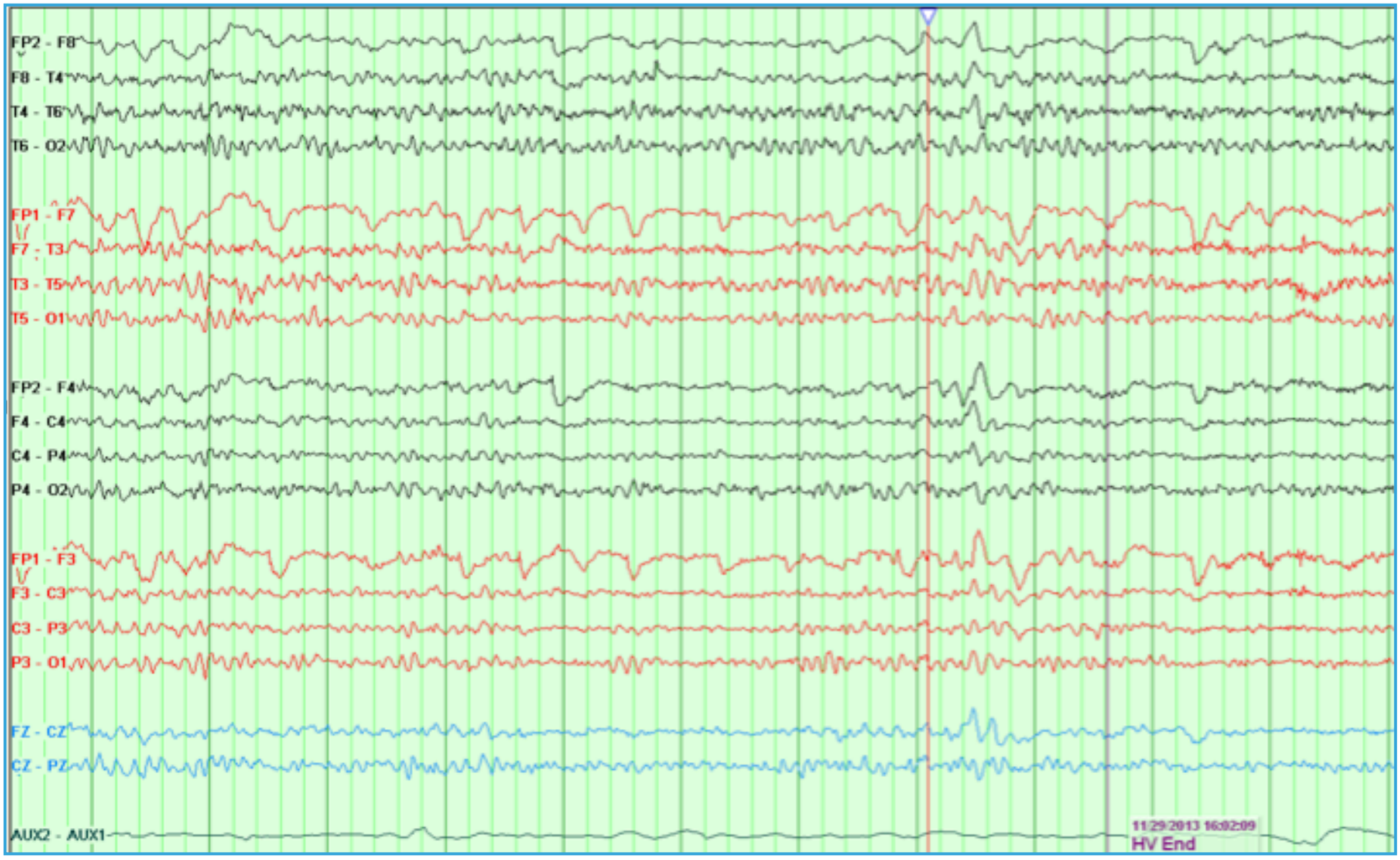
FOCAL SPIKES AND SHARP WAVES: FOCAL TEMPORAL LOBE EPILEPSY

25 years old man with episodes of nocturnal hyperkinetic movements



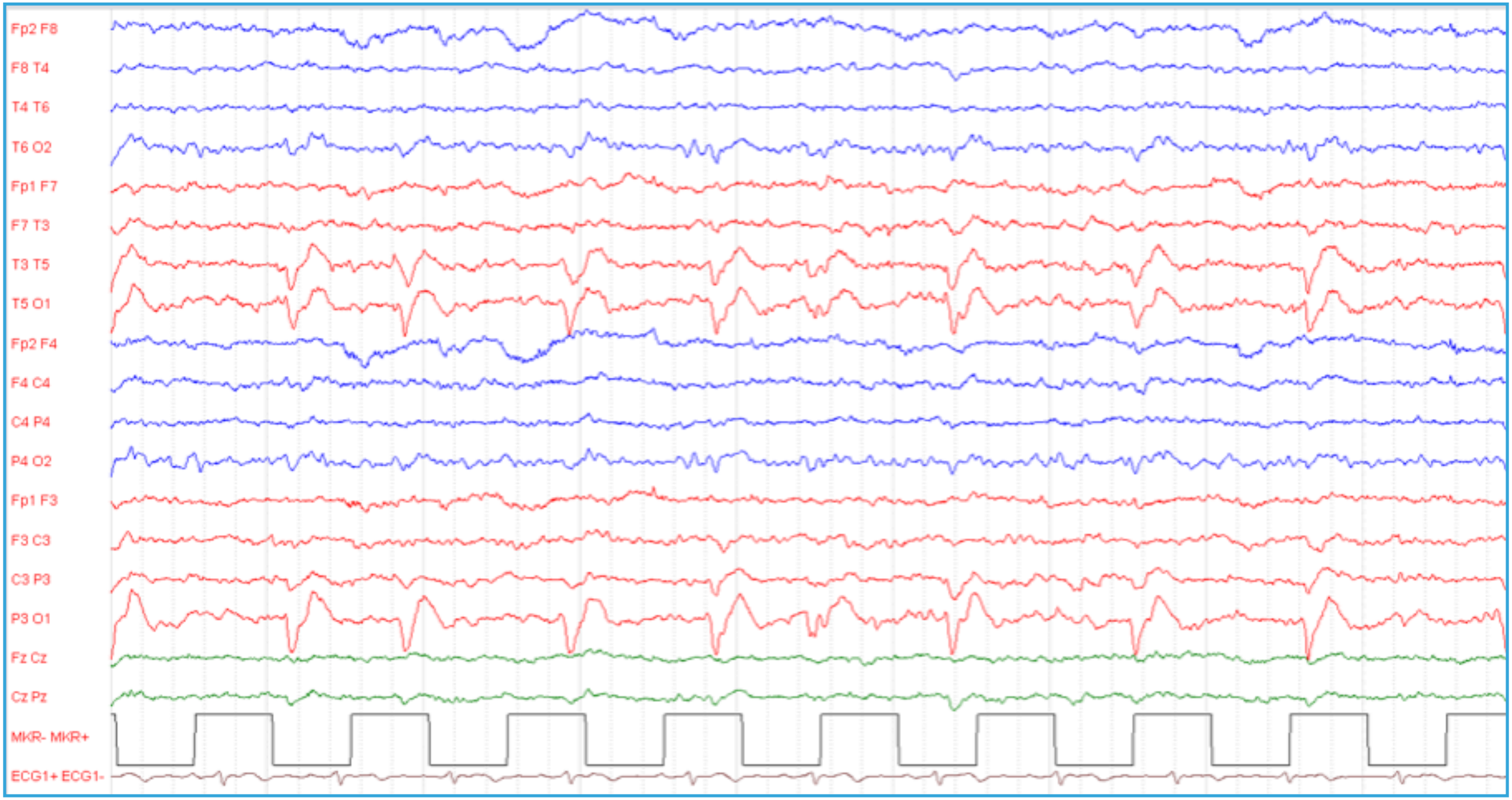
FOCAL INDEPENDENT SPIKES : FOCAL FRONTAL LOBE EPILEPSY

23 years old woman with a history of mild traumatic brain injury, episodes of semi numbness and a first generalised tonic clonic seizure during sleep



NON SPECIFIC NON WELL LOCALIZED SHARP WAVES: FOCAL PARIETAL EPILEPSY

Young woman with episodes of visual hallucinations



FOCAL PERIODIC OCCIPITAL SHARP WAVES: FOCAL OCCIPITAL EPILEPSY

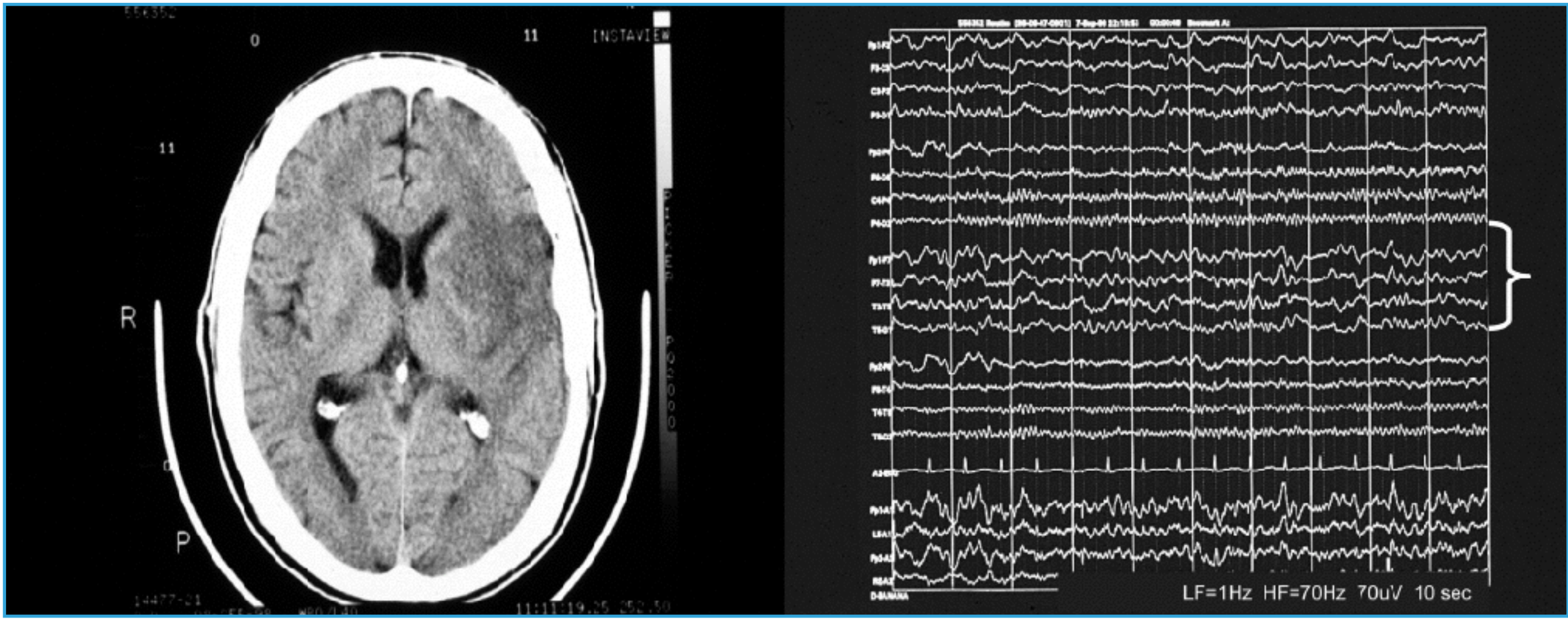
17 years old man with generalized epilepsy (after and before treatment)

DRUGS EFFECT

20 years old woman with focal epilepsy (after and before stoping treatment)

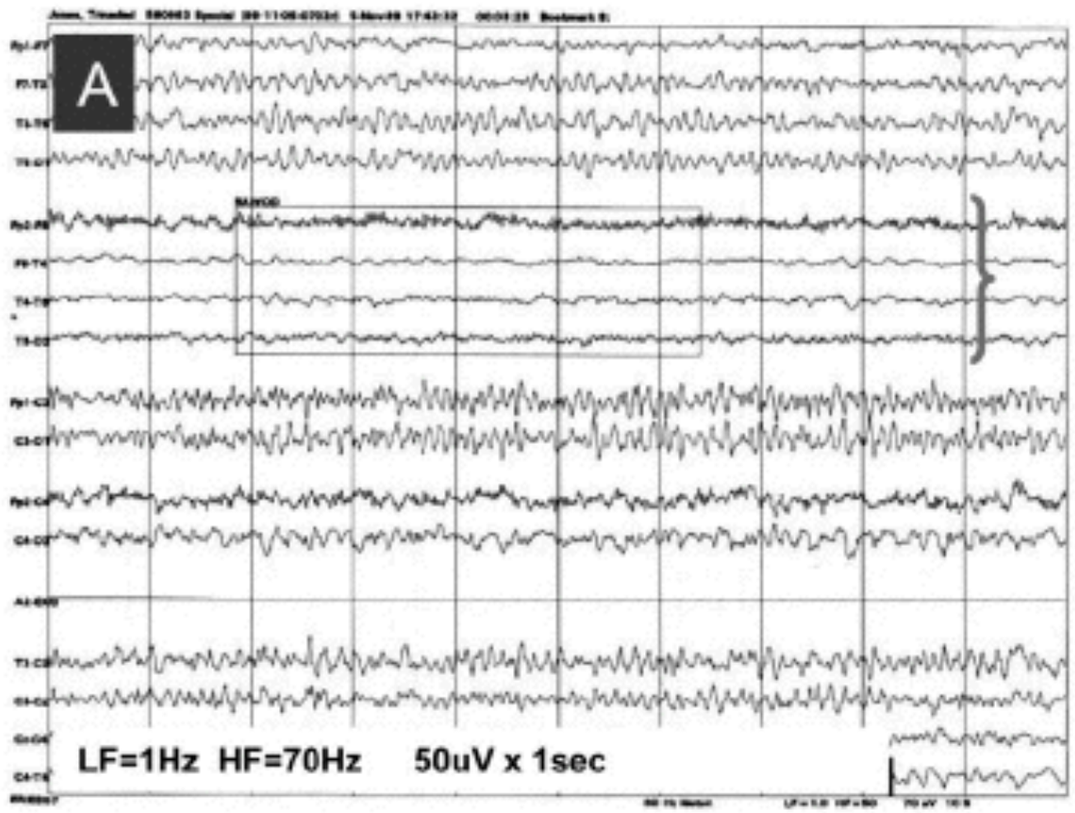
DRUGS EFFECT

Stroke



Stroke (early EEG findings)

A



B

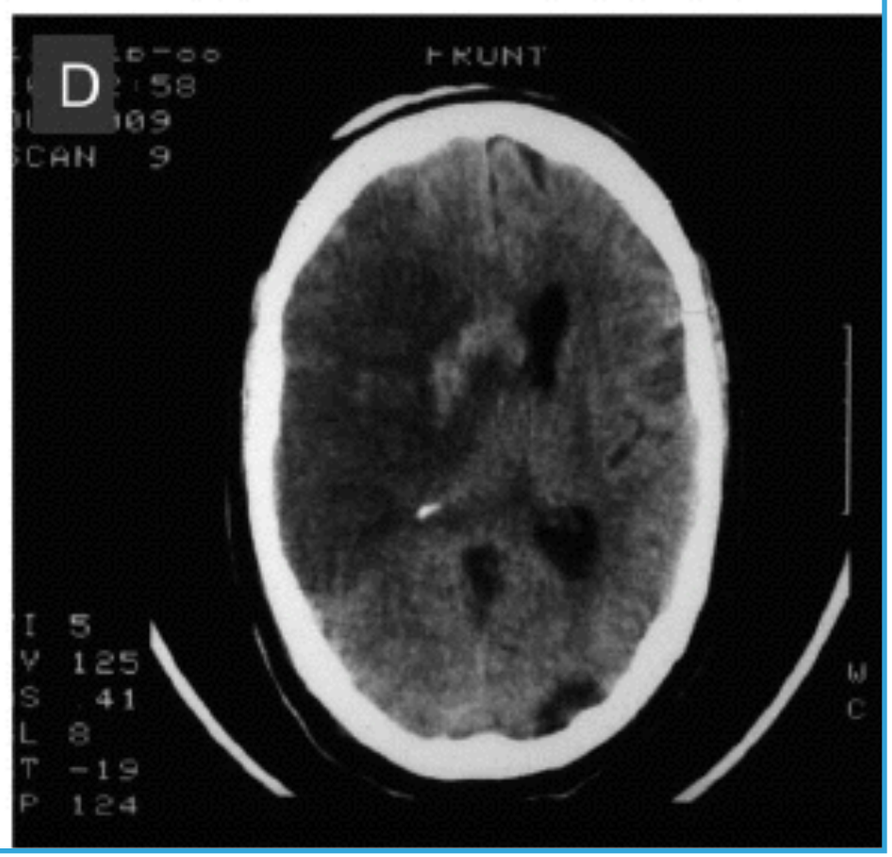
C

EARLY XenonCTCBF STUDIES IN RAWOD PATIENTS

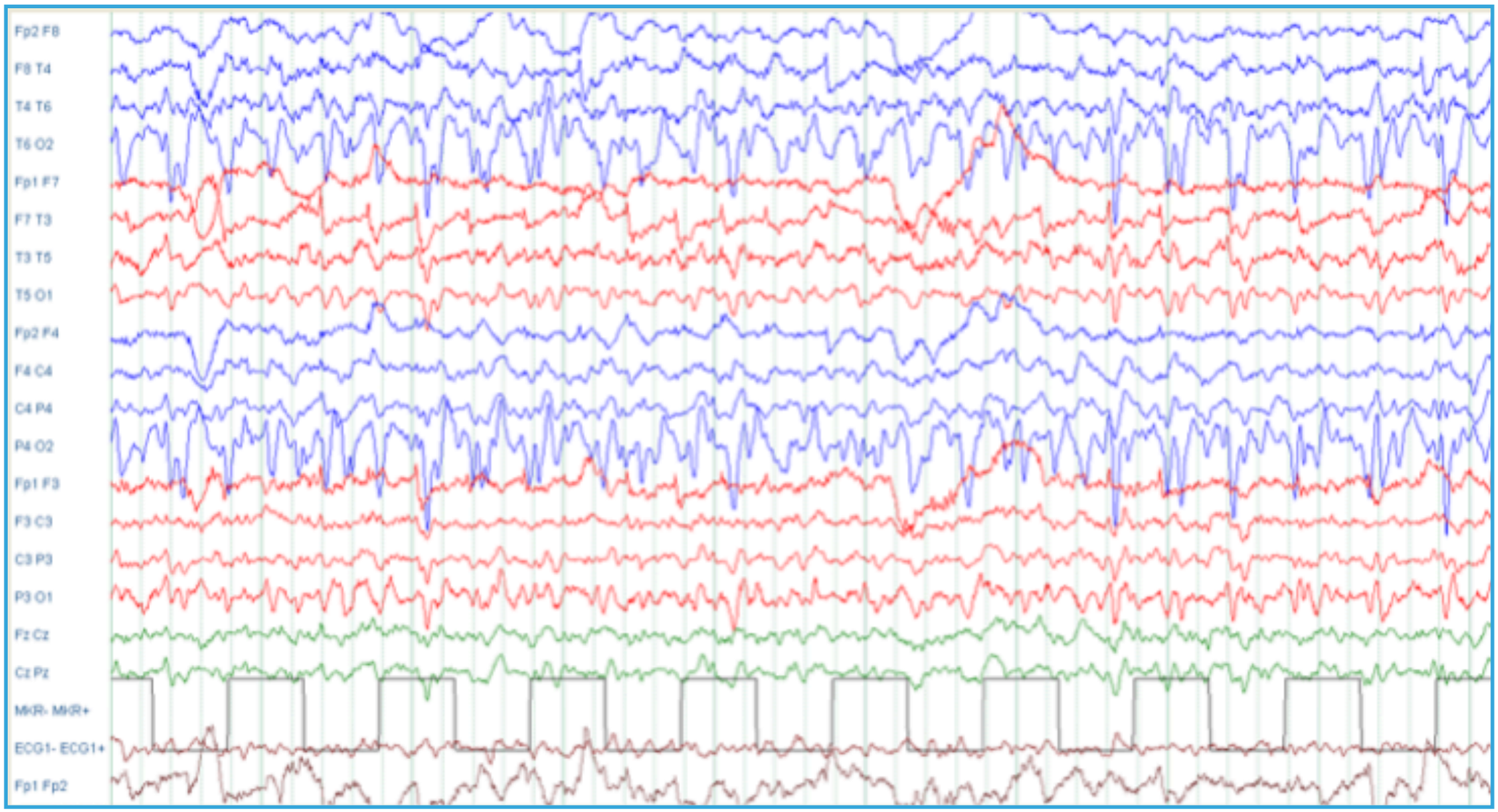
PATIENT	MINHSS (NIHSS)[b]	V_i (%)[c]	$mCBF_i$ (cc/100gm/min)[d]	INFARCT ON INITIAL CT
1	10 (35)	52.9	10.5	+
2	10 (35)	47	6.8	+
3	8 (28)	60.6	10.1	–
4	8 (28)	43.4	10.0	+
5	10 (35)	53.9	5.7	–
6	10 (35)	49.8	8.3	–
MEAN RESULTS	9.3 (33)	51.2 ± 6.6	8.6 ± 2.2	

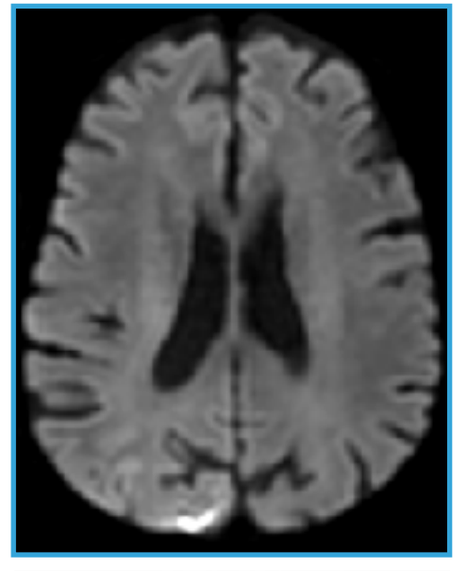
c) Vi=percent volume of ischemic tissue in the affected hemisphere
d) mCBFi = the weighted mean cerebral blood flow in the ischemic region
See handout for formulas calculating these values

D

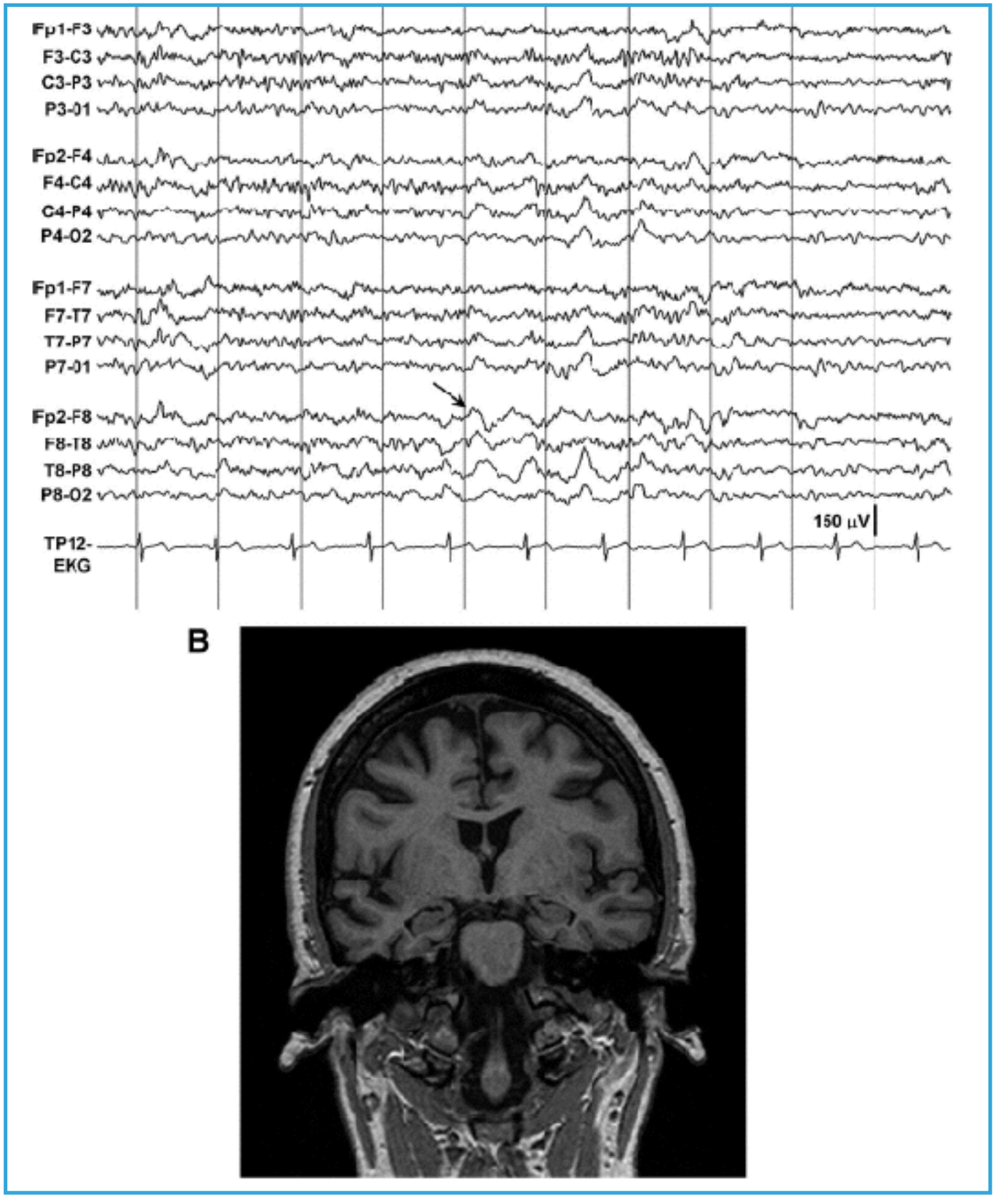


Stroke and epilepsy (confirmed by EEG findings)

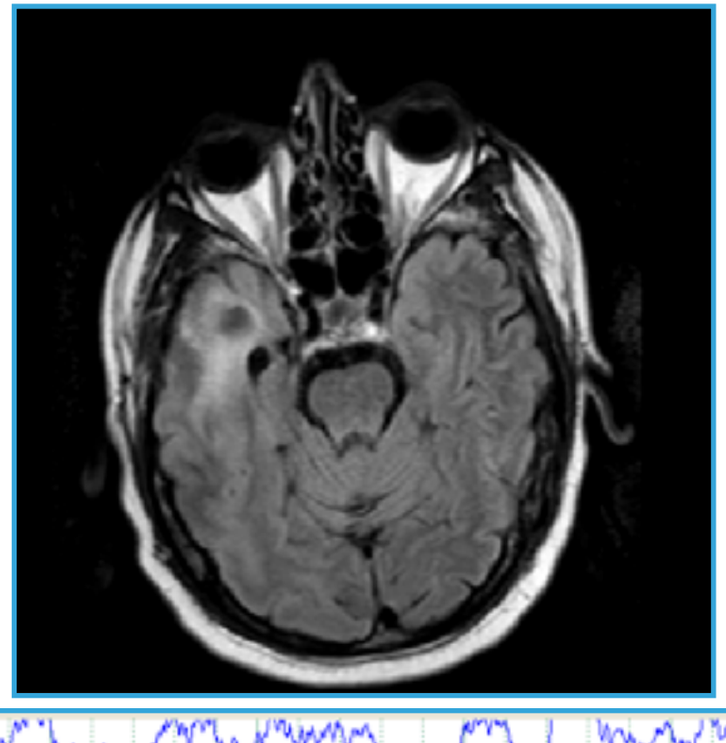


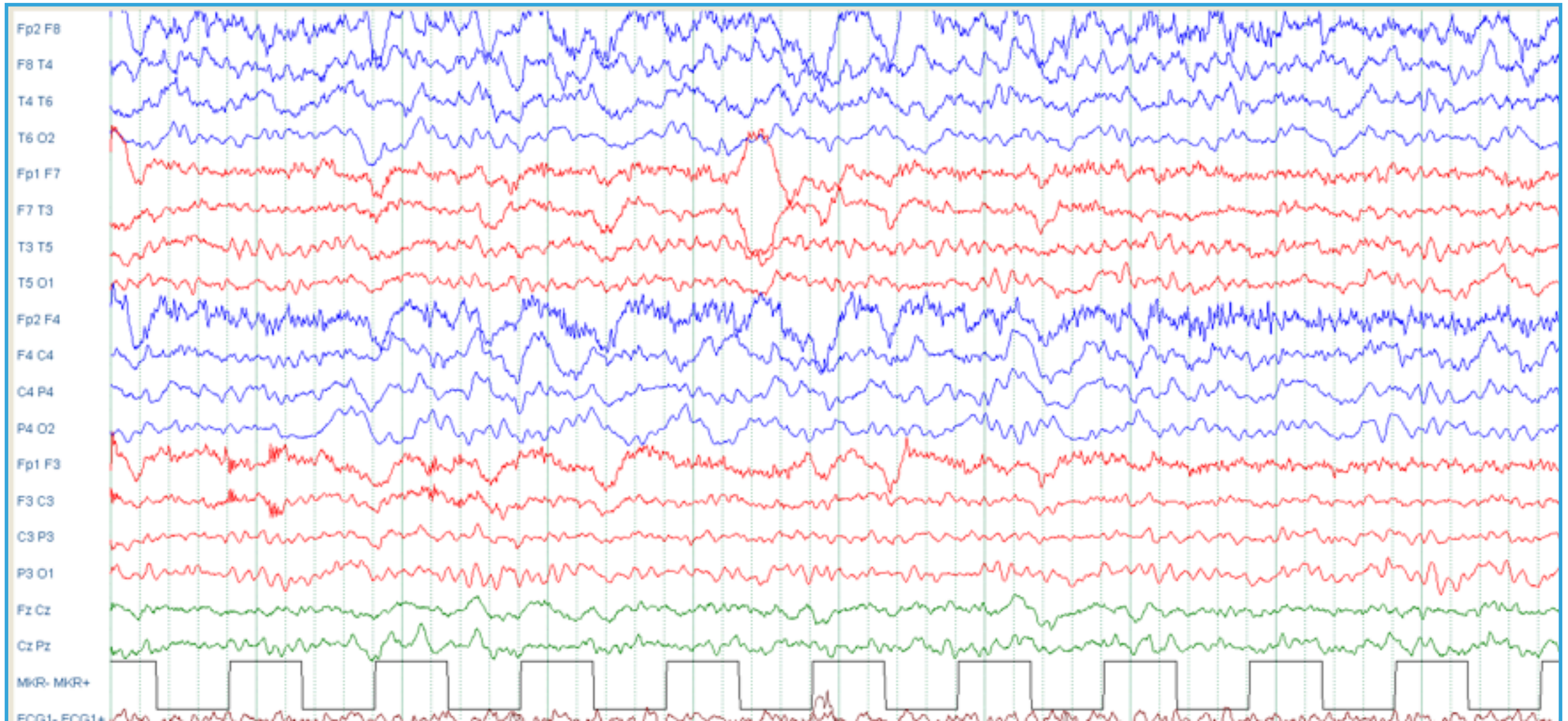


Alzheimer disease



Tumor




Fp2 F8
F8 T4
T4 T6
T6 O2
Fp1 F7
F7 T3
T3 T5
T5 O1
Fp2 F4
F4 C4
C4 P4
P4 O2
Fp1 F3
F3 C3
C3 P3
P3 O1
Fz Cz
Cz Pz
MKR- MKR+
ECG1- ECG1+

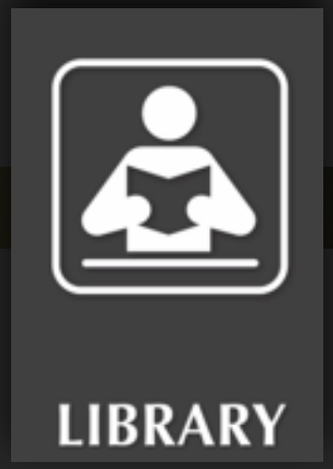
24H VIDEO EEG

Continuous recording

1. Needs special equipment
2. Qualified staff
3. More informative

THANKS FOR YOUR ATTENTION

Dionysios Pandis, Neurologist



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4. Introduction to sleep electroencephalography, Selim R Benbadis, Sleep: A Comprehensive Handbook, Edited by T. Lee-Chiong. Copyright # 2006 John Wiley & Sons, Inc.

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- http://www.bem.fi/book/13/13.htm