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# elettro encefalo grafia

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**EEG, ERP**

**corso di neuroscienze cognitive**

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**1**

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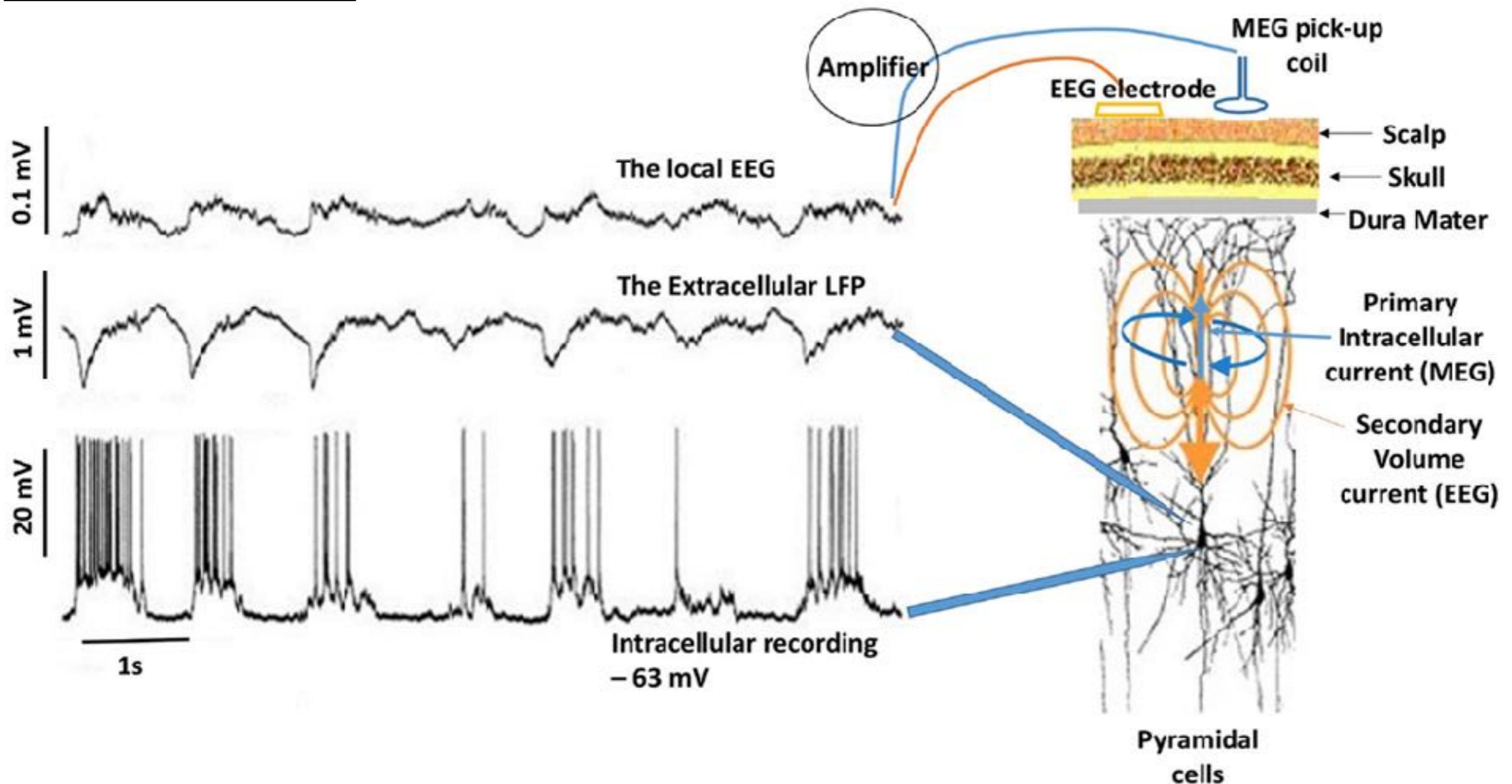
# elettroencefalografia (EEG)

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- *cosa viene misurato?*
    - modificazioni elettriche in gruppi di neuroni
  - *come viene misurato?*
    - differenze tra due elettrodi nello scalpo
  - *che tipo di variazioni possono essere misurate?*
    - correlate al sonno; disordini neurologici
  - *come vengono misurate queste modificazioni?*
    - Frequenza, Ampiezza, Forma (onde specifiche)
-

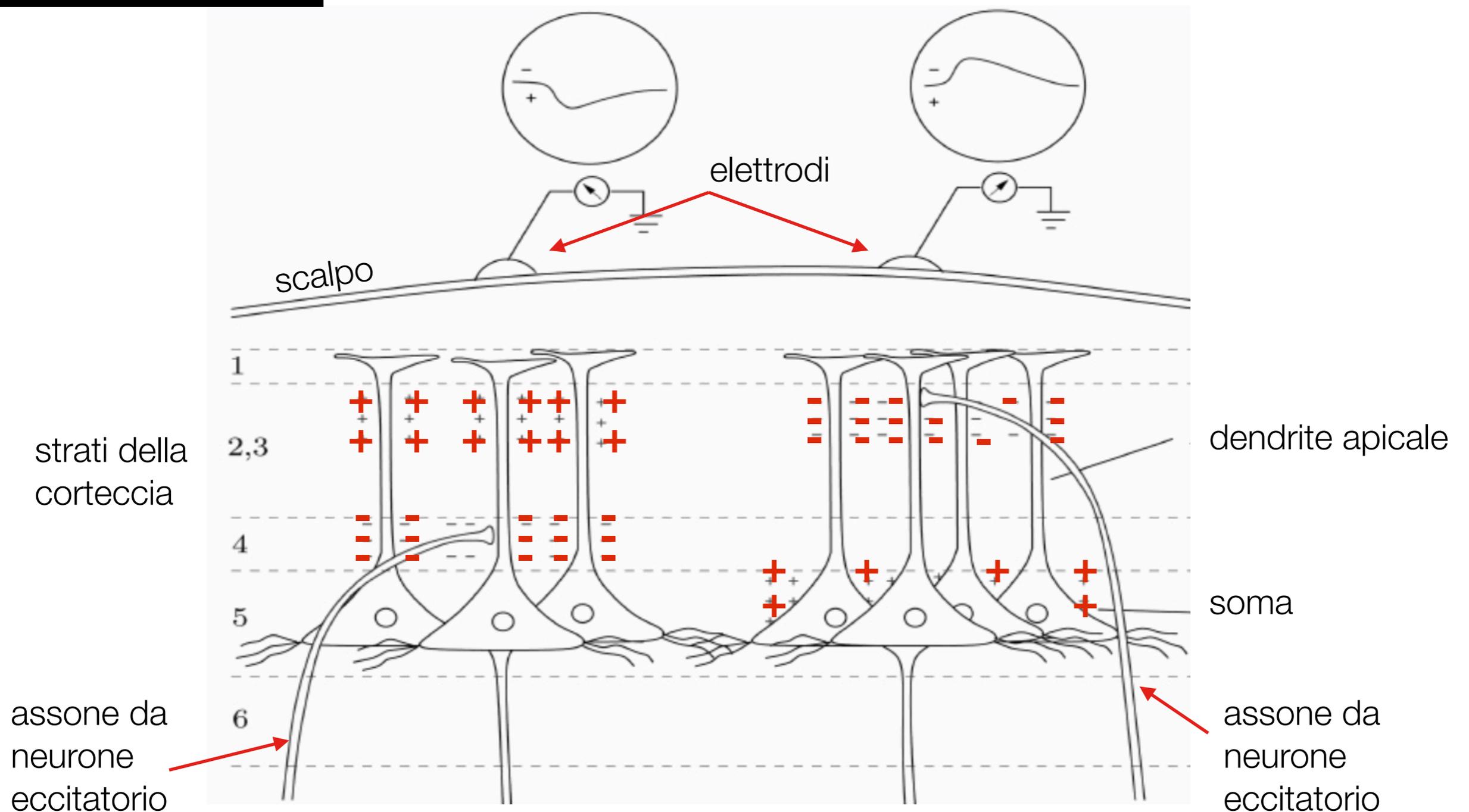
# origine del segnale EEG

Baillet et al., IEEE Sig. Proc. Mag., 2001



# origine del segnale EEG

Baillet et al., IEEE Sig. Proc. Mag., 2001



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# dove nascono i potenziali?

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- non sono potenziali d'azione, ma **potenziali post sinaptici** eccitatori o inibitori
  - comportamento di massa di neuroni corticali
  - non tutte le cellule contribuiscono alla stessa maniera
  - riflettono l'attività di neuroni vicini all'elettrodo
  - le strutture profonde non contribuiscono (non direttamente)
-

# elettrodo e cuffia EEG/ERP

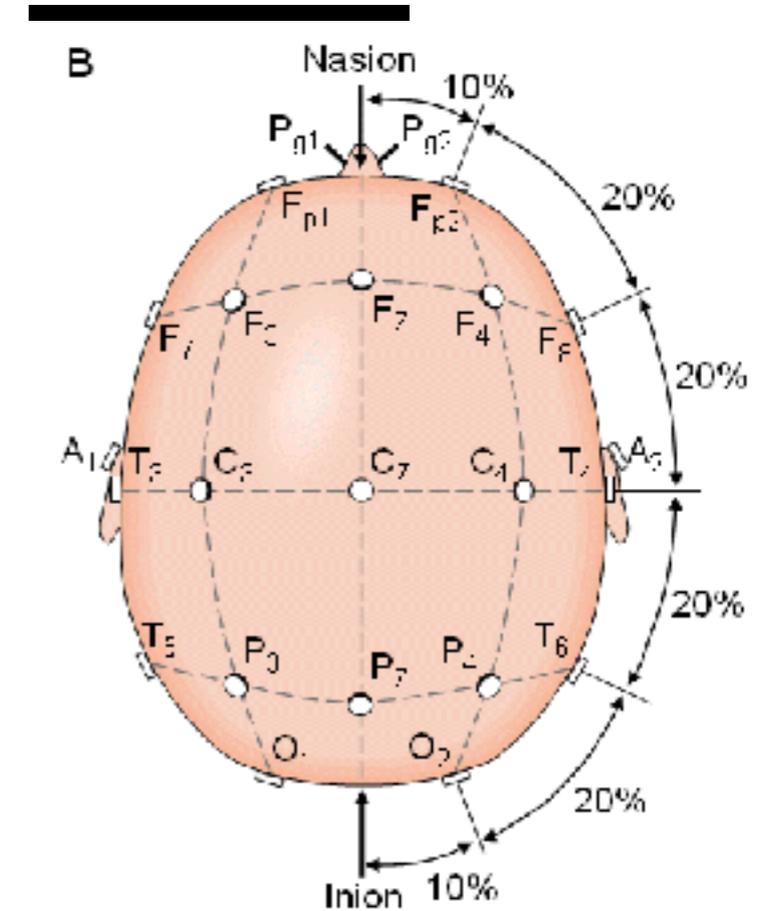


## Elettrodi

Stagno o argento/cloruro d'argento



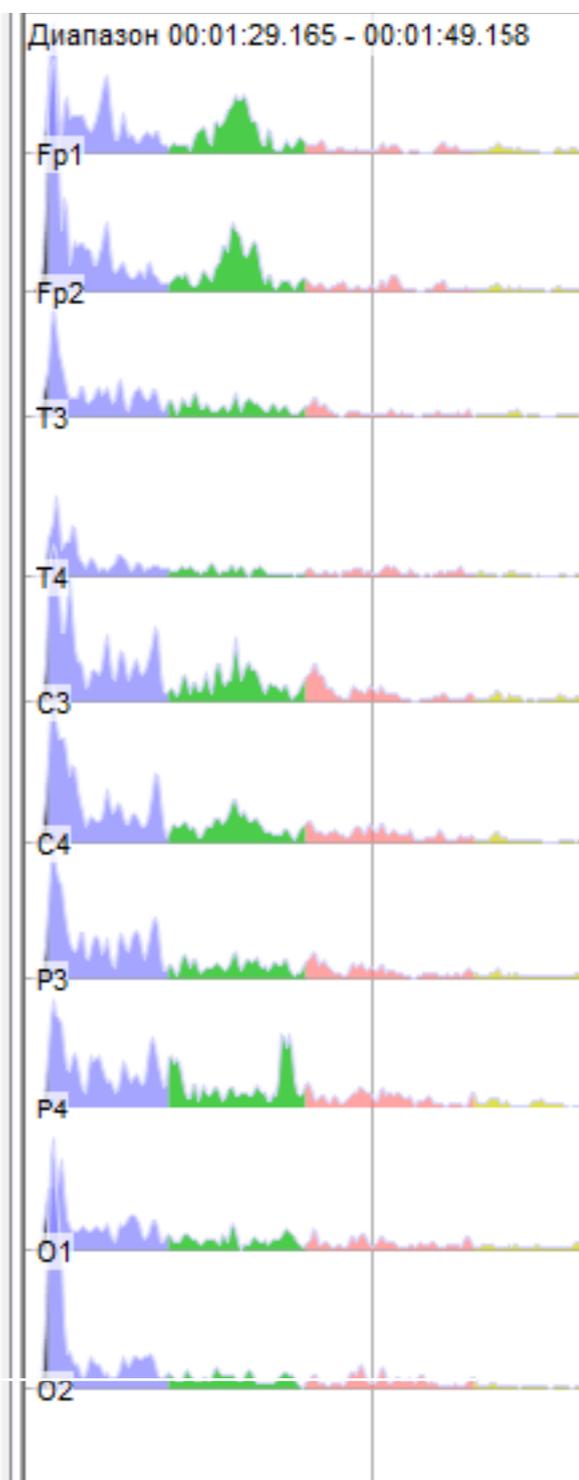
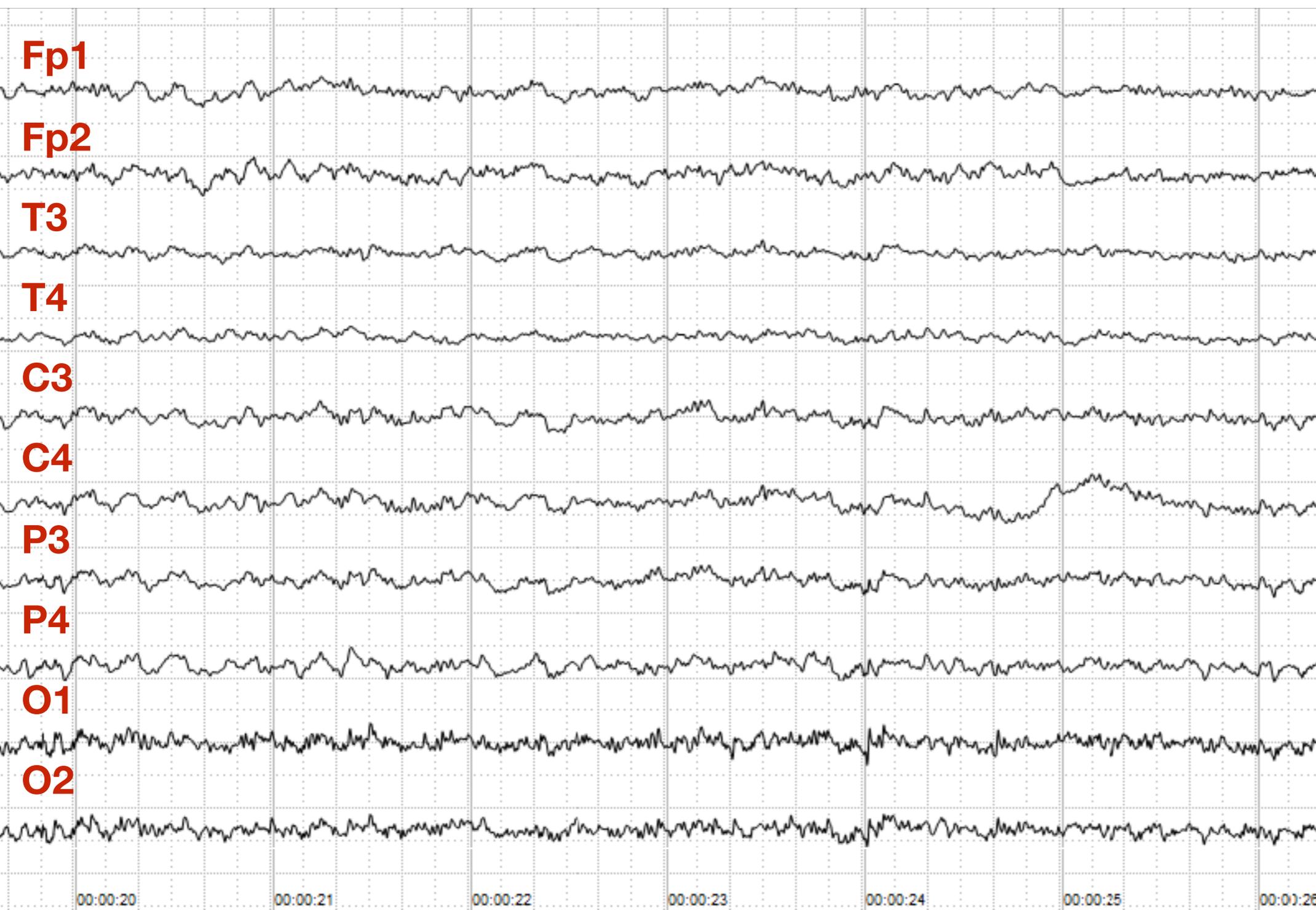
## Cuffia Con 64 Elettrodi Di Superficie



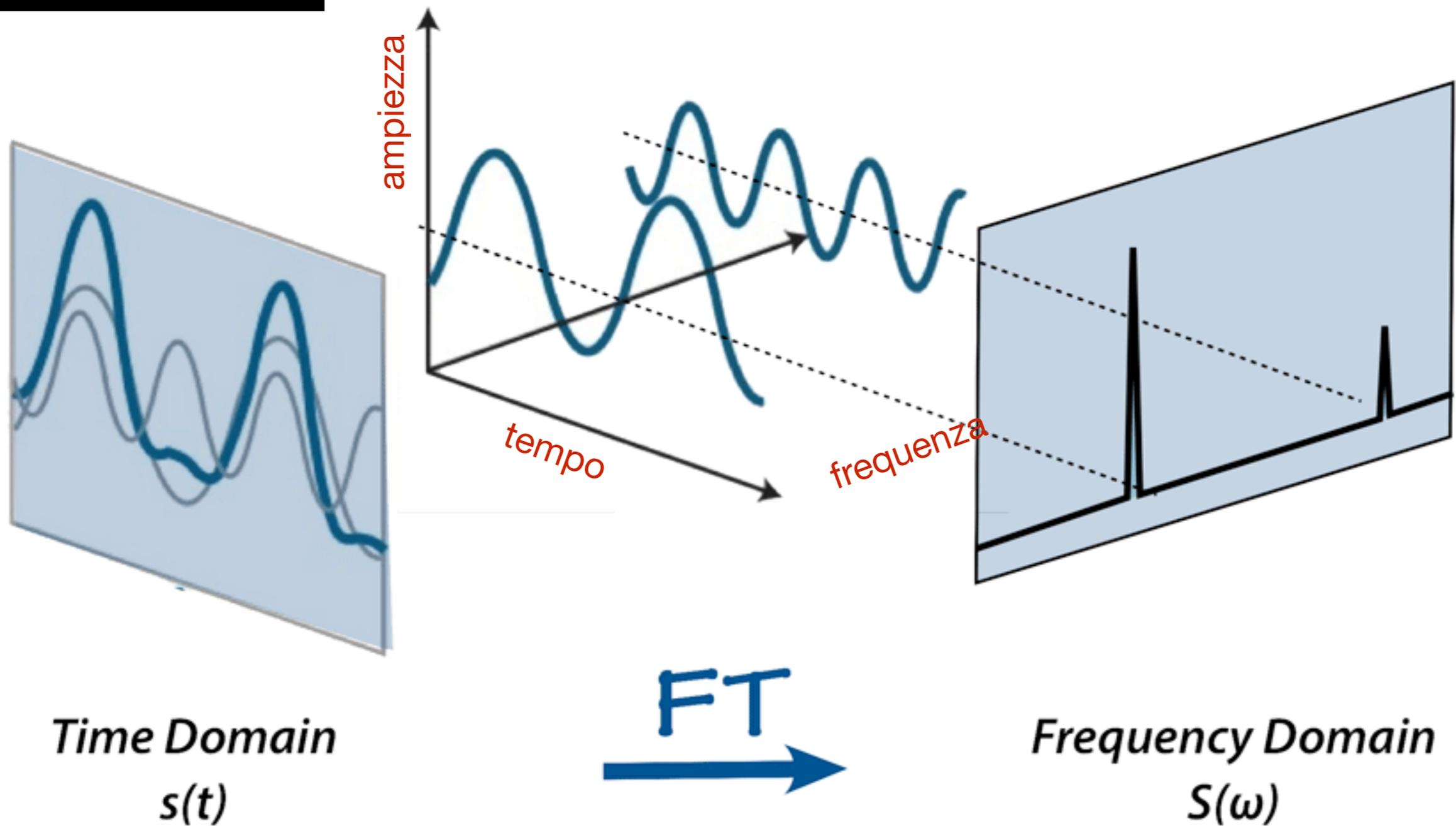
## Sistema 10-20

# onde EEG

ritmo beta

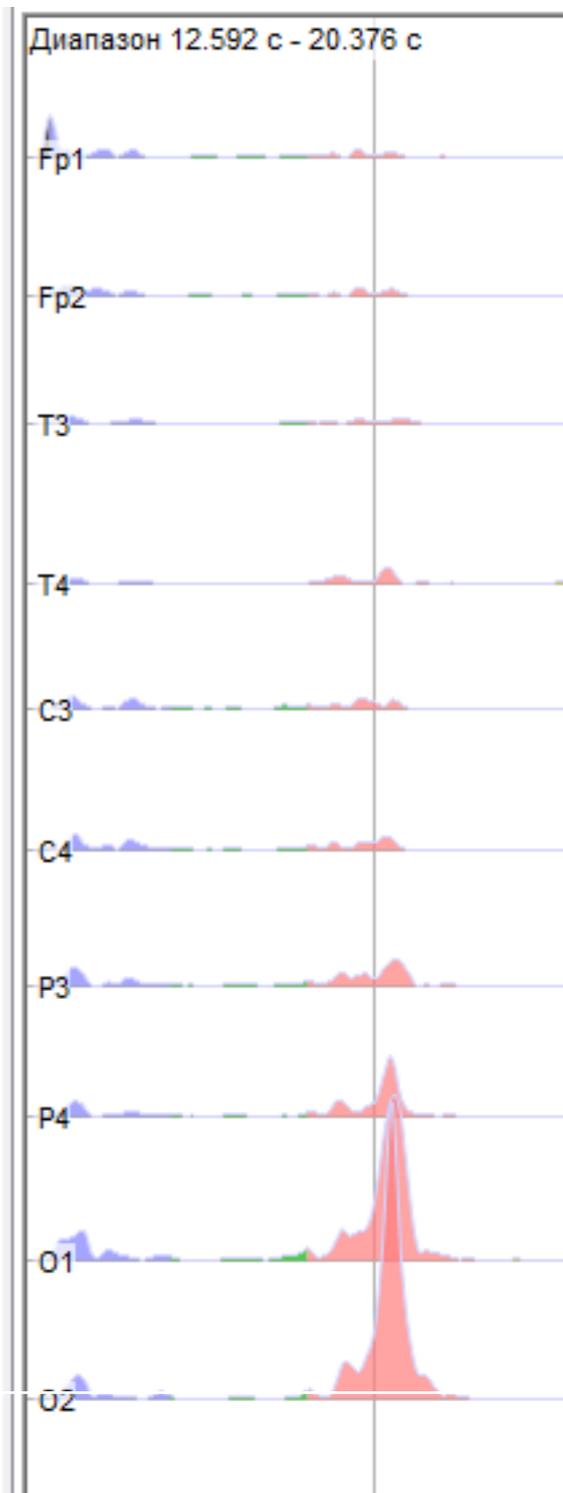
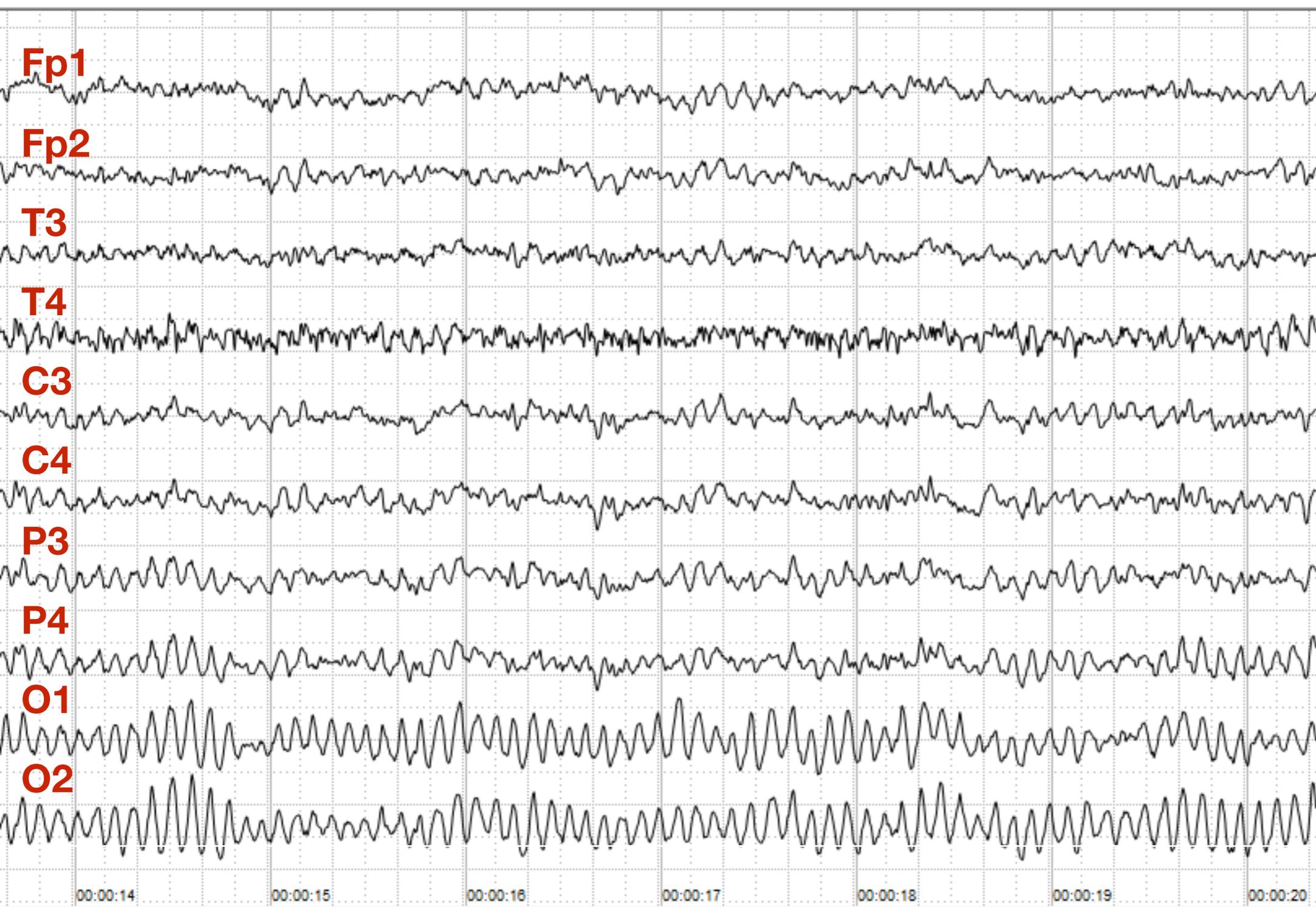


# trasformazione di Fourier



# onde EEG

ritmo alfa



# onde EEG

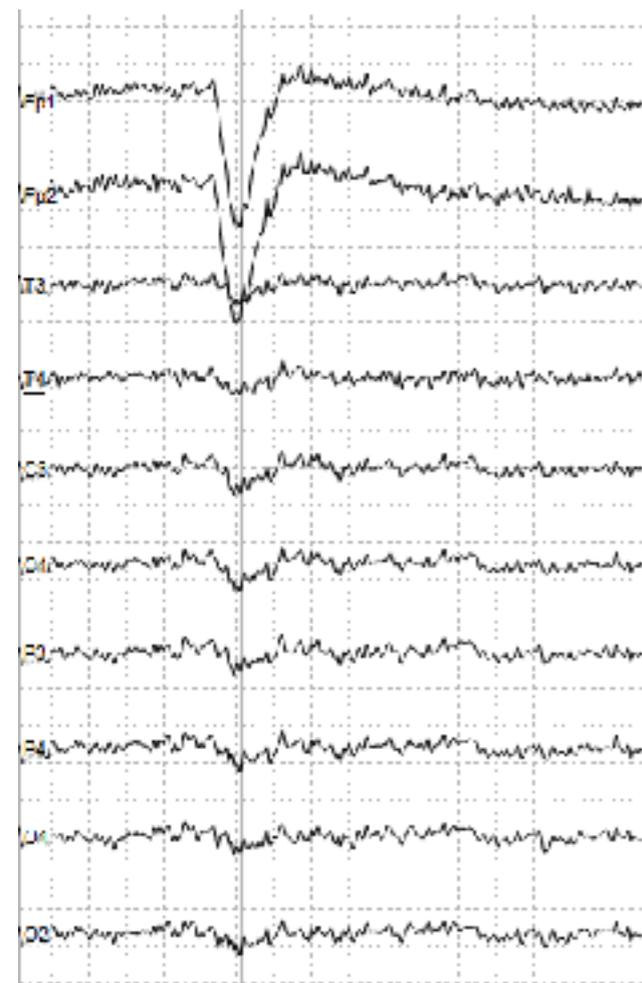
possibili artefatti

ammiccamento

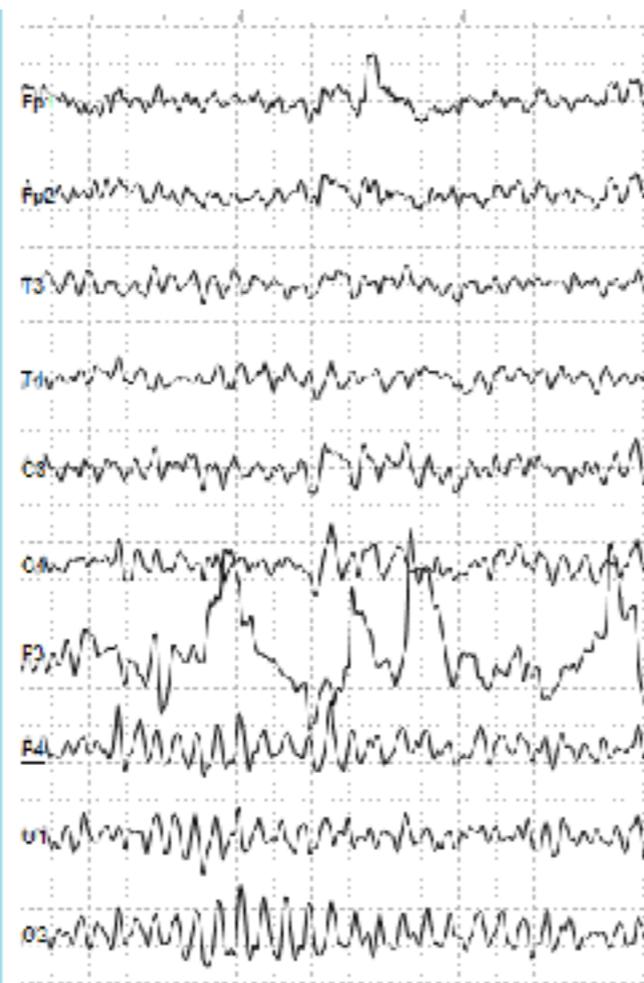
impedenza  
elettrodo

artefatto  
da sudorazione

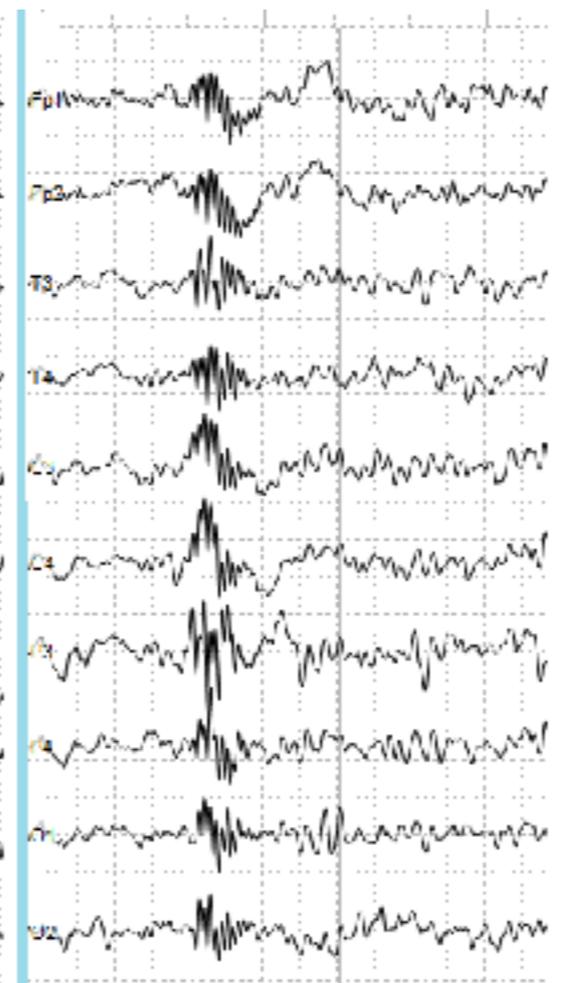
impedenza  
referenza



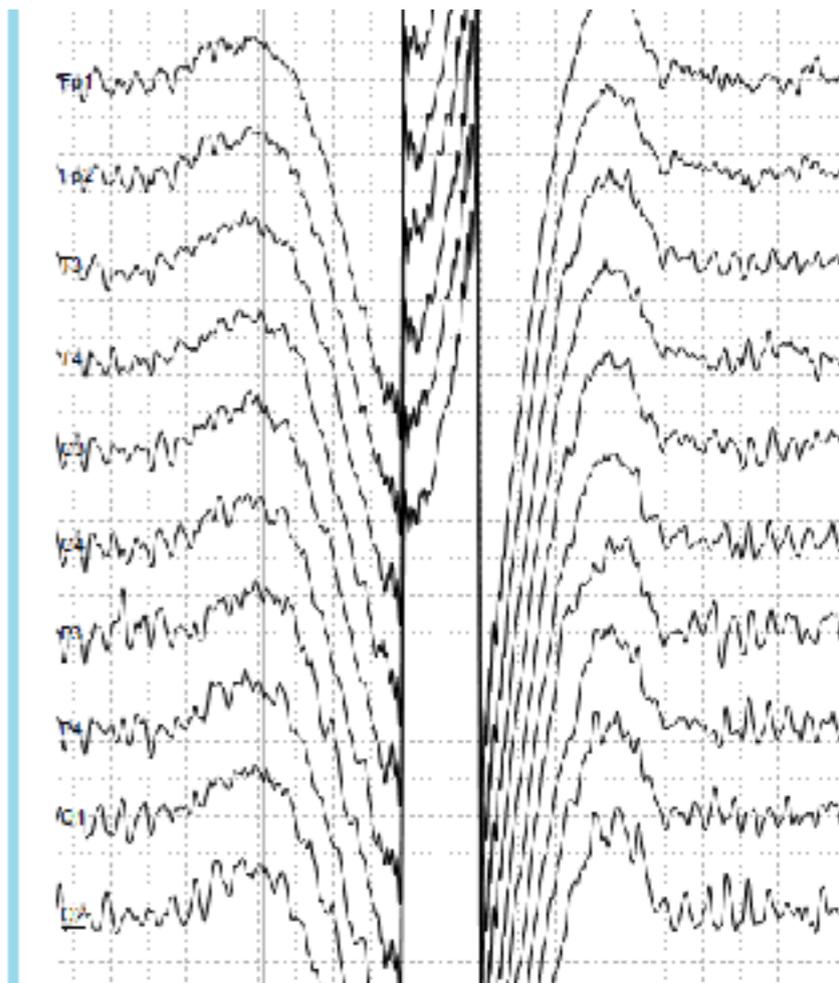
1



2



3



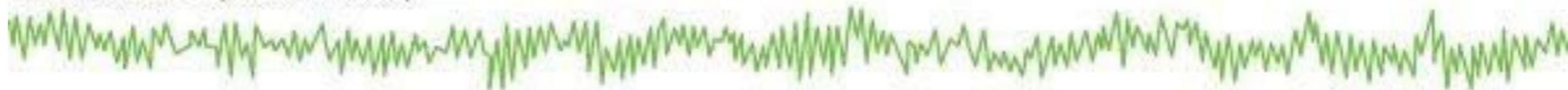
4

# onde EEG

ciclo sonno veglia

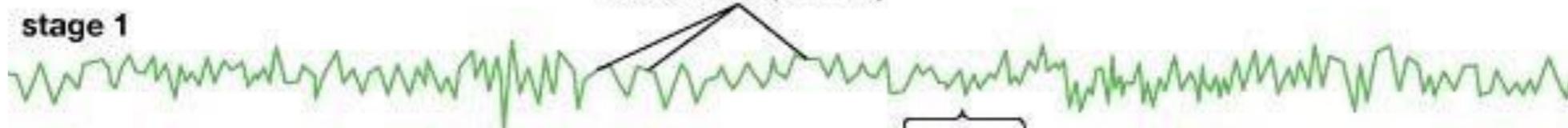
Electroencephalogram (EEG) showing typical brain waves of sleep and wakefulness

wakefulness (relaxed state)



stage 1

theta waves (4–7 Hz)



stage 2

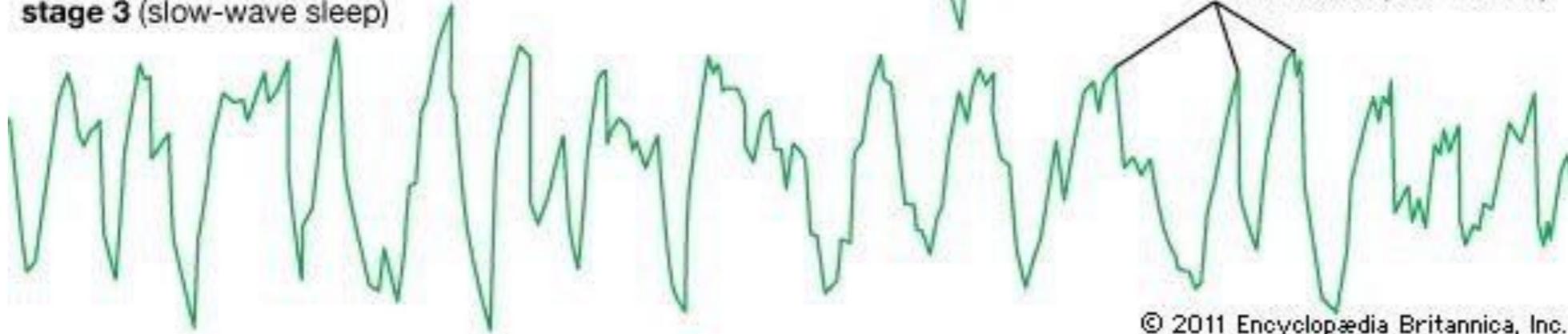
sleep spindle (11–15 Hz)

K-complex



stage 3 (slow-wave sleep)

slow waves (0.5–2.0 Hz)



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# **Aspetti clinici**

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# EEG e diagnosi di epilessia

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- “scarica epilettiforme interictale”  
**IED** “interictal epileptiform discharge”
  - persone **sane** possono presentare IED
  - pazienti **neurologici non epilettici** possono presentare IED
-

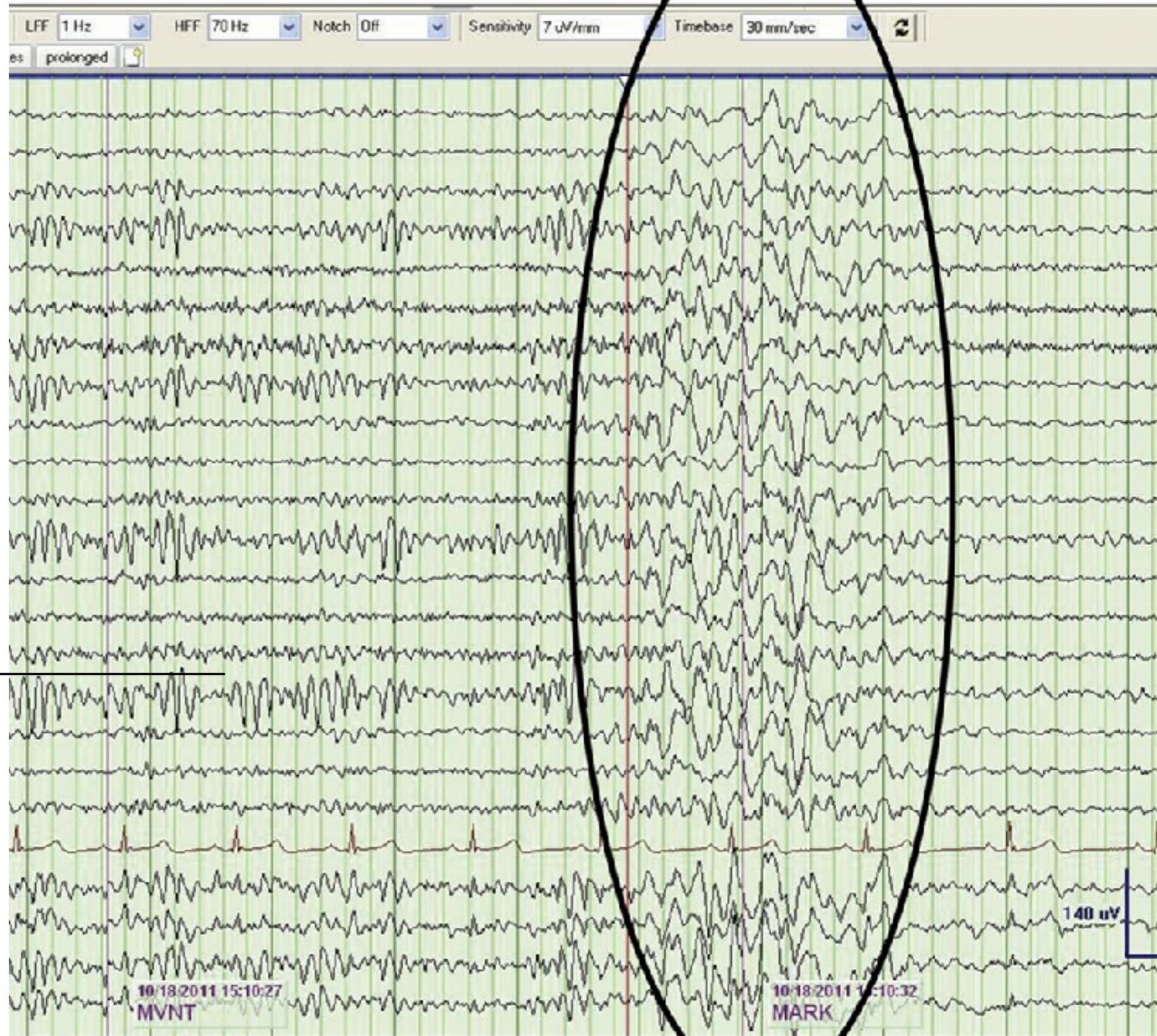
# onde EEG

epilessia



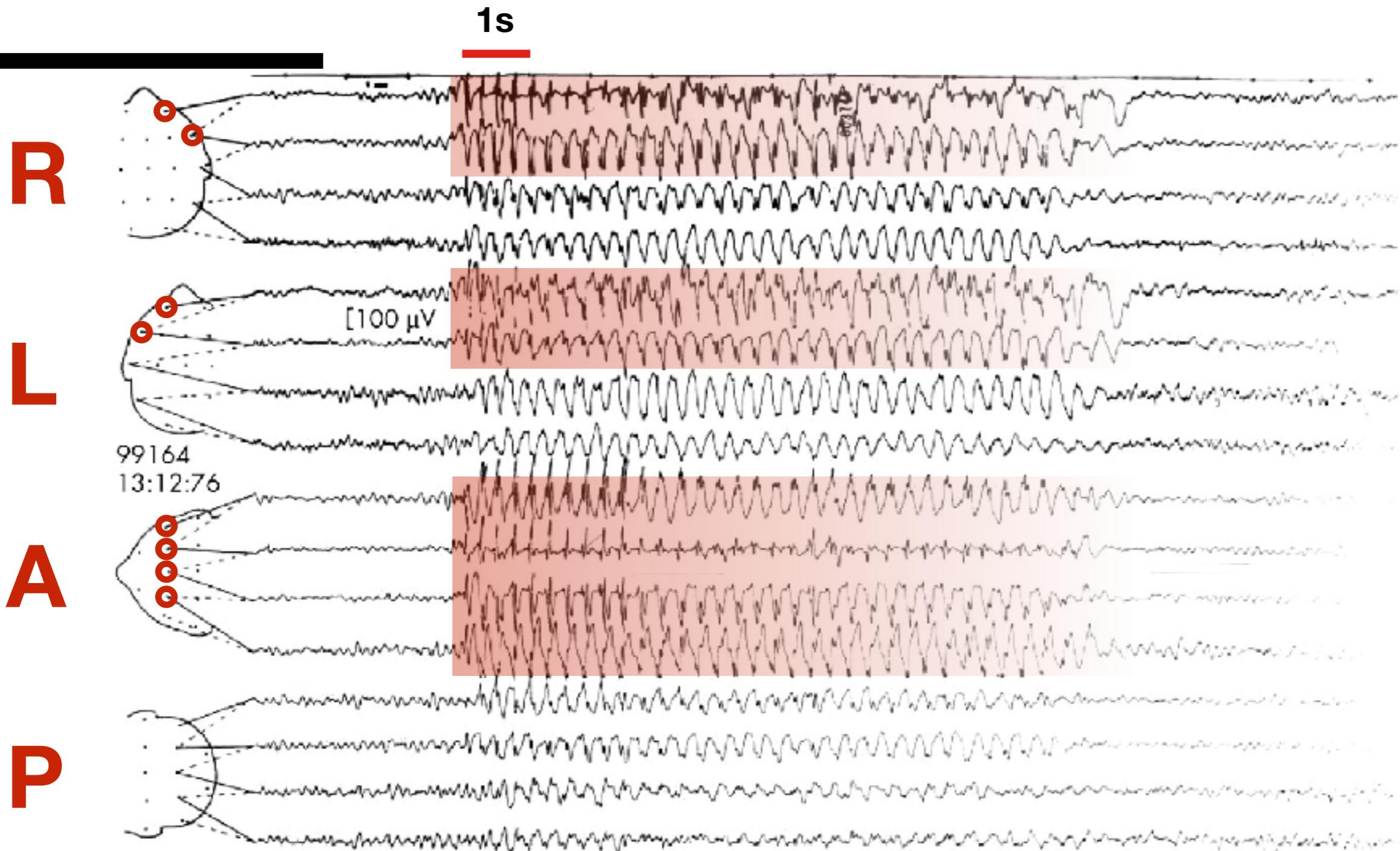
# onde EEG

epilessia

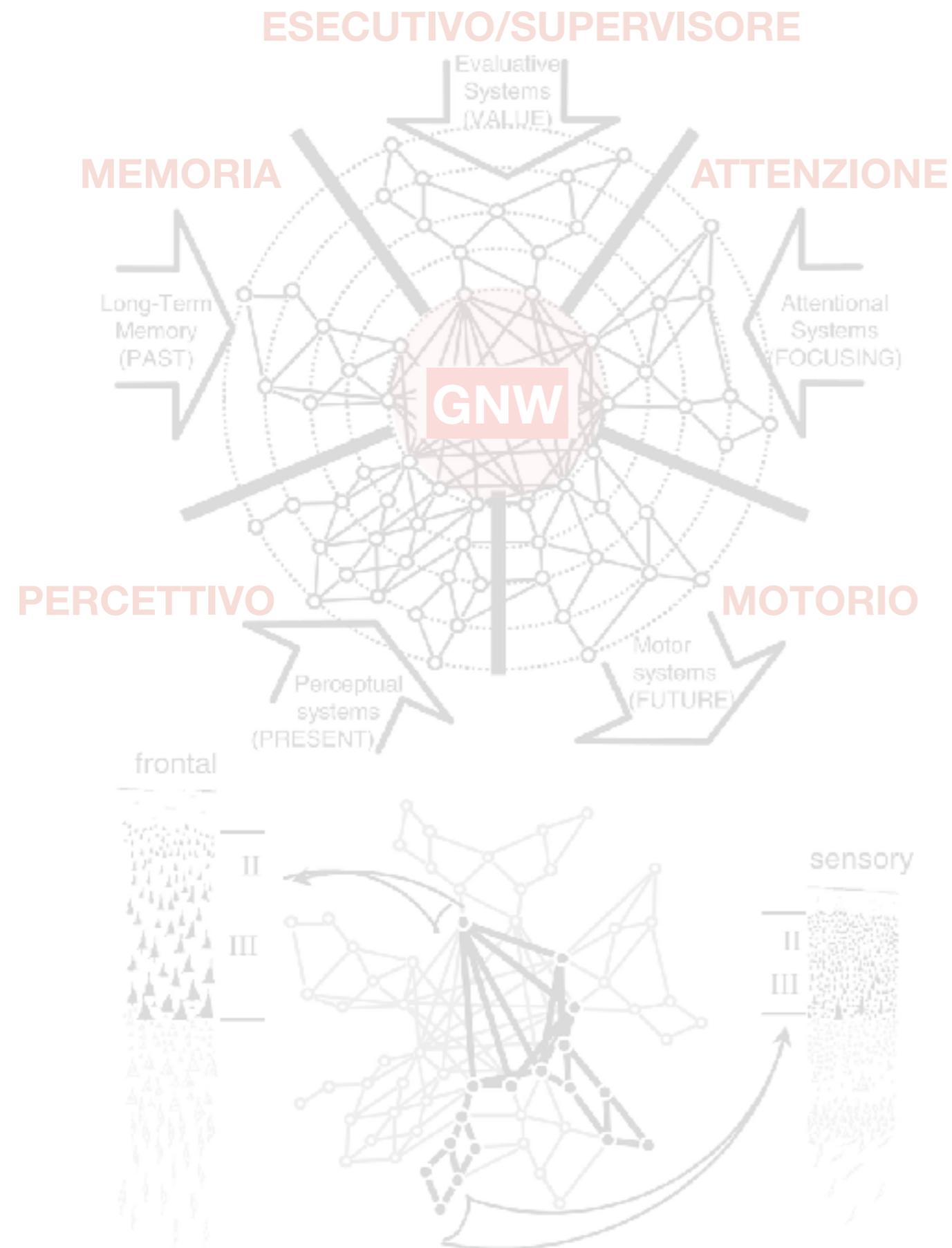


# onde EEG

epilessia



# EEG e livelli di coscienza



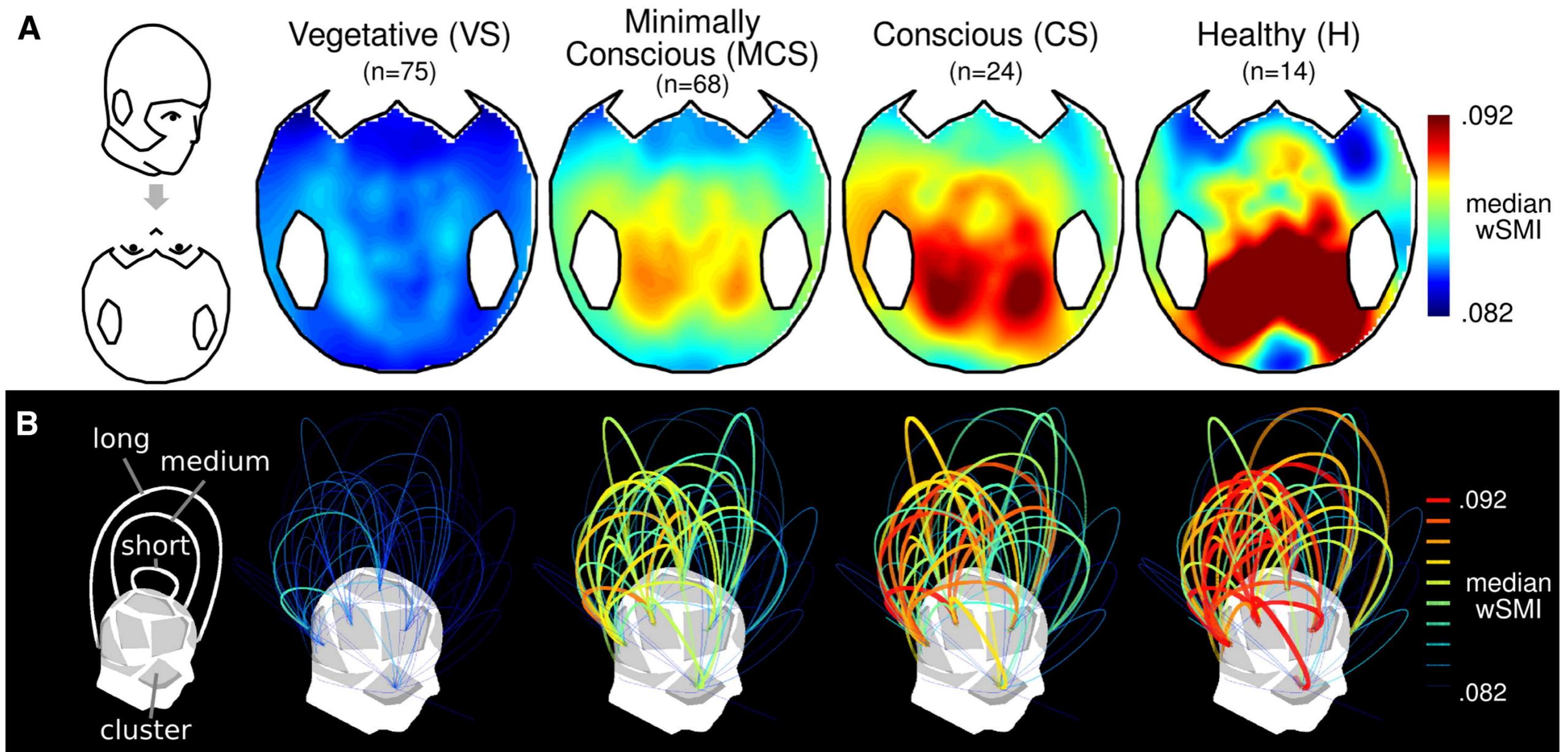
Global Neuronal Workspace (**GNW**) hypothesis

indice di connettività tra aree:  
*weighted Symbolic Mutual Information*  
(**wSMI**) → basato su EEG

Dehaene, S., Kerszberg, M., and Changeux, J.P (1998)

# EEG e livelli di coscienza

King, et al. Current Biology (2013)



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# stato vegetativo e minima coscienza

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## **stato vegetativo:**

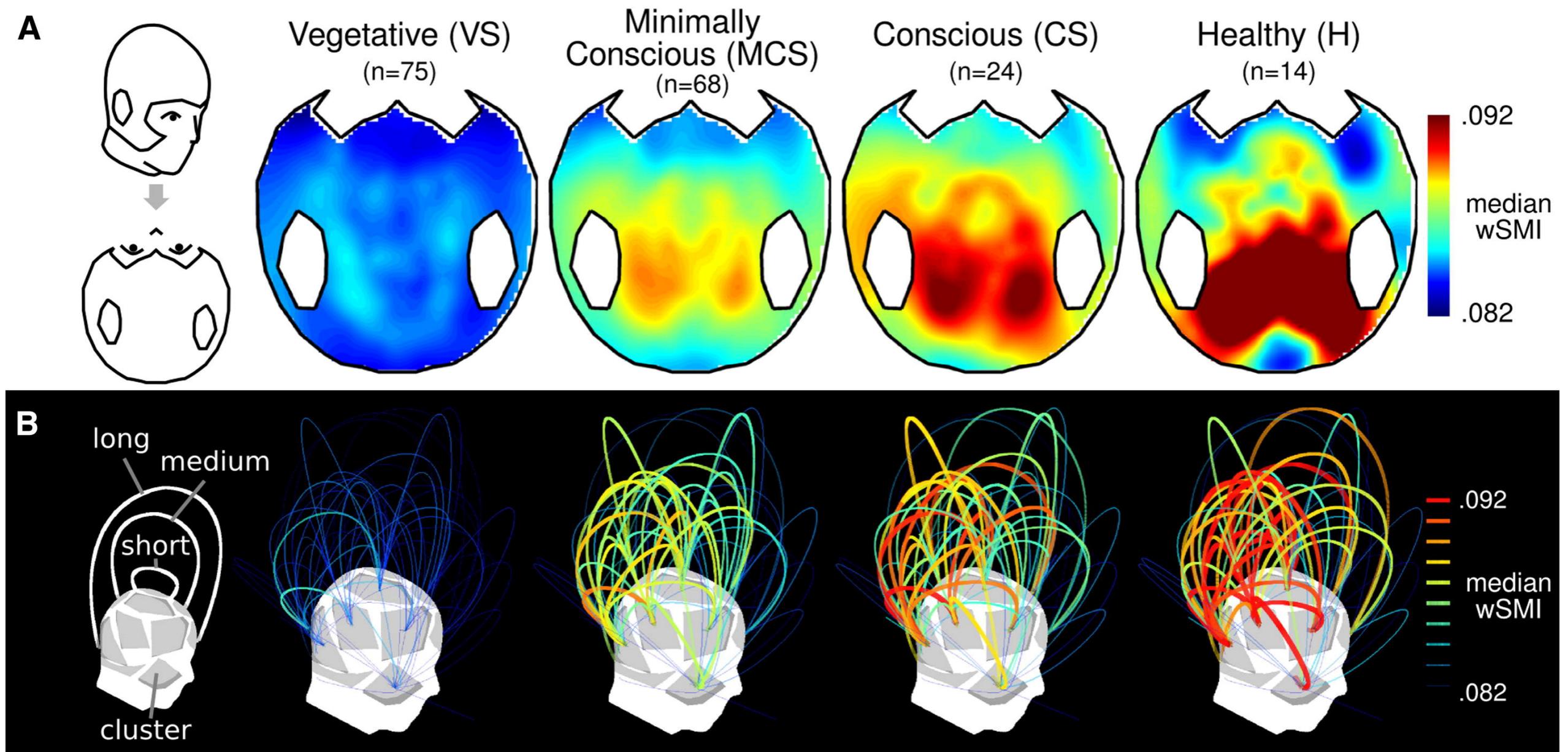
- no consapevolezza, interazione, risposte a stimoli esterni, comprensione linguistica
- si riflessi semplici (es. pupillare) ciclo sonno-veglia, riflessi complessi (es. deglutizione)

## **minima coscienza:**

- frammenti di interazione con l'ambiente; afferramento, contatto visivo, risposte stereotipate
-

# EEG e livelli di coscienza

King, et al. Current Biology (2013)



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# ERP event related potentials

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“Potenziali elettrici associati a specifici eventi di tipo sensoriale, percettivo, cognitivo, o motorio”

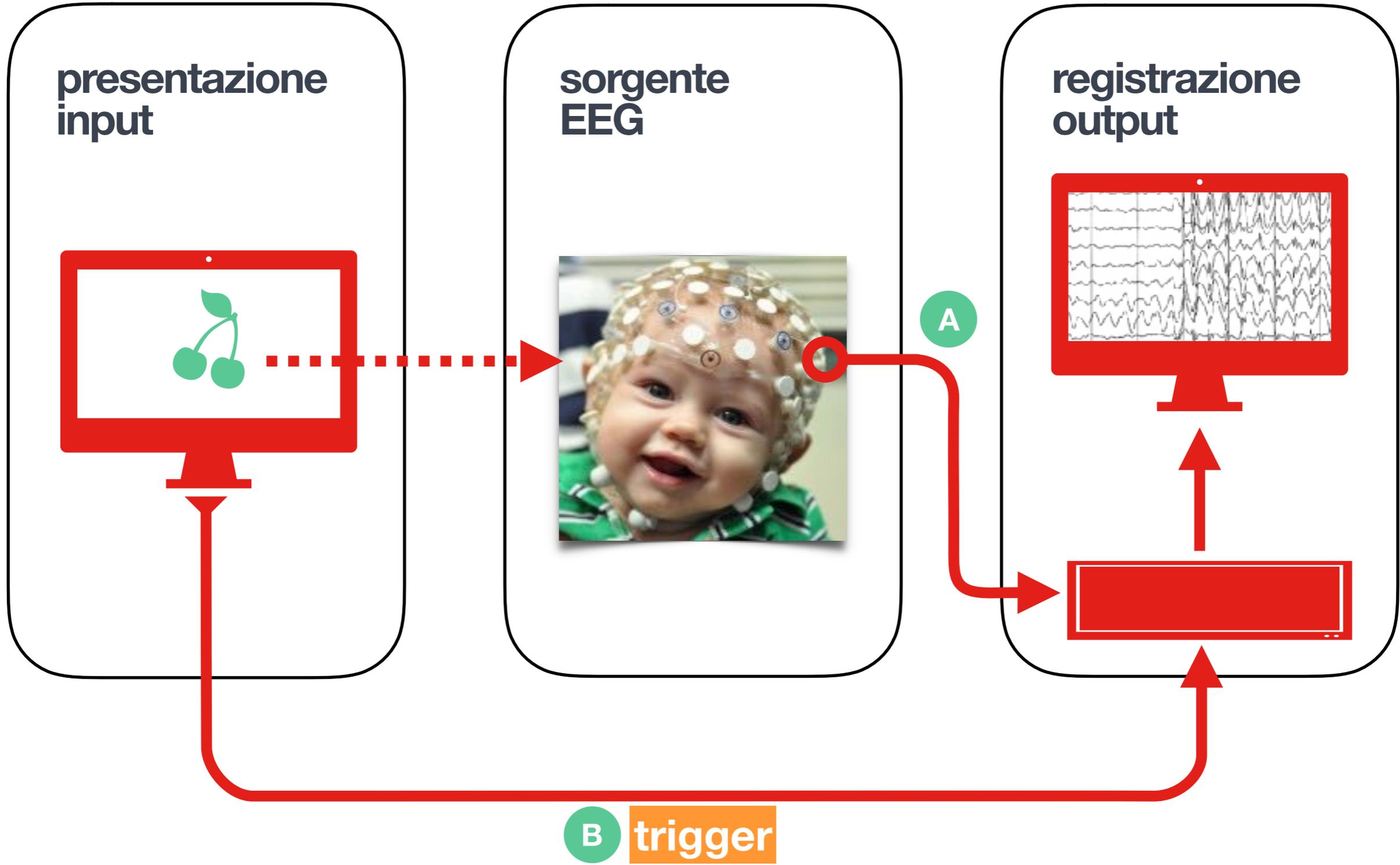
- dall'EEG agli ERP...

**Medie sincronizzate** di tante prove corrispondenti allo stesso evento

**attenuazione** del rapporto **segnale/rumore**; ciò che rimane è “relato all’evento”

EEG = 20-50  $\mu\text{v}$  / ERP = 1-10  $\mu\text{v}$

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**stimulus**

**response**

- X premi pulsante A
- X premi pulsante A
- O premi pulsante B
- O premi pulsante B
- X premi pulsante A
- X premi pulsante A

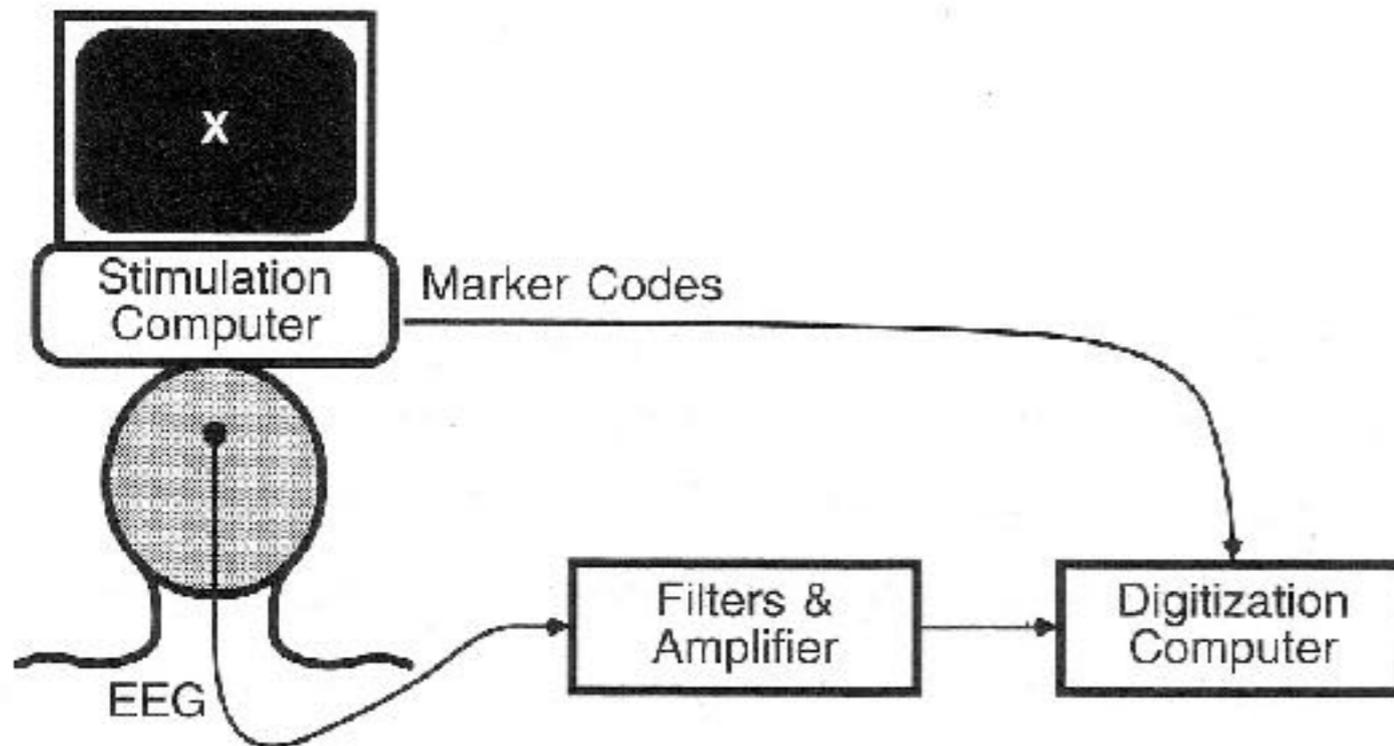
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# oddball paradigm

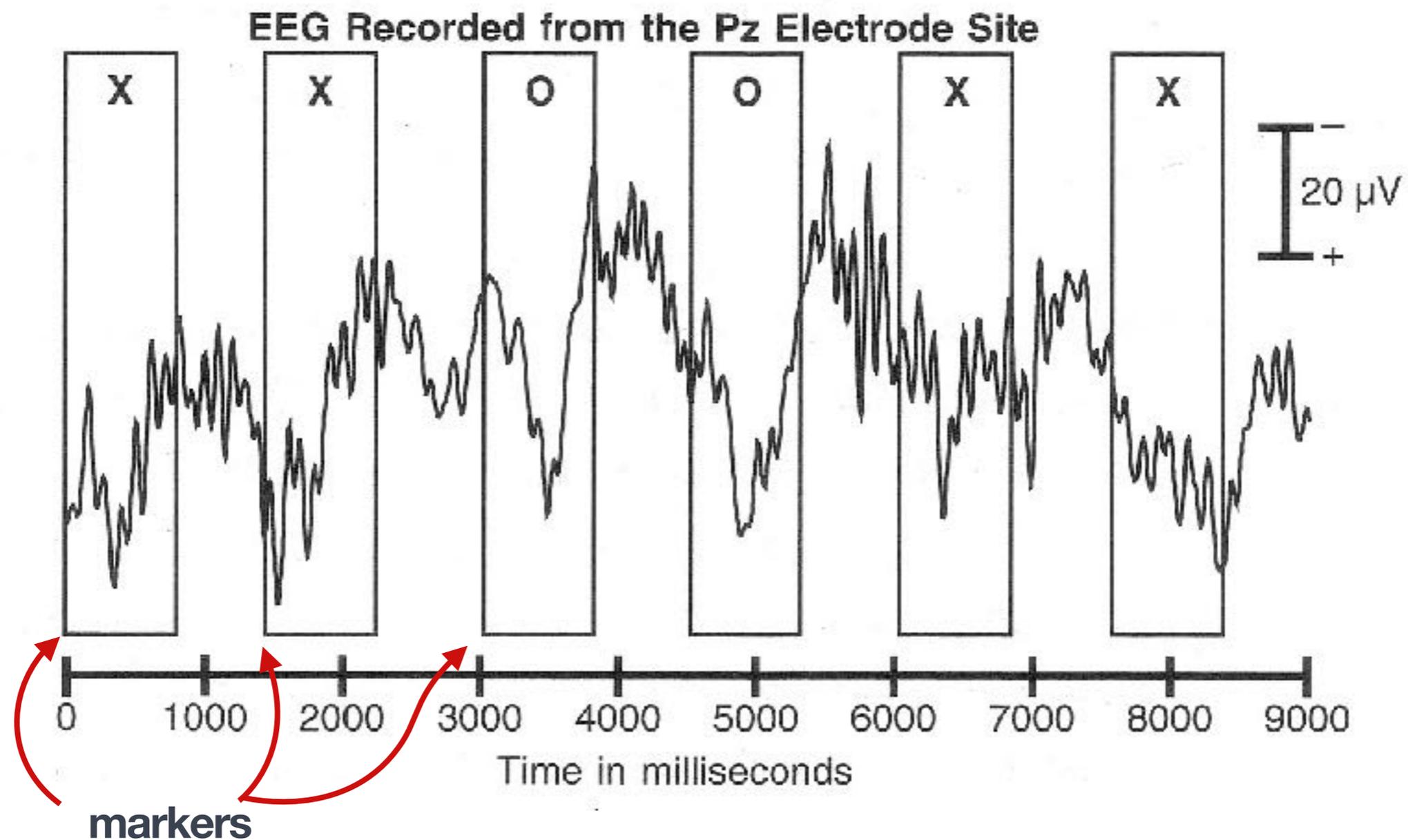
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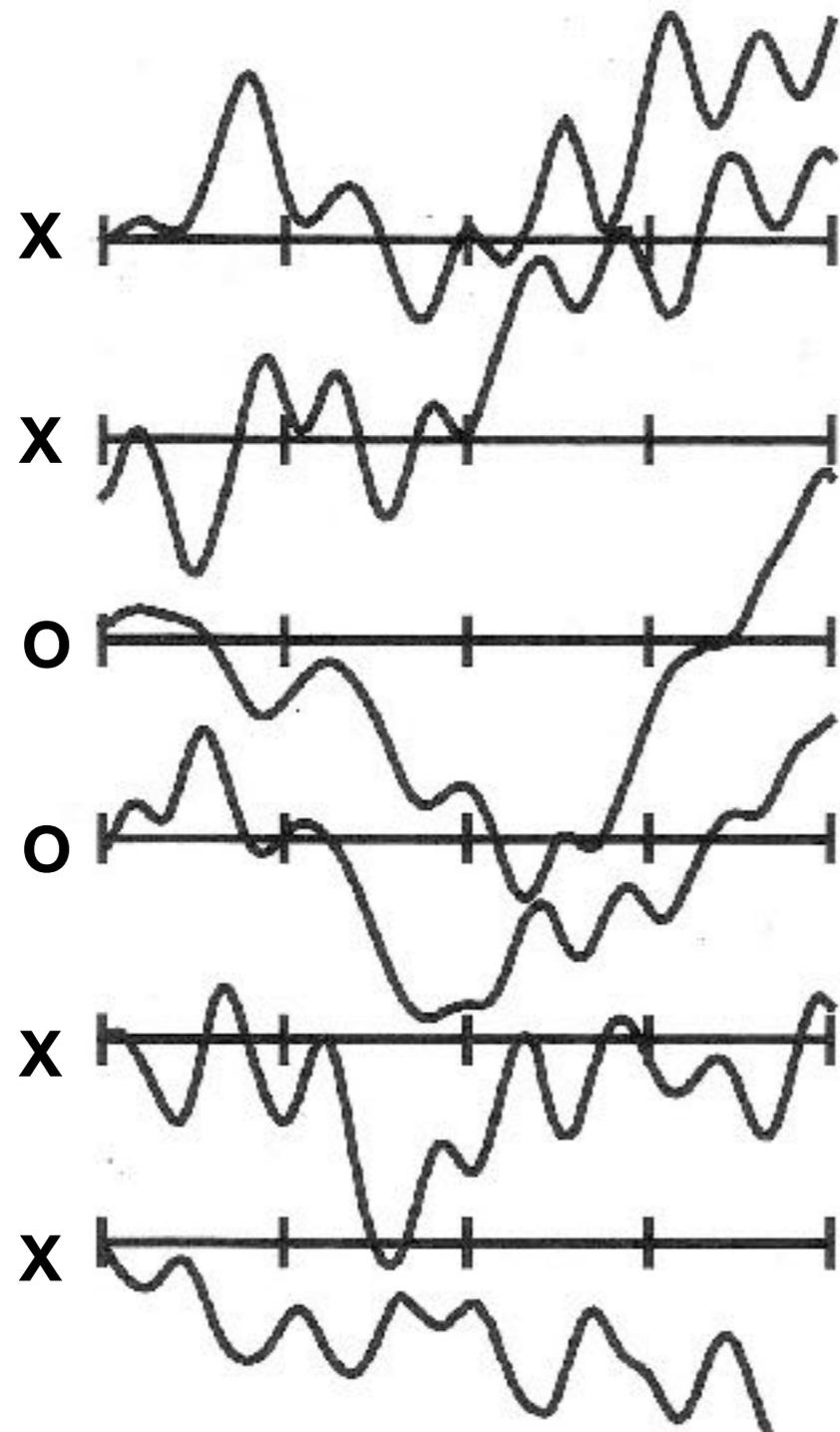
80 % stimoli **X**

20% di stimoli **O**

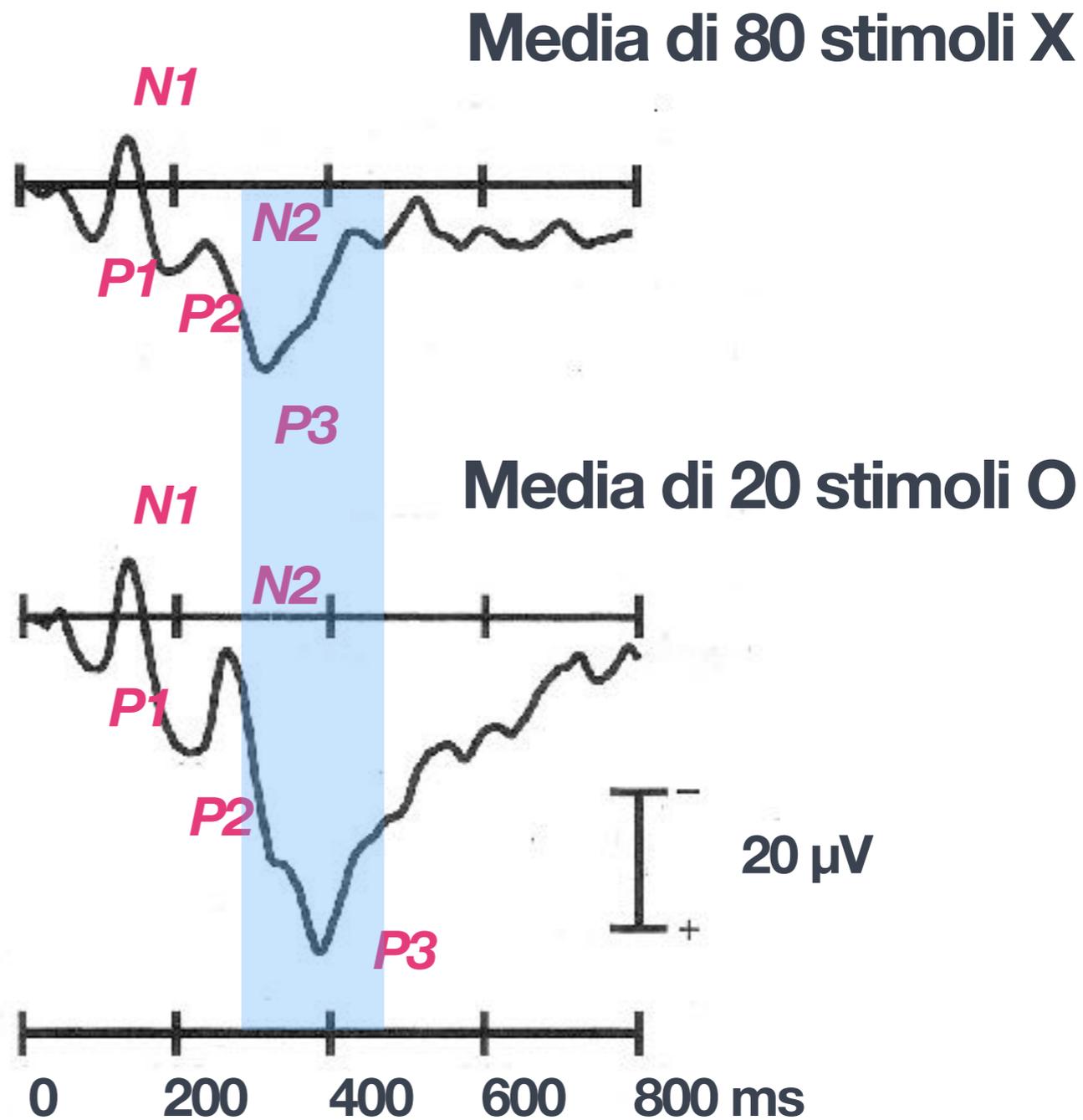


# EEG registrato da elettrodo Pz





segmenti EEG (epoche)  
secondo i codici  
marker



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# **artefatti EEG**

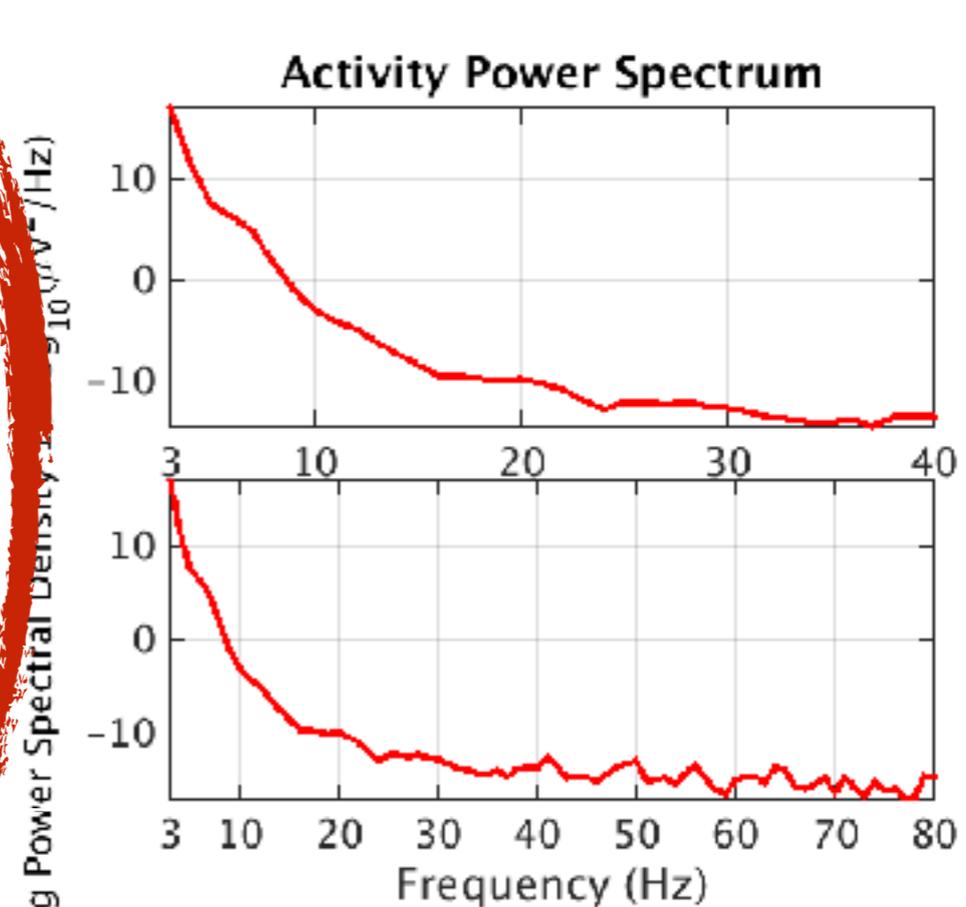
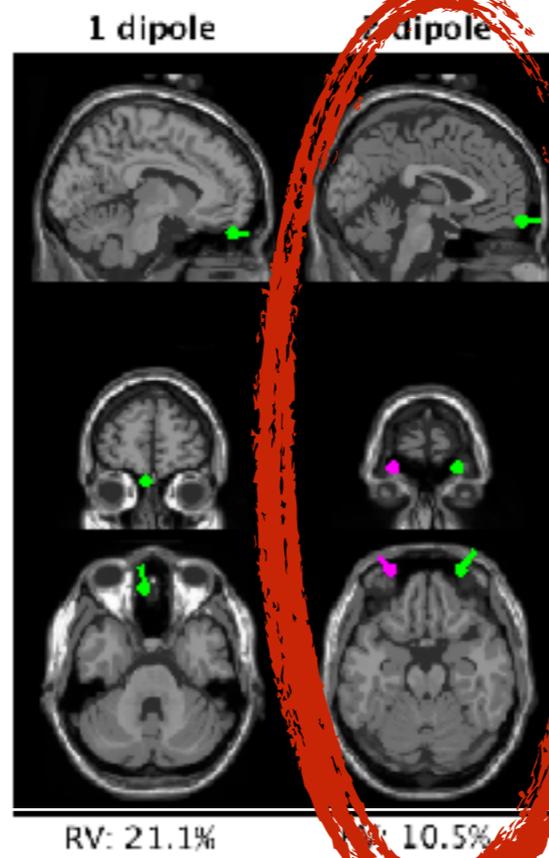
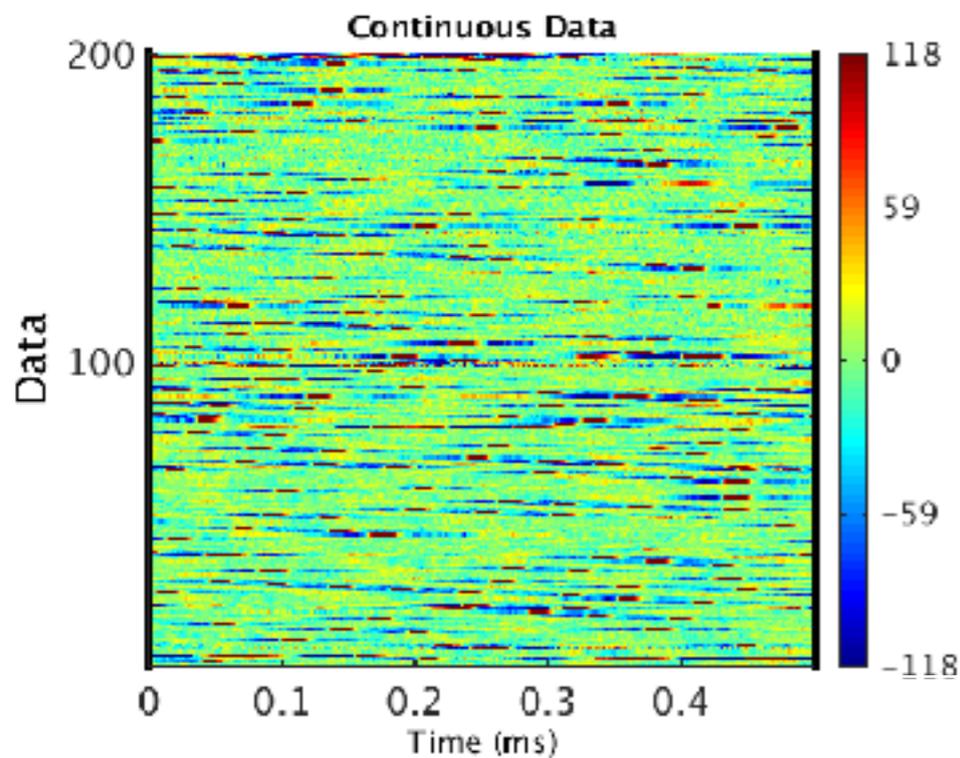
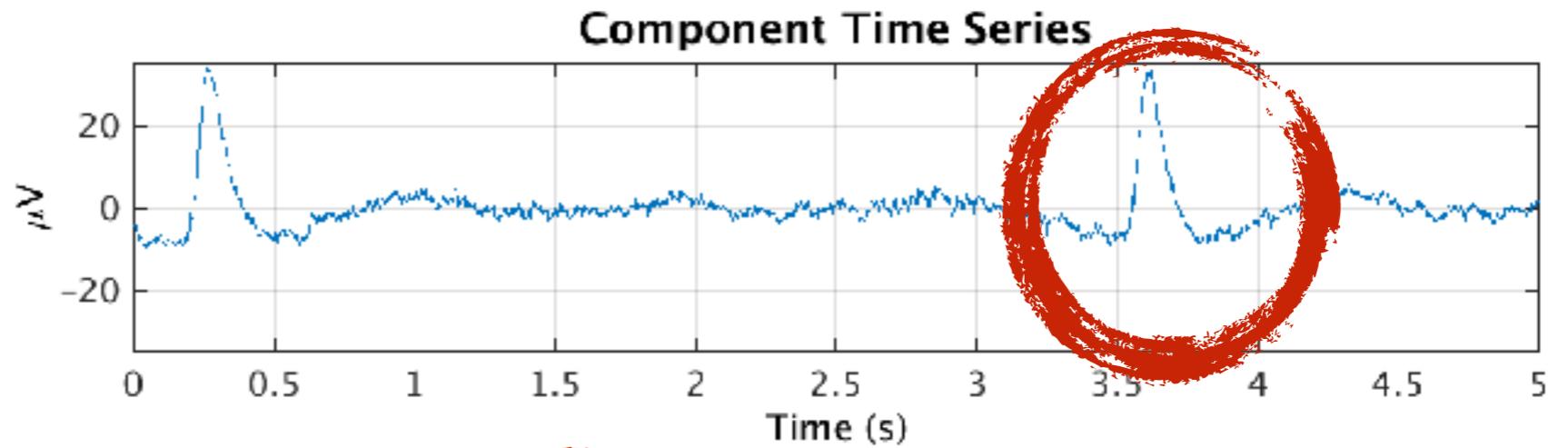
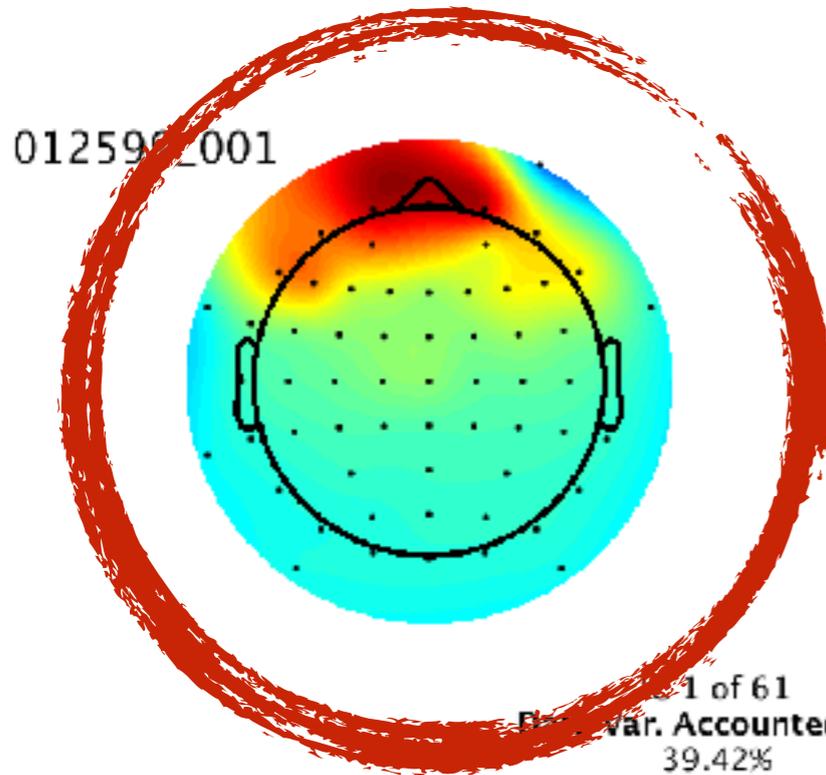
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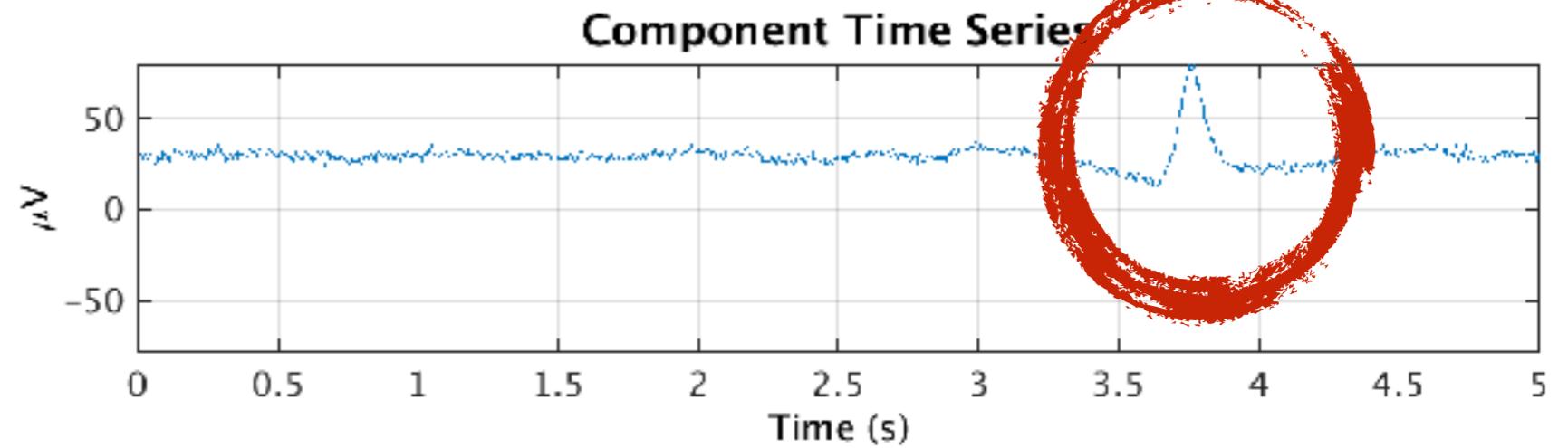
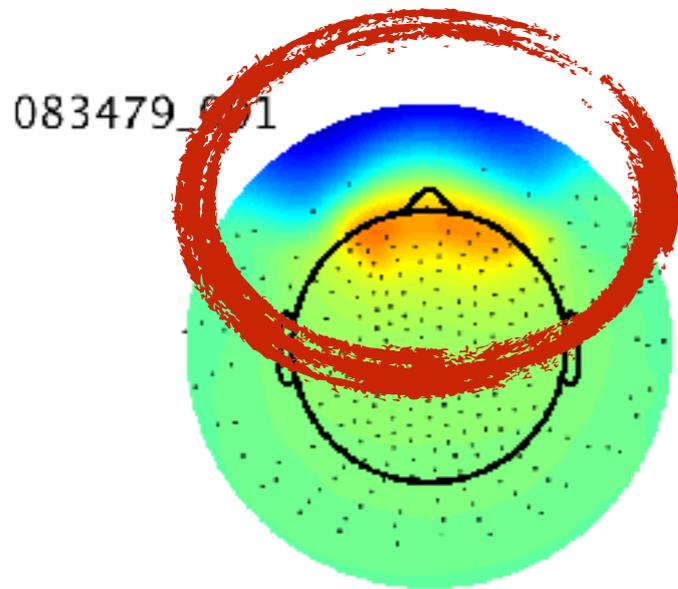
# Eye components

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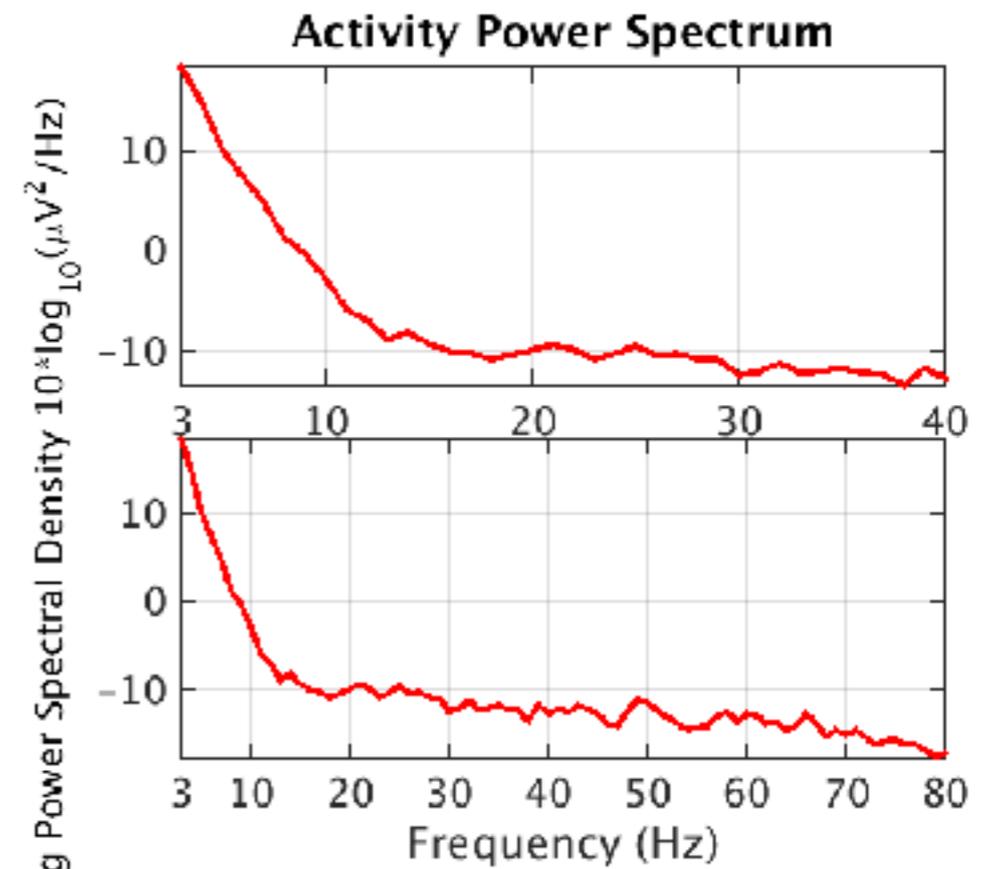
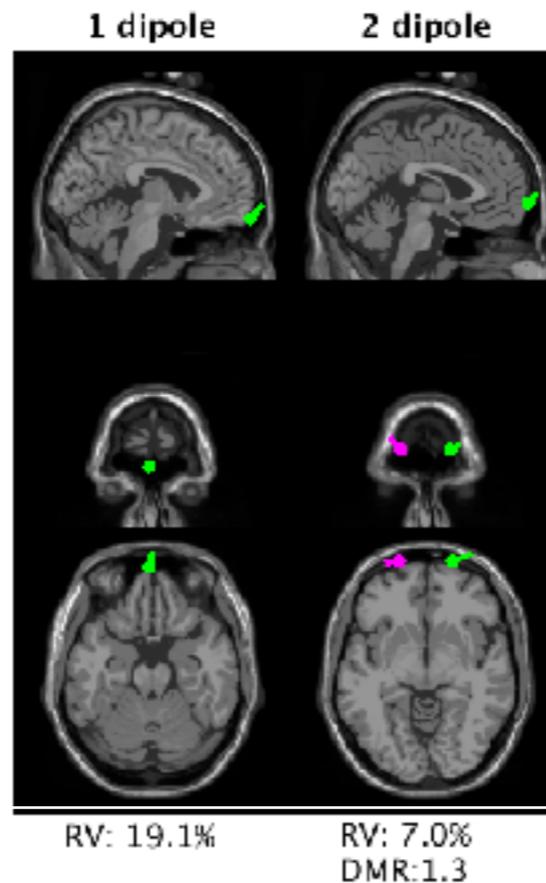
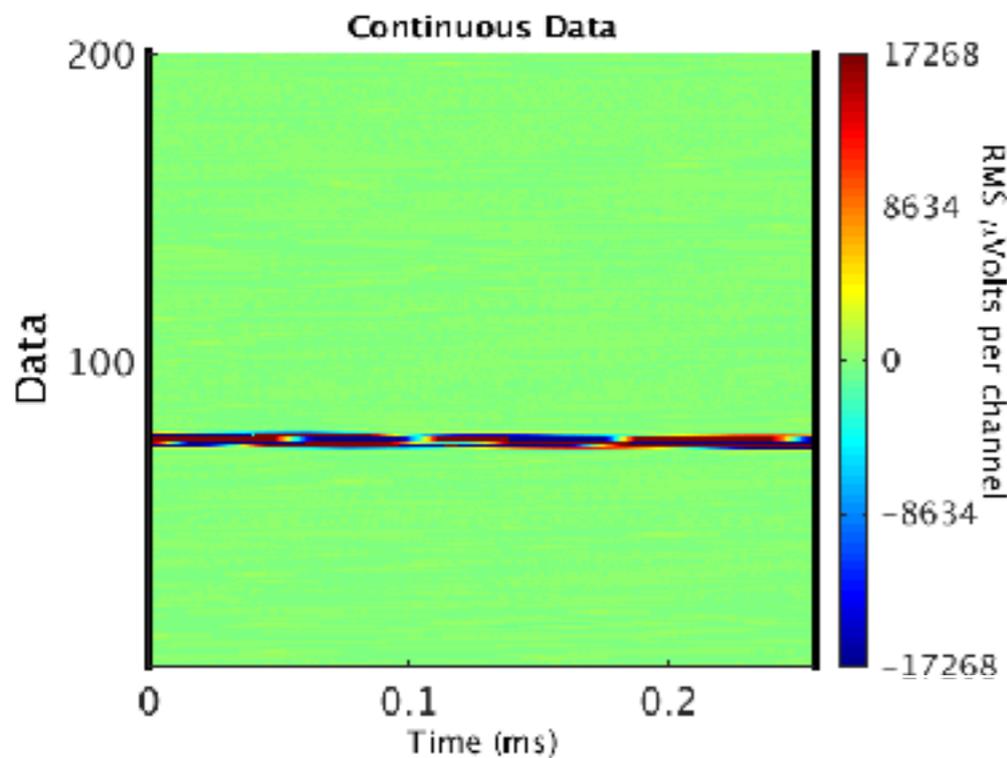
# Eye component



# Eye component

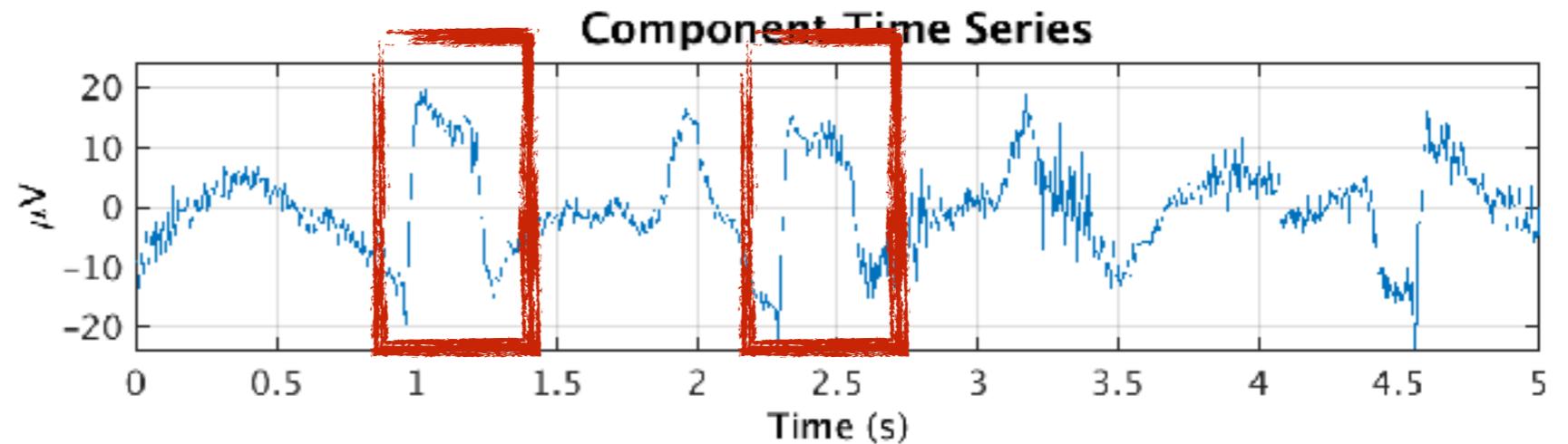
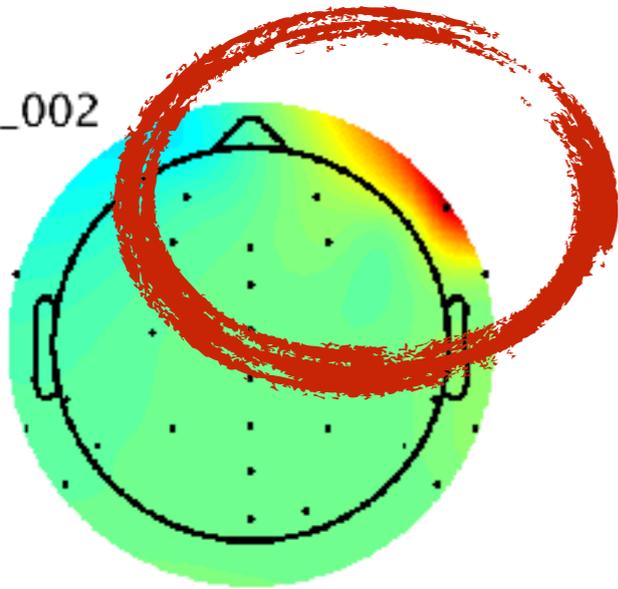


IC 1 of 229  
Data Var. Accounted For:  
22.29%

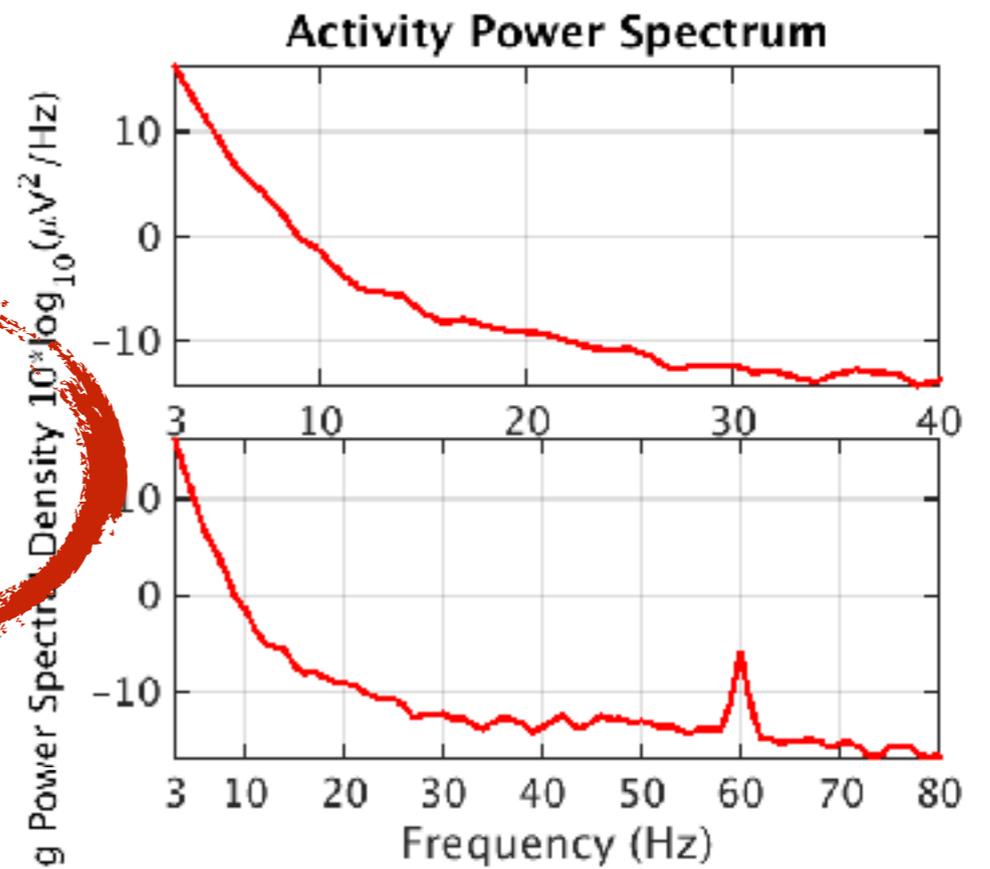
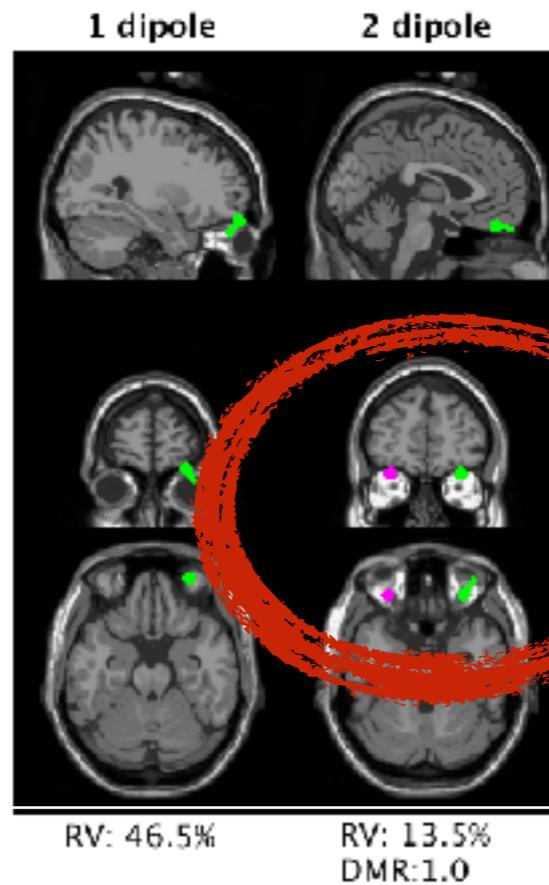
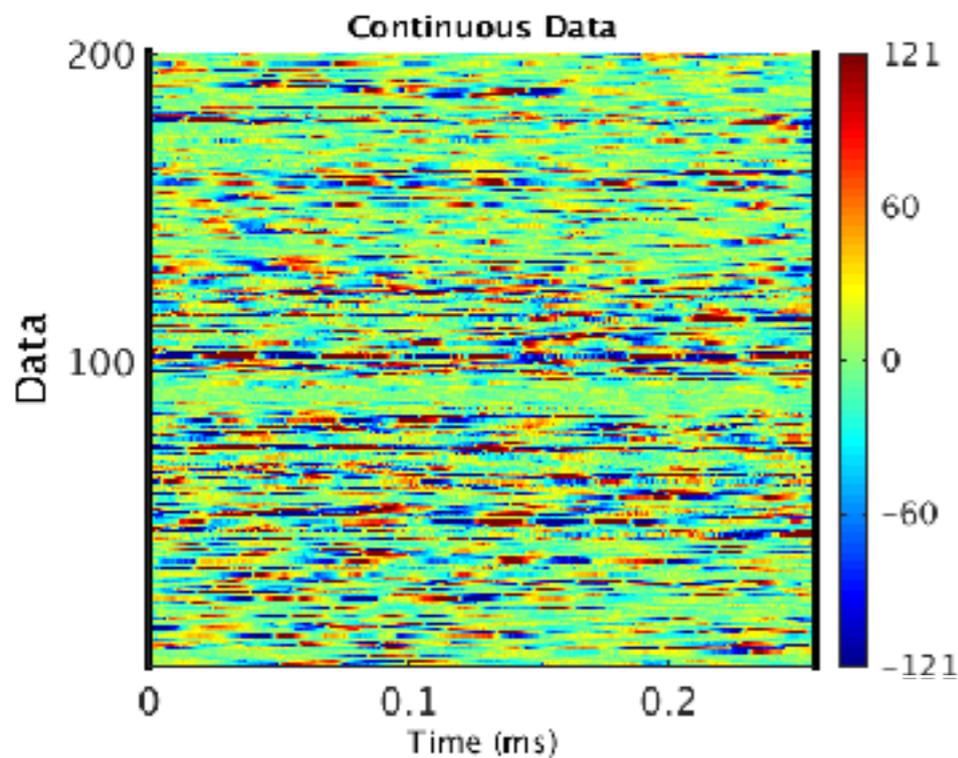


# Eye component

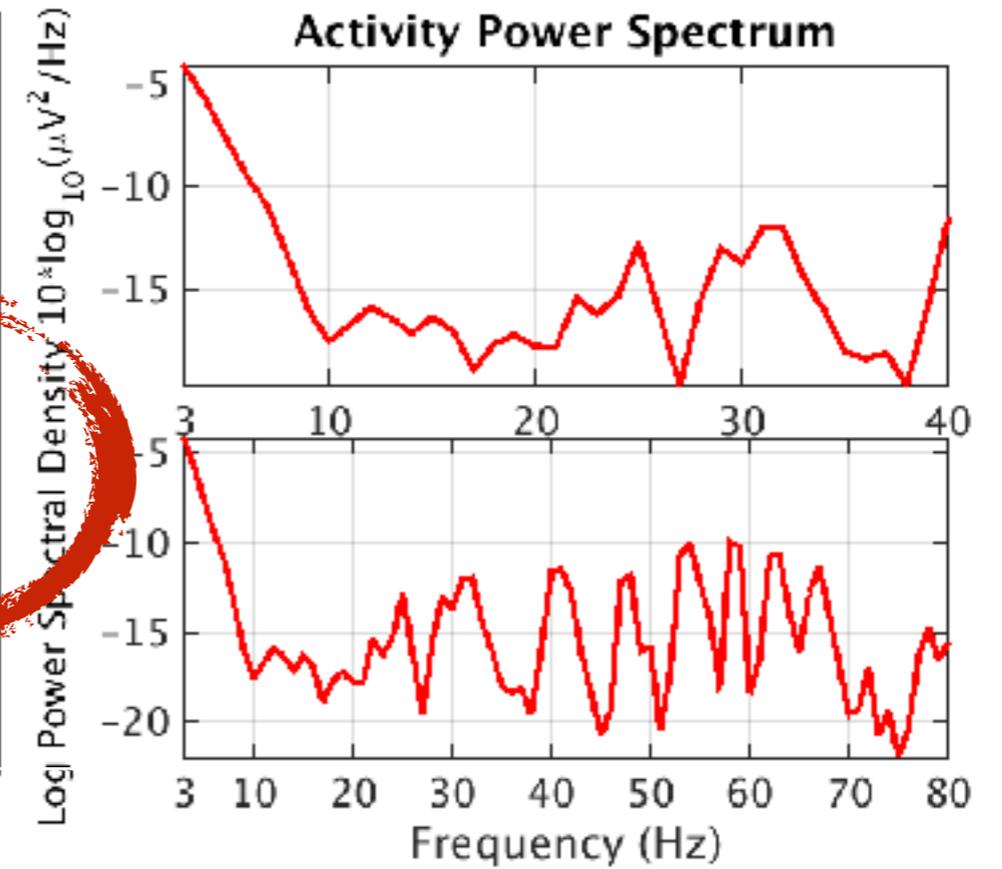
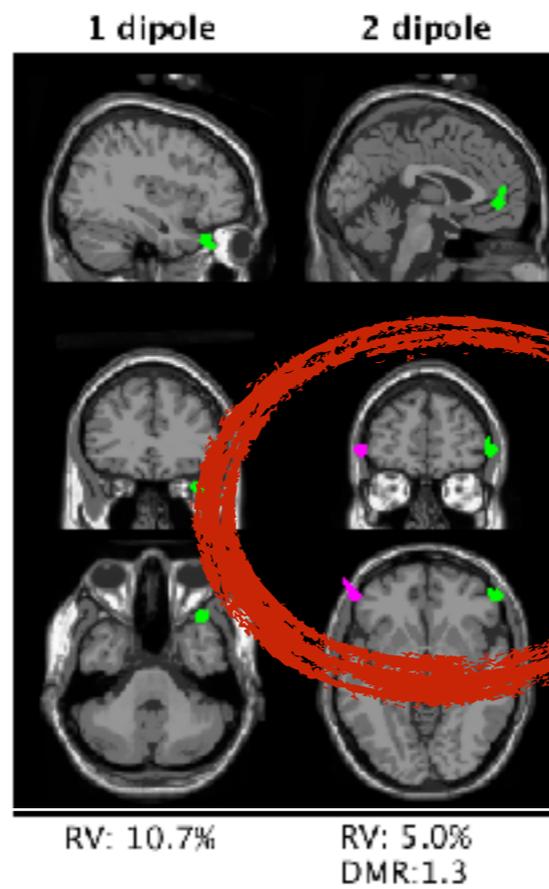
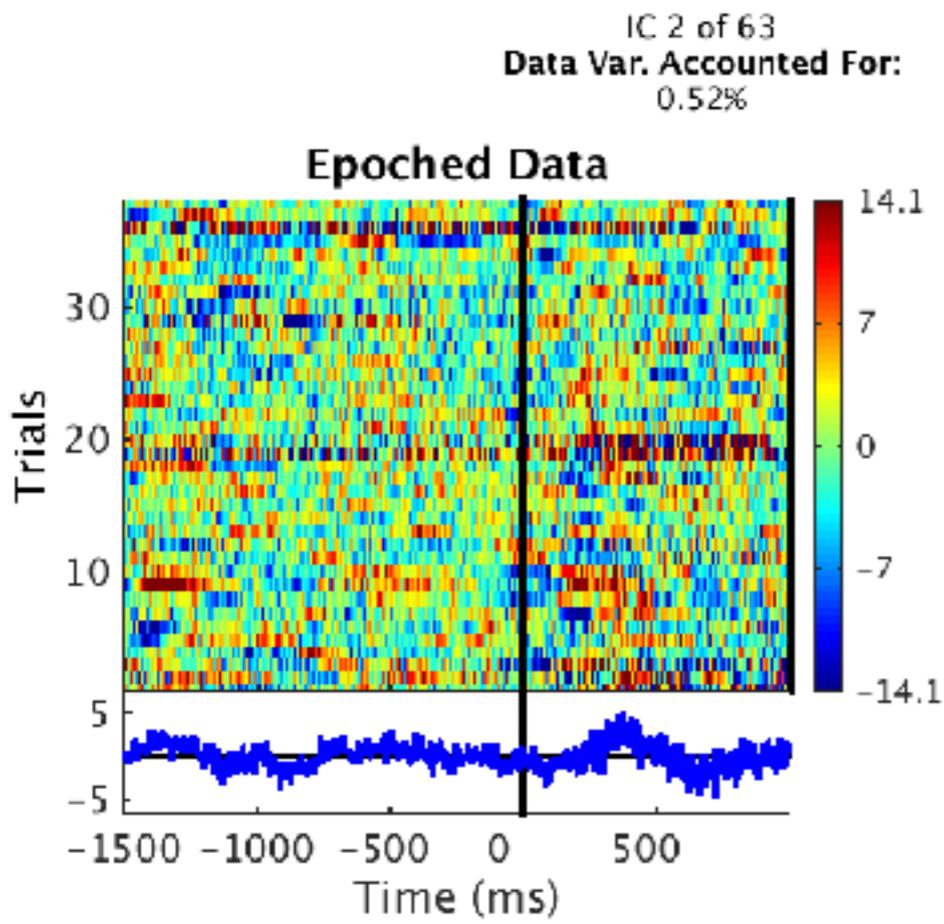
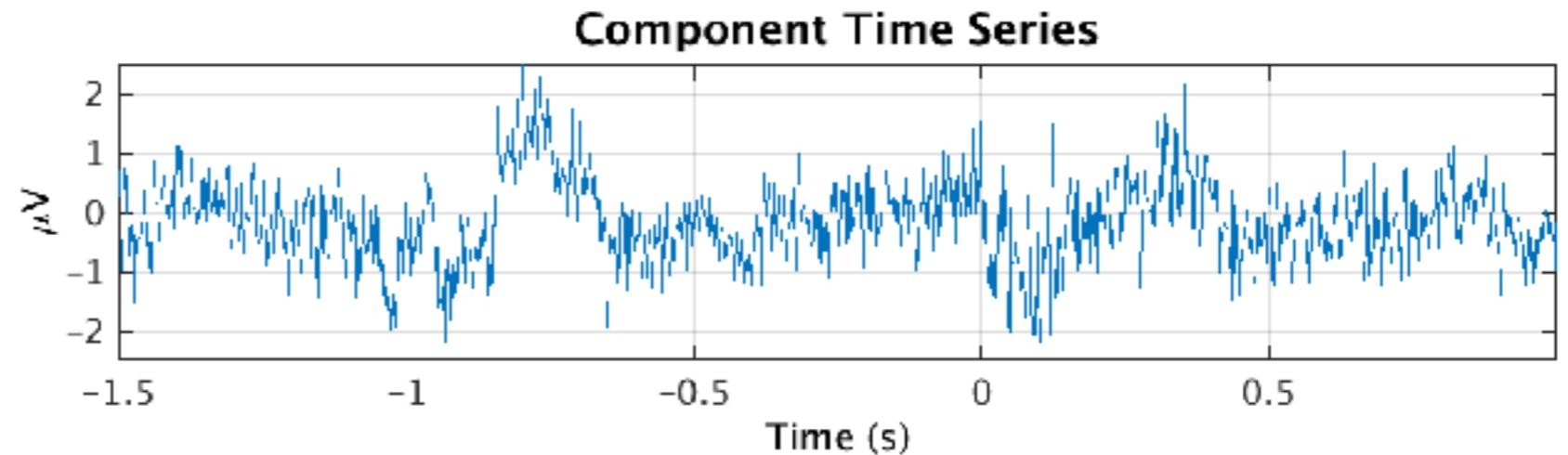
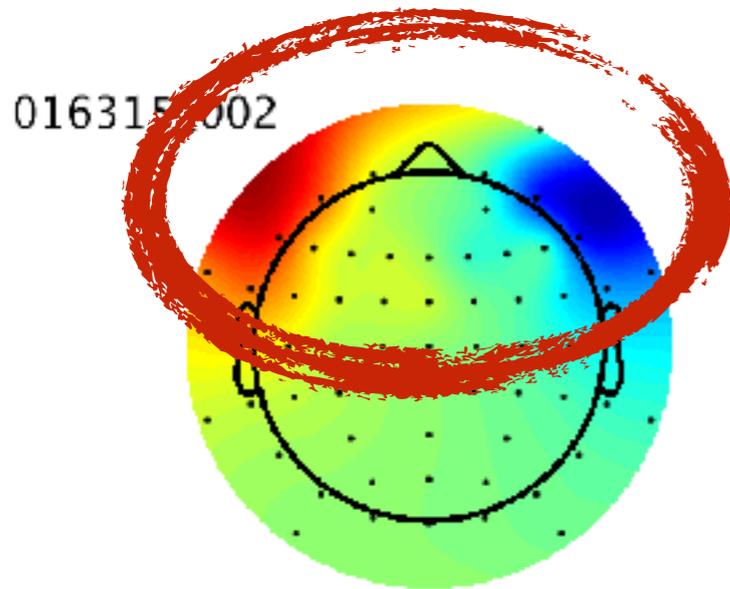
061491\_002



IC 2 of 35  
Data Var. Accounted For:  
19.69%



# Eye component

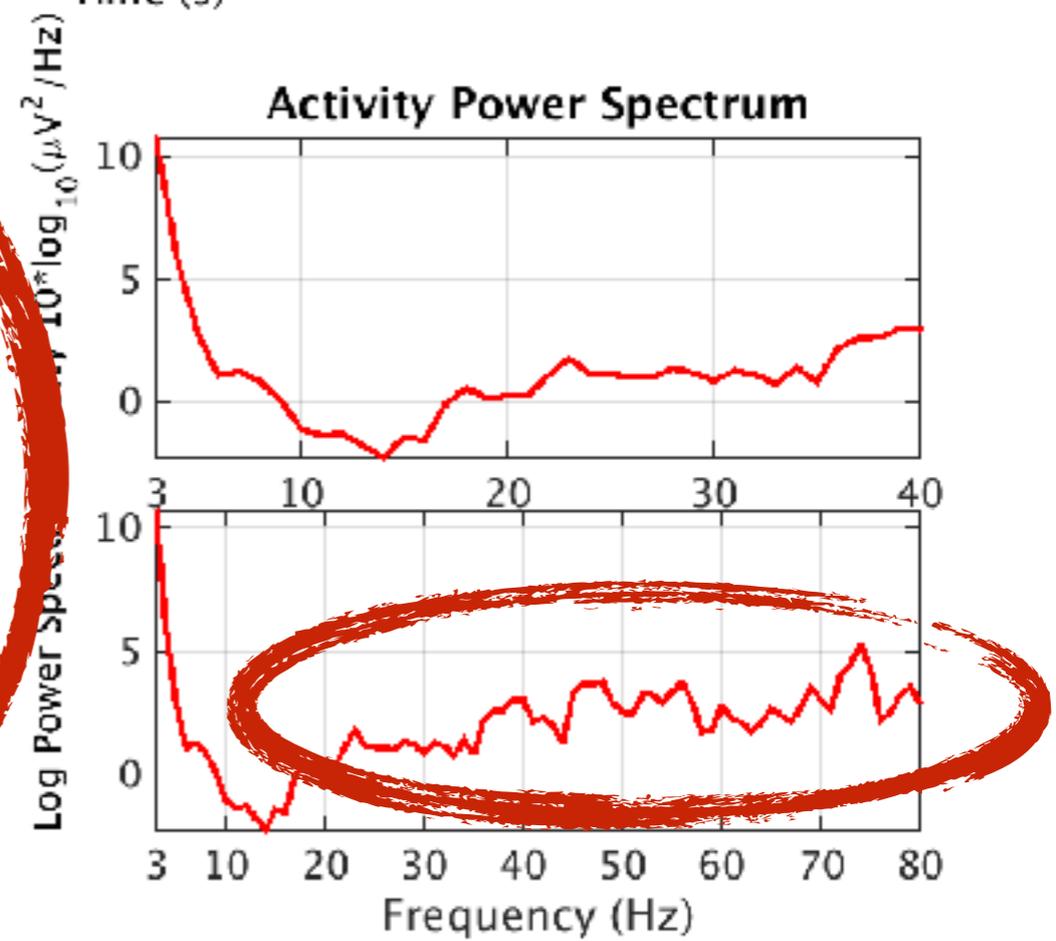
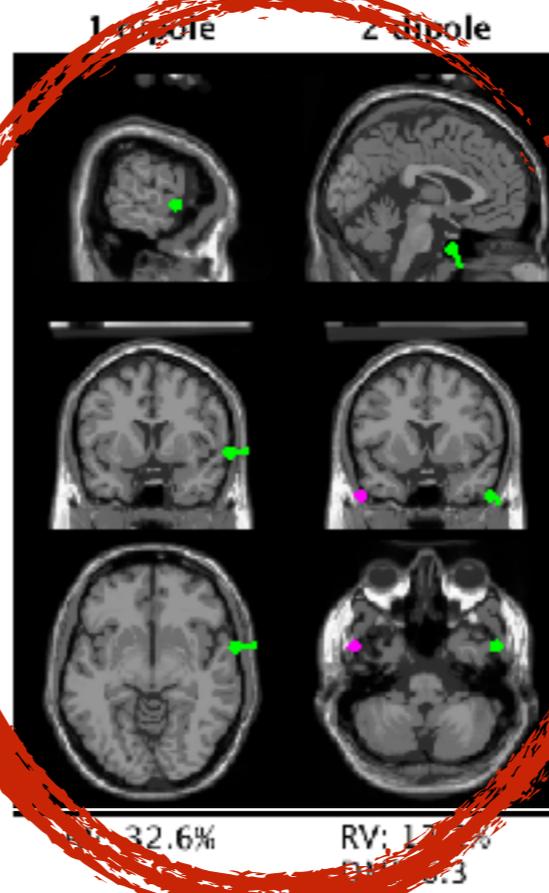
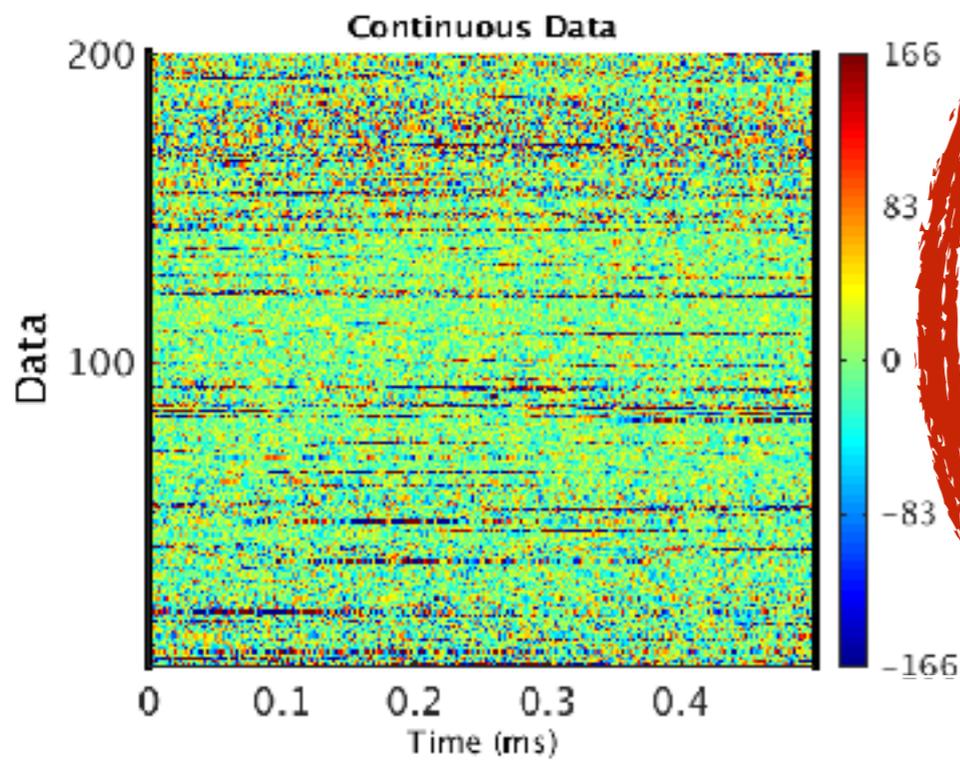
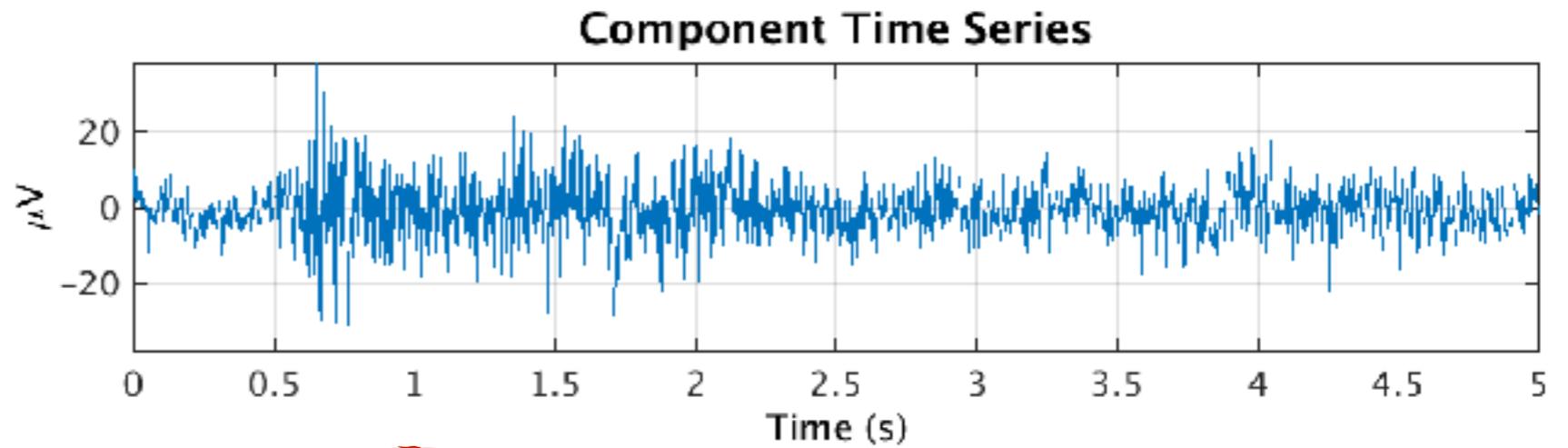
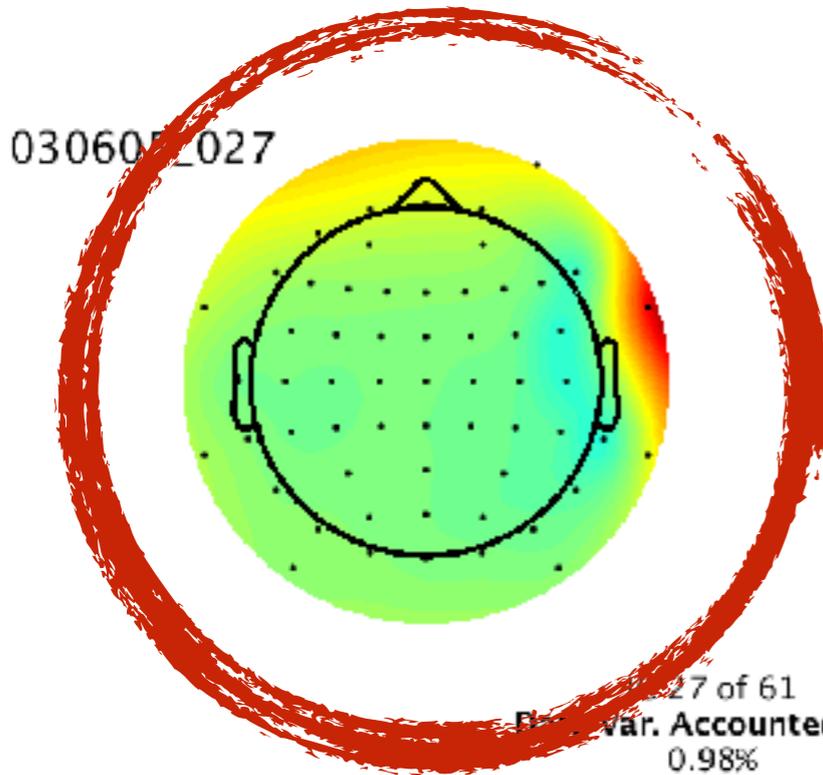


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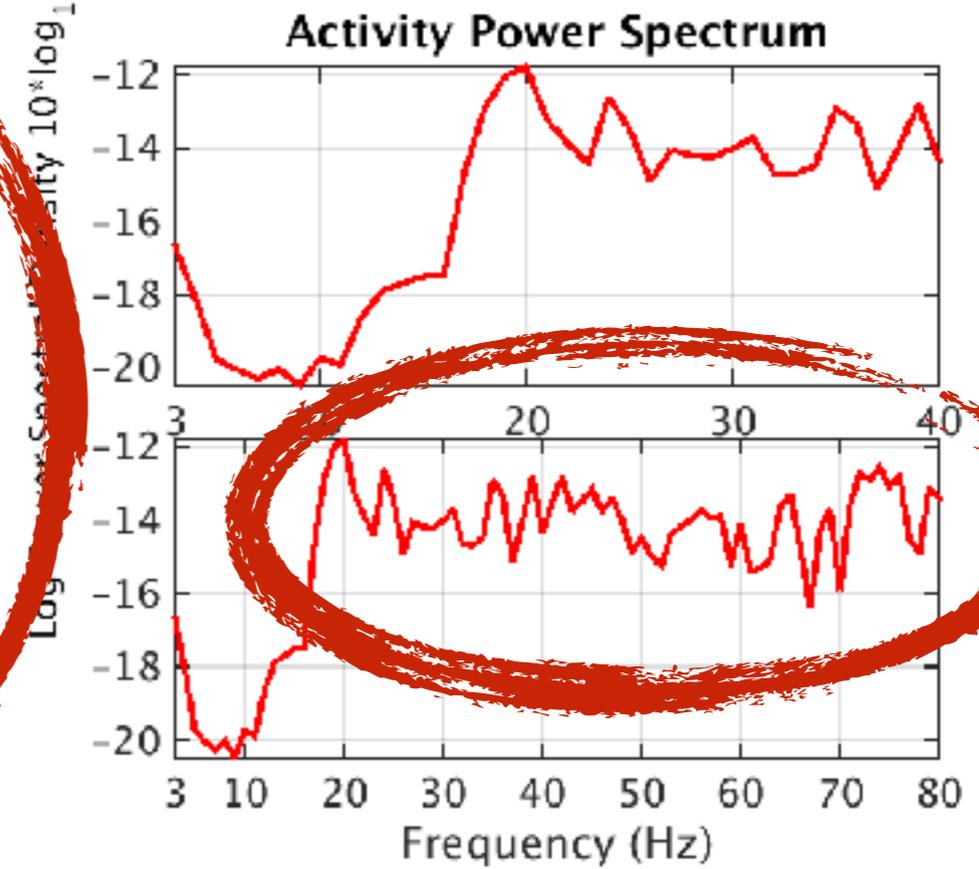
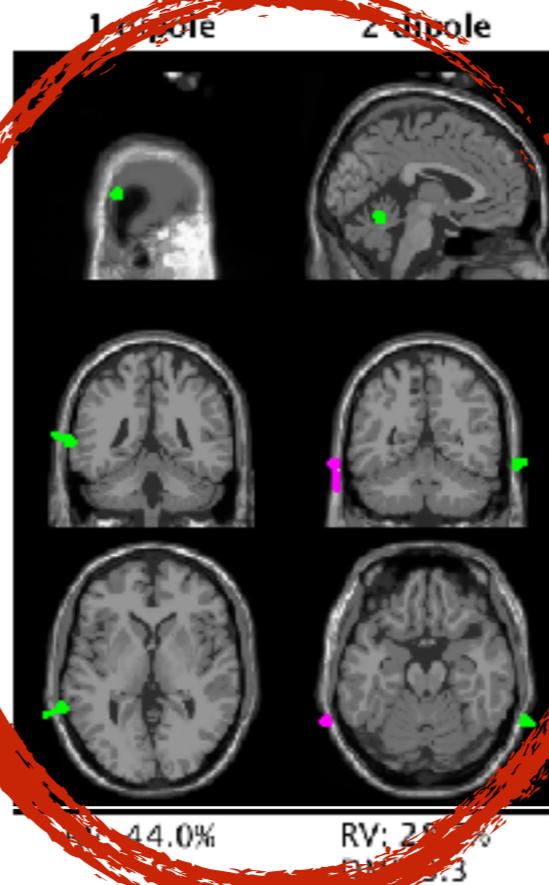
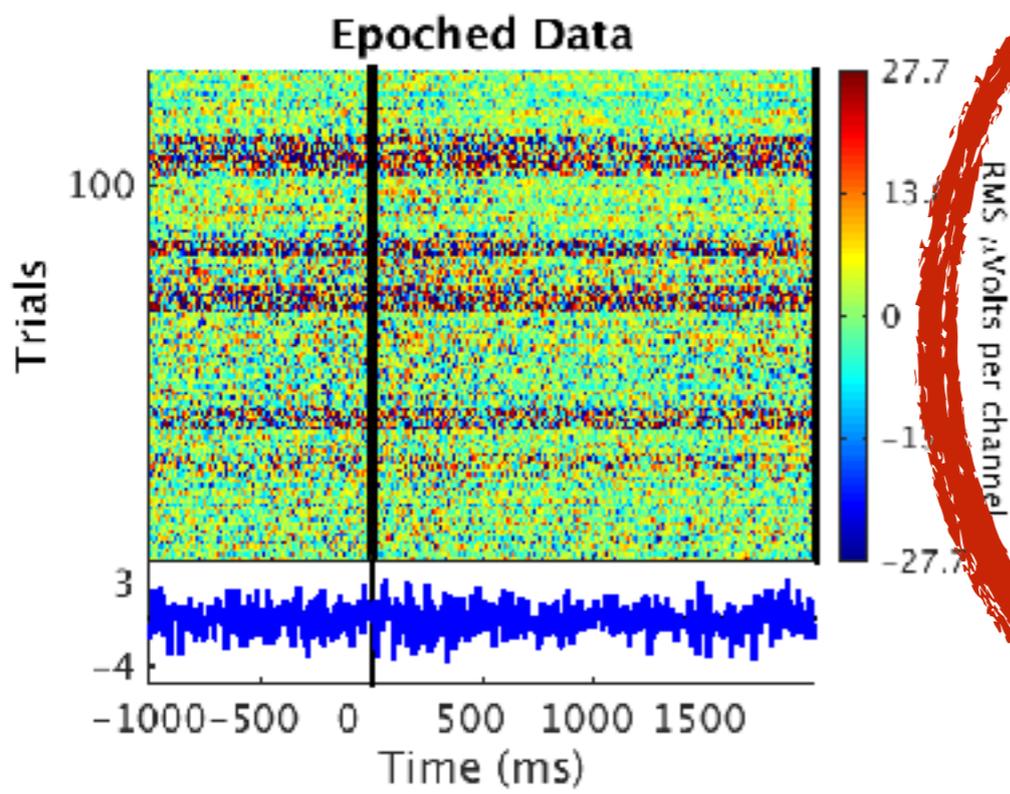
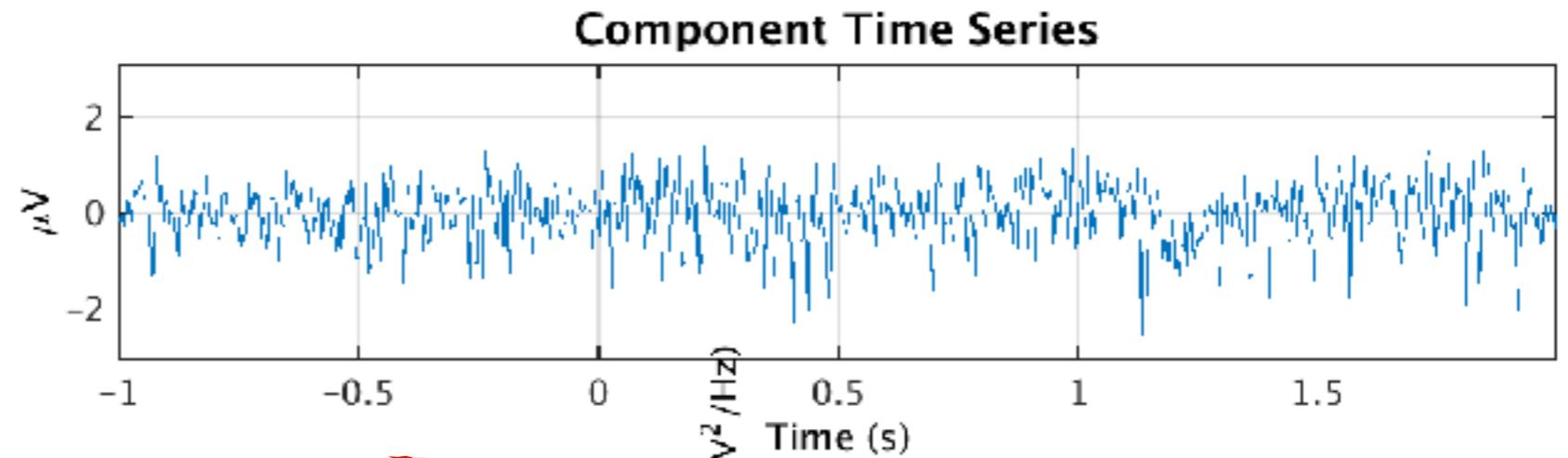
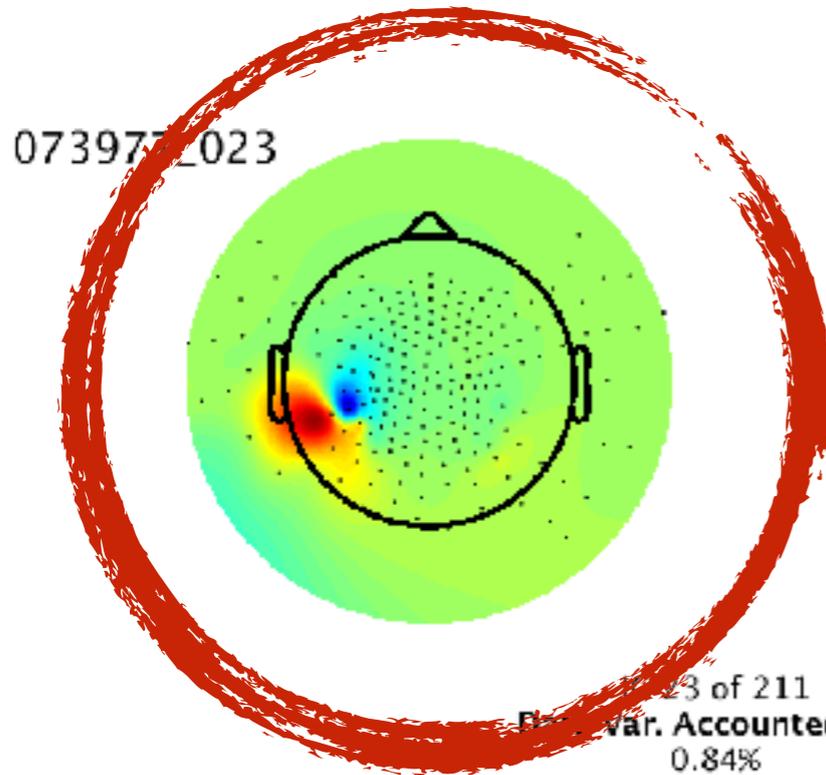
# **Muscle components**

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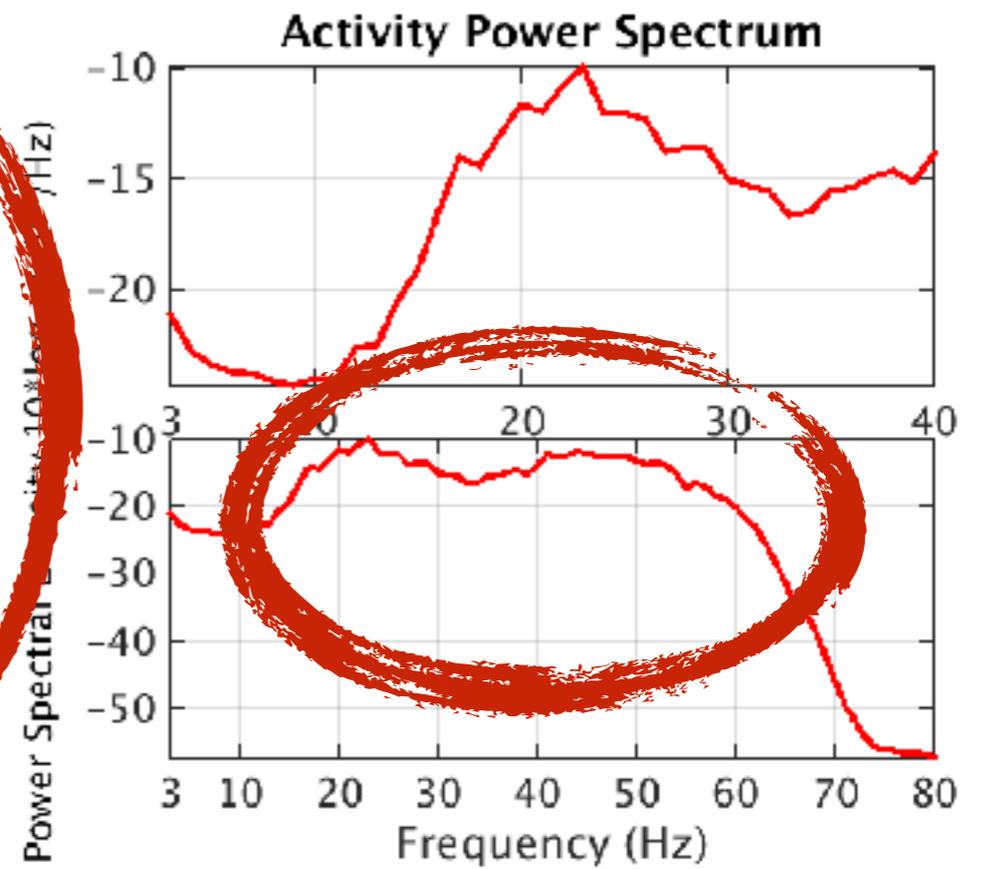
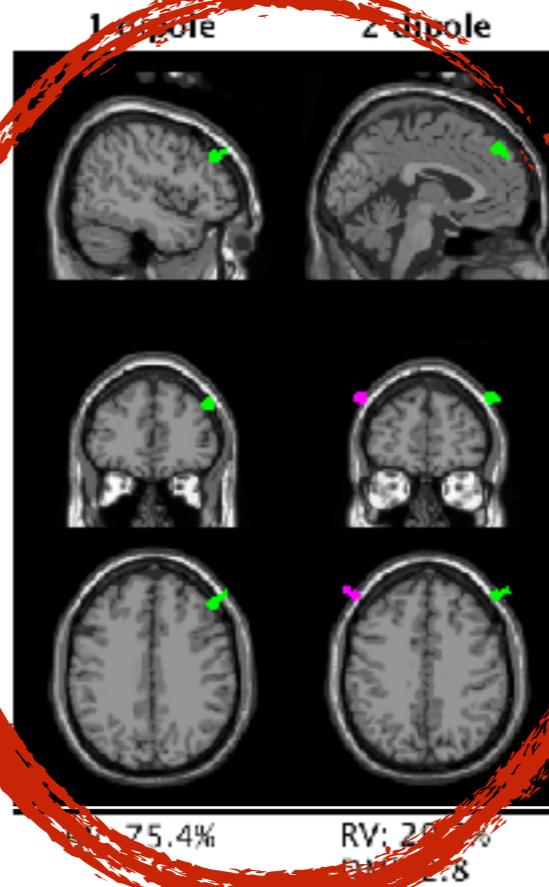
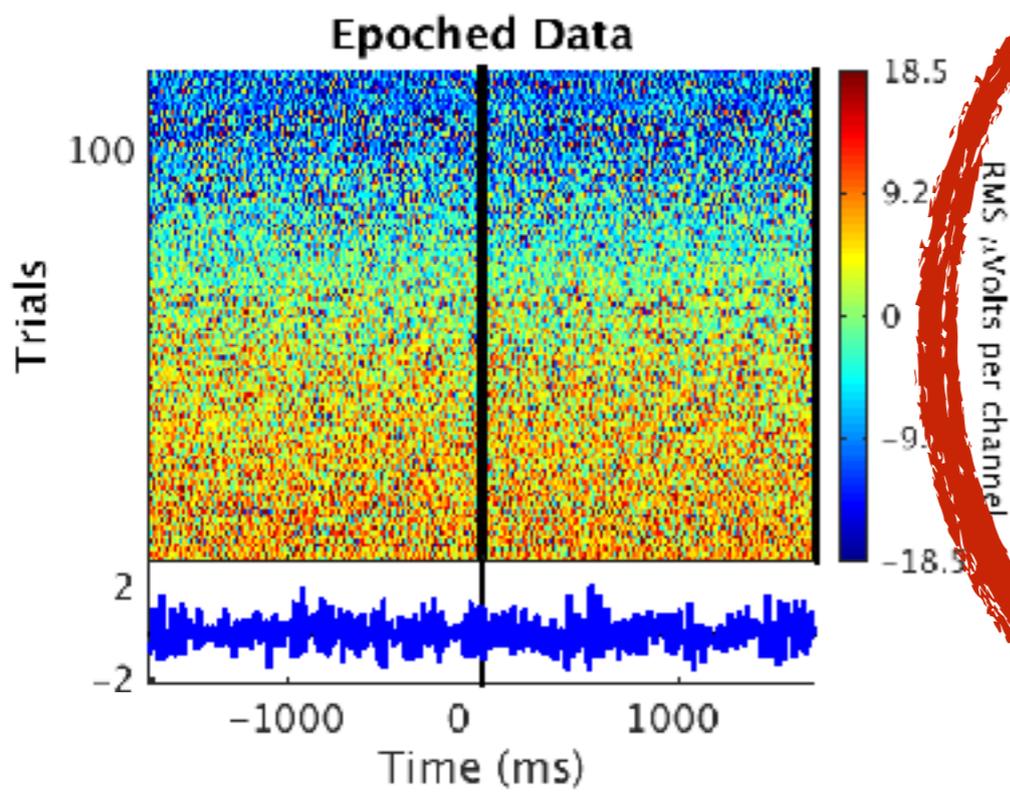
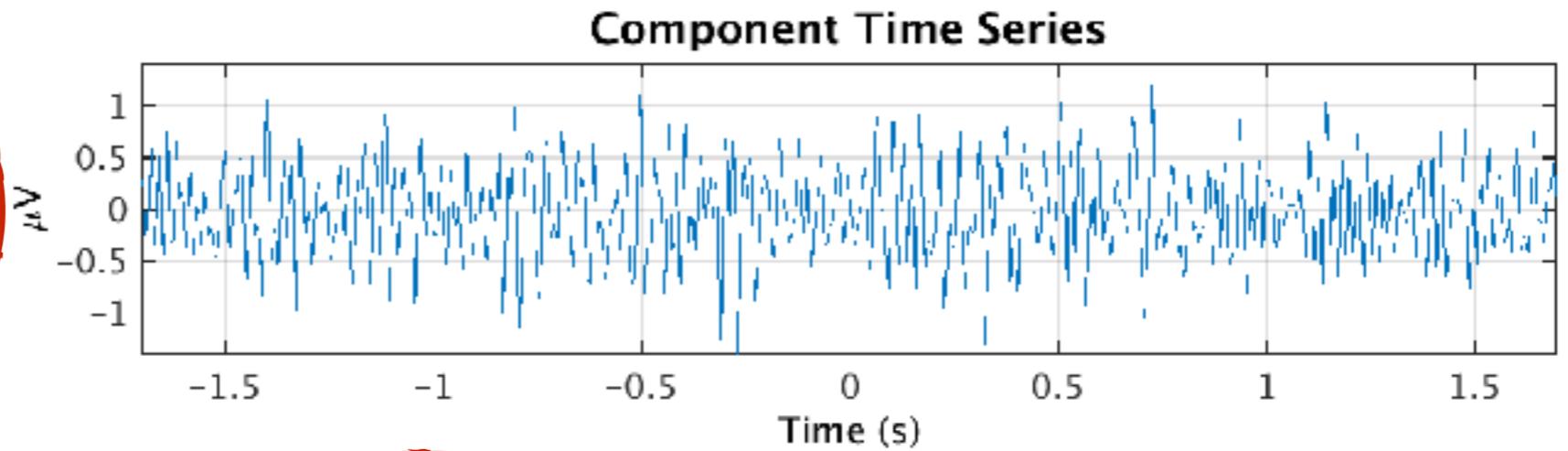
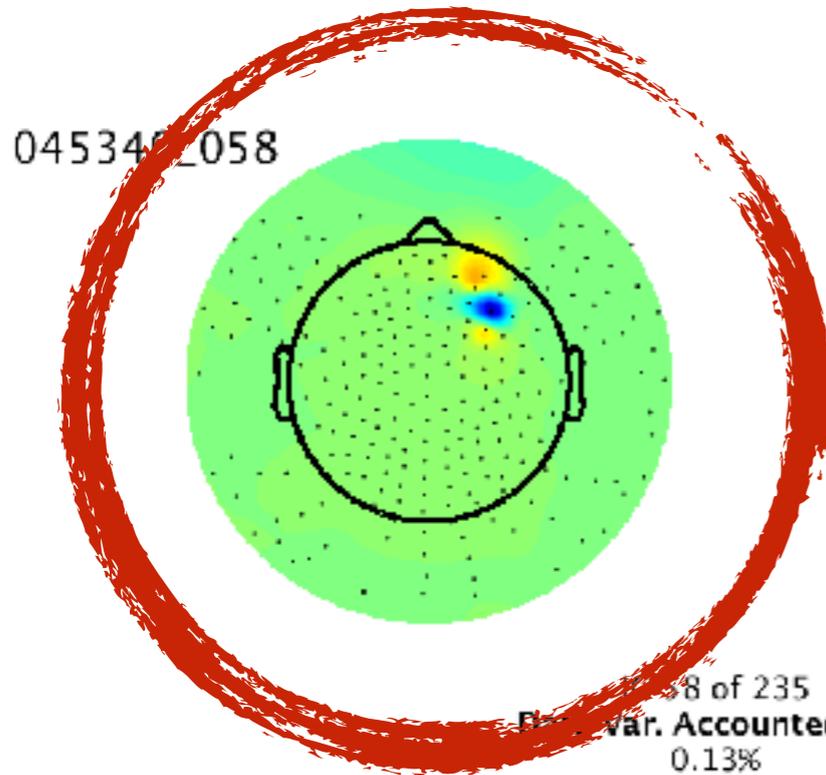
# Muscle component



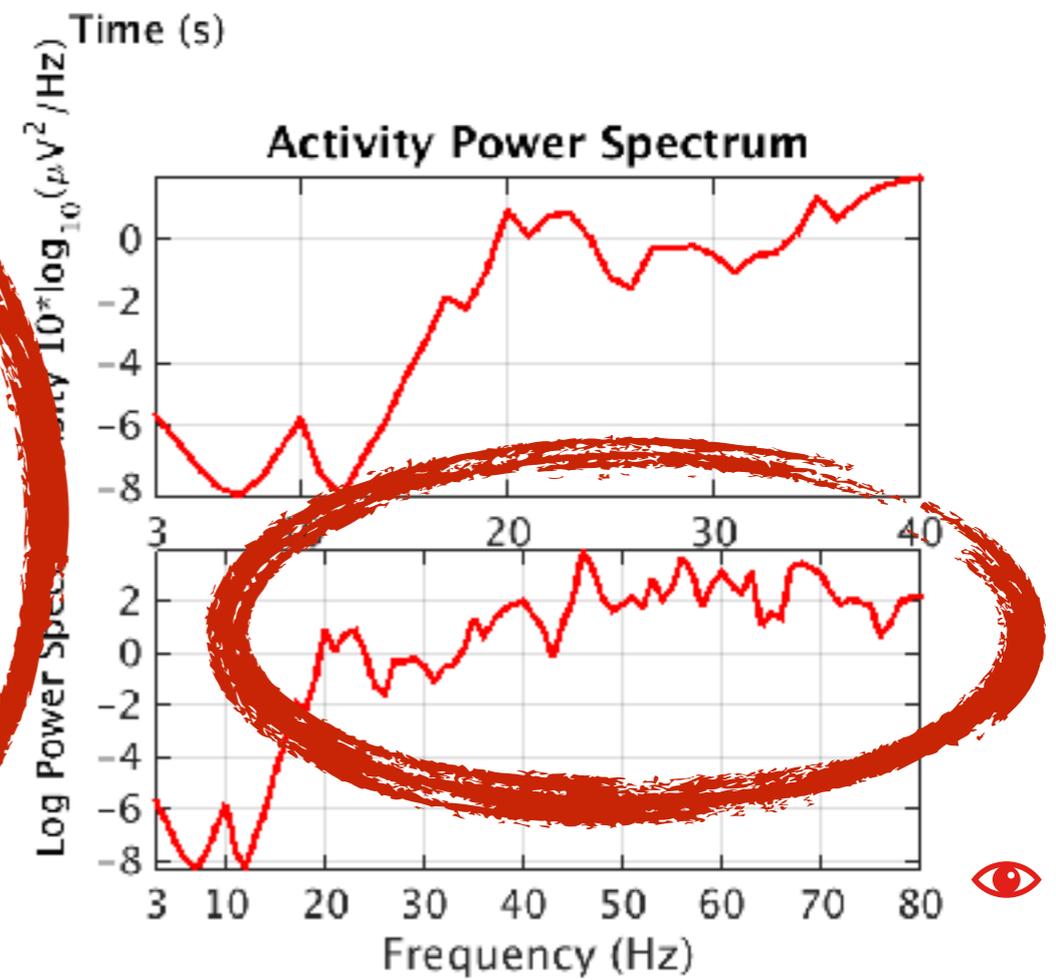
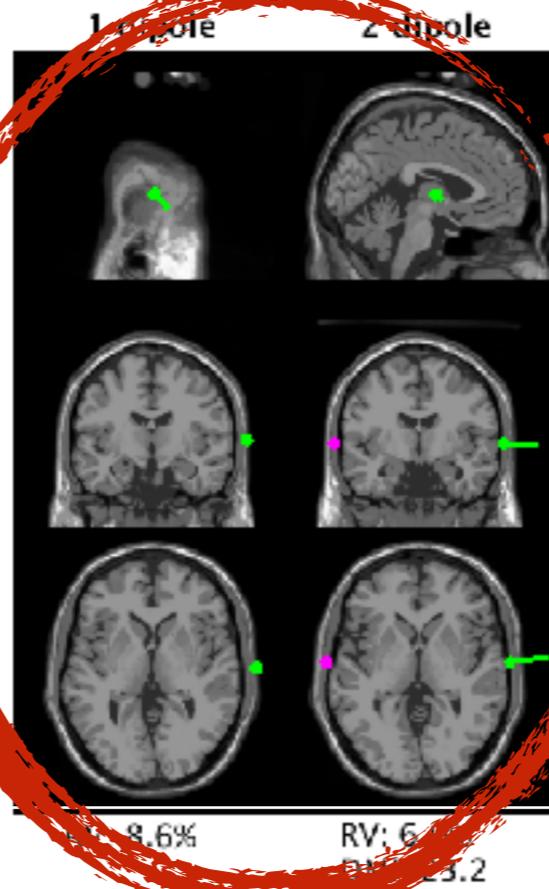
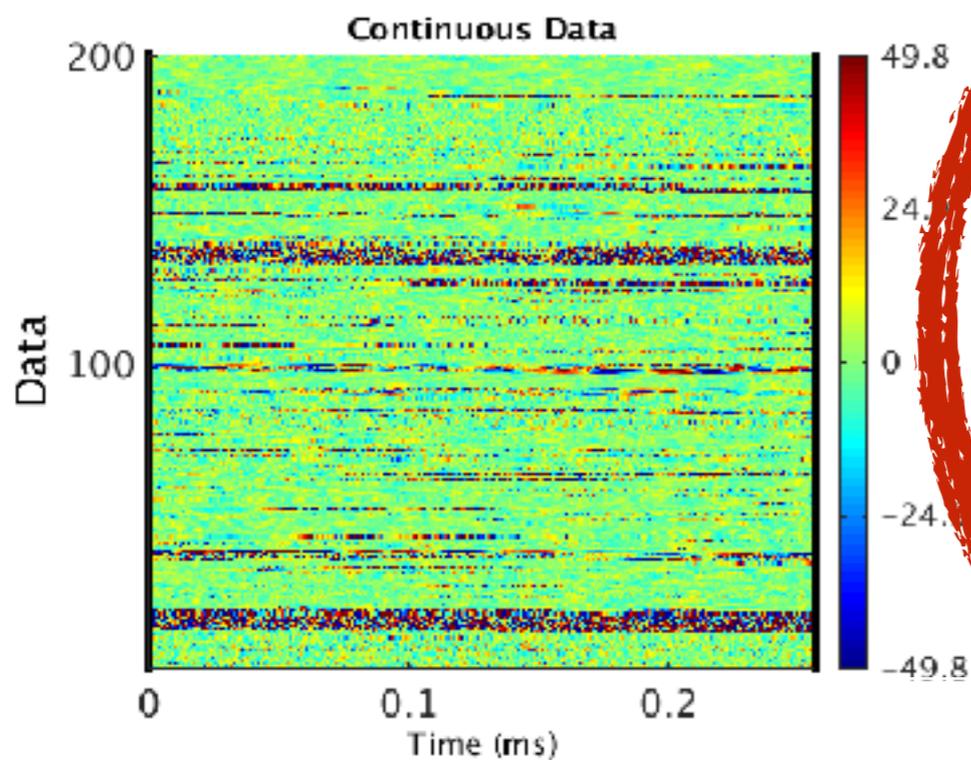
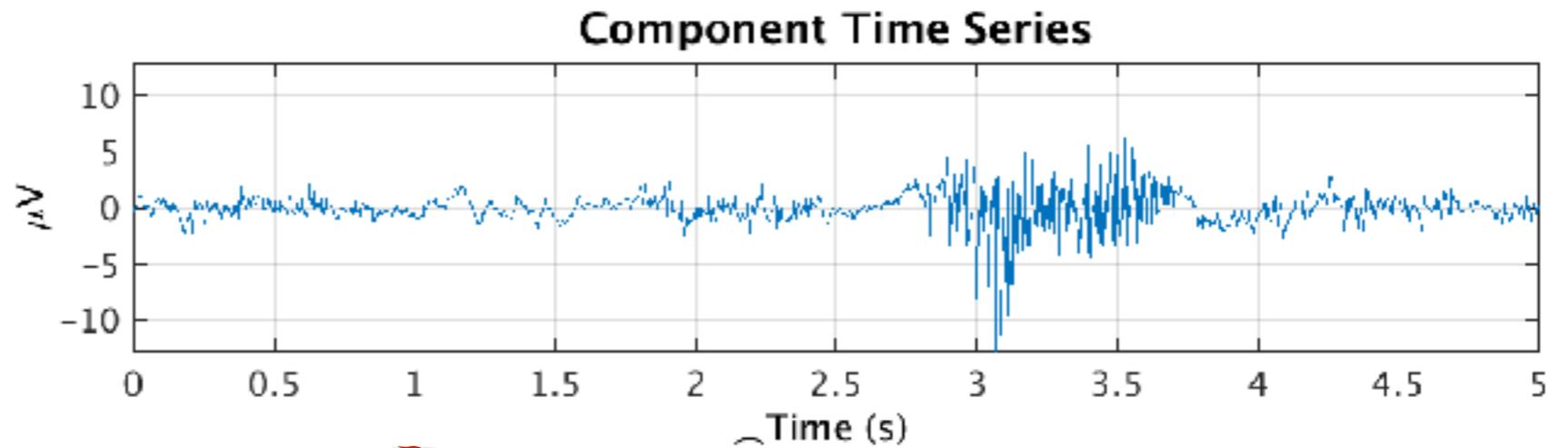
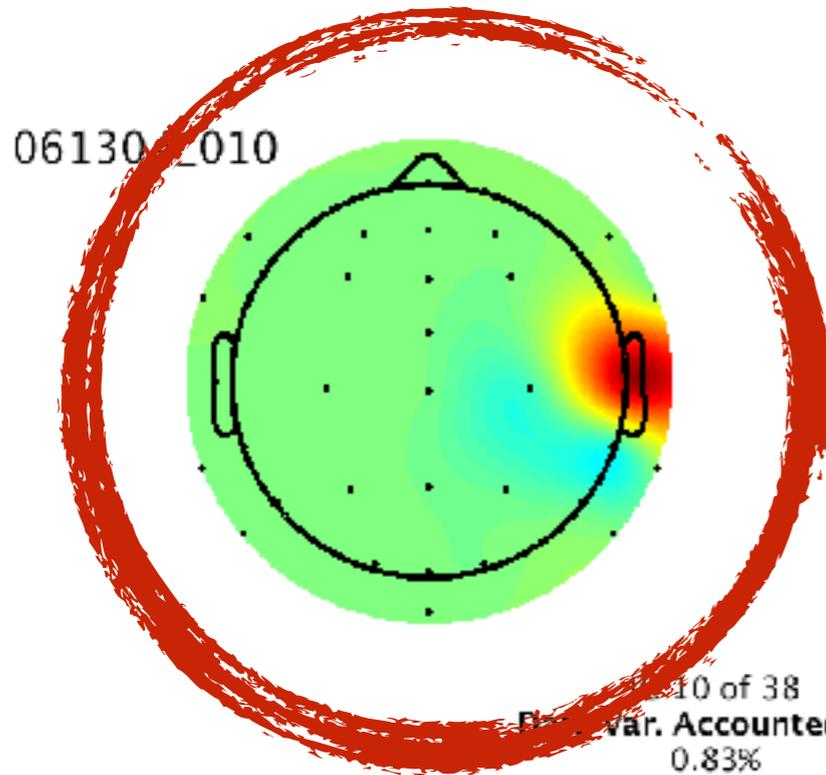
# Muscle component



# Muscle component



# Muscle component

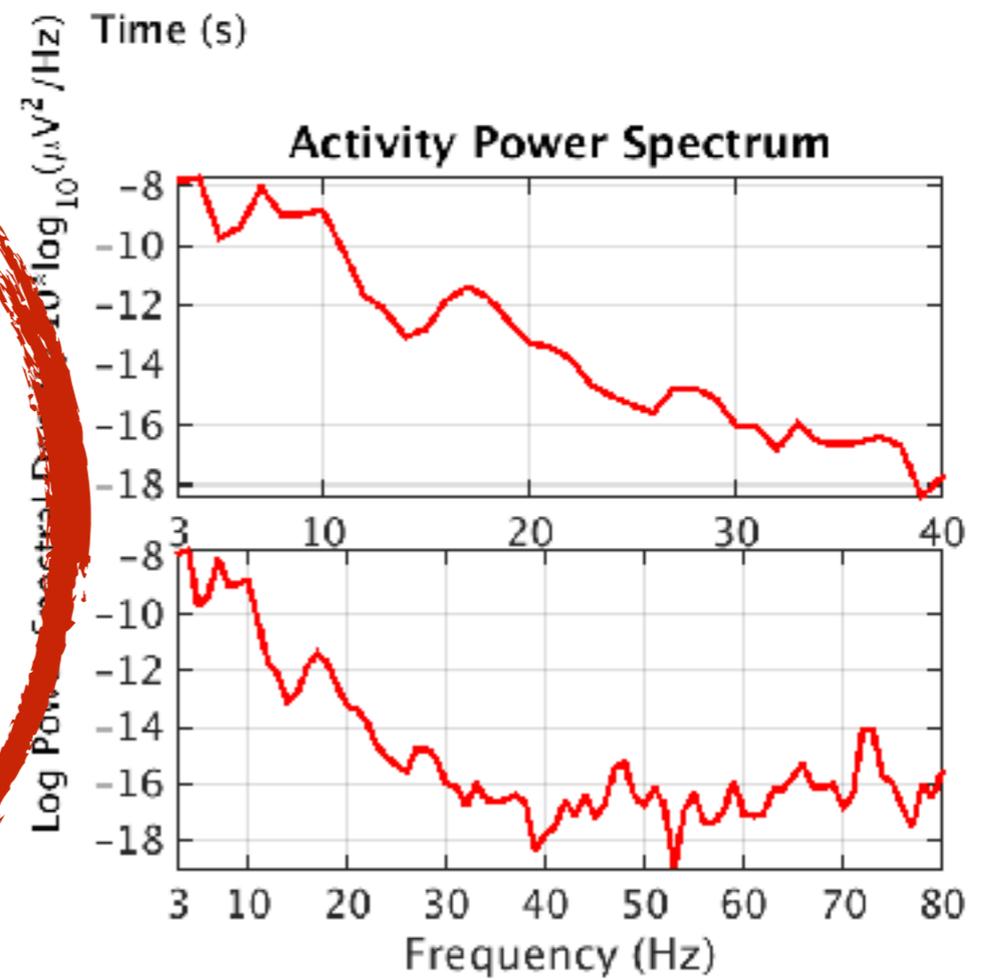
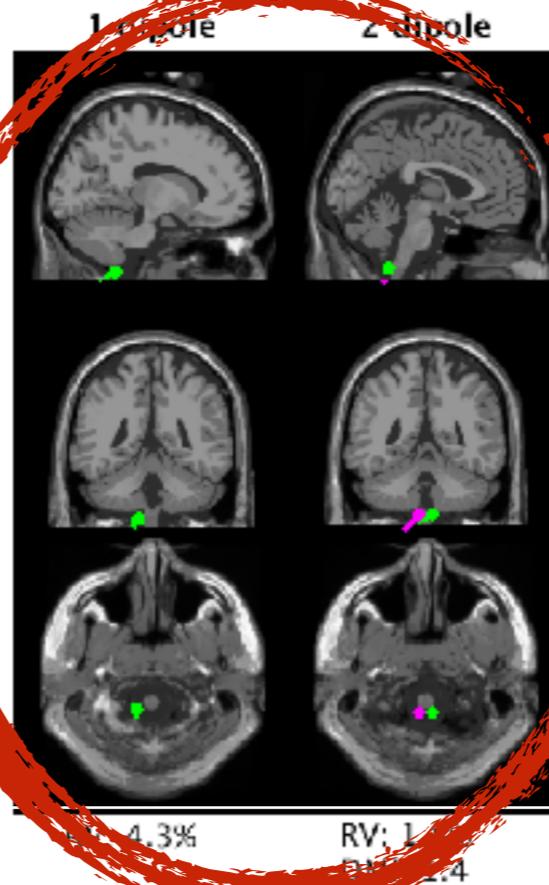
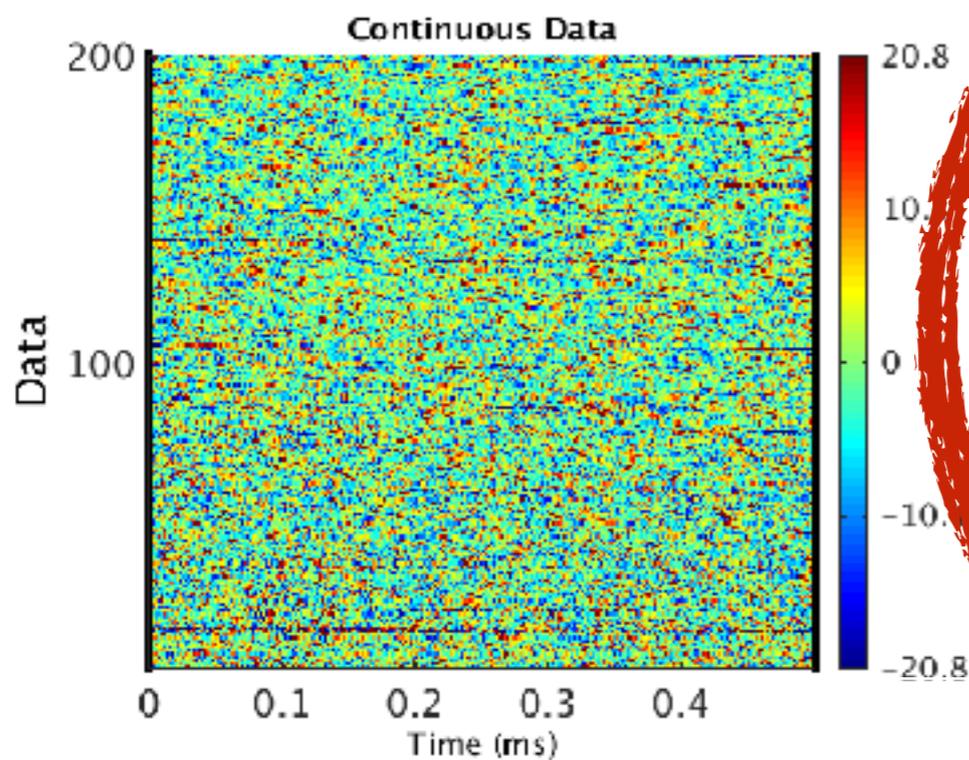
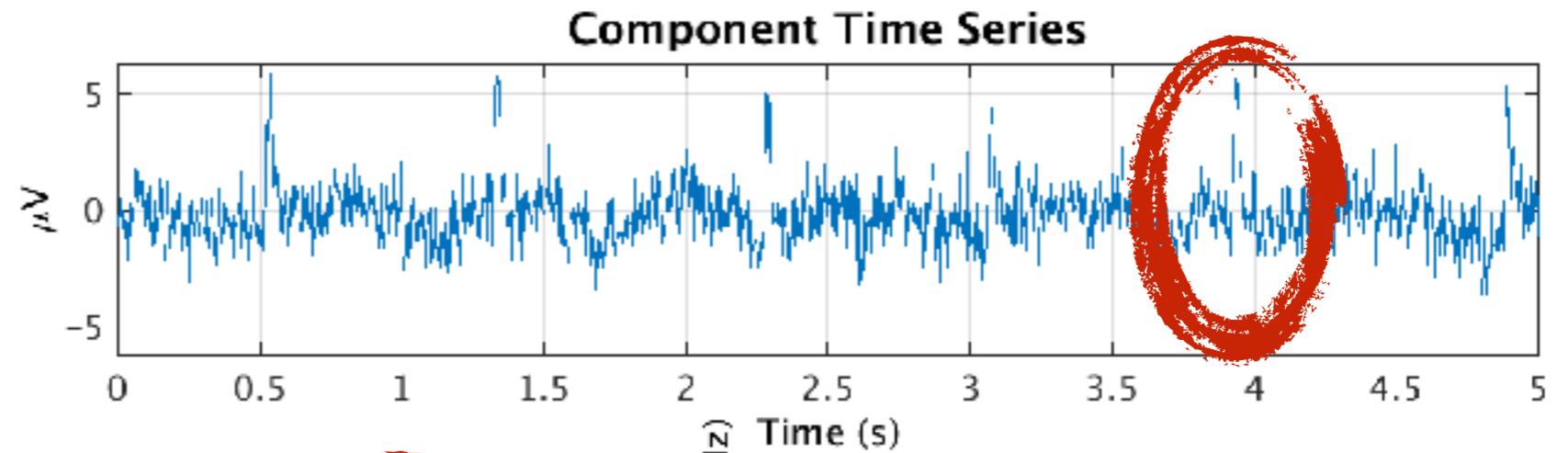
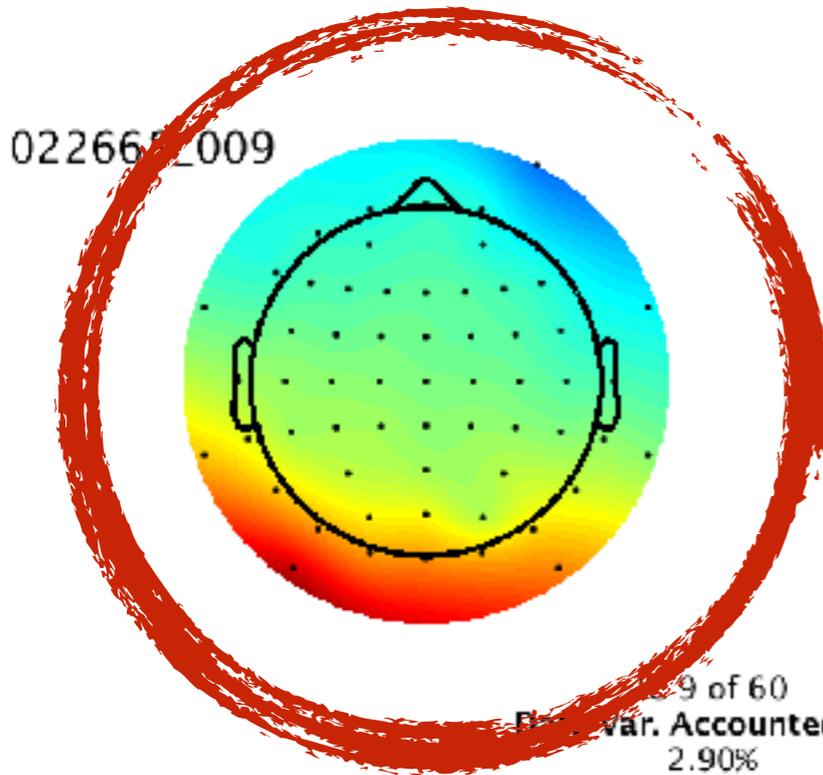


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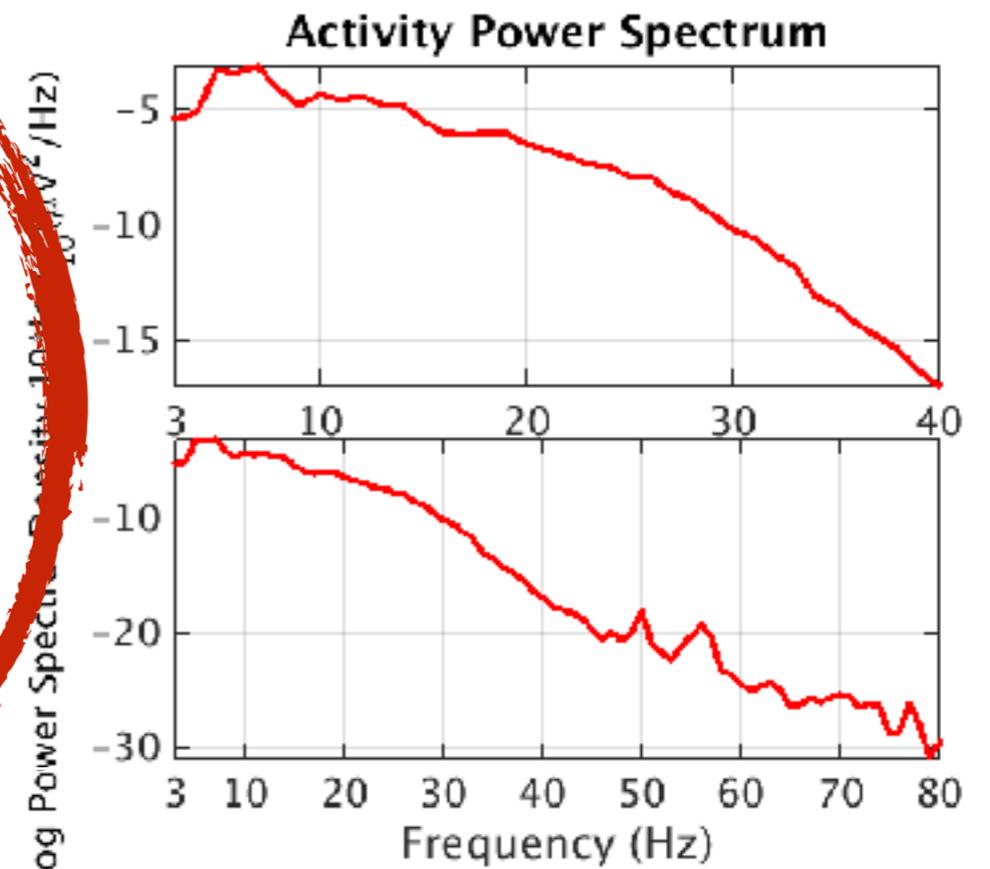
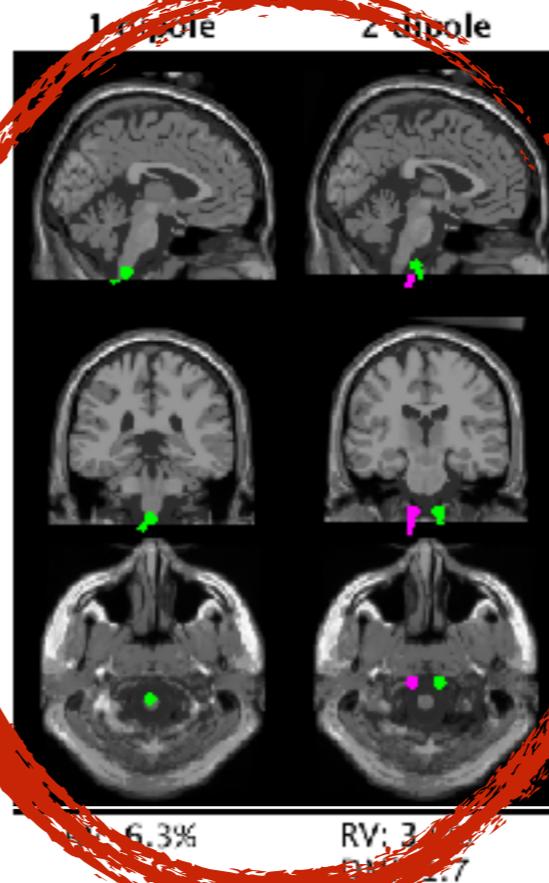
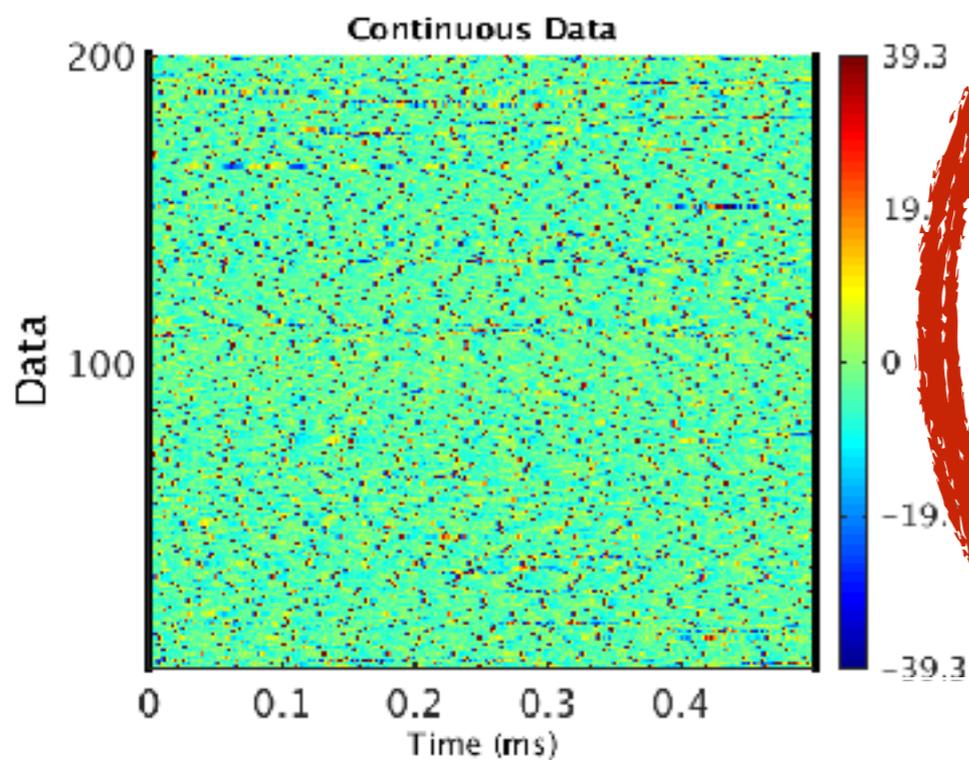
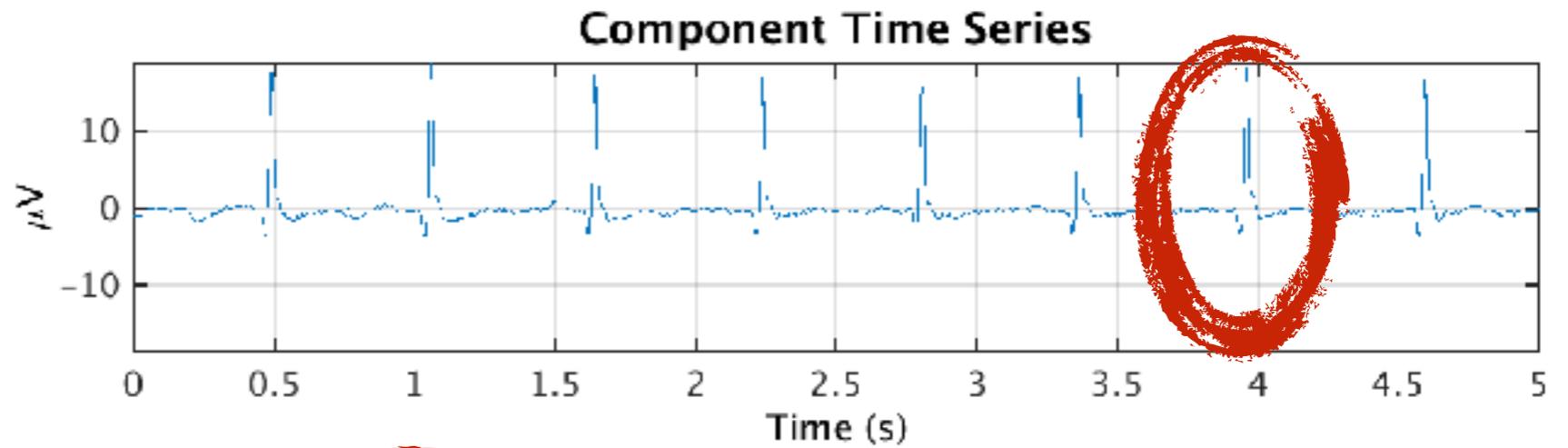
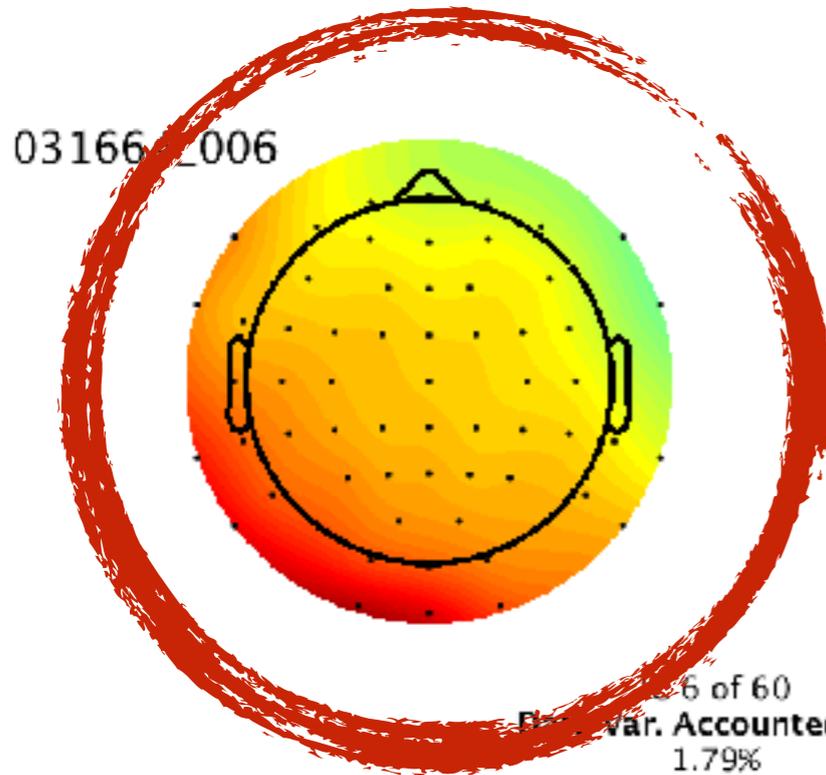
# Heart components

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# Heart component



# Heart component



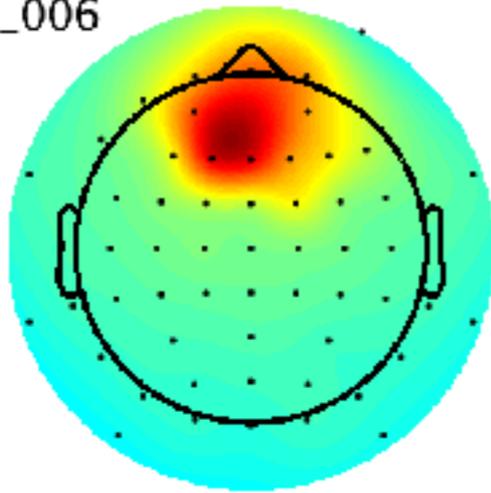
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# Line noise

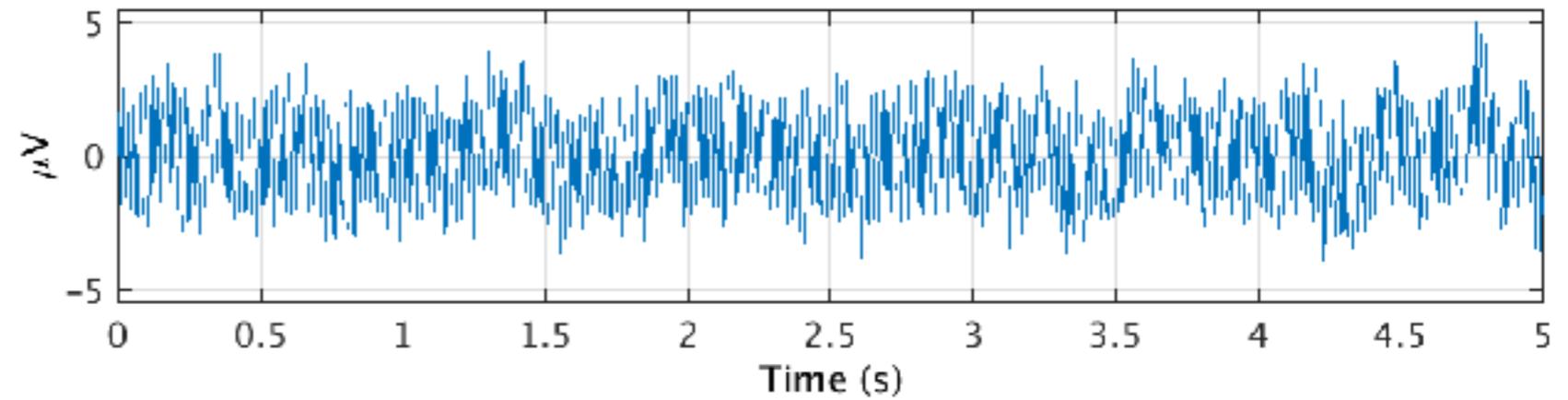
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# Line noise

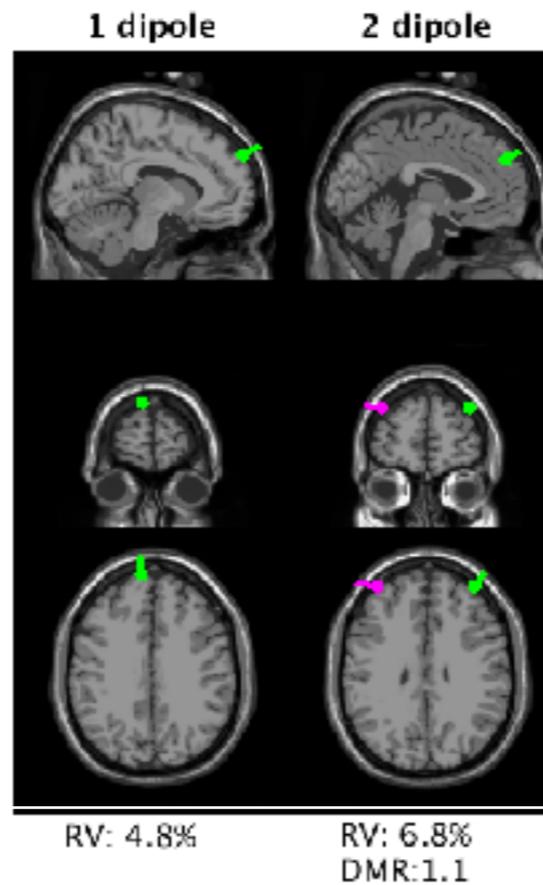
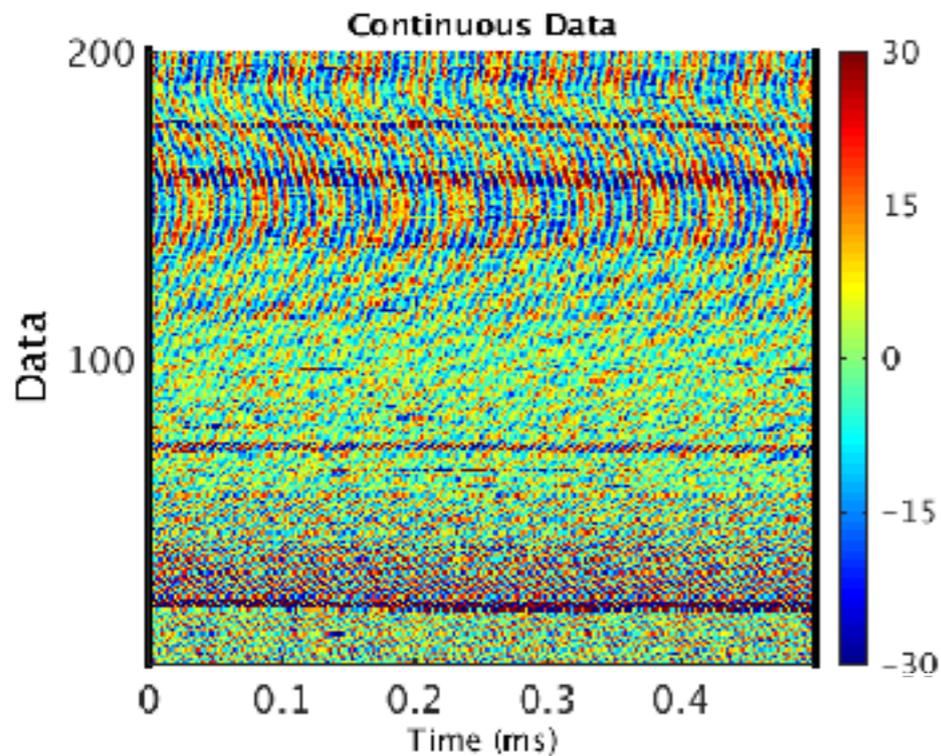
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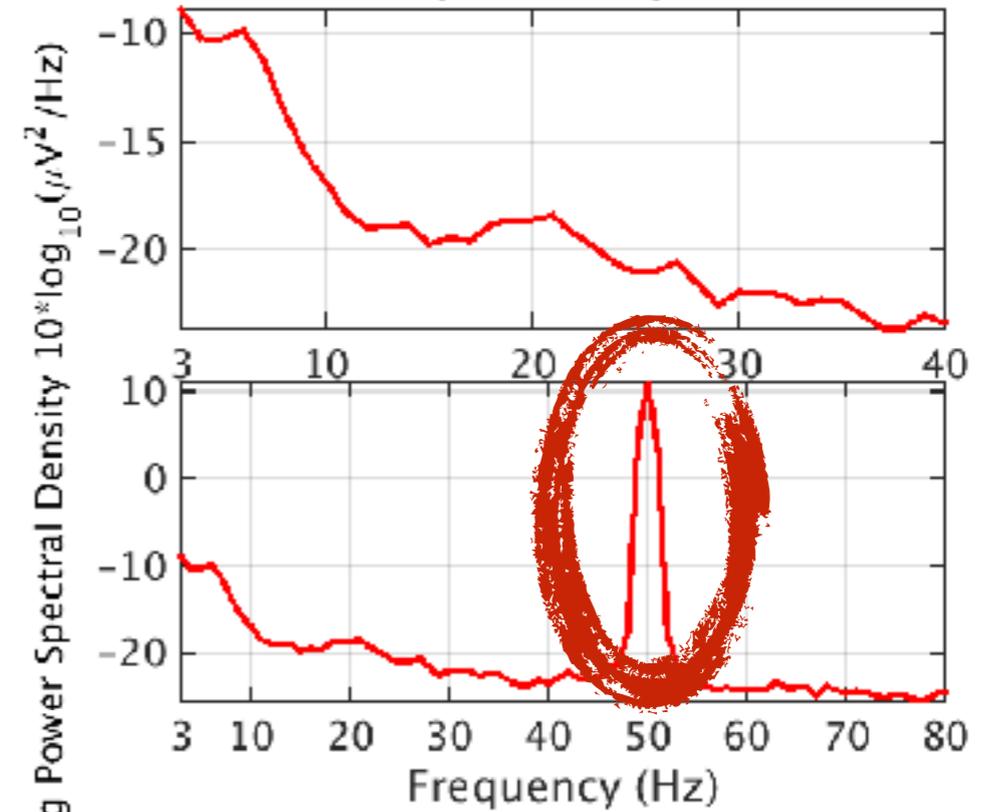
### Component Time Series



IC 6 of 58  
Data Var. Accounted For:  
2.01%

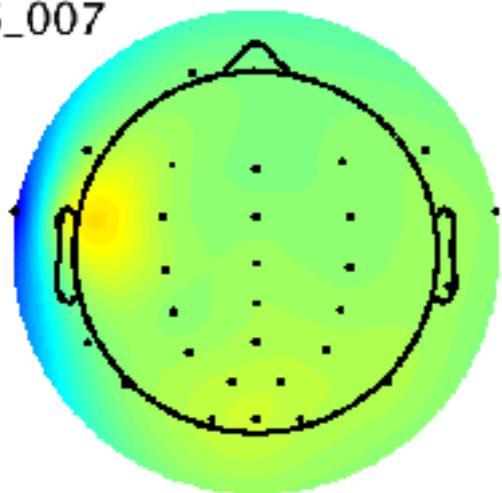


### Activity Power Spectrum

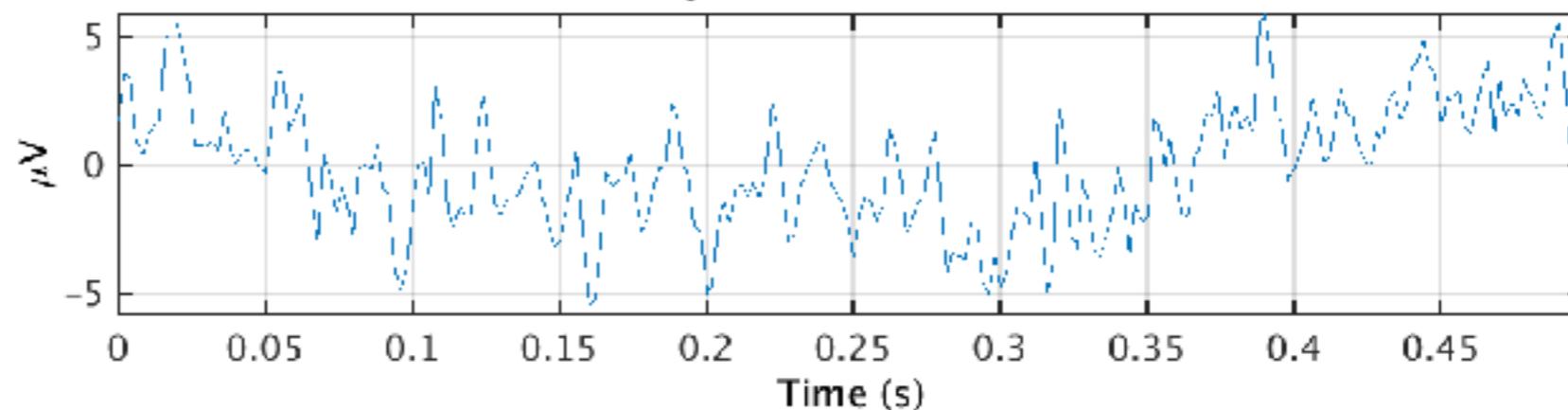


# Line noise

067886\_007

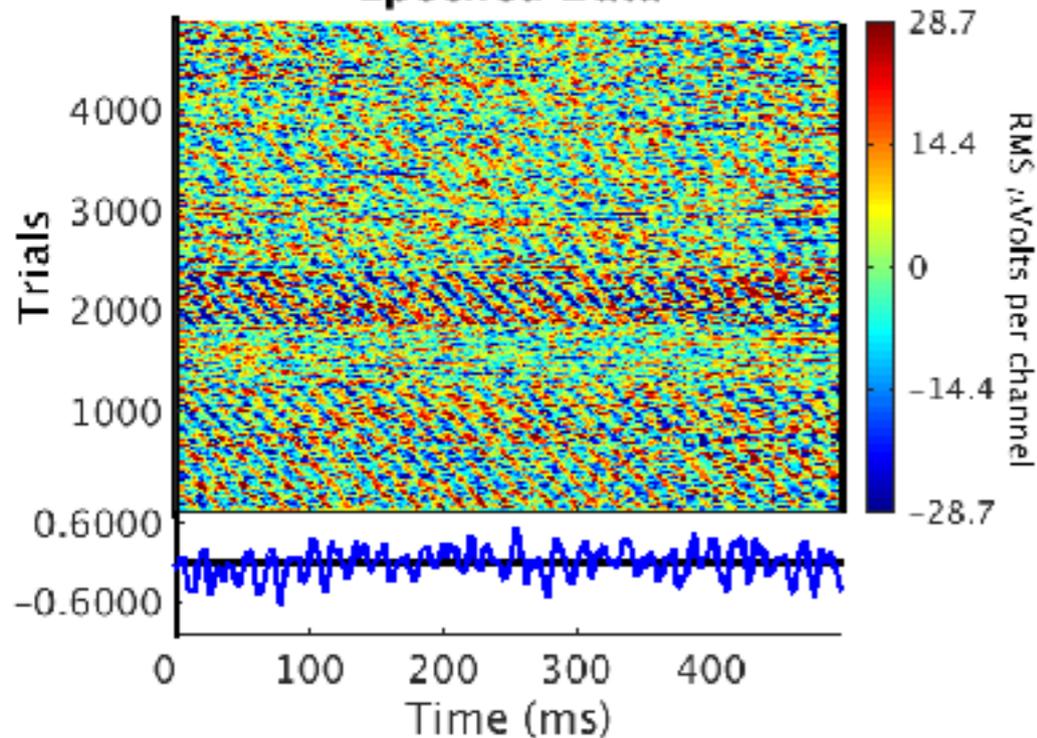


### Component Time Series



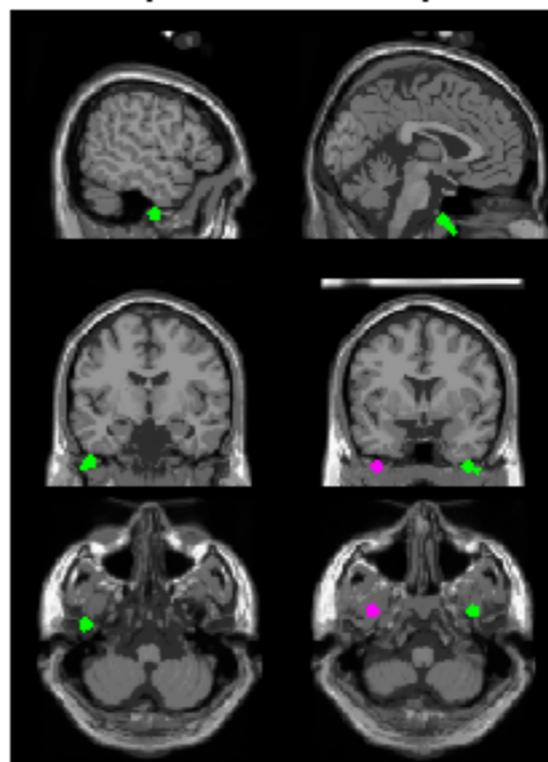
IC 7 of 32  
Data Var. Accounted For:  
3.09%

### Epoched Data



### 1 dipole

### 2 dipole

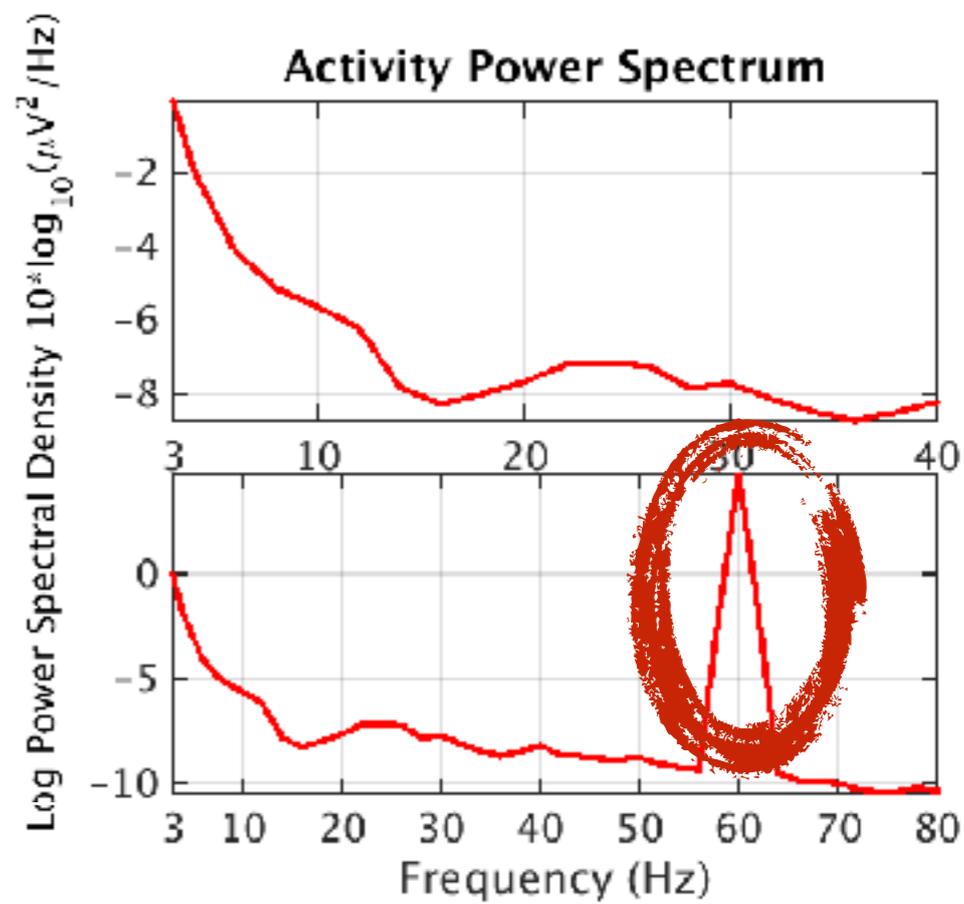


RV: 22.3%

RV: 11.9%

DMR: 9.8

### Activity Power Spectrum



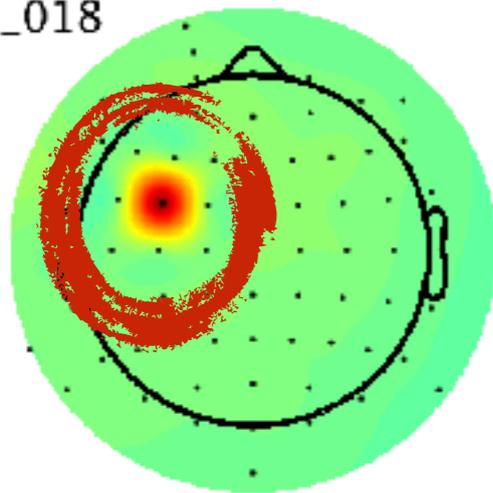
---

# Channel noise

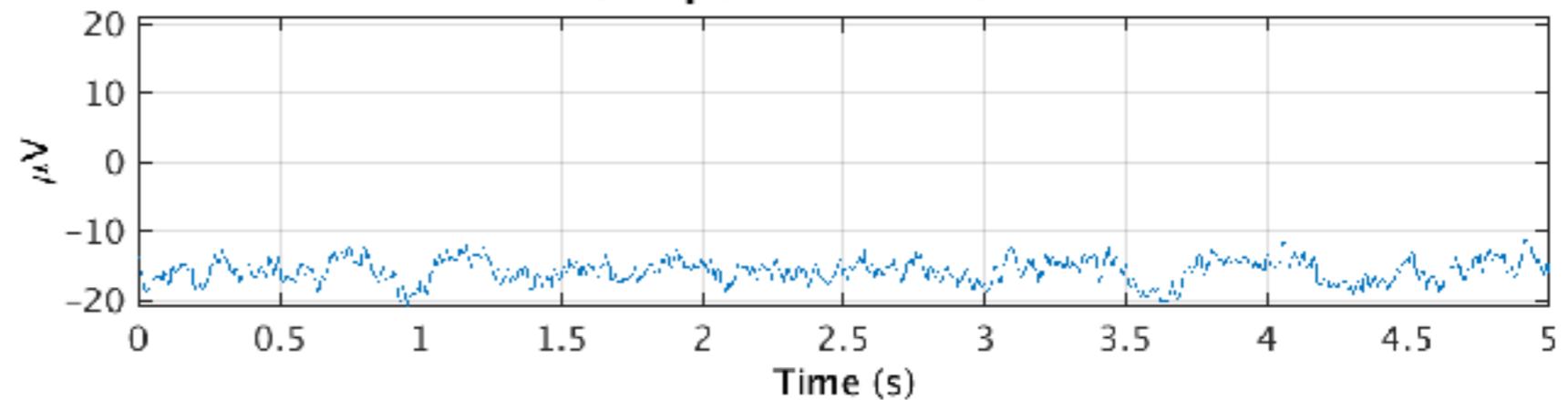
---

# Channel noise

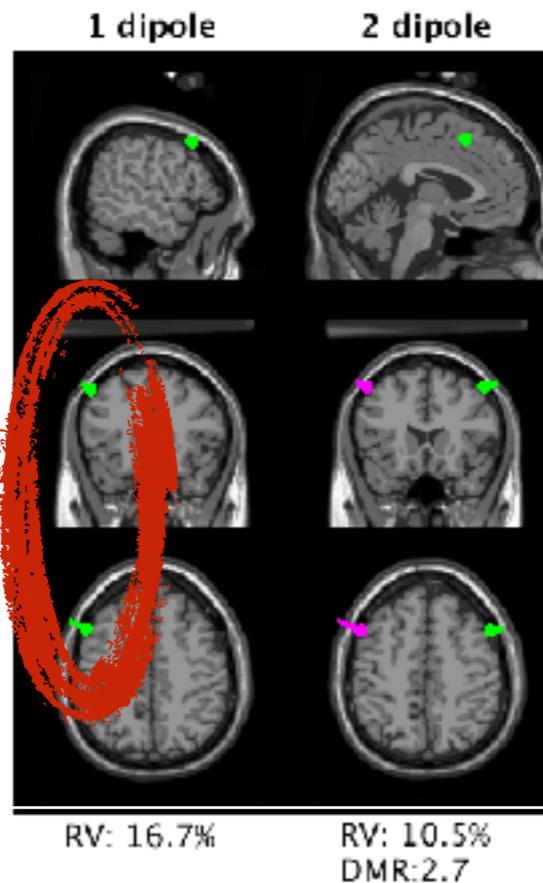
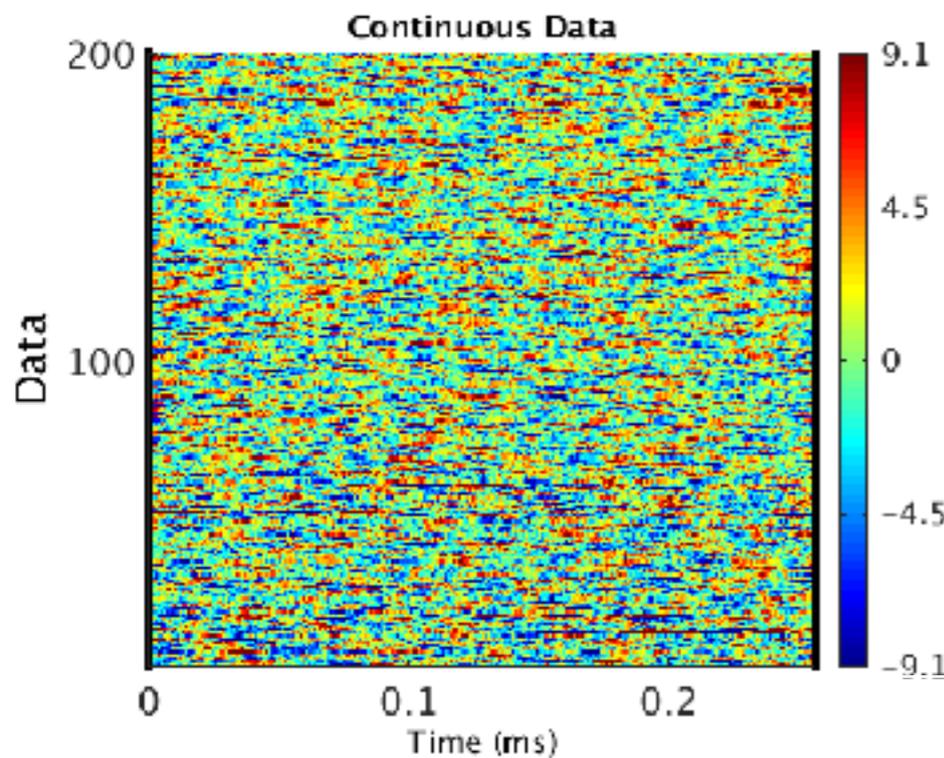
046462\_018



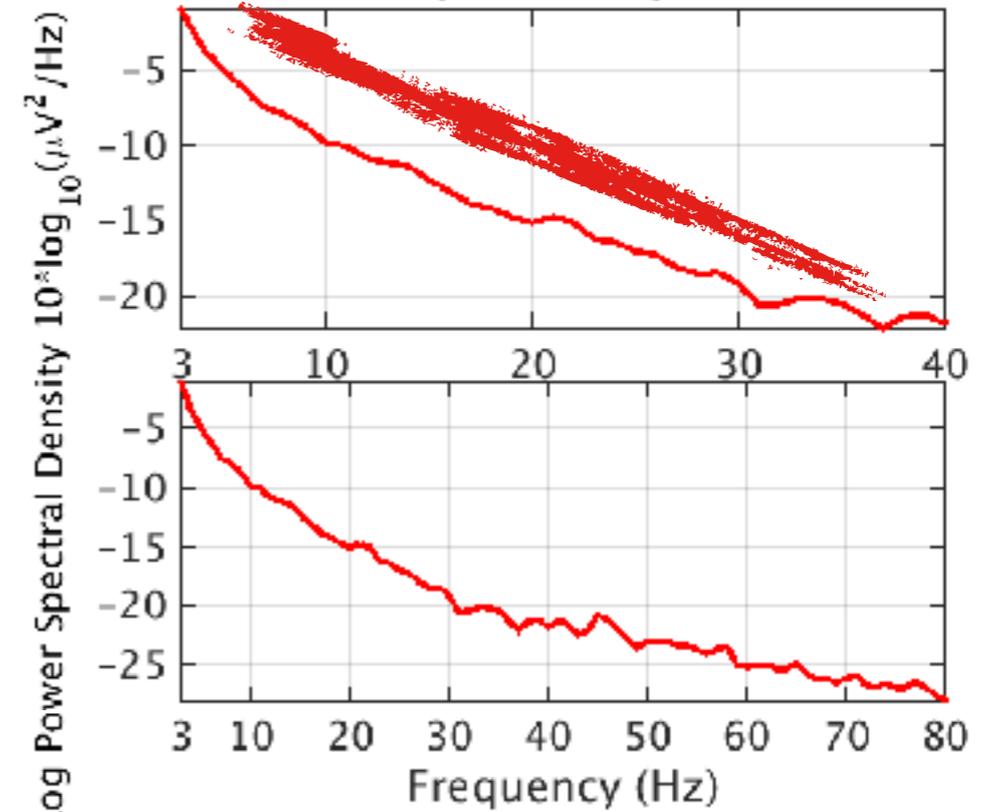
### Component Time Series



IC 18 of 65  
Data Var. Accounted For:  
1.54%

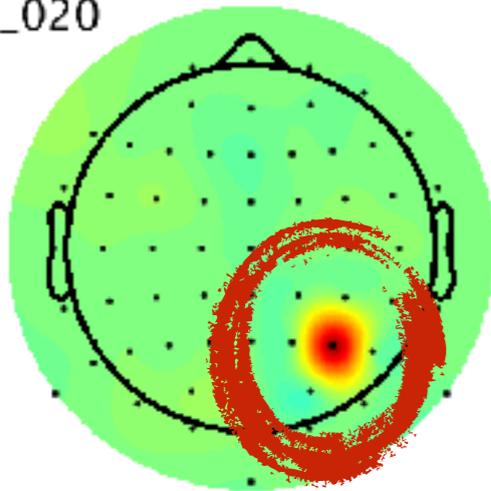


### Activity Power Spectrum



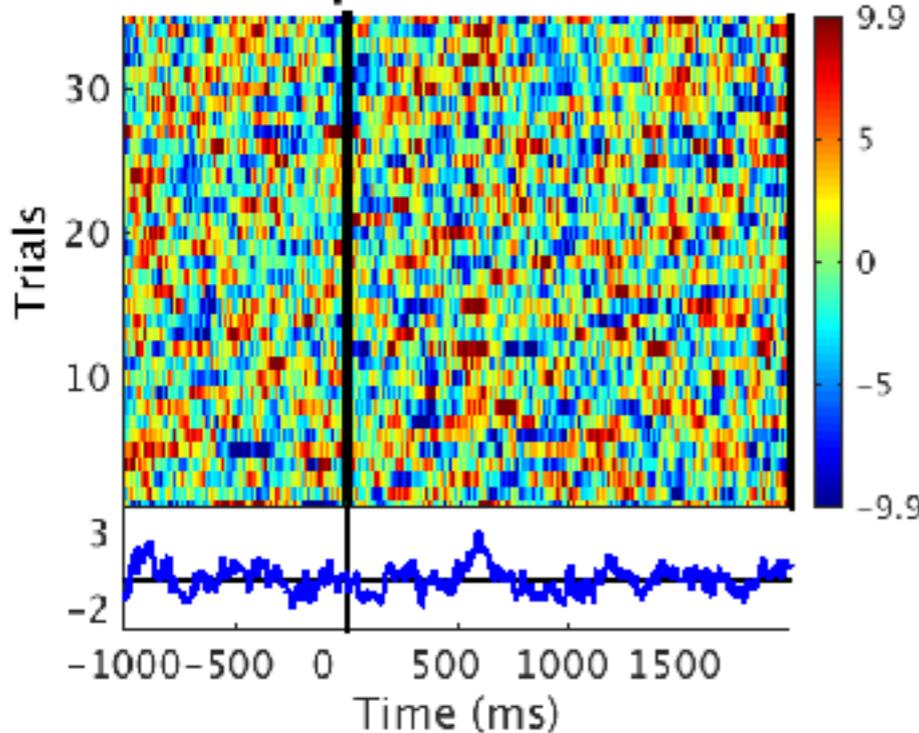
# Channel noise

046786\_020

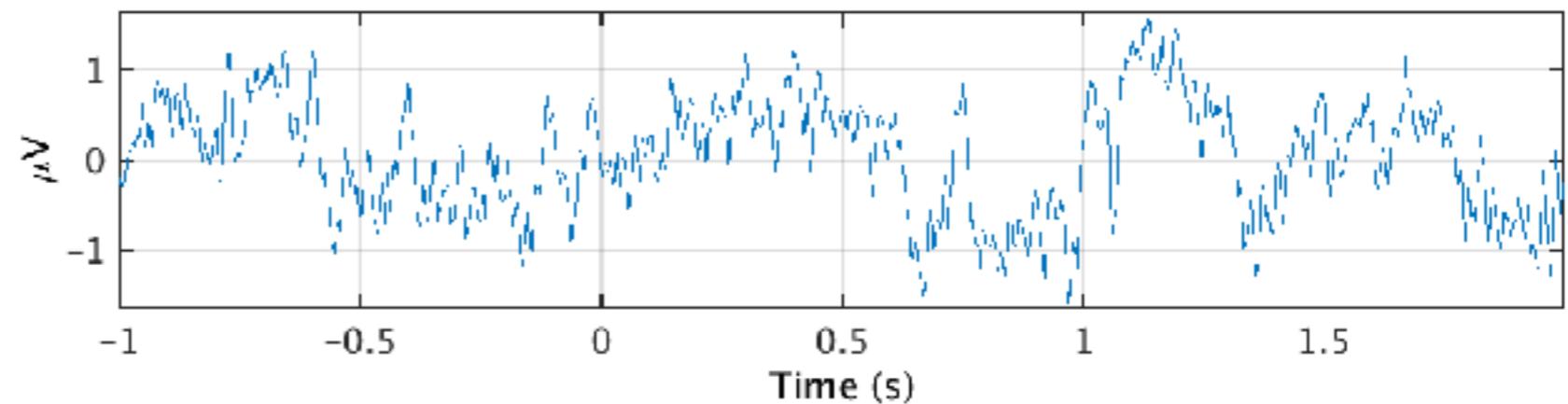


IC 20 of 63  
Data Var. Accounted For:  
0.37%

Epoched Data

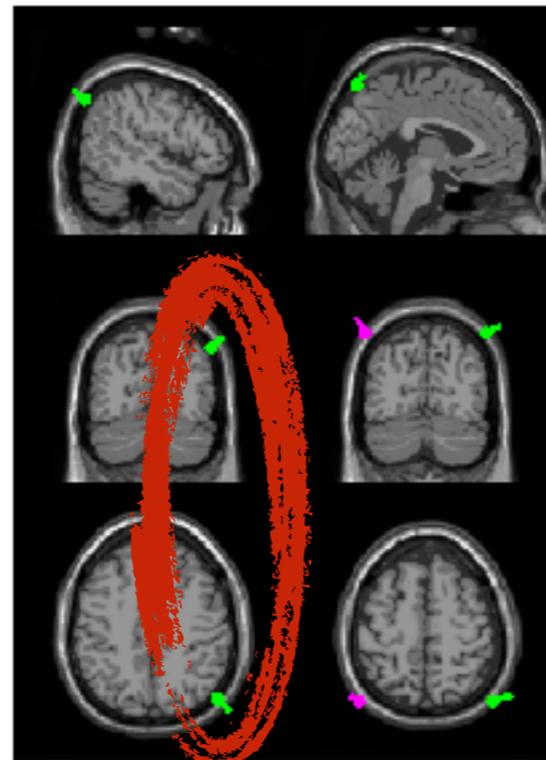


Component Time Series



1 dipole

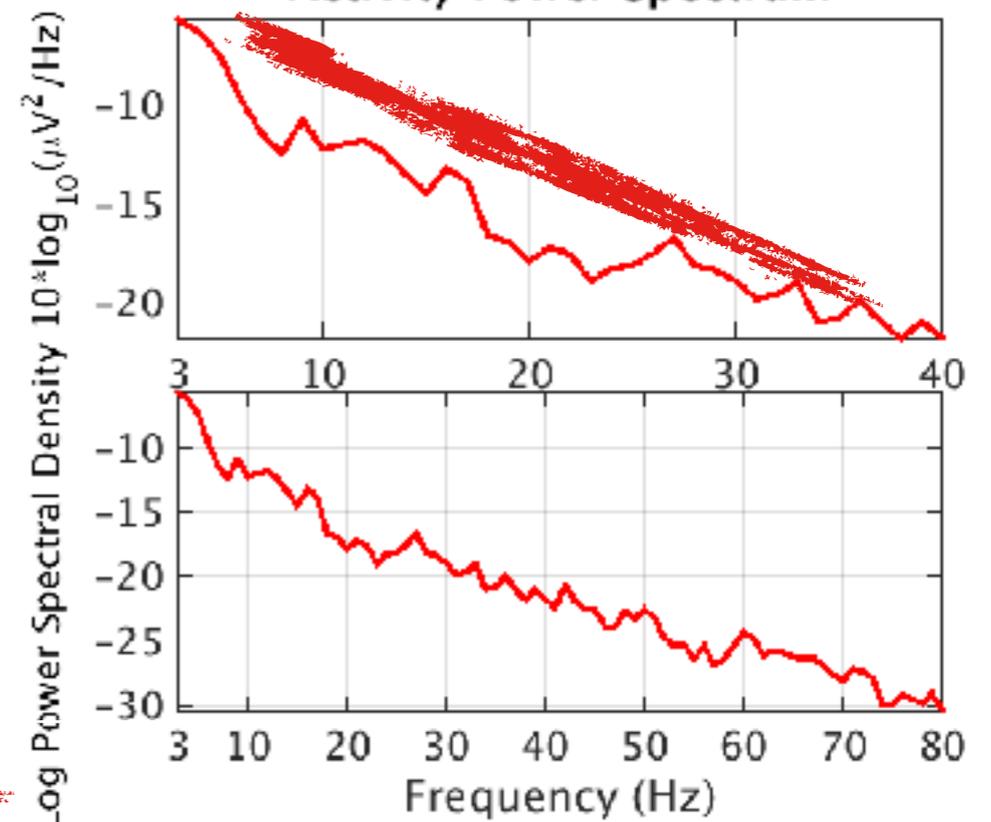
2 dipole



RV: 16.7%

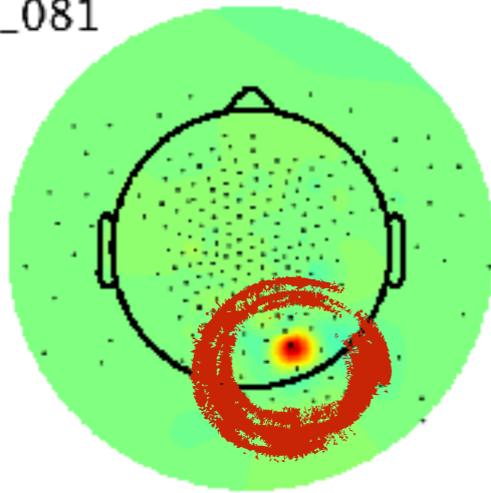
RV: 3.0%

Activity Power Spectrum

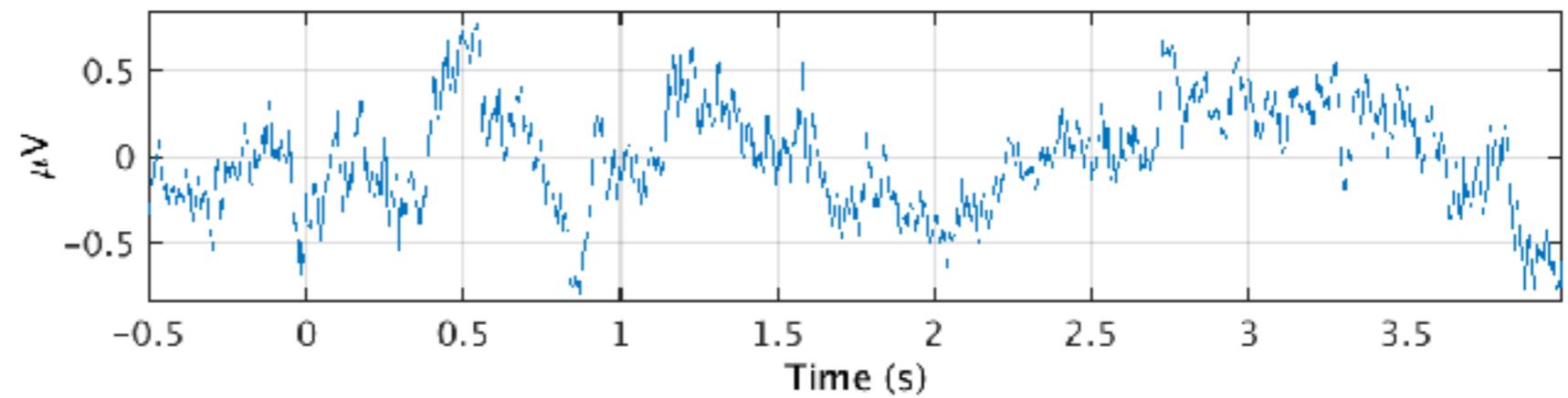


# Channel noise

074724\_081

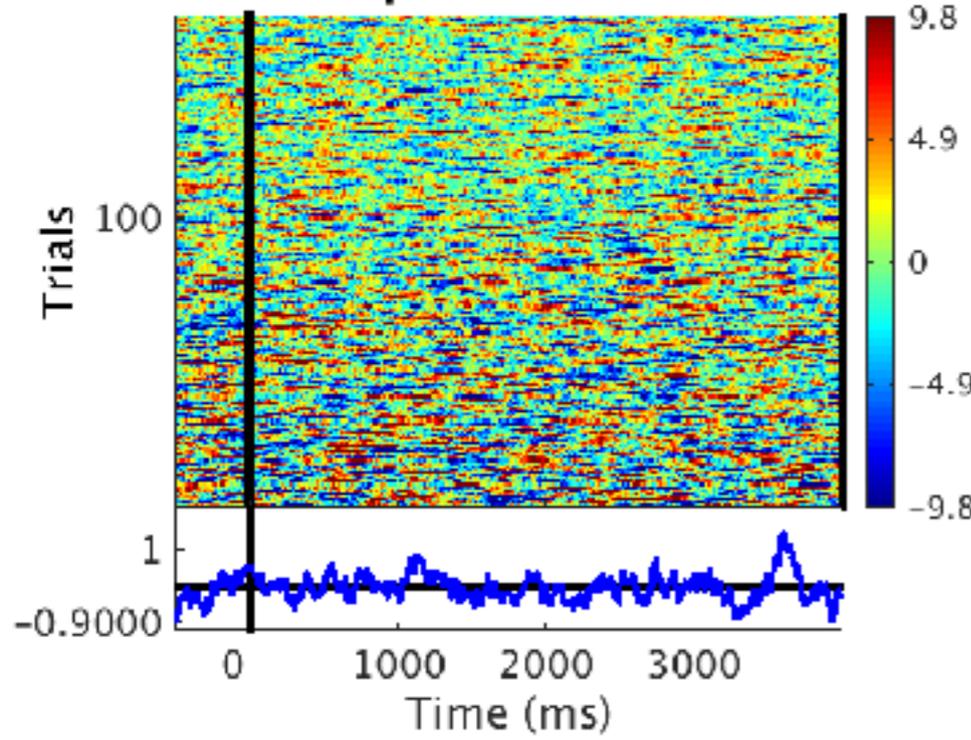


### Component Time Series

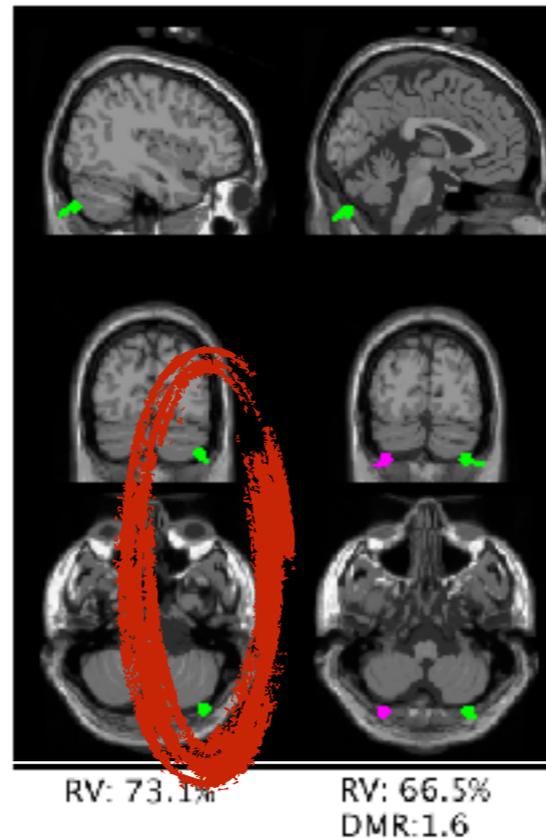


IC 81 of 218  
Data Var. Accounted For:  
0.11%

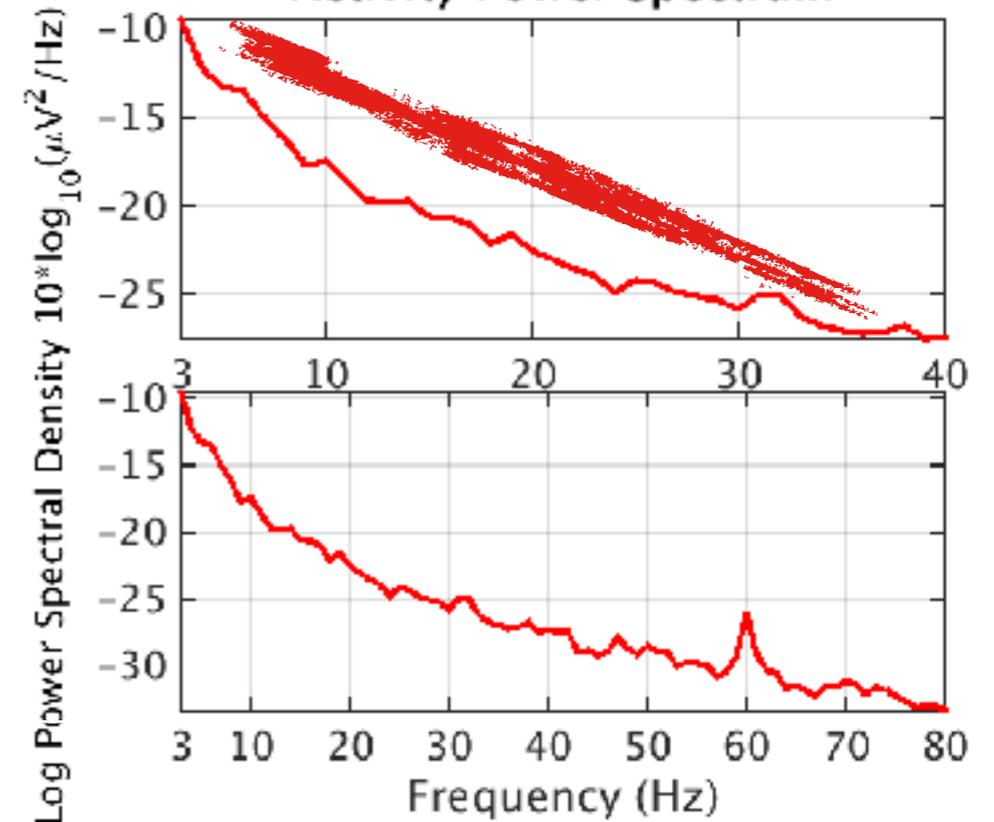
### Epoched Data



### 1 dipole 2 dipole



### Activity Power Spectrum



---

# ICLabel: Learning to Classify Independent Components of EEG Data

[What Is This Site?](#)

[Need To Register?](#)

[Forgot Your Password?](#)

[Just want to practice?](#)

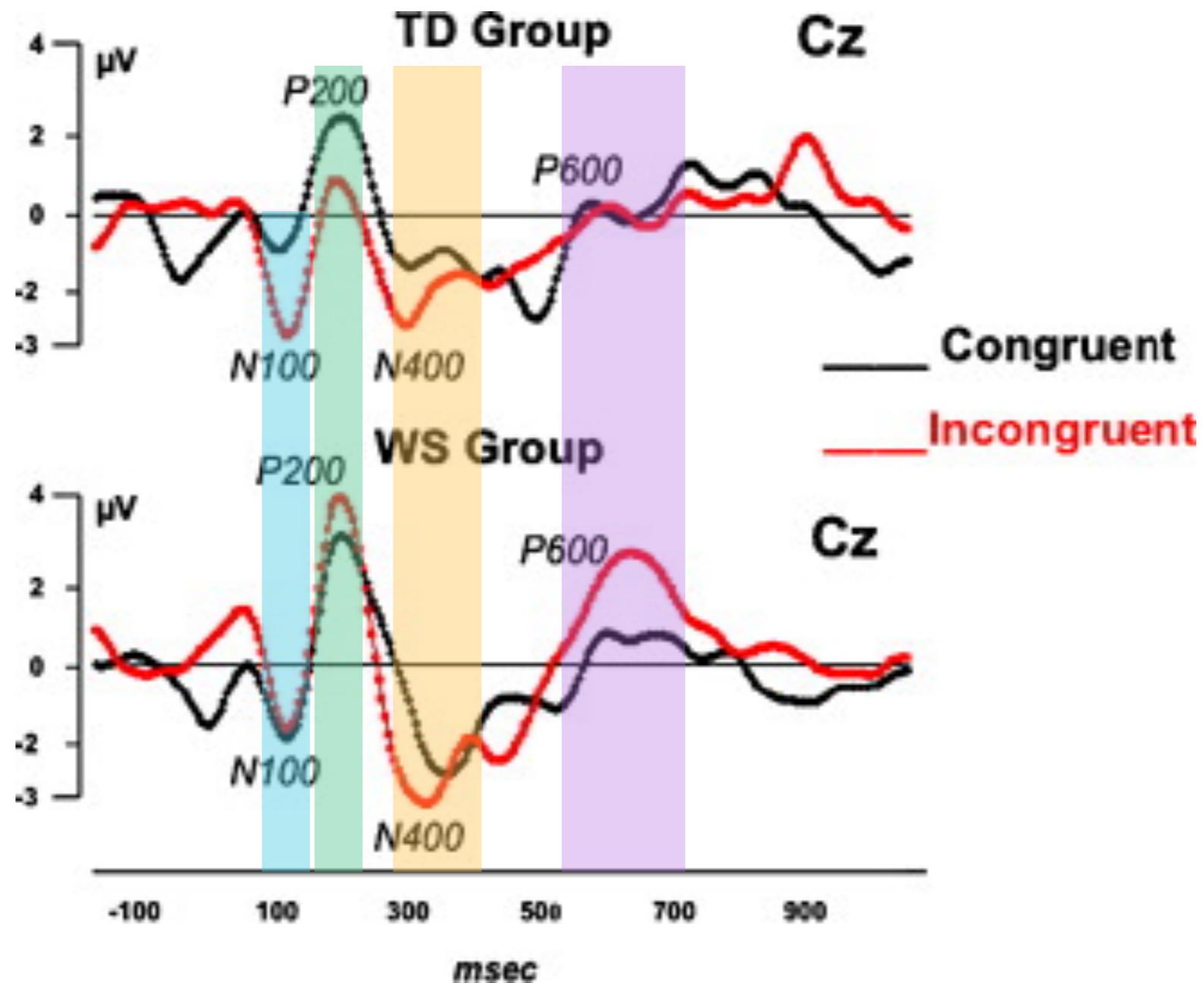
[Check Out The Leaderboard!](#)

<http://labeling.ucsd.edu>

---

# main ERP components

- endogene < ~250 ms
- esogene > ~250 ms



---

# componenti esogene

---

- **componenti visive**

**P1, N1** attenzione spaziale, processi discriminativi

**N170** facce

- **componenti uditive**

**MMN** (mismatch negativity) 160 - 220 ms. nella  
linea mediana centrale

serie di stimoli identici con occasionali stimoli  
differenti (L L L L L L L H L L L H L)

processo automatico di confronto tra lo stimolo  
e la traccia mnestica

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---

# componenti endogene

## P300

---

- **P3** - P3a frontale e P3b parietale (più comune)

elicitata da stimoli bersaglio infrequenti ma  
**“attesi”**

ampiezza modulata dallo sforzo del compito →  
allocazione di risorse? attenzione?

- **What is novel in the novelty oddball paradigm? Functional significance of the novelty P3 event-related potential as revealed by independent component analysis**

Debener, Makeig, Delorme, Engel (2005)

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# componenti endogene

## P300

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... cosa si sapeva della P300 nel (2004)

- solo uno stimolo **non atteso ma rilevante** elicitava P3

PARADIGMA: ODDDBALL

TASK

gruppo1

gruppo2

(1) toni frequenti (80%);

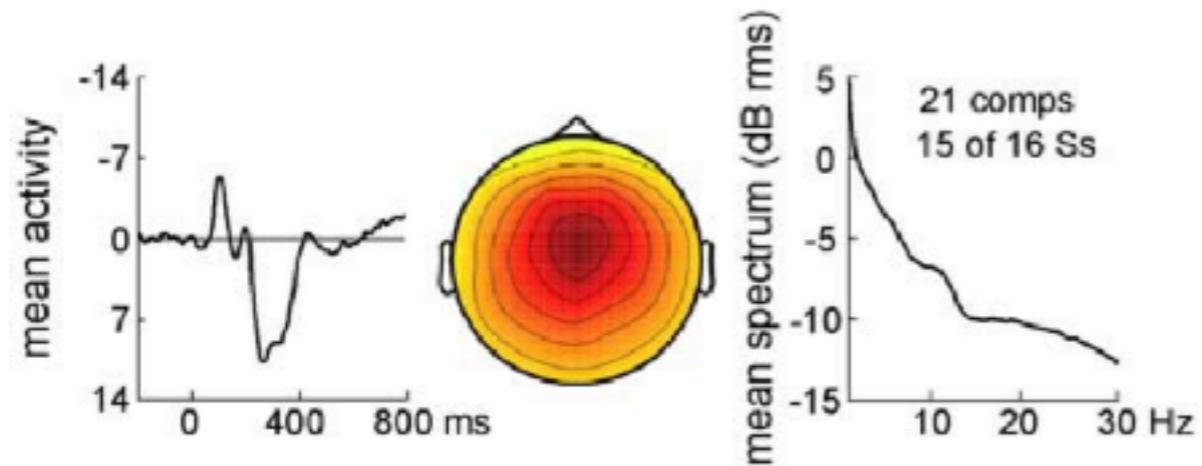
(2) toni non frequenti (10%);

(3) suoni naturali nuovi (10%)

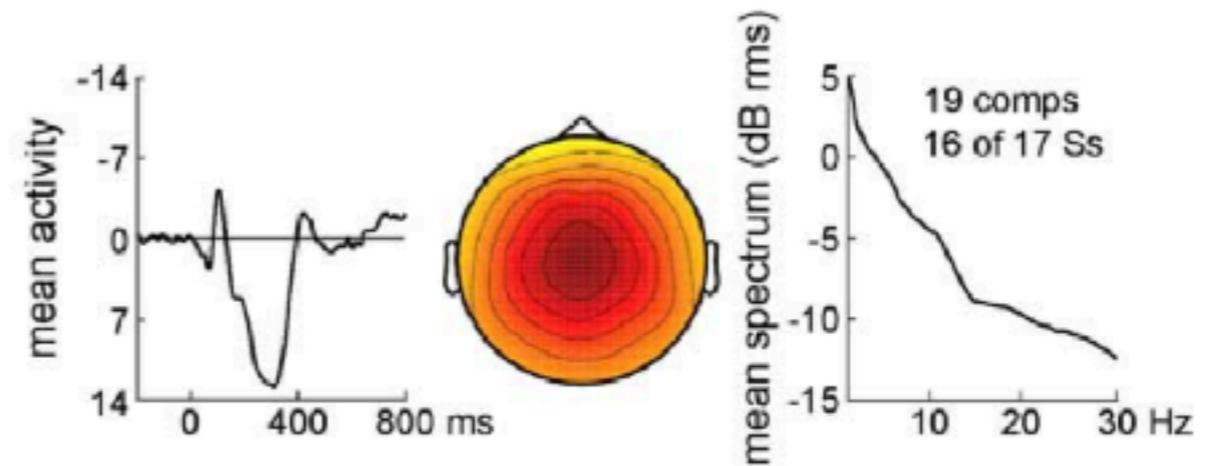
← count

← count

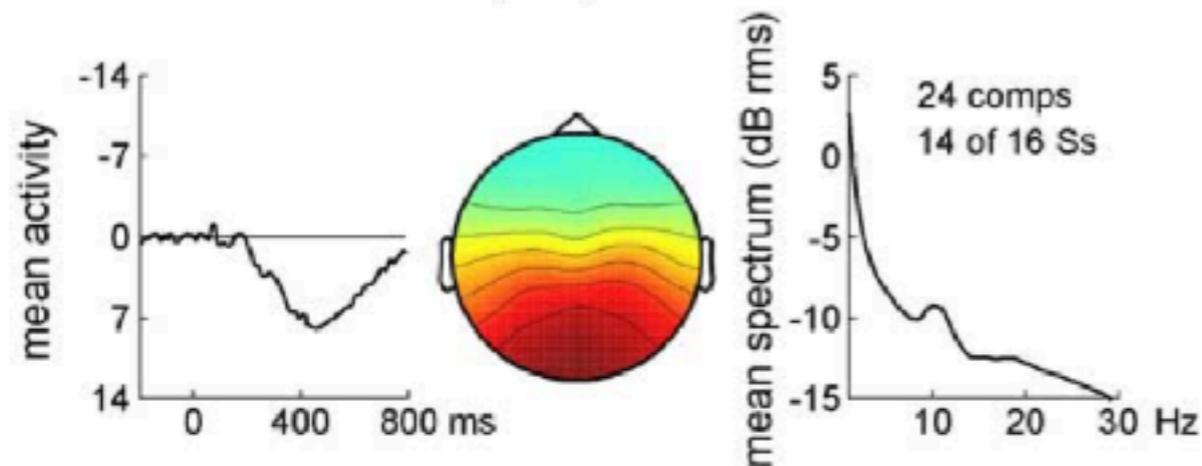
**A.** Frontal P3 cluster (FP3): Group 1 (count rare tones)



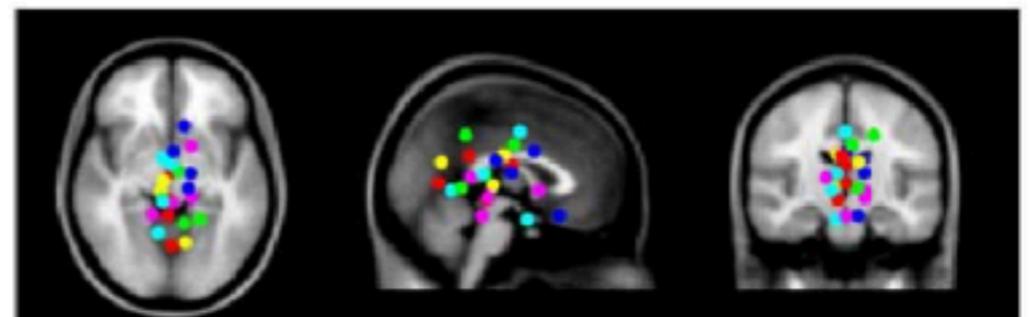
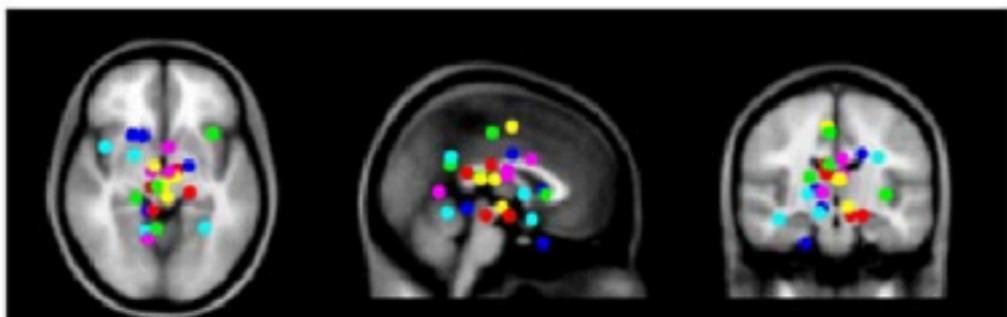
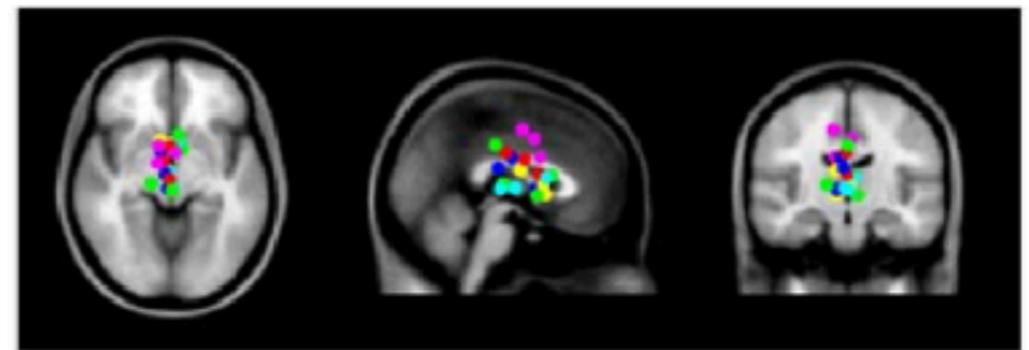
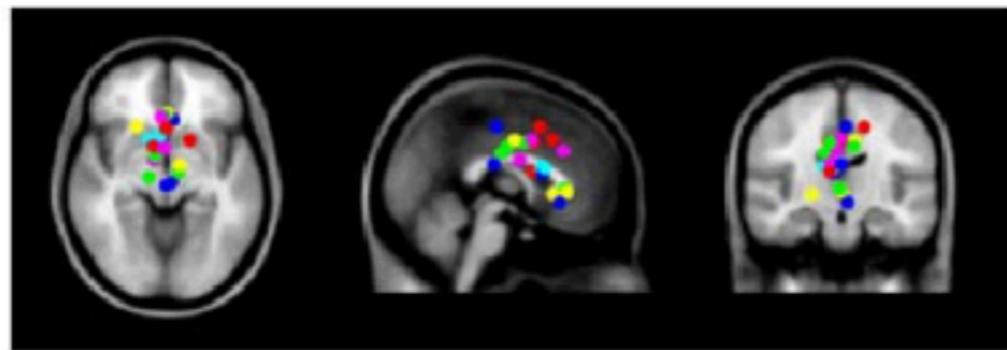
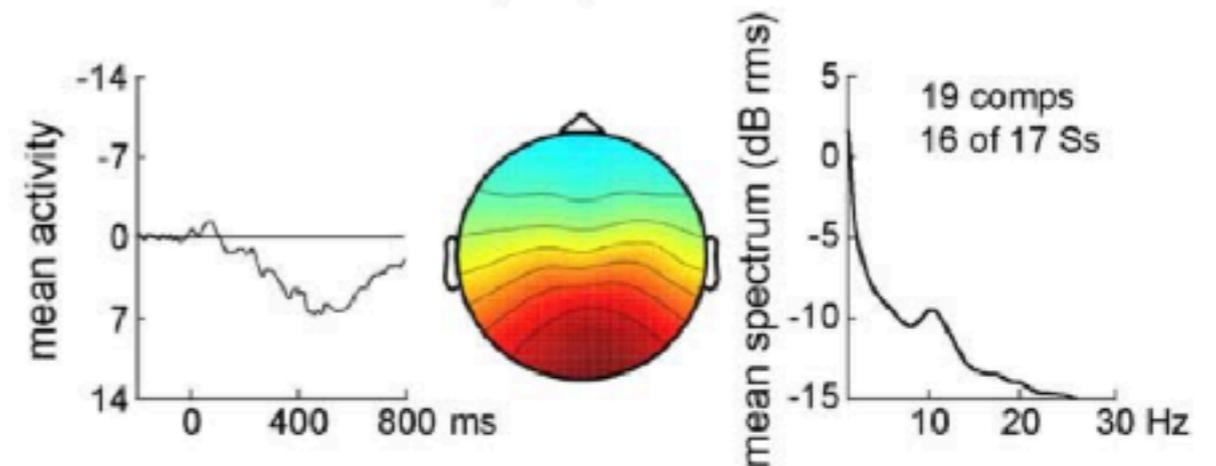
**C.** Frontal P3 cluster (FP3): Group 2 (count novel sounds)



**B.** Parietal P3 cluster (PP3)



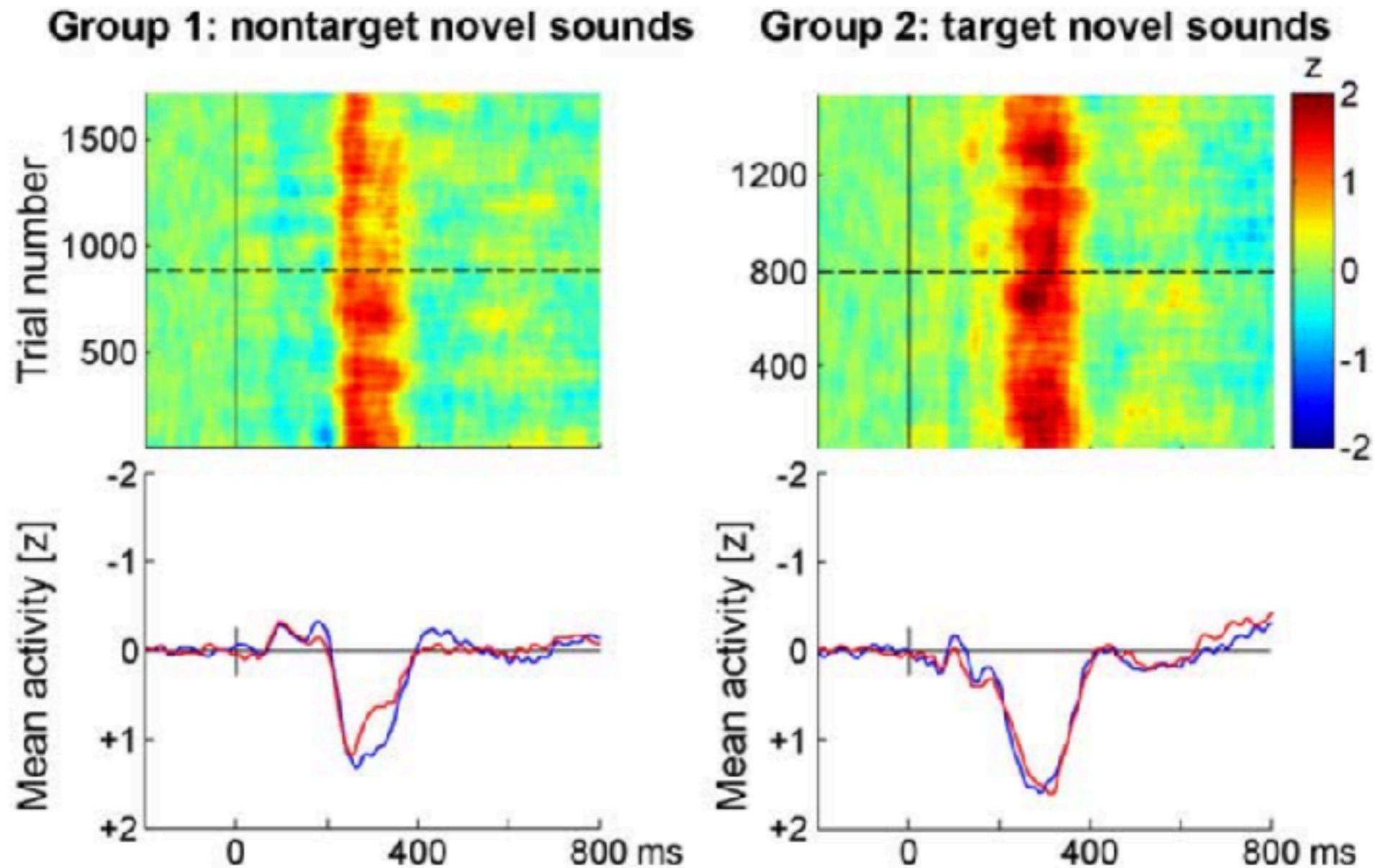
**D.** Parietal P3 cluster (PP3)



# componenti endogene

## P300

### FP3 cluster ERPs



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# componenti endogene CDA

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nature

Vol 438|24 November 2005|doi:10.1038/nature04171

LETTERS

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## **Neural measures reveal individual differences in controlling access to working memory**

Edward K. Vogel<sup>1</sup>, Andrew W. McCollough<sup>1</sup> & Maro G. Machizawa<sup>1</sup>

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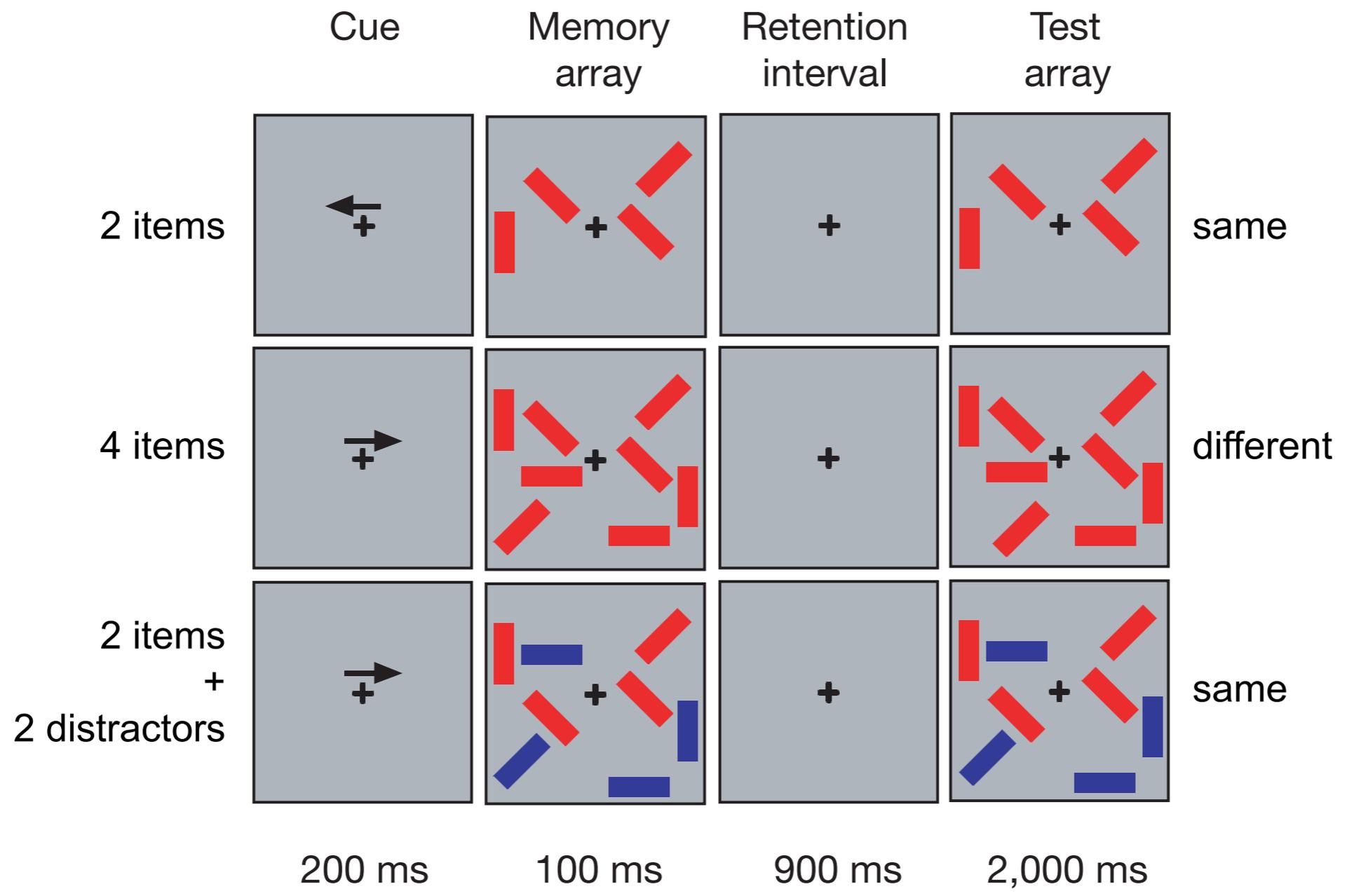
---

# componenti endogene

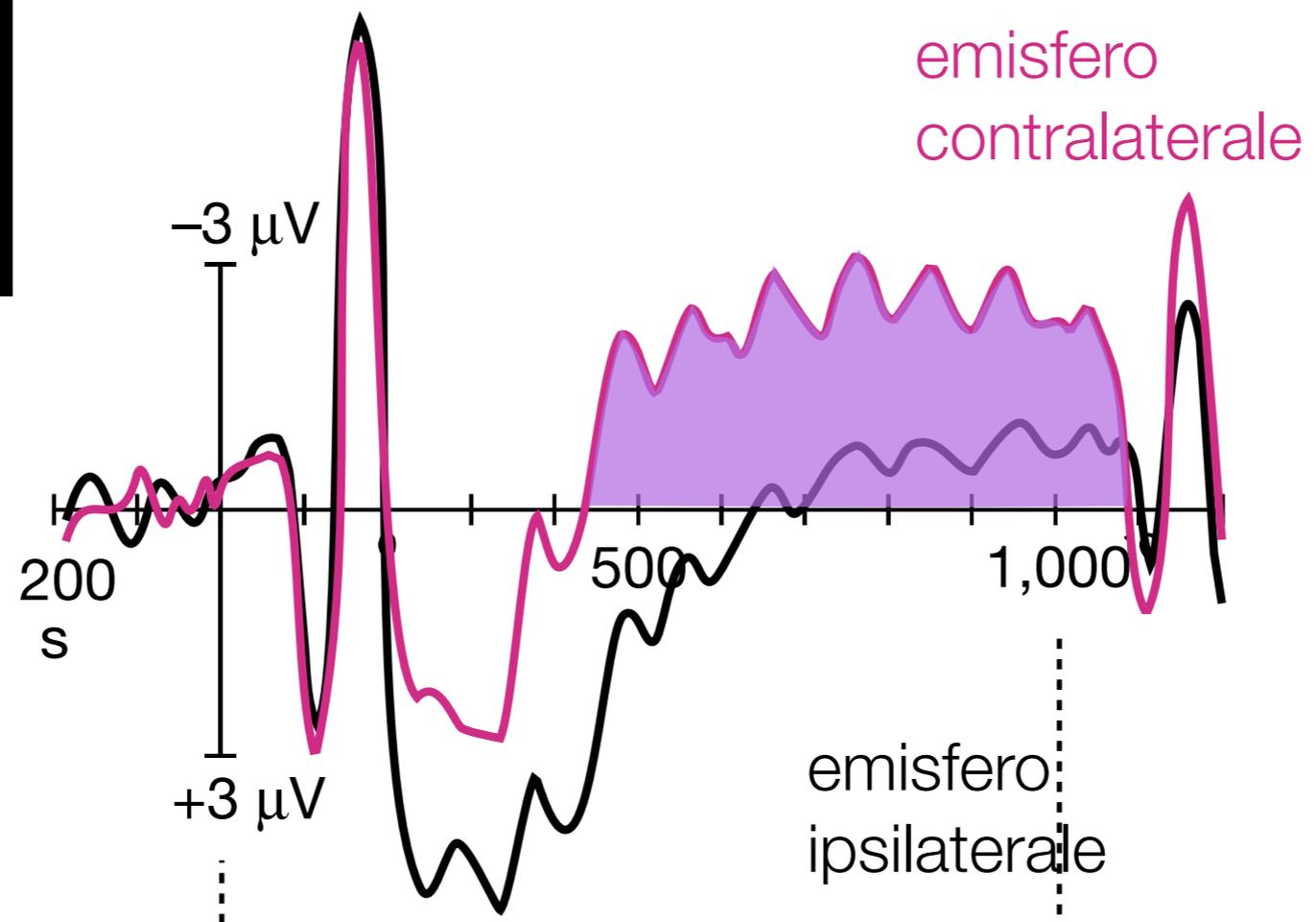
## CDA

---

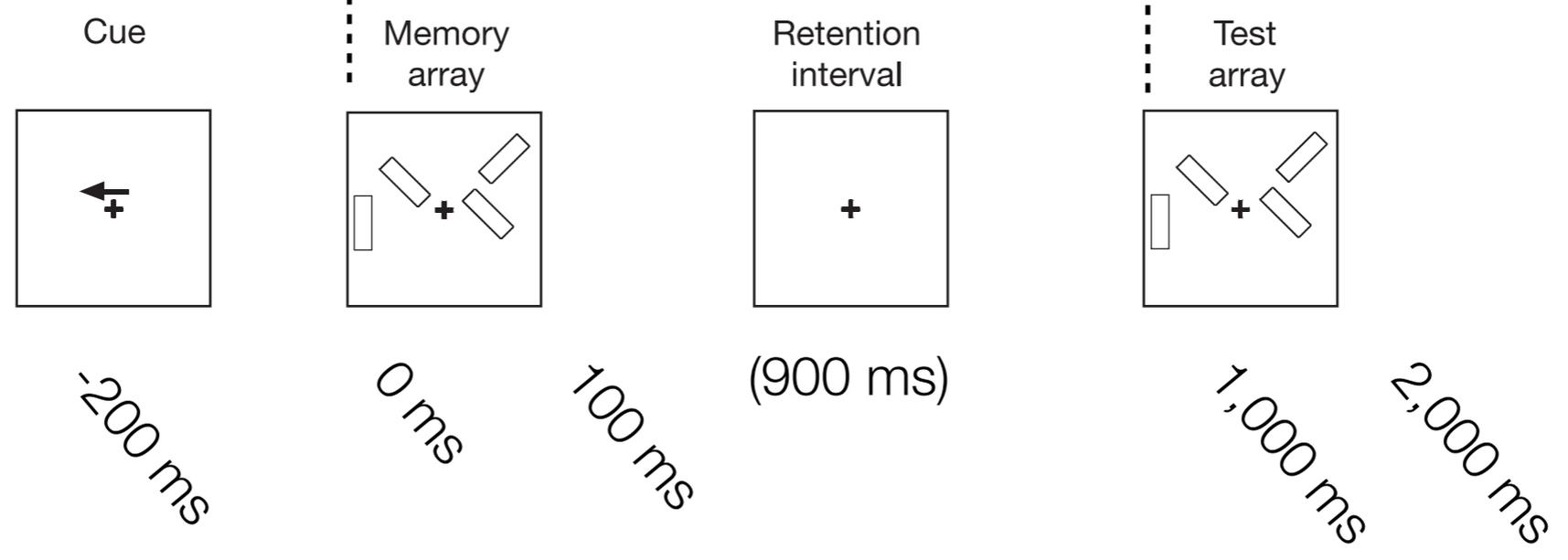
- STM visiva può mantenere solo rappresentazioni di tre o quattro elementi contemporaneamente
  - nel 2004 non era ancora stato scoperto un indice neurofisiologico di questo limite di capacità di immagazzinamento
  - **SCOPO:** trovare nell'uomo evidenze elettrofisiologie di attività cerebrale che riflettano la codifica e il mantenimento di informazioni in STM visiva
-

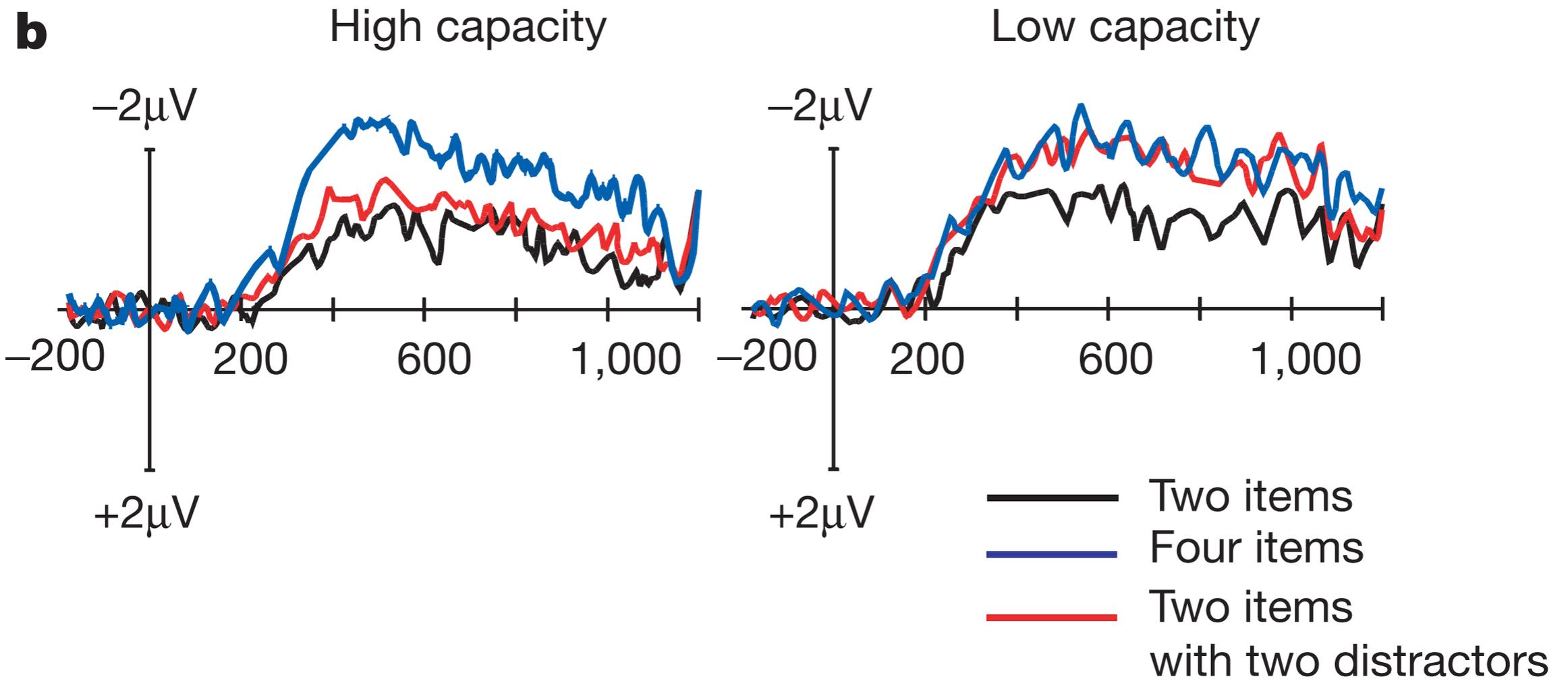


grande-media di  
elettrodi laterali,  
occipitali e  
parietali  
posteriori



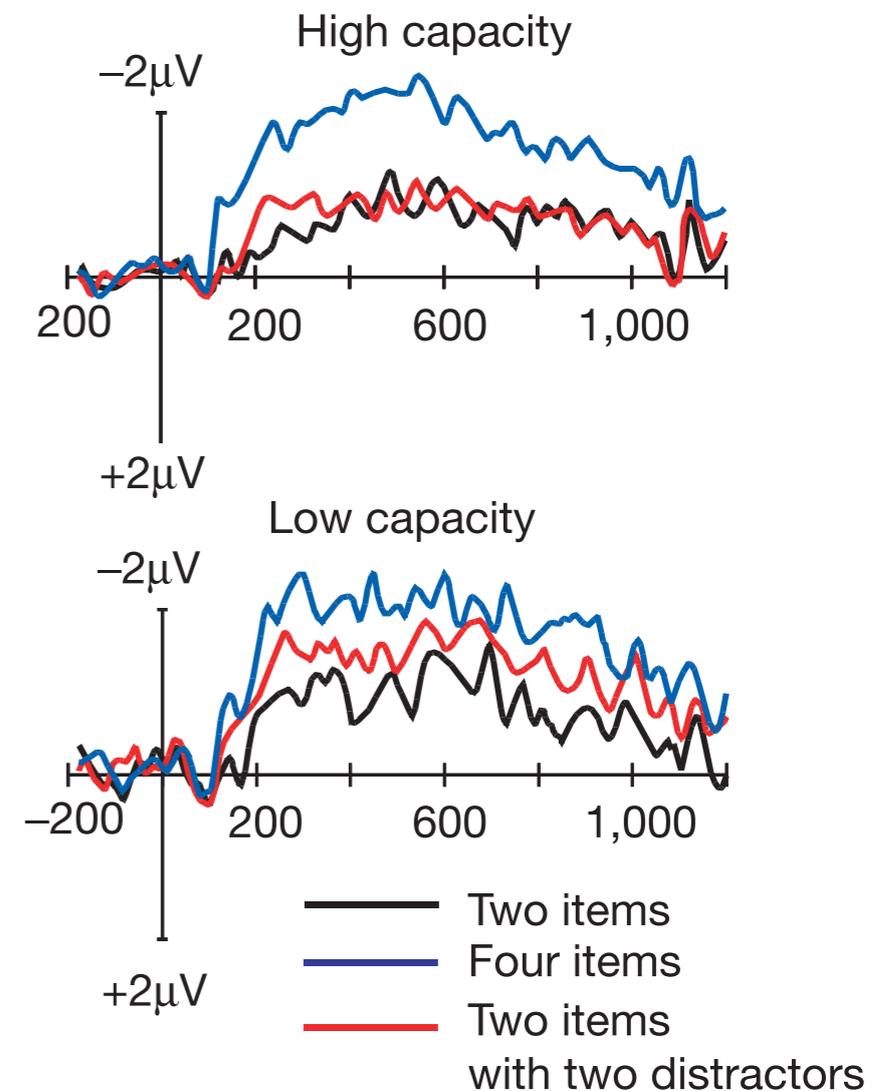
CDA  
contralateral  
delay activity





# natura della CDA

- incapacità **generale** degli individui “low capacity” di esercitare un controllo efficace in ogni aspetto del funzionamento della WM?
- incapacità **specificata** degli individui “low capacity” di escludere elementi irrilevanti in ingresso in VSTM



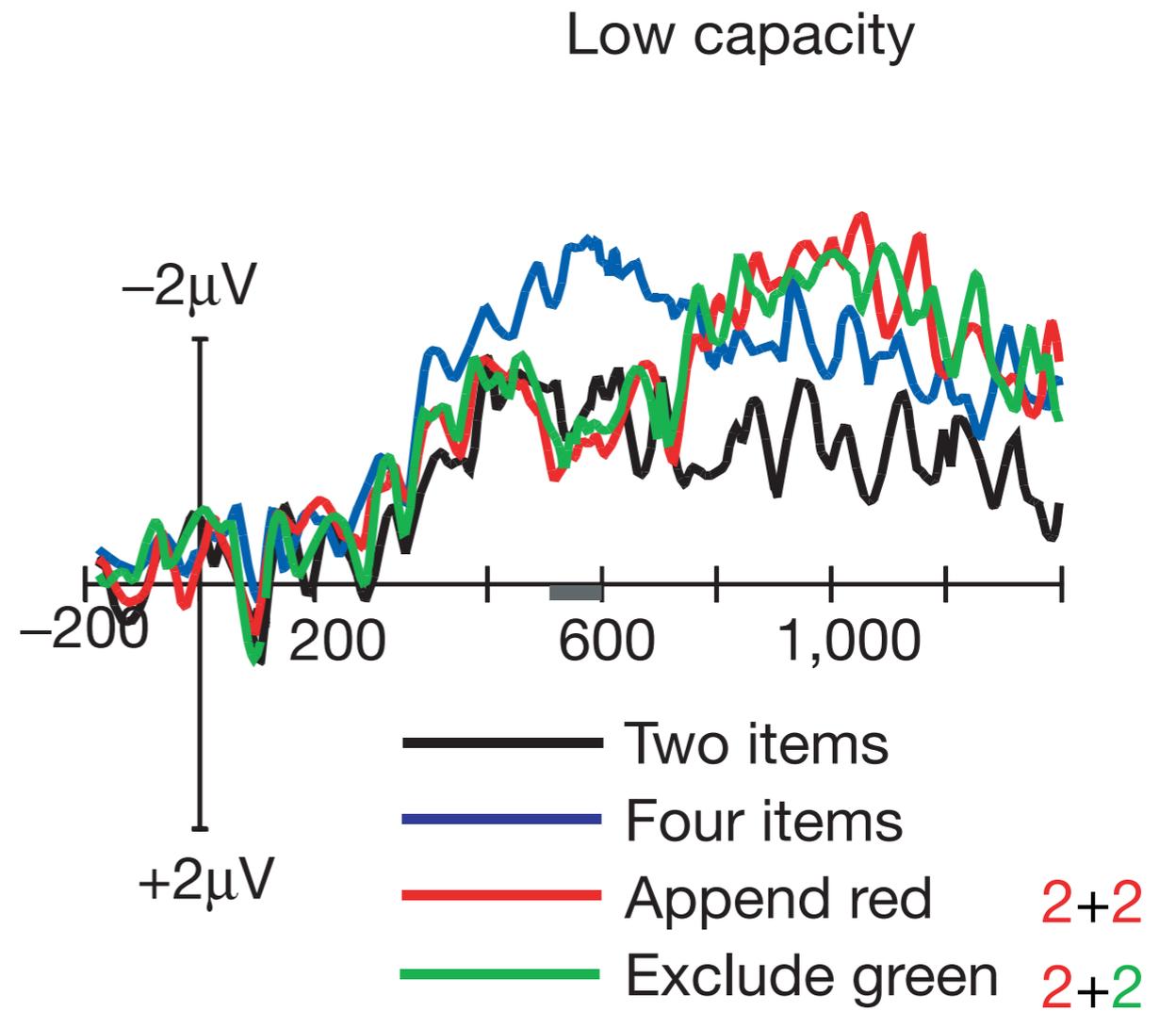
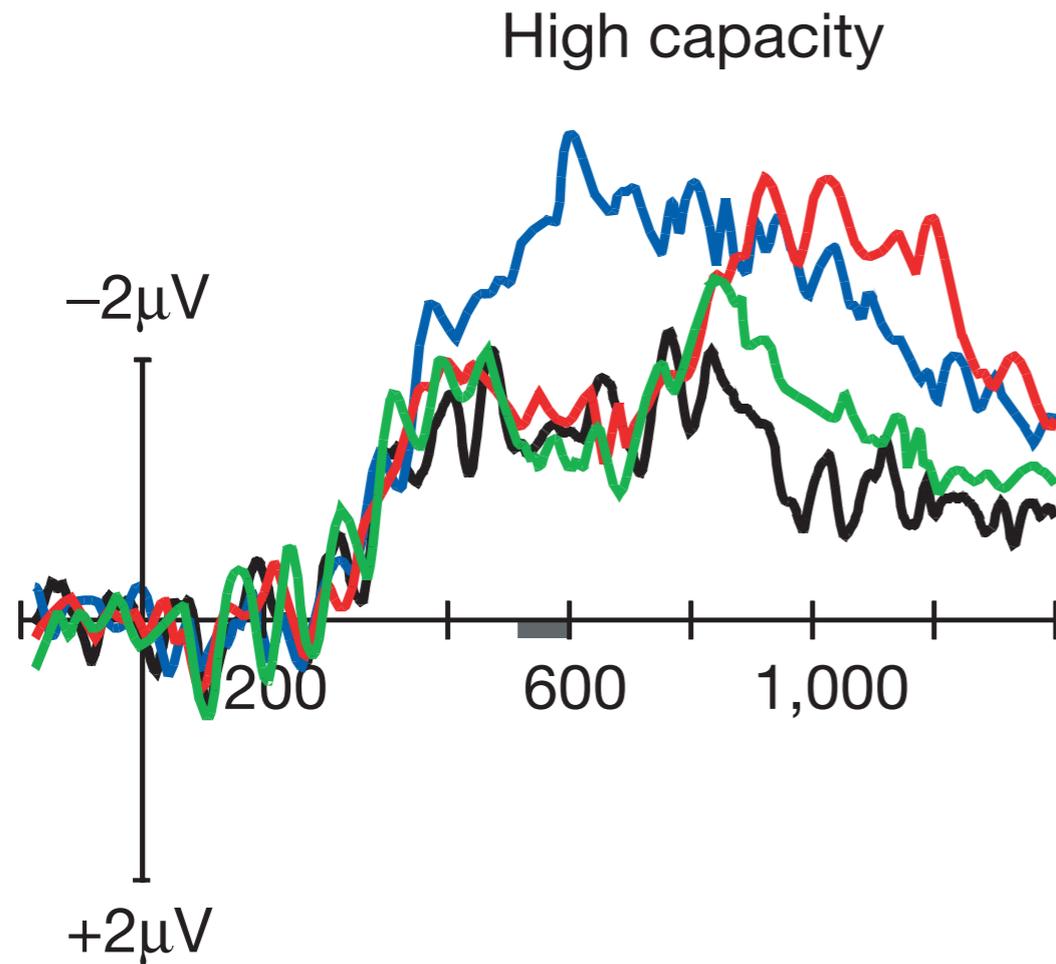
	Cue	Memory array	Retention interval	2nd memory array	Retention interval	Test array	
2 items							same
4 items							different
2 items							same
4 items							different
	200 ms	100 ms	400 ms	100 ms	400 ms	2,000 ms	

exclude green append red

50%

	Cue	Memory array	Retention interval	Test array	
2 items					same
4 items					different
	200 ms	100 ms	900 ms	2,000 ms	

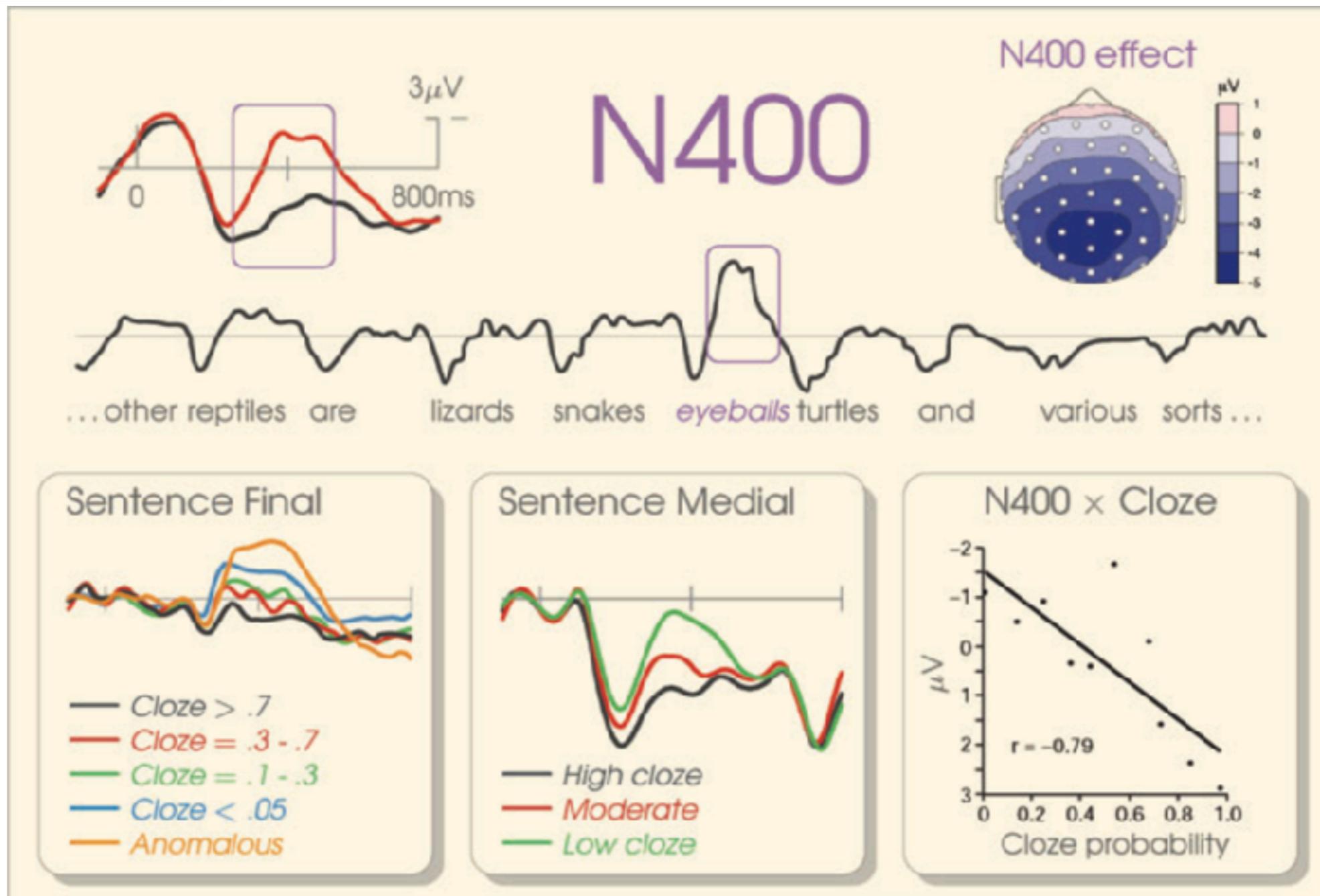
50%



**results**

# componenti endogene

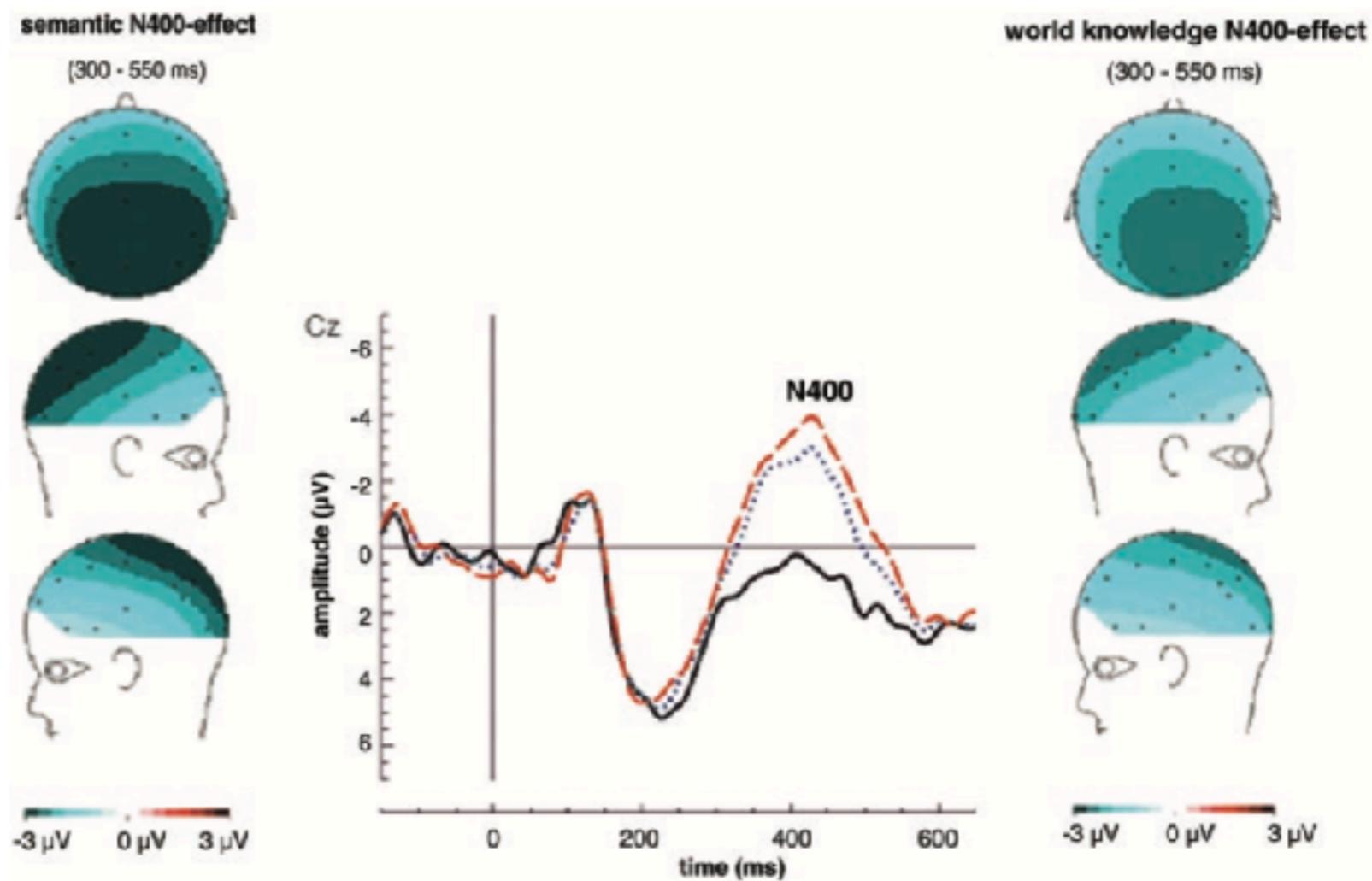
## N400



# componenti endogene

## N400

word  
effect



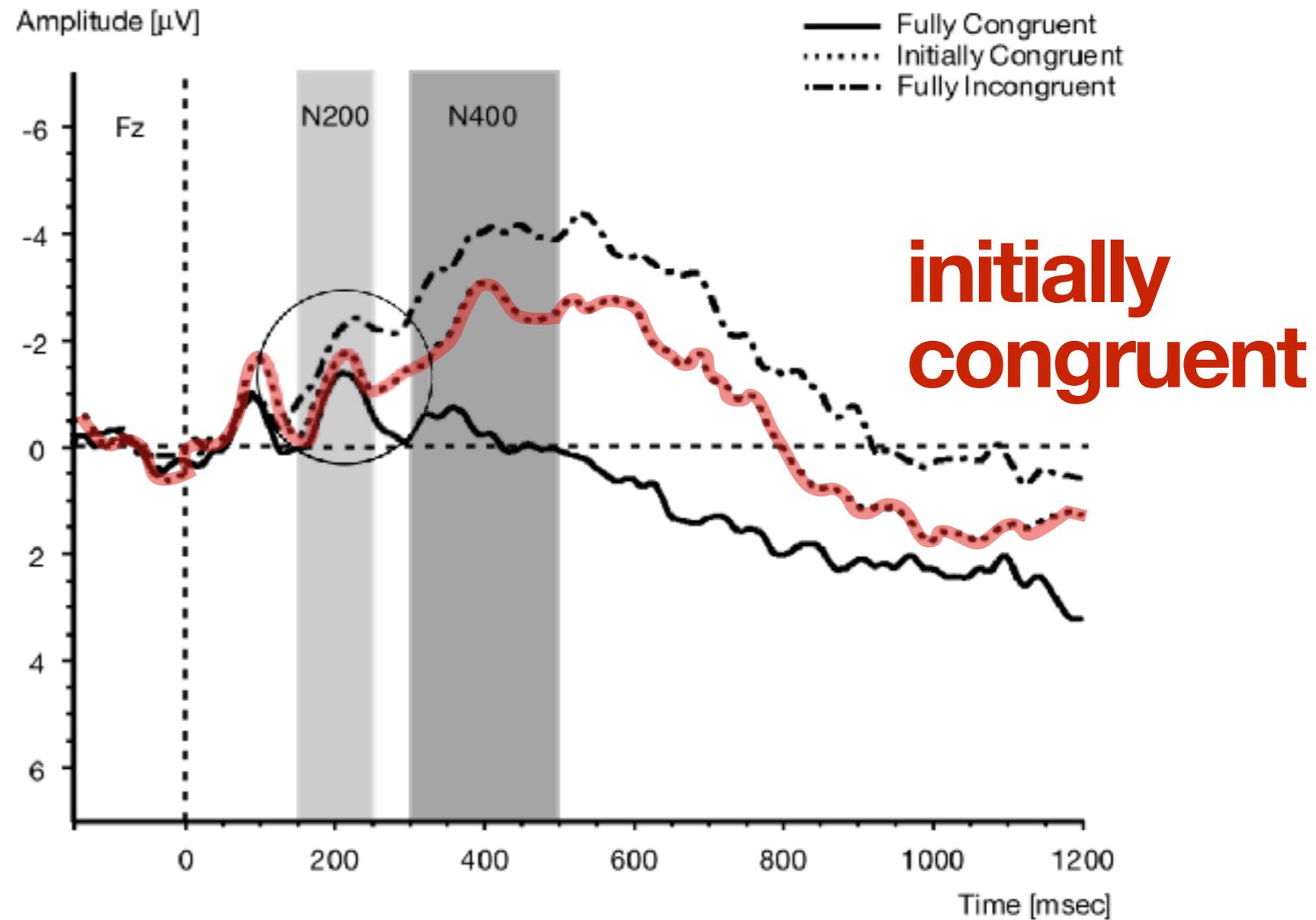
world  
effect

**correct:** The Dutch trains are yellow and very crowded.  
**world knowledge violation:** The Dutch trains are white and very crowded.  
**semantic violation:** The Dutch trains are sour and very crowded.

# componenti endogene N400

“It was a pleasant surprise to find that the car repair bill was only 17 dolphins”.

dollars  
**dolphins**  
scholars



---

# N400 e violazioni di informazioni di genere

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- violazione di informazioni sociali, aspettativa sociale, status sociale, norme sociali
  - stereotipi di genere e razziali
  - N400 fronto/centrale
-

---

# N400 e violazioni di informazioni di genere

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- violazione di informazioni di genere del sé generano una N400?



io bacio una ragazza

lui bacia una ragazza



io bacio un ragazzo

lei bacia un ragazzo

---

# N400 e violazioni di informazioni di genere

